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**AN EMPIRICAL INVESTIGATION INTO THE DECISION-MAKING  
PROCESSES OF NEW INFRASTRUCTURE DEVELOPMENT**

**BENJAMIN DEHE**

A thesis submitted to the University of Huddersfield in partial fulfilment of the  
requirements for the degree of Doctor of Philosophy

The University of Huddersfield

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## List of Abbreviations

3PD	Third Party Development
AEC	Architecture, Engineering and Construction
AEDET	Achieving Excellence Design Evaluation Toolkit
AHP	Analytical Hierarchy Process
ANOVA	Analysis Of Variance
BIM	Building Information Modelling
BPR	Business Process Re-engineering
BSC	Balanced Score Card
BTS	Barlett's Test of Sphericity
CA	Competitive Advantage
CBA	Choosing by Advantage
CLMS	Closed-Loop Management System
CPMC	California Pacific Medical Centre
DGH	District General hospital
DM	Decision-Makers
DMAIC	Define, Measure, Analyse, Improve and Control
DMP	Decision-Making Process
DoE	Design of Experiment
DOH	Department Of Health
DST	Dempster-Shaffer theory
DV	Dependent Variables
EBD	Evidence Based Design
EFQM	European Foundation for Quality Management
ELECTRE	Elimination et Choice Translating Reality
ER	Evidential Reasoning
FBC	Full Business Case
FMEA	Failure Mode Effect Analysis
GDP	Growth Domestic Product
GIS	Geographic Information System
GNP	Growth National Product
HoQ	House of Quality
IDS	Intelligent Decision Systems
IGLC	International Group for Lean Construction
IS	Information System
IV	Independent Variable
JIT	Just-In-Time
KMO	Keiser-Meyer-Olkin
KPIs	Key Performance Indicators
LCI	Lean Construction Institute
LPS	Last Planner System
MBNQA	Malcolm Baldrige National Quality Award
MCDA	Multiple Criteria Decision Analysis
MIR	Make It Rational
MRA	Multiple Regression Analysis
MS	Management Science
MT	Management Theories
NID	New Infrastructure Development

OBC	Outline Business Case
OM	Operations Management
OpEx	Operational Excellence
OR	Operational Research
OS	Operations Strategy
PBLCF	Partial & Bespoke Lean Construction Framework
PC	Public Consultation
PCA	Principal Component Analysis
PDCA	Plan-Do-Check-Act
PDSA	Plan-Do-Study-Act
PFI	Private Finance Initiative
POM	Production and Operations Management
PPP	Private Public Partnership
PROMETHEE	Preference Ranking Organisation Method for Enrichment Evaluations
PSS	Planning Support System
QFD	Quality Function Deployment
RBV	Resource Based View
SEC	Strategic Estates Committee
SMART	Simple, Multi-Attribute Rating Technique
SMED	Single Minute Exchange of Die
SMM	Soft Systems Methodology
SOP	Standard Operating Procedures
SPC	Statistical Process Control
SPSS	Statistical Package for the Social Sciences
SSDP	Strategic Service Delivery Plan
SSM	Soft System Methodology
TCE	Transaction Cost Economics
ToC	Theory of Constraints
TOPSIS	Technique for Order Preference by Similarity to an Ideal Solution
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQC	Total Quality Control
TQM	Total Quality Management
VIF	Variance Inflation Factor
VoC	Voice of the Customer
WWP	Weekly Work Plans

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## **The Author**

Ben is a Lecturer in Operations Management at the University of Huddersfield. He moved to the Business School early 2012 and has focused his work in the application of Operational Excellence concepts and theories. Six-Sigma Black-Belt certified and passionate about continuous improvement, since 2005, Ben has been applying, researching, consulting, and teaching Operational Excellence methodologies within manufacturing, built environment, transactional and more recently in the sport context. Previously, he worked for Renault in France and Rolls-Royce Motor cars in England, as Logistics and Production Planner, where he gained his manufacturing experience.

He currently teaches at UG, PG levels as well as on Executive Programmes the following subjects: Operations Management, Project Management, Operations Strategy and Decision-making.

He first graduated in Industrial Logistics in France, then, pursued in Supply Chain Management and completed an MSc in Operations Management before starting his PhD part-time in 2010. Ben's thesis focuses on the decision-making processes and mechanisms required to enhance the planning and design of new infrastructure using Lean thinking methodologies.

As part of his PhD journey, he participated in and presented at international conferences: the 22<sup>nd</sup> Production and Operations Management Society (POMS) Conference in Reno, Nevada, US; the European Operations Management Association (EurMA) Conference in Dublin, Ireland; and the British Academy of Management (BAM) Conference in Liverpool, UK. He has also co-written a paper published in the International Journal of Operations and Production Management (IJOPM).

## **Abstract**

### **An Empirical Investigation into the Decision-Making Processes of New Infrastructure Development.**

The aim of this research is to present and discuss the development and deployment of Lean thinking models and techniques applied to improve the decision-making within the planning and design processes of new infrastructures, within a healthcare organisation.

In the UK, healthcare organisations are responsible for planning, designing, building and managing their own infrastructures, through which their services are delivered to the local population (Kagioglou & Tzortzopoulos, 2010). These processes are long and complex, involving a large range of stakeholders who are implicated within the strategic decision-making. It is understood that the NHS lacks models and frameworks to support the decision-making associated with their new infrastructure development and that ad-hoc methods, used at local level, lead to inefficiencies and weak performances, despite the contractual efforts made throughout the PPP and PFI schemes (Baker & Mahmood, 2012; Barlow & Koberle-Gaiser, 2008). This is illustrated by the long development cycle time – it can take up to 15 years from conception to completion of new infrastructure.

Hence, in collaboration with an NHS organisation, an empirical action research embedded within a mixed-methodology approach, has been designed to analyse the root-cause problems and assess to what extent Lean thinking can be applied to the built environment, to improve the speed and fitness for purpose of new infrastructures. Firstly, this multiphase research establishes the main issues responsible for the weak process performances, via an inductive-deductive cycle, and then demonstrates how Lean thinking inspired techniques: Multiple Criteria Decision Analysis (MCDA) using ER and AHP, Benchmarking and Quality Function Deployment (QFD), have been implemented to optimise the decision-making in order to speed up the planning and design decision-making processes and to enhance the fitness for purpose of new infrastructures.

Academic literatures on Lean thinking, decision theories and built environment have been reviewed, in order to establish a reliable knowledge base of the context and to develop relevant solutions. The bespoke models developed have been tested and implemented in collaboration with a local healthcare organisation in UK, as part of the construction of a £15 million health centre project. A substantial set of qualitative and quantitative data has been collected during the 450 days, which the researcher was granted full access, plus a total of 25 sets of interviews, a survey (N=85) and 25 experimental workshops. This mixed-methodology research is composed of an exploratory sequential design and an embedded-experiment variant, enabling the triangulation of different data, methods and findings to be used to develop an innovative solution, thus improving the new infrastructure development process.

The emerging developed conceptual model represents a non-prescriptive approach to planning and designing new healthcare infrastructures, using Lean thinking principles to optimise the decision-making and reduce the complexity. This Partial & Bespoke Lean Construction Framework (PBLCF) has been implemented as good practice by the healthcare organisation, to speed up the planning phases and to enhance the quality of the design and reduce the development cost, in order to generate a competitive edge. It is estimated that a reduction of 22% of the cycle time and 7% of the cost is achievable. This research makes a contribution by empirically developing and deploying a partial Lean implementation into the healthcare's built environment, and by providing non-prescriptive models to optimise the decision-making underpinning the planning and design of complex healthcare infrastructure. This has the potential to be replicated in other healthcare organisations and can also be adapted to other construction projects.

## **1. Chapter One - Introduction**

This first chapter will set the scene, giving an overview of the thesis and introducing some of the concepts, literatures and findings that have formed the foundation for this research. In the first instance, the research background will be provided, followed by the motivations, aims and objectives, and then the research questions will be detailed. This chapter will also provide information regarding the scope of the research; the methodology employed and the thesis structure.



## **1.1. Research Background**

In the UK, healthcare organisations, formally known as Trusts, are responsible for planning, building and managing their healthcare infrastructures and facilities, such as hospitals, polyclinics, healthcare centres and GP practices, where their services are delivered to their local populations. In the '60's and '70's, substantial investments were made by the British government to build hospitals and healthcare infrastructures (Kagioglou & Tzortzopoulos, 2010). However, since then, health services have evolved towards a more community-based delivery system, closer to the population of the locality (Darzi, 2008; Department of Health [DoH], 2010). These factors led to out-dated and obsolete infrastructures, reaching their end of life, deemed no longer fit for purpose, in several areas. Moreover, it was established that, in order to improve healthcare services, the infrastructure, which is the primary interface and resource to deliver these services, required modernisation, complying with the national standards and accommodating innovation (CIAMS, 2010; Darzi, 2008; DoH, 2010).

Therefore, healthcare organisations needed to improve the planning, design, construction and management of future infrastructures to meet the forthcoming challenges (Fend & Tommelein, 2009; Lichtig, 2010). Although, these objectives have been under the radar of the Department of Health (DoH) for approximately 15 years, their answers to these issues were the introduction of PPP (Private Public Partnership) and PFI (Private Finance Initiative) schemes to support meeting the local needs through building public infrastructures in partnership with the private sector, thus transferring the risks. This has been successful to a certain extent, but faces criticism. It has been argued by Barlow and Koberle-Gaiser (2008) that throughout these schemes, the decisions have slipped away from the NHS partners, development costs have substantially increased, and designs are not without defect.

Additionally, within the current economic and social climate, healthcare organisations' decisions are carefully scrutinised by the public at large and the local populations, meaning that organisations become increasingly accountable to local communities (DoH, 2010; Ormerod, 2010). It is necessary to explain that, within healthcare organisations, the actual process of developing new infrastructure is lengthy and complex (Fernandez-Solis, 2008; Kagioglou & Tzortzopoulos, 2010). Complexity will be discussed further as a

critical concept of this thesis (French, 2013; Kurtz & Snowden, 2003; Snowden & Boone, 2007). Empirically, it can take up to 15 years to develop new infrastructures without even being in a position to meet local requirements. Hence, this research will be investigating the nature and the sources of the processes' bottlenecks that are preventing the optimisation of new infrastructure development (NID). It will be testing whether the root-cause problems are related to the decision-making processes, especially during the planning and design phases. Finally, models inspired from Lean thinking will be developed and implemented to address the emerging specific issues (Baker & Mahmood, 2012; Koskela, 2012; Schraven, Hartmann & Dewulf, 2011).

Firstly, this empirical action research investigates the nature of the problems associated with the new infrastructure development (NID) processes by: i) collecting process data, ii) undertaking interviews and iii) analysing a survey. Secondly, the researcher will develop and implement robust and transparent mechanisms allowing healthcare organisations to enhance the planning and design efficiency and effectiveness. It will be demonstrated that, by deploying suitable models and frameworks inspired from Lean thinking (*i.e.*: MCDA, Benchmarking and QFD), an organisation will be able to optimise planning and design decisions, in order to build healthcare infrastructures, which are innovative and fit for purpose, meeting the needs and requirements of users and the local population.

The complexity of the processes involved within the development of new healthcare infrastructures are largely recognised by their low volume and high variety (Gil, Tommelein, Stout & Garrett, 2005; Pellicer, Yepes, Teixeira, Moura & Catala, 2014). Hence, one may wonder to what extent Lean thinking can be applied, in this context, to streamline the processes and improve the transparency level of the decision-making during the planning and design phases (Alves, Milberg & Walsh, 2012). This research will demonstrate how applying Lean thinking models will support the organisation in planning and designing modern and flexible healthcare infrastructures, by overcoming the processes' bottlenecks and root-cause problems.

Finally, it is relevant to mention that infrastructure development processes in healthcare belong to the 'complex' domain, as Snowden and Boone (2007) defined it, a system without obvious causality. Even if one would claim that construction projects belong to the 'complicated' domain of the Cynefin framework, where there are formal connections

between cause and effect, it is argued and explained that the healthcare context adds an extra layer of uncertainty, which makes it ‘complex’. As one interviewee stated “*in healthcare, everything takes longer and everything is more complex*” (OPJB09). The organisation’s leaders and decision-makers must appreciate the consequences of dealing with complex situations and, in response, deploy both appropriate and suitable management and leadership actions, avoiding risk of failures and miscommunications (Snowed & Boone, 2007). Hence, as a first step, understanding and measuring the root-cause problems and the process bottlenecks seemed primordial, to avoid any sub-optimisation.

In this thesis, it will be argued that, to support complex infrastructure development, the different schemes and mechanisms, set up on a national basis (*i.e.*: PPP, PFI, 3PDs), are not always appropriately used at local level. The mechanisms used are not context specific and, largely, too prescriptive to suit the different organisations with diverse resources, skills and capabilities. Consequently, despite the best governmental effort, there are still several problems at local level, leading to slow development processes and weak performances.

## **1.2. Research Motivations**

There are different motivations associated with this research and they can be separated into three groups: i) empirical or practical motivations, driven by the recognition of a problem and poor performances in new infrastructure development, ii) theoretical motivations related to the application of Lean thinking concepts and theories within the built environment, to make a contribution to a recent established body of knowledge: Lean construction (Ballard & Howell, 2003; Koskela, 1992; Koskela, Howell, Ballard & Tommelein, 2002; Thomas *et al.*, 2003), and finally, iii) methodological motivations, adopting a pragmatic paradigm and applying mixed-methodology throughout an empirical action research (Creswell & Plano Clark, 2011).

### **1.2.1. Empirical or Practical Motivations**

Healthcare organisations’ improvement initiatives are often led by the national guidelines or reports, developed by governmental or commissioned bodies. Several reports have been explaining, from different perspectives (*i.e.*: Estates, Service quality, or the DoH), the importance of developing fit for purpose infrastructure (CIAMS, 2010; DoH, 2000; DoH,

2006). It is a critical objective for the NHS as it will support modernising the system, by enabling the 'one stop shop' concept and the service integration model. This, ultimately, will improve the experience for staff and patients alike and sustain the healthcare service in the UK (DoH, 2000; DoH, 2004).

The healthcare organisation, where the bulk of this empirical research has been undertaken, has identified and recognised the need to improve its new infrastructure processes development. This was driven not only by a national rationale, but by the recognition of its specific problems, translated by inefficiencies and ineffectiveness in the planning, design and management of new infrastructure, independently of the procurement route chosen: LIFT or 3PD. Furthermore, the organisation also acknowledged the potential cost-saving and service quality improvement that could be generated by redesigning the new infrastructure development processes.

### **1.2.2. Theoretical Motivations**

The application of Lean thinking within a different context than manufacturing has been a popular strategy to making a contribution to knowledge, as no universal set of theories are yet fully been established, due to its environmentally dependent nature (Bamford, 2011; Bamford, Forrester, Dehe & Leese, 2014; Jorgensen & Emmitt, 2008; Sousa & Voss, 2001) and its pre-paradigm evolution stage, as defined by Kuhn (1962; 1970). Research looked at Lean in services (George, 2003; Radnor & Boaden, 2008), in clinical processes (Fillingham, 2007; Holden, 2011; Radnor, Holweg & Waring, 2012) and, more recently, in the construction industry (Alves *et al.*, 2012; Ballard, 2008; Howell & Ballard, 1998; Jorgensen & Emmitt, 2008; Jorgensen & Emmitt, 2009; Koskela, 2004). It is also recognised that there is a gap in the literature where both academics and practitioners wonder and question whether Lean, applied in the Architecture, Engineering and Construction (AEC) industry, can be achieved following the same principles as in the other sectors, due to its inherent variability and uncertainty, which makes it so bespoke (Hamzeh, Ballard & Tommelein, 2009; Jorgensen & Emmitt, 2008; Koskela, Howell, Ballard & Tommelein, 2002). These fundamental questions are also a source of motivation and are linked with the contribution of this thesis.

### **1.2.3. Methodological Motivations**

Finally, methodological motivations underlie this piece of research. Empirically researching, developing and testing Lean models applied to a specific process, the planning and design of healthcare infrastructure is found relevant from an exploratory perspective. This is achieved by borrowing a pragmatic worldview in a mixed-method action research study (Tashakkori & Teddlie, 2003), materialised by a multiphase design, consisting of an exploratory sequential phase and an embedded-experiment variant phase (Creswell & Plano Clark, 2011).

This section has highlighted the research motivations, which are linked with the contribution of this thesis. The following section will present the aims and objectives.

### **1.3. Aims and Objectives**

The researcher's interest has been to identify and understand the main issues related to the lengthy and complex processes linked with the healthcare infrastructure development, and to deploy bespoke techniques to speed up the decision-making, enabling the development of modern, flexible, fit for purpose infrastructure. This research aims to establish how and to what extent Lean thinking can be adapted and implemented to improve the new infrastructure development in a NHS organisation, as well as to support managing the system complexity.

In order to satisfy the aims as stated above, a set of objectives has been identified: i) review the relevant literature on Operations Strategy and Management, Lean thinking, Lean construction and built environment, to establish the current and innovative practices, ii) measure the new infrastructure process performances and establish the root-cause problems and their relationships, iii) demonstrate the impact of implementing Lean tools and techniques to improve the decision-making process during the planning and design phases, and iv) develop a conceptual framework, optimising the performances of the new infrastructure development process in terms of speed (cycle time), quality (fitness for purpose), visibility (transparency of the decision-making) and cost (total capital cost).

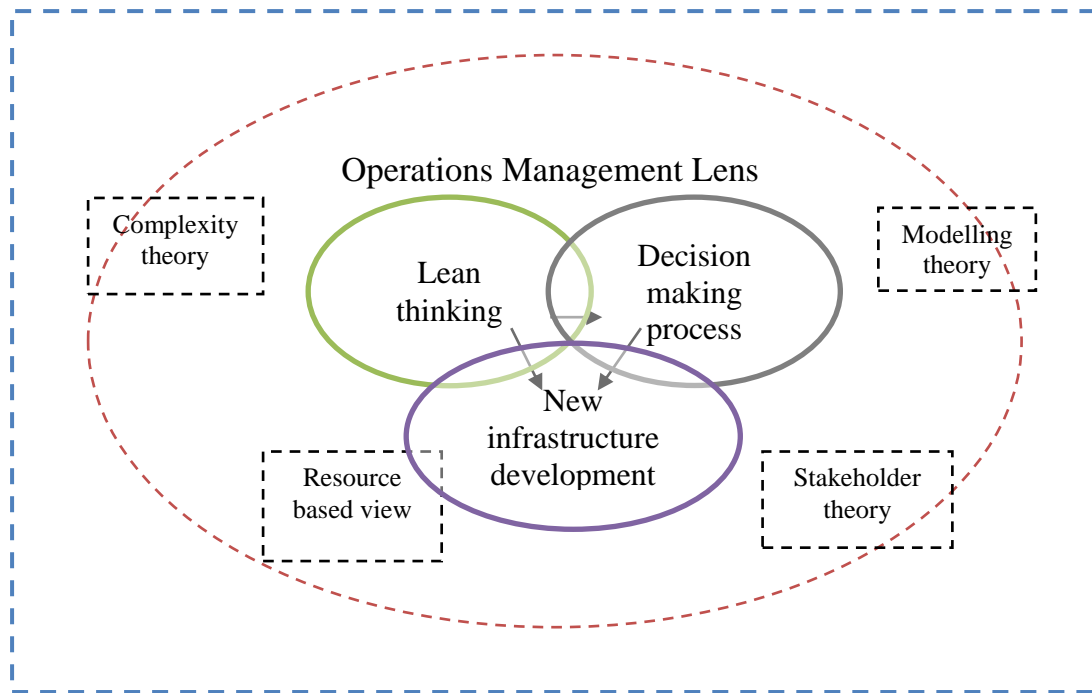
## 1.4. Research Questions

To structure the thesis argumentation and link it with the aims and objectives, two overarching research questions have been developed and a set of five associated sub-research questions framed:

*RQ 1: What are the root-cause problems associated with the new healthcare infrastructure development?*

*RQ 2: How should Lean thinking concepts be implemented to support the decision-making processes for new healthcare infrastructure development?*

These research questions can be conceptualised by the Venn diagram below. Figure 1.1 represents the three major research foundations defining the boundaries of the thesis. In line with the research questions, the Lean thinking body of knowledge provides a theoretical perspective. The decision-making process (DMP) provides the specific phenomenon being investigated. The new infrastructure development (NID) provides the unit of analysis and the context. This is encompassed and grounded within an Operations Management (OM) discipline, as a series of theoretical concepts are associated with it, such as: Resource Based View (RBV), complexity theory, stakeholder theory and modelling theory. Furthermore, Figure 1.1 presents the interactions between each element, which will be discussed and analysed throughout the set of sub-research questions and presented in Figure 1.2.



*Figure 1.1: Research foundations and boundaries*

As aforementioned, five sub-research questions have been developed to focus the thesis and make a contribution through the study of the highlighted and not so well established interactions between the different elements. In Figure 1.1, the interactions are corresponding to the overlapping zone between the elements.

*S-RQ1: Are the decision-making processes the main issues within the new infrastructure development?* This sub-research question represents the interaction between the decision-making process, the phenomenon studied and the context. It will be detailed and argued in the literature review that decision-making becomes a central and complex activity that organisations must learn to effectively manage to avoid sub-optimisation and weak performances (Nutt & Wilson, 2010).

*S-RQ2: Is there a common understanding of the process issues and performances amongst different groups of stakeholders?* This sub-research question can be theoretically justified, as it can be argued that: “from the stakeholder value perspective, an organisation should not be seen as an instrument of shareholders, but as a coalition between various groups of stakeholders with the intention of increasing their common wealth” (De Wit & Meyer, 2010, p.610). An organisation needs to create trust between all parties involved within a

project to be able to optimise the output or achieve the objectives set. In this specific research, taking the NHS stance, it is assumed that the project is the development of new healthcare infrastructure, where four categories of stakeholders are identified as affecting and being affected by the project: i) decision-makers, ii) providers, iii) contractors and suppliers, and iv) members of the public.

*S-RQ3: What Lean tools and techniques should be implemented to improve the planning and design phases?* This sub-research question represents the interaction between the Lean thinking, the theoretical concepts applied within a specific environment, and the new healthcare infrastructure development process. As Lean is environmentally dependent, the methodology deployed has to be tailored in order to be successful.

*S-RQ4: What are the most suitable models (ER or AHP) to optimise the decision-making processes in this research environment?* This sub-research question relates to modelling theories suggesting that: “*all models are wrong, but some are more useful than others*” (Box & Draper, 1987, p.424). Therefore, the researcher was keen to test different models and establish, in this specific context, which model would be the most suitable and satisfactory.

*S-RQ5: How can a Lean methodology reduce and help to manage the level of complexity?* In this sub-research-question, the researcher will be interested in studying the interaction between the complexity involved in the decision-making process and the Lean thinking using the Cynefin Framework (Snowden & Boone, 2007).

Figure 1.2 shows how the five sub-research questions are linked with the two overarching research questions. Moreover, to address how should Lean thinking be implemented it is relevant to fully explore the root-cause issues of the process in the first instance.



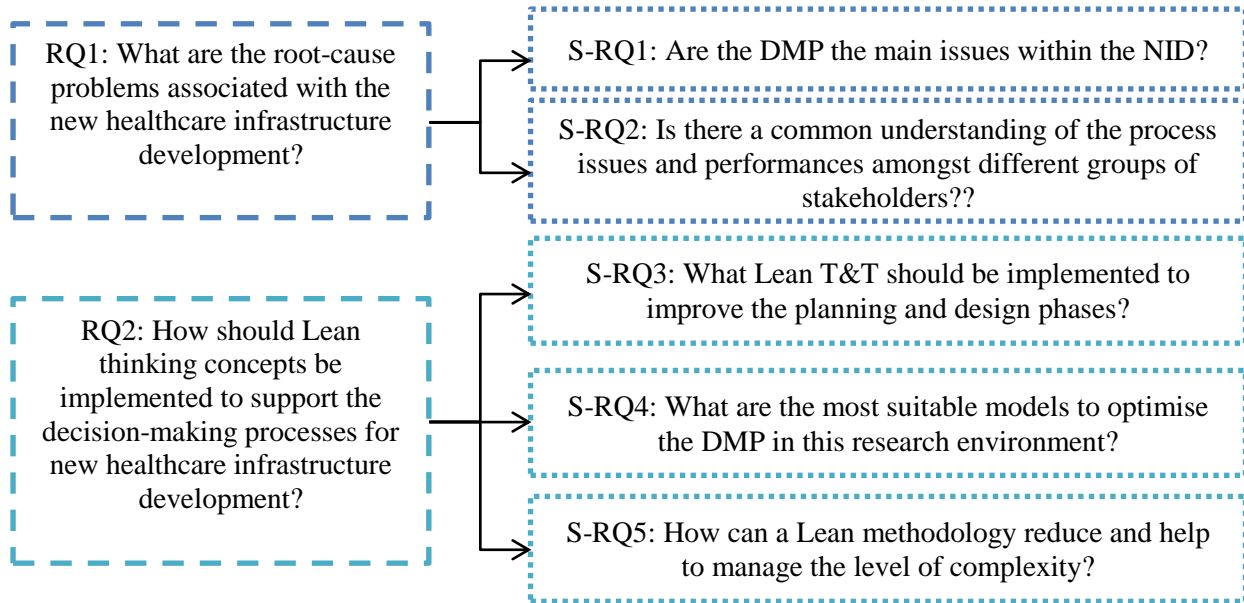


Figure 1.2: Structure of the research questions

## 1.5. Assumptions and Research Scope

This research is shaped around an empirical action research, embedded within a mixed-methodology, to investigate the root-cause problems and test a partial Lean thinking implementation. This will be fully explained and presented in the Research Methods chapter. The Lean methodology developed aims to improve the planning and design effectiveness and efficiency by both speeding up and enhancing the decision-making processes.

### 1.5.1. Assumptions

As previously pointed out, the researcher studies the new infrastructure development phenomenon from an Operation Strategy perspective. This is achieved by investigating issues, such as: the quality of the infrastructure, fitness for purpose and the process performances, in terms of speed, cost, variation, visibility, and transparency. This will lead to improving the overall perception of quality. It is assumed that the infrastructure is the most critical asset in providing quality healthcare services. Thus, organisations must be able to develop knowledge, capabilities and skills to optimise the development processes. In the private sector, infrastructures, where services are provided, are seen as superior resources in gaining a competitive advantage (Pellicer *et al.*, 2014; Too & Too, 2010). It will be both assumed and justified that the same principle applies in the public sector too. Indeed, considering the evolution of healthcare organisations in aiming to become world

class and evolving in a competitive market, the Resource Based View (RBV) becomes a suitable theoretical concept to justify the need for improving the processes behind the development of new healthcare infrastructure.

The unit of analysis taken is at the infrastructure level. This is believed to be more relevant and appropriate than at a higher level, which could have been the organisation itself, or a lower level, which could have been the individual decision-making process. The aim is to investigate to what extent a Lean thinking methodology can be developed to optimise and improve the planning and design of new healthcare infrastructure development by overcoming the root-cause problems.

### **1.5.2. Research Scope**

As presented in Figure 1.1 above, the overarching body of knowledge is Operations Management. However, the thesis is built around three bodies of knowledge: Lean thinking, decision theories and built environment. Figure 1.3 illustrates the scope of the research based on these three core bodies of knowledge. The scope is first defined by the environment in which the research has taken place, which is a healthcare organisation in the north of England. The second key aspect, in defining the scope, is the clear interaction and interface between the elements presented. It will be investigated to what extent Lean thinking techniques can support the optimisation of decision-making processes, such as infrastructure rationalisation, location decisions, design decisions and performance management.

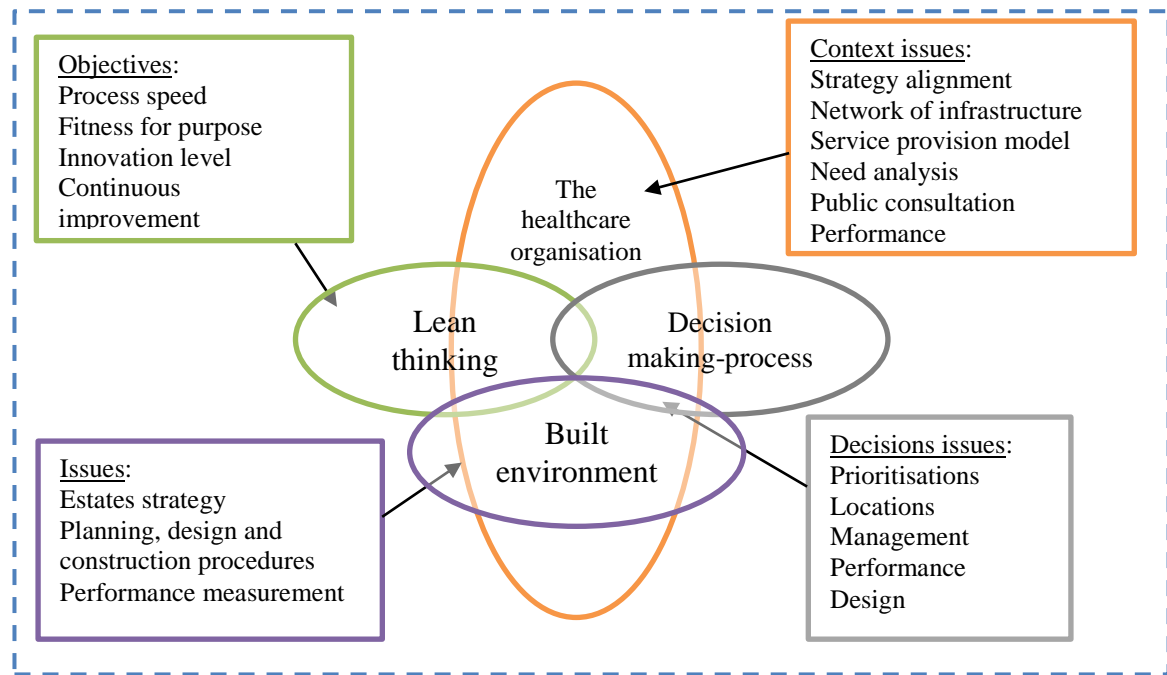


Figure 1.3: Research scope

## 1.6. Methodological Approach and Research Process

To answer the main research questions – *What are the root-cause problems associated with the new healthcare infrastructure development? How should Lean thinking concepts be implemented to support the decision-making processes for new healthcare infrastructure development?* – and the five sub-questions, a mixed-methodology, embedded within an empirical action research method, has been designed in narrow collaboration with an NHS organisation. The researcher spent over two years, about 450 working days, within the organisation, collecting data through observations, meeting participations, formal semi-structured and structured interviews (N=25), a survey (N=85), and a series of experimental workshops (N=25), to understand the phenomenon and develop a solution. The pragmatism paradigm was borrowed, in line with the researcher ontology, to undertake this multiphase research (Creswell & Plano Clark, 2011; Plano Clark & Creswell, 2008). Due to the fact that, on a daily basis for two years, the researcher was granted full access to the organisation, thus large and rich data, changes implementation and iterations were part of the research process. These types of research methodologies have great benefits, by allowing inductive-deductive cycles to be undertaken, deeply understand the phenomenon and context, and testing solutions (Maylor & Blackmon, 2005; Tashakkori, & Teddlie, 2003); in this case, the improvement of the

decision-making processes within the planning and design of healthcare infrastructure. The subjectivity element involved in this type of research is recognised. However, the researcher is confident of the contribution, which will be demonstrated notably by the thorough, robust and transparent research methodology applied (Maylor & Blackmon, 2005).

Despite being iterative by nature, this multiphase research is composed of two key studies: i) an exploratory sequential phase, where the findings are presented in Chapter Four and ii) an embedded-experiment variant, where the experimental findings are presented in Chapter Five.

The first set of findings is aimed at investigating the issues and performances regarding the new infrastructure development process, whereas the second set of findings is aimed at developing the frameworks and testing the models as part of the implementation of a Lean thinking methodology (*i.e.*: MCDA, Benchmarking and QFD).

Firstly, using qualitative and quantitative techniques, the research investigated the problems associated with the new healthcare infrastructure development. 17 interviews were undertaken in the first instance, followed by another set of eight interviews (25 interviews in total). Based on the preliminary analysis of the first wave of interviews, a survey instrument was designed (N=85), aiming to measure the problems identified and establish whether or not there is a common understanding and perception across the different group of stakeholders. The survey was developed and sent to 140 stakeholders (both internal and external) with direct interests or responsibilities within new infrastructure development. 85 completed and valid responses were gathered and analysed (Response Rate, RR = 60.7%). The rationale for the survey was to collect data in order to corroborate the findings against the qualitative output and validate the root-cause of the problem (Forza, 2002). Concurrently, another set of quantitative data was collected and analysed to measure the process performance and capability. The researcher was able to compile the cycle time data for 30 infrastructure projects from 2000 onwards. Therefore, it was possible to triangulate and develop a robust understanding of what was happening within the planning and design of new healthcare infrastructure processes.

Based on these findings, and during a total of 25 specific experimental workshops, the researcher was able to develop Multiple Criteria Decision Analysis (MCDA), performance

framework and Benchmarking, and Quality Function Deployment (QFD) models, in order to implement Lean thinking to overcome and resolve the root-cause problems. The findings are presented in the experimental development section of the thesis in Chapter Five.

Therefore, this mixed-methodology, embedded within an empirical action research, was iterative by nature and follows a cycle of inductive-deductive-inductive studies (Plano Clark & Creswell, 2008). It has been used to facilitate a data triangulation and a methodology triangulation, in order to build robustness and validity into the research (Modell, 2005; Modell, 2009). The diversity of the data's nature and sources enabled the development of a conceptual model, representing a Partial & Bespoke Lean Construction Framework (PBLCF) to improve the effectiveness and efficiency of healthcare infrastructure development.

### **1.7. Research Findings**

This evidence-based research demonstrates and confirms that the fitness for purpose of new infrastructure development can be improved by enhancing the effective planning processes and by optimising the decision-making within the planning and design phases. These points are achieved by: i) ensuring consistent and robust needs analysis, ii) developing methods to optimise and make the site selection transparent, iii) safeguarding the effectiveness and representativeness of the engagement and outcome of the public consultation, iv) ensuring the alignment between the departmental strategies, and v) capturing the service needs and contributing to the design decision.

The suggested and developed solutions, to address these issues, are part of the decision-making processes' realm, and were inspired from the Lean thinking: MCDA using ER and AHP; Benchmarking using a bespoke performance measurement system; and QFD using iterations of the HoQ (House of Quality). However, it is established that to gain even more substantial benefits and to develop a competitive edge, these Lean thinking techniques had not only to be adapted to this specific environment, but also they had to be integrated and synchronised, as described in the final conceptual model: the Partial & Bespoke Lean Construction Framework (PBLCF) presented in Chapter Seven. It will enable the organisation to enhance the fitness for purpose of complex infrastructure, enhance the innovation level, and trigger a continuous improvement roadmap throughout the

optimisation of the planning and design decision-making, as well as, reduce the development cycle time by up to 24% and the cost by an estimated 7%.

## **1.8. Thesis Overview**

This thesis follows a classical structure composed of seven chapters as Figure 1.4 below illustrates.

Chapter One sets the scene and introduces the research in its broader sense, presenting the research aims and objectives, the research questions and sub-questions, as well as introducing the research methodologies. It ends by briefly highlighting some of the findings.

Chapter Two establishes and reviews the literature. It discusses the Operations Management and Operations Strategy literature, conceptualises the Lean thinking body of knowledge, details decision-making theories and contextualises infrastructure development in the built environment academic literature. These themes are presented, discussed and analysed from an academic literature perspective, it enables to justify the five sub-research questions. It is in this chapter that the theoretical frameworks are presented and the theoretical concepts justified. RBV, stakeholder theory, modelling theory, and complexity theory are used to justify and demonstrate the findings, and support the contribution to knowledge.

Chapter Three details the research methodology. This chapter is organised in a top-down manner, from the research paradigm (*i.e.*: pragmatism) down to the data analysis, explaining the mixed-methodology embedded in an empirical action research method. The rationale for presenting it in such fashion is to demonstrate the logic and alignment between the philosophical stances borrowed, the aims and objectives, the research questions and the findings.

Chapter Four summarises the research findings. This chapter relies on the rich primary data directly collected by the researcher. It explicitly presents the organisation, details its new healthcare infrastructure development processes, measures the baseline performances, and analyses the root-causes of the problems throughout the interviews and survey analysis.

Chapter Five presents and discusses the models developed and implemented to support the organisation in optimising the planning and design decision-making processes. This is where MCDA, performance framework and Benchmarking, as well as QFD findings, are presented.

Chapter Six provides a summary of the analysis and answers the five sub-research questions. It presents the conceptual models developed to solve the identified problems and suggests how the Lean techniques fit within the detail of the new infrastructure development process.

Finally, Chapter Seven closes this research by presenting the Partial & Bespoke Lean Construction Framework (PBLCF), providing an exhaustive conclusion, along with some recommendations. It ends by suggesting areas for future research, after critically assessing the validity and reliability of this study.

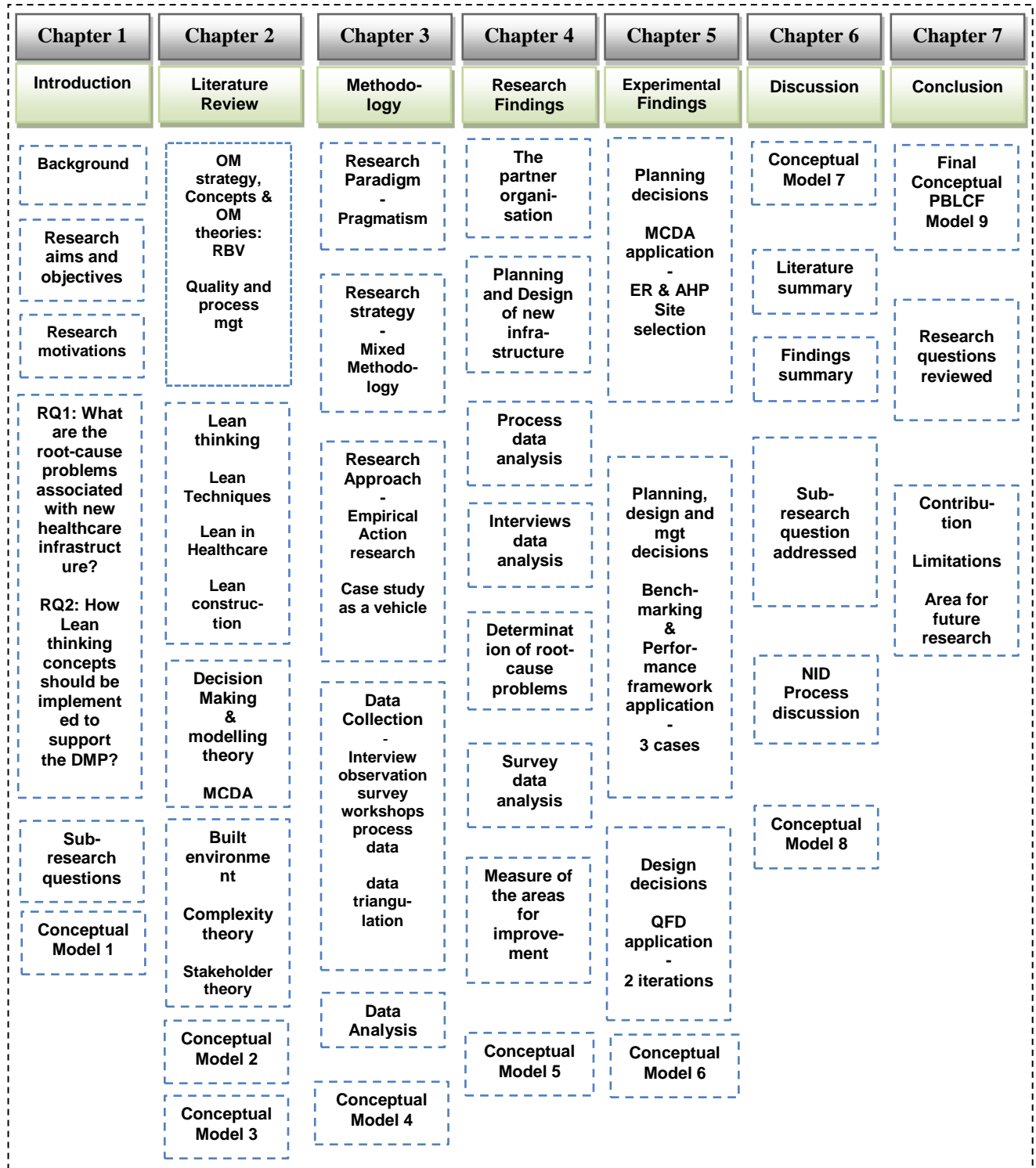


Figure 1.4: Thesis structure



## **2. Chapter Two: Literature Review**

In this chapter, the literature of the three main bodies of knowledge, upon which this thesis is relying, will be reviewed. Lean thinking will be defined and explained from different perspectives, and its application in the different context and industries detailed. Decision theory and decision-making will then be reviewed, from modelling theories to the application of specific techniques (*i.e.*: MCDA). Then, the built environment and the infrastructure development, as a body of knowledge, will be discussed, leading to the introduction of the complexity theory. However, this chapter will start by reviewing the history and the foundation of Operations Strategy (OS) and Operations Management (OM), which are the overarching disciplines and lenses borrowed to undertake and complete this research. Throughout this chapter, several concepts drawn from theories will be detailed, which will help the researcher to set the theoretical boundaries of this research and justify the five sub-research questions, as well as to clarify the assumptions made.

## **2.1. Operations and Processes Strategy and Management**

In this first sub-chapter of the literature review, the researcher will contextualise the study and build the foundations upon which to introduce the three bodies of knowledge. This section will define a predominant theory, RBV, and detail the evolution of two main pillars of the management literature: Operations Management and Quality Management. They will be reviewed, as their concepts are the underlying foundations of this thesis.

### **2.1.1. Business Strategy: an Introduction**

#### **2.1.1.1. Business Strategies: Origin and Definitions**

Historically, strategies were commonly described as ‘the art of planning and conducting a battle’. By semantically decrypting the Greek word ‘strategos’, meaning ‘leading an army’, one can comprehend this definition. In today’s business world, where capitalism is the dominant economic model, organisations must compete to gain market shares and customers in order to survive in the long term. Therefore, whatever their business models or sectors, organisations must have identified goals and a purpose, both of which are formulated by the overall strategy (De wit & Meyer, 2010; Tushman & Anderson, 2004). The strategy development is considered as the ‘science or art’ to shape the competitive edge of a firm, and to design the mechanisms facilitating cross-functional decisions that will enable the organisation to achieve its goals (Cousins, Lamming, Lawson & Squire, 2008; David, 2005; Hayes & Wheelwright, 1984).

It is widely accepted that business strategies are selected differently according to the organisation ethos and environment. From the literature, three levels of strategy can be identified: corporate, business unit, or functional (De Wit & Meyer, 2010). Independently of the level, the underlying process and objectives of a strategy remain similar – it is the integrated set of choices and decisions involved when positioning a firm, or business unit, to earn superior financial returns over the long term (Cousins *et al.*, 2008, p.11). Johnston and Clark (2008) defined strategy as the direction and scope of an organisation over the long term. They explained that this is achieved by matching the resources and capabilities to the changing environment, and, according to markets’, customers’ and stakeholders’ expectations. Mintzberg, Quinn and Ghoshal (1997), and Johnson, Scholes and Whittington (2007) emphasised some commonalities and success factors found within strategy development. They explained that strategies must integrate the whole firm’s

activities and operations in order to be efficient and effective, both in terms of process and content. Moreover, they argued that strategies should be associated with the vision and the mission that the senior leaders have identified, and they must be translated and communicated throughout the organisation. Academics and practitioners believe that tangible mechanisms in place need to be used in order to be effective, *i.e.*: balanced scorecard, closed-loop management systems, and other performance frameworks (Kaplan & Norton, 2008a,b; Singh & Wood-Harper, 2011; Zhang, Bamford, Moxham & Dehe, 2012).

#### **2.1.1.2. Articulation of Business Strategies**

There are three levels identified here: corporate, business unit, and functional. Therefore, key issues and challenges are the articulations and alignments between and within these levels. Christopher (2005) and Slack, Chambers, Johnston and Betts (2006) argued that by maintaining coherent strategic links between the three primary functions: marketing, research and development, and production; plus the secondary functions: sale, finance, engineering, IT and human resources, a firm can reach a competitive advantage. This means that the processes of formulation and deployment are as important as the strategy content. Top-down and bottom-up processes are advocated in the literature to satisfy an effective articulation (De Wit & Meyer, 2010; Hayes & Wheelwright, 1984; Hill & Hill, 2012). Kaplan and Norton (2008a) agreed, stating that the successful development and deployment of an effective strategy is paramount to all organisations, whatever their core businesses and sectors: manufacturing, construction or service; private or public. As Quinn (1980) explained, the strategies are the cement and mortar to link a firm's missions, goals, governance and actions (*as cited in Zhang et al., 2012*).

#### **2.1.1.3. Business Strategy and Performances Measurement Systems**

Assuming that strategy is the set of decisions taken in order to manage the organisation's capabilities, operations and resources to create products or services satisfying the stakeholders' and customers' requirements, in line with the corporate vision and mission (Slack *et al.*, 2006), it is critical to clarify its boundaries and objectives. Warnock (2000) and Grant (2010) both explained that the role of the business strategy is to transform the ideas, purpose, vision and mission into a set of decisions and actions, to achieve the organisation's objectives. However, in order to achieve this, performance measurement

systems and models must be in place to evaluate and control any deviations between the targets and bottom-lines, which will become the responsibilities of each level or unit managers. There are the old adages: “*what you measure is what you get*” and “*you cannot manage what you don’t measure*” (Deming, 1986; Kaplan & Norton, 1992; Kaplan & Norton, 2001a,b), which it seems relevant to introduce here. It has been recognised that performance measurement systems can assist in translating high-level strategies into measurable targets, and enabling employees to align their daily activities with the corporate strategy (Mintzberg, 1998). Kaplan and Norton (2001c) identified that linking formal measurements to strategies was an enabler of higher financial performance. Therefore, they encouraged the implementation of the balanced scorecard (BSC) to cascade strategy down the firm, and the closed-loop management system (CLMS) to guarantee performance management feedback (Kaplan, 2001; Kaplan & Norton, 2001a), as detailed in Zhang *et al.*, (2012).

This section has introduced and contextualised the rationale for developing and deploying a strategy. In order for firms to be successful, and sustaining a competitive advantage over time, they will need to articulate and align the different functions constituting the firm. Therefore, both the process and the content of the strategy deployment are critical, and it is suggested that the use of frameworks and models around performance measurement can support this activity and the decision-making. In this section, it was advocated that, although there are three different levels, the same concepts apply. In the following part, the Operations Strategy (OS) will be discussed in greater detail, as this is the relevant level in this research.

### **2.1.2. Operations Strategy: Content and Process**

Operations Strategy is likely to fit within the functional level of the organisations. Slack *et al.*, (2010), amongst others, clearly identify the three necessary core functions in an organisation to achieve the competitive advantage: marketing, operations, and product and service development, arguing that the other functions are supporting these primary dimensions within the firms. Consequently, Operations Strategy takes all of its meaning and importance for an organisation, as Figure 2.1 below suggests.

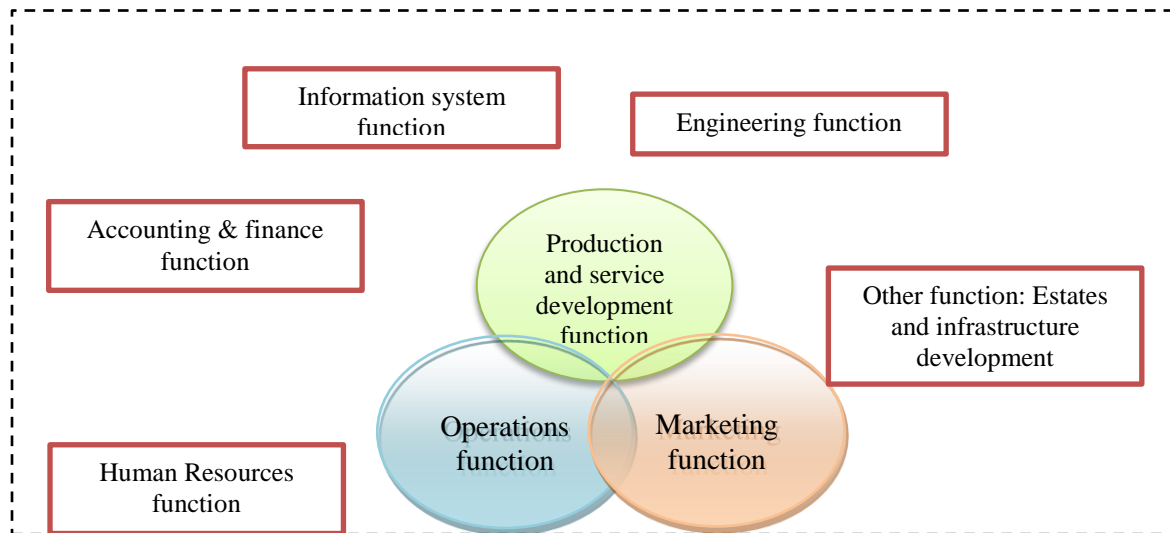


Figure 2.1: Core and support functions in an organisation (adapted from Slack et al., 2010)

Having said that, Rytter, Boer and Koch (2007, p.1094) defined Operations Strategy more specifically as *“the pattern of decisions which shape the long-term capabilities of any type of operations and their contribution to overall strategy, through the reconciliation of market requirements with operations resources”* (Slack & Lewis, 2002, p.16). This definition can be associated with Boyer, Swink and Rosenzweig (2005, p.442), who defined Operations Strategy as a *“set of decisions and plans involving the developing, positioning, and aligning of managerial policies and resources so that they are consistent with the overall business strategy”* (Anderson, Cleveland & Schroeder 1989; Skinner 1969; Swamidass 1986).

Therefore, the Operations Strategy is materialised by the process of articulating the three core functions of the business and integrating the other support functions, such as: engineering, human resources, accounting and finance, information system, as well as estates and infrastructure development.

As for its link with the overall strategy, the Operations Strategy (OS) is expected to implement two elements: the content and the process. Rytter *et al.*, (2007, p.1094) and Martín-Peña and Díaz-Garrido (2008, p.200) explained that the content deals with how

operations can contribute to the creation of the competitive advantage; whereas, the process deals with its deployment throughout the functions. It is important to note that these authors identified that the majority of the Operations Strategy literature discusses the content aspect, rather than the process. Rytter *et al.*, (2007, p.1094) pointed out that “Dangayach and Deshmukh (2001) reviewed 260 papers on manufacturing strategy from refereed journals and international conferences and found that only 23 (9%) addressed process issues”. This is in line with another academic study, reporting that only 8 out of 37 (22%) articles published in POMS (Production and Operations Management Society) investigated the OS process (Boyer *et al.*, 2005). Hence, Rytter *et al.*, (2007) concluded that, clearly, the research focus is unbalanced. They suggested research focusing on OS process should become a priority, to increase the knowledge base (Anderson *et al.*, 1989; Boyer *et al.*, 2005; Dangayach & Deshmukh, 2001).

#### **2.1.2.1. Operation Strategy Content**

Martín-Peña and Díaz-Garrido (2008, p.200) concluded that there are two basic elements which can be identified in the Operations Strategy content: competitive priorities and operations decisions. They argued that the competitive priorities “define the area in which the operations must be focused to support gaining the competitive advantage”. On the other hand, the operations decisions are “the set of actions that help in achieving the operations and corporate goals”. In their paper, Martín-Peña and Díaz-Garrido (2008) built on research by Hayes and Wheelwright (1984) and Hill (1989), to explain that key decisions can be organised into two categories: structural and infrastructural decisions. This is emphasised by Boyer *et al.*, (2005, p.444), who explained that the “most important and central concerns are the need to link manufacturing structural and infrastructural decisions with overall business plans, and thus guide business by building capabilities essential to the formulation and achievement of the firm’s overall strategy”. This process leads to the development and sustainability of a competitive advantage, primarily from a top-down approach as Figure 2.2 suggests.

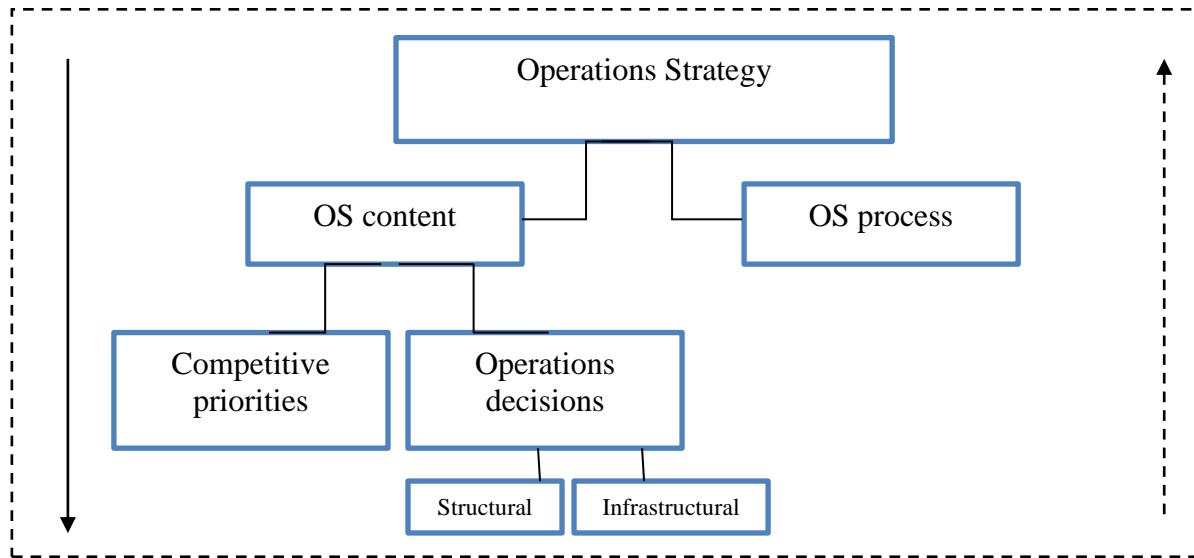


Figure 2.2: The top-down approach to Operations Strategy content

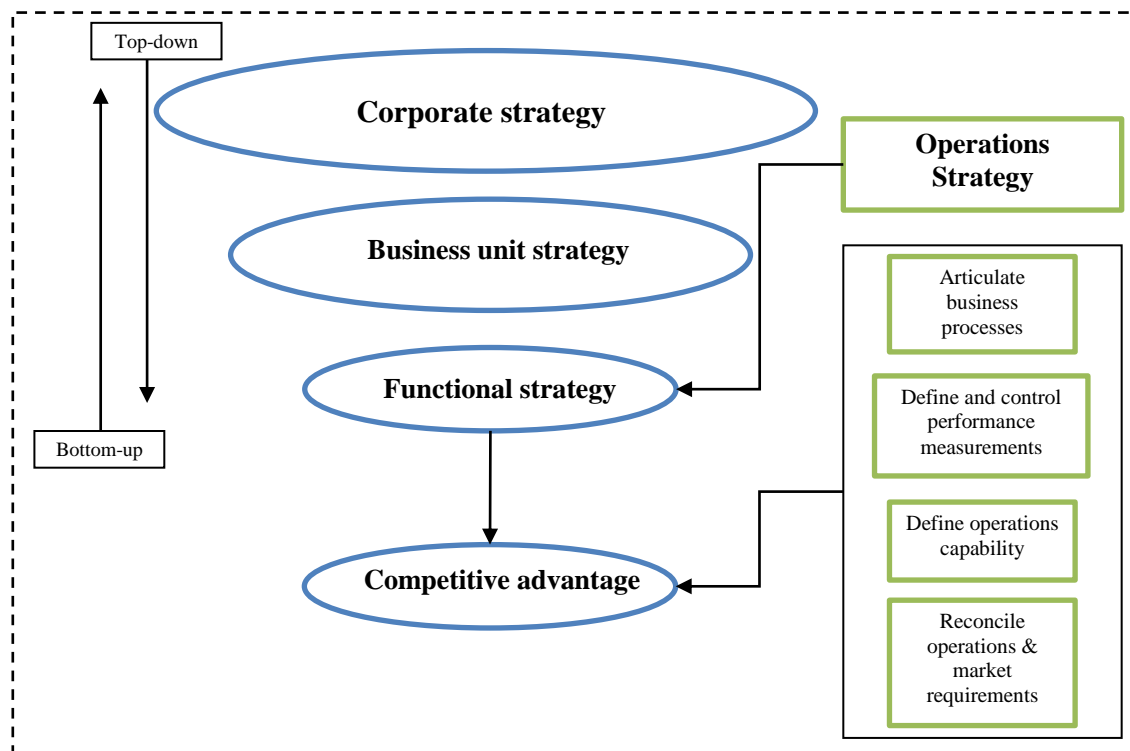
#### 2.1.2.2. Operations Strategy Process

On the other hand, as aforementioned, the process is tacit and little academic knowledge has been captured. It is acknowledged that the process is less structured, it is iterative and influenced by several factors. In other words, the OS process is assimilated to a bottom-up approach. If it is assumed that the OS process is the process that allows *“the pattern of decisions which shape the long-term capabilities of any type of operations and their contribution to overall strategy”* (Slack & Lewis, 2002, p.16), one can accept and understand why, so far, little evidence has been captured about it. It is complex and environmentally dependent, hence difficult to generalise. Having said that, in the decision-making literature, there are cases that show how the management of data and information has been used and aggregated to support strategic and long term decisions, shaping the strategy and its content (Tushman & Anderson, 2004). This will be explored later, through the application of decision-making modelling. However, it shows a scientific approach, or rational view, of the strategy development and deployment.

#### 2.1.3. The Mission of an Operations Strategy

In this section, the focus remains on the Operations Strategy, which is the set of decisions taken in order to manage the firm’s operations and resources to create products or services satisfying the customer requirements, in line with the corporate strategy (Slack *et al.*,

2006). According to that logic, Slack *et al.*, (2006, p.38) have identified four missions of Operations Strategy. They stated that: i) it articulates a vision of how the business's processes can contribute to the overall strategy; ii) it translates the customer requirements into clear processes and defines the level of performance objectives, in terms of quality, cost, speed, dependability and flexibility; iii) it makes decisions to shape the operations capabilities, allowing long term development and sustaining potential competitive edge; and, finally; iv) it reconciles market requirements, operations policy and capabilities, as illustrated in Figure 2.3 (as cited in Dehe, 2009).



*Figure 2.3: Missions of an Operations Strategy*

However, it is important to appreciate that these described concepts and processes are valid at different levels of the organisation: corporate, business or functional. This has to be stated as, in this research, most of the processes studied and examined are between the business and the functional level, in relation to the new infrastructure development (NID).

Finally, to support and understand strategies' development and formulation, two major management theories need to be considered: Resource Based View (RBV) and Transaction Cost Economics (TCE), both allowing an organisation to set a plan of action



to gain a competitive advantage, following certain assumptions according to the theory lens used (Barney, 2001; Cousins, 2005).

#### **2.1.4. The Competitive Advantage and Different Operations Strategies**

The notion of competitive advantage was established by Professor Michael Porter, from Harvard Business School, in the '80's. Porter (1980) explained that the competitive advantage source is within the firm's capacity to differentiate itself from the competition, according to the customer's perception. This is, therefore, the ultimate goal for any organisations. Through its strategy, the firm needs to build and sustain a competitive advantage (Cousins, 2005; Yoo, Lemak & Choi, 2006). This emerged when Porter (1980) challenged the traditional ideas that were dominating during the '60's and '70's, that firms with better leaders and managers would make better decisions and would be better than the competition, as Cockburn, Henderson and Stern (2000, p.1126) remarked. Barney (1991) explained that, since the '60's, the dominating framework, used to explain why certain firms were performing better than others, existed in the 'internal strength exploitation'. It was suggested that the competitive edge was generated by exploiting internal strength and neutralising external threats. However, Porter's contribution was achieved by shifting the focus from a macroeconomics' perspective to a microeconomics' analysis of the firm's environment. According to Cockburn *et al.*, (2000, p.1126), Porter defined models for understanding why some firms were likely to be more profitable than others. The five forces model, as illustrated in Figure 2.4, enables the environment to be mapped and the assessment to be made of the extent to which competitors, new entrants, substitutes and bargaining power pressurise a firm's margins.

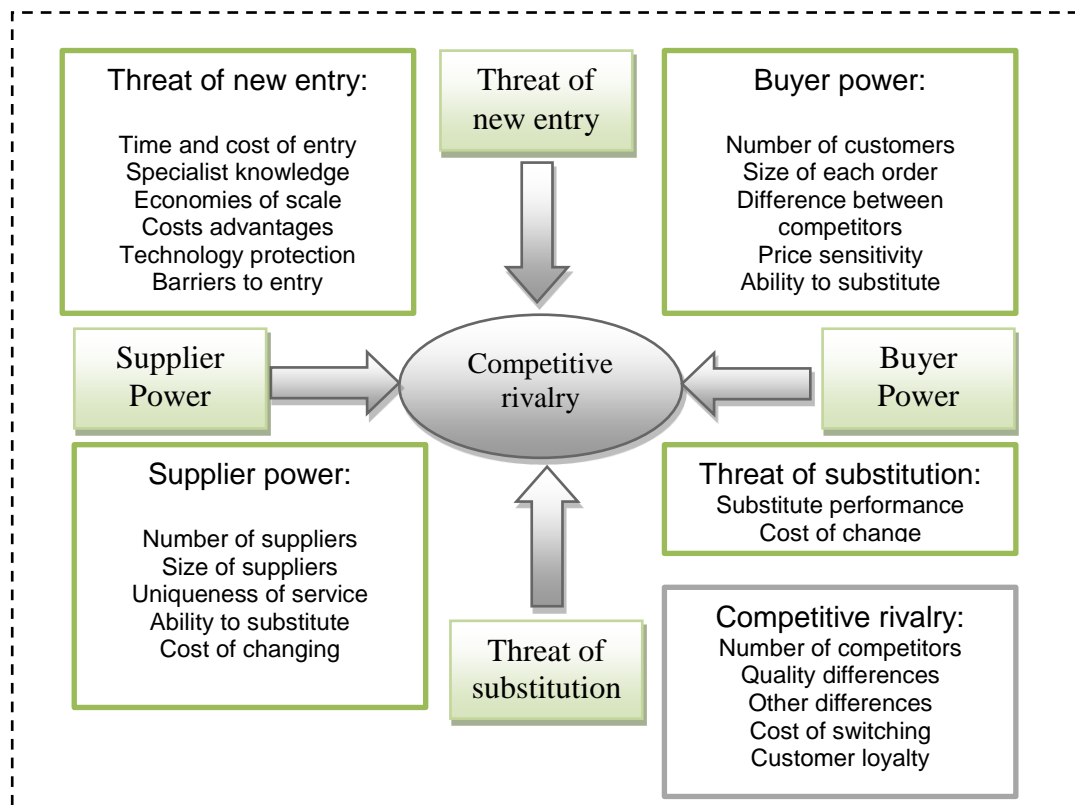


Figure 2.4: Porter's five forces model (adapted from Cockburn *et al.*, 2000)

It is widely accepted that there are two types of competitive advantage (CA): cost advantage or value advantage (Hill & Hill, 2012; Yoo, Lemak & Choi, 2006). Firms need to associate their CA with their business strategies, and design their structures and operations accordingly to sustain a competitive edge. However, the strategic literature shows that this might be too simplistic. In reality, the source and origin of the competitive advantage is much more complex and less established than it was suggested earlier (Cockburn *et al.*, 2000). To support this argument, Cockburn *et al.*, (2000, p.1126) argued that the early studies of competitive advantage were, by nature, based on historical qualitative analysis, which suggests that, as a phenomenon, developing a competitive advantage was complex and environmentally dependent. However, Porter challenged these ideas and created new sets of concepts in strategy. For this reason, Cockburn *et al.*, (2000, p.1124) explained that “*strategy is centrally concerned with the process of how firms and managers respond to and exploit environmental signals. In the last 20 or 30 years, there have been several powerful frameworks for evaluating the determinants of*

*differential performance, from Porter's five forces framework to the resource-based view (RBV) to transaction-cost economics (TCE)''.*

If these frameworks take a different perspective to explain heterogeneous performance, they have in common two underlying assumptions: i) competitive advantage arises through earlier, or more favourable access to resources, markets, or organisational opportunities, and; ii) that exploiting such opportunities reflects some degree of active interpretation of internal and external environmental signals by managers (Cockburn *et al.*, 2000, p.1124).

Therefore, from an Operations Management perspective, there are three main strategies that can be accepted and identified to achieve a competitive advantage, carrying these assumptions. Martín-Peña and Díaz-Garrido (2008, p.214) summarised them as: i) cost advantage, with strategies aiming to minimise costs; ii) speed and flexibility advantage, by quickly adapting (speed and flexibility) to the consumers' needs, and; iii) innovation advantage, with strategies implementing new technologies and new operations processes, adapting to the needs and preferences of the customers, as a way to differentiate themselves from the competition.

Having discussed and presented Operations Strategies, their content and processes, and having defined Operations Strategies as the set of decisions that shape the long term design of a firm, in order to develop a competitive advantage, the next section will focus on the Resource Based View (RBV), a theory designed to materialise the concepts introduced so far.

#### **2.1.5. Mechanisms to Reconcile Strategic Decisions and Competitive Advantage through RBV**

Boyer, Swink and Rosenzweig (2005, p.446) argued that RBV provides a solid theoretical foundation for understanding the role that Operations Strategy can play in creating and sustaining a competitive advantage. Moreover, Boyer *et al.*, (2005, p.447) explained that the need for alignment, though implicit, is extremely important, and that, unfortunately, due to the frequencies at which operational decisions are made by different individuals in the firm, there is often a high degree of misalignment.

This can be linked with previous arguments suggesting that key objectives, such as cost, flexibility and quality, can be aligned and that they can be understood by all decision-makers within the firm, yet, at the lower level, these objectives and trade-offs might not be suitably translated. This leads to the misalignment of the metrics within the different functions, creating sub-optimisation within the process.

The RBV was developed by Penrose (1959) when she argued that organisations can be seen as a bundle of productive resources and capabilities that are under the direct control of the management. Therefore, it can be assumed that the infrastructure is one of the key productive resources of a firm. Moreover, in his articles, Barney (1991; 2001) clearly defined what is meant by resources – they are all the assets: plant, equipment, land, raw materials, inventory and capabilities: organisational processes, information and knowledge, as well as the human capital: training, intelligence, and experience. These combinations of resources will give the firm a competitive advantage (Grant, 1991; Yoo, Lemak & Choi, 2006). Within RBV, there is an inherent assumption that must be clarified: resources are heterogeneous or limited in supply and may not be completely mobile across firms as well as being “*endowed with differential level of efficiency*” (Mahoney & Pandian, 1992; Peteraf, 1993). Therefore, the “*RBV examines the implications of this assumption for analysing the sources of sustained competitive advantage*” (Barney, 1991, p.101). Resources that are more efficient and effective, the so-called ‘superior resources’, allow firms to gain the competitive advantage by producing at lower cost or better satisfying their customers. Therefore, RBV contributes towards identifying these superior resources and supports the organisation in sustaining them over the long term. However, Mahoney and Pandian (1992), and Cousins (2005) explained that, if resource heterogeneity is temporary, the gain will be eaten away eventually. There are three criteria that are identified by Barney (1991, 2001) and Peteraf (1993): i) imperfect imitability, ii) imperfect substitutability, and iii) imperfect mobility, all impacting upon sustaining a competitive advantage, as is represented in Figure 2.5 and 2.6.

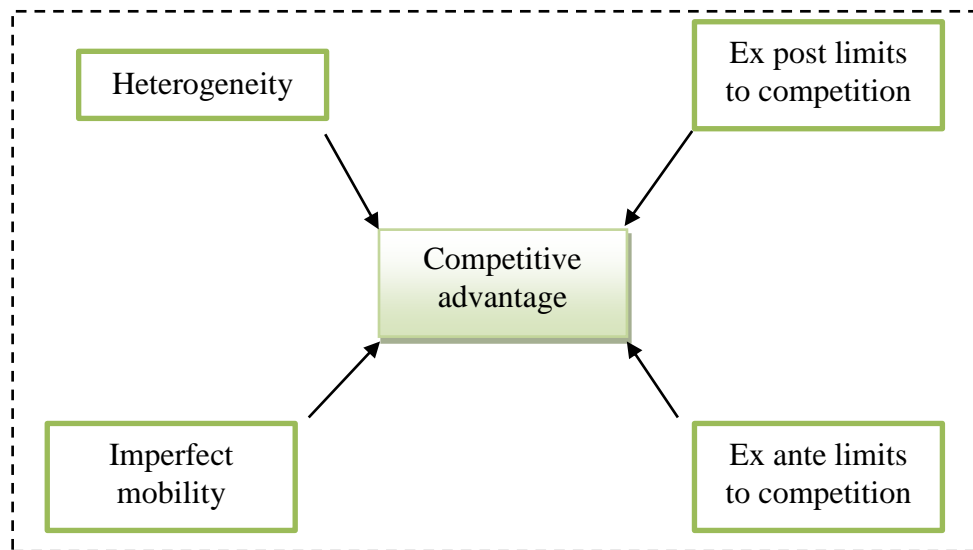


Figure 2.5: The cornerstone of competitive advantage (adapted from Peteraf, 1993)

Therefore, it “cannot be expected to sustain competitive advantage if the superior resources are evenly distributed across all competing firms and highly mobile” (Barney, 1991, p.103), as suggested in Figure 2.6.

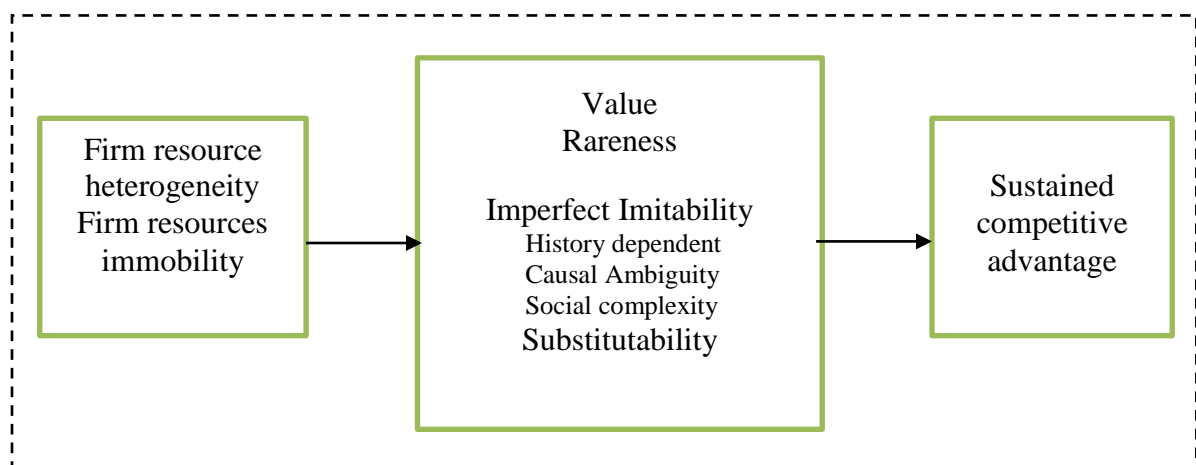


Figure 2.6: The element constituting the competitive advantage using an RBV view (adapted from Barney, 2001)

RBV has been criticised mainly by the contributors of the TCE (Transaction Cost Economics), which attempts to explain the existence of firms, stating that the concept of opportunism is not considered in the RBV theory. However, Cousins (2005) and Cousins *et al.*, (2008) concluded that neither RBV nor TCE offers complete theory set, but that

both are useful in understanding fundamental Operations Management decisions and Operations Strategy questions.

Hence, this is one of the main arguments justifying the multiple theoretical concepts, borrowed by the researcher, to undertake this thesis. As neither RBV nor TCE could offer complete theories, it was believed that drawing from multiple theoretical concepts, within an Operations Management lens and discipline, was appropriate (Godsell, Martin, Johnson and Guo, 2013). This will also be justified by having a set of concepts that fit both private and public sectors, such as the stakeholder theory, modelling theory and complexity theory. Hence, RBV will be used as one of the theoretical concepts, but will be associated with others to fully cover the theoretical background of this multi-disciplinary thesis.

#### **2.1.5.1. OS Should Reconcile Strategic Decisions with Objectives**

Few businesses have the resources to pursue every single action that might improve their operation performances and gain or sustain the competitive advantage. Therefore, to some extent, an Operations Strategy should indicate the way the operations might best achieve the objectives. If the objective is to compete on costs, the firm might investigate outsourcing its non-core activities, which refers to the Make or Buy decision that has been extensively discussed in the Operations Management literature throughout RBV or TCE (Cousins, 2005; Cousins *et al.*, 2008; Slack *et al.*, 2010). Having said that, it is recognised that there are several categories of OS decisions, Slack *et al.*, (2006; 2010) identified a taxonomy of OS decisions that needs to be tackled by the firms, as the table below shows (Slack *et al.*, 2006, p.43).

<b>Strategic Decisions</b>	
in the design of operations	<p><b>Which products or services should be developed and how should the development process be managed?</b></p> <p><b>Should the firm develop its products/services in-house, or outsource the design?</b></p> <p>Should the operation outsource some of its activities, or take on more in-house activities?</p> <p>Should the firm expand by acquiring its suppliers or customers? If suppliers, which particular ones? If customers, which particular ones?</p> <p><b>How many operation sites should the firm have?</b></p> <p><b>Where should the operation sites be located?</b></p> <p><b>What activities and capacity should be allocated to each site?</b></p> <p>What type of technology should the operation be using?</p> <p>How should the firm be developing its employees?</p> <p>What role should the people who staff the operation play in its management?</p>
in the planning and control	<p>How should the operation forecast and monitor the demand for its products and services?</p> <p>How should the operation adjust its activity levels in response to demand fluctuation?</p> <p><b>How should the firm monitor and develop its relationship with its suppliers?</b></p> <p>How much inventory should the firm have and where should it be located?</p> <p><b>What approach and system should the operation use to plan its activities?</b></p>
in the development of operations performances	<p><b>How should the operations' performances be measured and reported?</b></p> <p><b>How should an operation ensure that its performance is reflected in its improvement priorities?</b></p> <p><b>Who should be involved in the improvement process?</b></p> <p>What should the improvement process be?</p> <p>How should the operation maintain its resources so as to prevent failure?</p> <p>How should the firm ensure continuity if failure occurs?</p>

*Table 2.1: Strategic decisions that may need to be addressed in an OS (adapted from Slack et al., 2006)*

It is relevant to notice that some of the key decisions will be applied to the new infrastructure development process throughout the thesis, such as: which products or services should be developed and how should the development process be managed? Should the firm develop its products/services in-house, or outsource the design? How many operation sites should the firm have? Where should the operation sites be located? What activities and capacity should be allocated to each site? What type of technology should the operation be using? How should the firm monitor and develop its relationship with its suppliers? How should the operations' performances be measured and reported?

How should an operation ensure that its performance is reflected in its improvement priorities?

#### **2.1.5.2. OS to Align Market Requirements with Operations Resources**

As previously discussed, the Operations Strategy should reflect the planned position of the organisation, whilst remaining aligned and consistent within the firm. It was established, according to the competitive advantage concept, which states that firms compete primarily on either cost or excellence of their products and services, or on a high level of customer service. This means that the operations function must respond by proving its ability to perform in a manner that is appropriate for the intended market position. The process and resources within the firm, or within the operations, also need to be developed in the long term, to provide the business with a set of competencies, or capabilities. These capabilities can be developed over time or can be acquired (Slack *et al.*, 2006, p.47).

This abstract explanation becomes concrete when it is applied to infrastructure development within a firm. As it will be discussed in greater detail, infrastructures are a primary asset for most organisations, whatever the business focus and strategy (Fernandez-Solis, 2008; Schraven *et al.*, 2011; Too & Too, 2010). For example, let's assume and imagine a university wanting to expand and increase its renown. Through its strategy, improving staff outputs and quality, increasing the number of top students, will also be associated with developing state of the art infrastructures. The rationale behind this will be to attract staff and students, but also to be able to provide the necessary capacity and facility to improve service delivery. This infrastructure development will provide support in aligning market and stakeholders' requirements, with the resources. The same rationale would apply for healthcare infrastructures.

#### **2.1.6. Assumption: Does the Public Sector have the Same Issues?**

As the above discussion was predominantly referencing to competitive firms in the private sector, one may wonder if this rationale is also valuable in the public sector. There is a shift towards the privatisation of the public sector, and, despite the tendency of contrasting private and public, most business models and theories are now adapted and implemented in the public sector. Public organisations, such as the NHS or Higher Education institutions, are also strategizing, and must aim to manage their resources in the most



effective and efficient manner to develop value for money products and services, and to provide these products and services at a high quality standard, as expected by the stakeholders. Therefore, the researcher assumes and believes that Operations Strategies and competitive advantages are also applicable to public sector organisations; hence, RBV and concepts drawn from the Operations Management discipline are appropriate.

In the following section, Operations Management, as a discipline, will be discussed and reviewed, notably by studying its history and understand how it evolved out of production management. This will be relevant in order to introduce and understand the Lean thinking phenomenon, which will be reviewed in great detail in this chapter, and identified as one of the core bodies of knowledge in this thesis.

## **2.1.7. Operations Management and Production Systems**

### **2.1.7.1. Introduction**

Radnor and Barnes (2007, p.384) defined Operations Management (OM) as “*concerned with the management of organisational activities which produce goods and/or deliver the services required by its customers*”. Operations Management is the management of a production system that provides goods or services to/for a customer, and involves the design, planning and control, and the improvement of the system (Hill, 2009; Sprague, 2007). At this stage, it is relevant to note that ‘production’, is used in the broadest sense of ‘poiesis’, which, in Greek means to make or to create, embracing also the design aspect, and which has been theorised since Aristotle (Koskela, 2012). Scientific management, initiated by Taylor, Ford and Gilbreth was one of the first attempts to systematically treat management and process improvement as a scientific problem. Scientific management was a theory of management that analysed and synthesised workflows. Its main objective was to improve economic efficiency and workforce productivity. In order to appreciate this in more detail, the following section provides a brief and suitable history of this discipline.

### **2.1.7.2. The 20<sup>th</sup> Century: an Evolution in the Production System**

In their paper, Radnor and Barnes (2007, p.386) explained that three distinctive periods can be identified throughout the 20<sup>th</sup> century of what is known today as Operations and Process Management. The transitions from one to another happened gradually.

#### ***From the End of the Ninetieth Century to the Second World War***

Based on Adam Smith's (1776) ideas, from the end of the nineteenth century to the Second World War, the concepts of scientific management emerged, which founded the dominant concepts of Operations Management. This principally occurred in Europe and the US. Smith (1776) ingeniously predicted that specialisation of labour and the adoption of large scale machinery would enable massive increase in productivity by transforming the craft production. It is relevant to note that he was already concerned with the management of production. Bamford and Forrester (2010) explained that the father of the scientific management is Frederick Taylor (1911), who intended to capture and define scientific management in his manuscript. Taylor (1911) suggested that: i) a science for each element was developed to replace the old rule of thumb methods; ii) workers must be carefully selected and trained; iii) managers and workers must collaborate and cooperate to insure all of the work meets the requirements developed; and iv) there is an equal division of the work and responsibility for the managers and the workers. As a discipline, Operations Management evolved with the help of several other contributors. Henry Gantt, known for the theory of planning (*i.e.*: Gantt chart), Frank and Lillian Gilbreth (*i.e.*: work studies), and Henry Ford (*i.e.*: Fordism) have all set the foundation of what OM is today (Bamford & Forrester, 2010). Koskela and Ballard (2012, p.726) explained that all were by background engineers and looked at the management from a scientific perspective. They were concerned with the optimisation of the production system; hence they developed concepts and theories, such as: division of labour, methods studies, work measurement, standardisation and mass production, in order to increase productivity. These concepts, or theories, were based on the scientific analysis of existing processes and activities collected through observations, measurements and experiments. This has become known as 'Taylorism'. However, one of the main criticisms, led by the behavioural school of thought scholars, was the de-humanisation aspect involved in the scientific management; for instance with the Hawthorne experiments of Elton Mayo

(Radnor & Barnes, 2007, p.387). Today, Operations Management is combining both aspects of scientific management, the optimisation of the production system combined with the human perspective, recognising that the human resource is the most critical and valuable resource of a firm (Slack *et al.*, 2006, 2010).

### ***From the Second World War to the Mid 1980's***

The second period runs from the Second World War to the mid '80's, which saw the quantitative perspective to expand even further throughout the discipline. Voss (2007) and Filippini (1997, p.655) explained that, according to Buffa, it is possible to trace the three main phases of evolutionary development in the field of OM to after the Second World War. He referred to the industrial management from 1950, where: i) time and motion study, plant layout, production control and descriptions of how production systems worked, started to emerge and grow throughout production units; ii) the Operational Research (OR) studies were carried out, providing the methodology that enabled the looking at and analysing of operating units through a scientific lens; and iii) the emergence of Operations Management, as an independent and functional discipline within management. Similarly, Voss (1995, p.17) explained that the quantitative development within OM was due to two factors and phenomenon; firstly, through the progress of Operational Research (OR) and its spread from military application to the business world, and, secondly, through the work from Shewhart and Deming in the application of statistical principles in the management of quality.

Voss (1995, p.20) summarised that OM academics think of Taylor, Ford, Gantt and Gilbreth as having contributed to building new theories. Radnor and Barnes (2007, p.387) said that, despite the knowledge expansion of the discipline, *"there was a gradual increase in the influence of human relations movement at the expense of Taylorism"*. This was changing the role of the worker and concepts of empowerment, job enrichment, job enlargement and teamwork, and these became primary concerns. Finally, Locke (1982, p.14) strongly argued that *"Taylor's views were fundamentally correct and have been generally accepted. Most of the major criticisms that have been made of Taylor are unjustified"*. He even admitted that Taylor's genius has not been appreciated by many contemporary writers, as he had broken into a new pre-paradigm, as per Kuhn's (1962) definition.

### ***From the 1980s to the Present***

The third identified period is from the 1980's to the present. This is the fusion area, where mass-customisation happened and where aggregations between the different concepts occurred. Radnor and Barnes (2007, p.390) stated that *"this promoted a more strategic consideration of operations"*. This is when the Japanese production model started to influence the west, and when the worker emancipation was emphasised and integrated. This model influenced the modern Quality Management and Lean theories (Lillrank, 1995).

#### **2.1.7.3. From Scientific Management to Operations Management – an Academic Perspective**

Having reviewed the history and the evolution of Operations Management, as a discipline, from an industrial perspective, and acknowledged its major empirical contributors, it is believed that an overview of its academic development is relevant and appropriate, with 1959 as a renaissance point (Singhal & Singhal, 2007).

#### ***In 1959***

Koskela and Ballard (2012, p.726) argued that the switch from a production-centric view of management, to a social science-oriented view from a research and educational perspective, occurred in 1959. This was marked by the publication of two influential books from Gordon and Howell (1959) and Pierson (1959), which were critical of established business education. Both publications investigated the issues within the teaching and research of American Business Schools, in relation to management and production as disciplines. It was suggested that teaching and research should be more analytical (Andrew & Johnston, 1982, p.143). Moreover, Andrew and Johnston (1982, p.143) explained that, in 1957, with the launch of the first artificial Earth satellite, Sputnik, by the Soviet Union on 4<sup>th</sup> of October, academic communities were stimulated. Thus, the *"lack of rigorously trained engineers, scientists, and other highly skilled professionals emerging from the Universities and Business Schools was highlighted"*. Koskela and Ballard (2012, p.726) explained that, throughout their suggestions and findings, Gordon and Howell and Pierson somehow *"discredited the classical management and organisation science that evolved from the beginning of the 20th century"*. They prescribed that management should be approached through three branches: i) the behavioural science, as promoted by Simon (1947), and March and Simon (1958); ii) the

neoclassical economics, which provides a basis for decision-making analysis; and iii) quantitative modelling, which was growing fast with the progress of computers. Moreover, Andrew and Johnston (1982, p.143) said that “*Schools of business responded by adopting a perceptually more rigorous arts and sciences model of research based education (Nistal, 1979-80). This meant an increased rigor and quantification*”. Koskela and Ballard (2012) argued that this led to developing scientific management as a technical discipline, connected to production and design, leading to three primary consequences: “*i) the science of organisation and management became an extension of production and industrial management; ii) the interest was in organisational engineering and design and in studying prescriptive principles and best-practice; and iii) management was studied by engineers and managers of productive operations*”.

### ***From the Mid to Late 1960's***

Andrew and Johnston (1982, p.144) explained that as a result of these industrial developments, Production and Operations Management (POM) gradually became more models and techniques-oriented. Slack, Lewis and Bates (2004, p.374) stated that around the same time that Taylor was working and developing his ideas, a demand for formal management education was emerging, and scientific management formed a key component of many syllabuses (Gordon & Howell, 1959). However, the scope of OM had become too wide and descriptive, including personnel management, accounts, and general management topics. Therefore, the programmes were “*dismantled and differentiated into the several functional fields*” (Buffa, 1982), and OM began to be associated more with Operational Research/Management Science (OR/MS) techniques, which were developed further during the Second World War, and seemed to offer OM a suitably scientific and quantitative way forward, to further support the decision-making behind the management of production systems, as Buffa (1982) explained (*as cited in Slack, Lewis & Bates; 2004, p.374*).

### ***The Modern Time***

Filippini (1997, p.655) explained that, during the 1970s, OM research was dominated by the abstract application of techniques, and was not involved enough in empirical studies. In his paper, Voss (1995) showed and compared the research agenda in the 1980's, which is a relevant indicator of the evolution of the discipline. In the first instance, Voss

identified the content of Operations Management, and he compiled the results as in Table 2.2 below.

<b>Content of Operations Management in the 1980's</b>	<b>Buffa (1980)</b>	<b>Voss (1984)</b>
Production planning and control	√	√
Purchasing	√	√
Facilities	√	√
Process design	√	√
Process technology		√
Job design, work organisation	√	√
Organisation structure	√	
Management of technical change		√
Maintenance and reliability	√	√
Quality control	√	√
Work measurement	√	
Manufacturing policy		√
Cost estimation		√
Systems approaches		√
Physical distribution		√
Service operations		√

*Table 2.2: Content of Operations Management in the 1980s (adapted from Voss, 1995)*

Voss (1995) confirmed the focus on quantitative, or scientific, techniques and cited critical path analysis, linear programming and inventory modelling as other emerging key themes. He also compared the research agendas between the US and the UK in the 1980's, as Table 2.3 shows. He discussed the “*sharp contrast between the research types undertaken in the US and the UK*”. While, in the US, 69% of the publications fall under the modelling or simulation categories, in the UK, 80% of the papers fall under the conceptual, field and case based categories. He then provided an explanation as to why these differences

occurred, but did not make any specific reference to the 1959 publications, as Koskela and Ballard (2012) argued. It is worth noting that Prasad and Babbar (2000) called for further OM empirical studies that span a wider range of countries, to strengthen and generalise findings.

<b>Rank</b>	<b>US</b>	<b>UK</b>
1	Modelling	Conceptual
2	Simulation	Field
3	Conceptual	Survey
4	Survey	Case
5	Case	Modelling
6	Field	Simulation

*Table 2.3: Ranking of frequency of research papers by type of research (adapted from Voss, 1995)*

This explains, to a certain extent, why Slack, Lewis and Bates (2004, p.372) said “*OM’s underpinnings are fragmented. Indeed it could be argued that the specific genealogy of modern OM is a curious amalgam of very different academic disciplinary inputs, for example: systems theory, decision theories, strategy theories and practical application*”. This also supports one of the researcher’s assumptions of pragmatism and the application of multiple theoretical concepts, and the theories falling under the OM discipline. This also leans towards what Godsell *et al.*, (2013) found in their review of management theories (MT) between 2002 and 2011, applied to the Operations Management field, where, throughout this decade of publication in the most prestigious scientific journals (JOM, IJOPM, DS, POM, IJPR and MS), 35 different grand management theories (MT) have been applied. Table 2.4 provides the nine most popular theories used in OM research between 2002 and 2011.

Ranking	Management Theory (MT)	No. of occurrences	% of occurrences
1	Transaction Cost Economics	73	26.84%
2	Resource Based View	65	23.90%
3	Contingency Theory	38	13.97%
4	Social Exchange Theory	15	5.51%
5	Institutional Theory	12	4.41%
6	Agency Theory	11	4.04%
7	Resource dependence theory	9	3.31%
8	Organisational Knowledge Creation (SECI Model)	6	2.21%
9	Evolutionary theory for economics and management	6	2.21%
10	Other MTs	37	13.60%

*Table 2.4: The nine most popular management theories as used in OM Research 2002-2011 (adapted from Godsell et al., 2013)*

#### **2.1.7.4. OM and its Role within the Organisation**

In this section, the researcher further explains the relationships between OS, OM, and their roles within the firm to sustain a competitive edge, and how this is linked with decision-making. According to Koskela and Ballard (2012, p.731) “*Simon (1976, p.292) promoted and defined a firm as an information processing system*”. This is consistent with management theory’s turn, away from pure production, in 1959, as well as with the researcher’s ontological assumptions: ‘reality as a contextualised field of information’, which will be discussed in Chapter Three. This led Koskela and Ballard (2012) to state a critical issue for academics and practitioners: “*the central problem is not how to organise to produce efficiently, although this will always remain an important consideration; but how to organise to make decisions and to process information*”. If the two seem to overlap somehow, the focus is on the decision-making process, which will be a core element of this thesis. Theoretically, this argument justifies the rationale behind this thesis, which is investigating the decision-making processes in the production and delivery of healthcare infrastructure. How should a firm be organised to optimise the decision-making in order to improve the new healthcare infrastructure development; a key asset in sustaining quality and innovation from an RBV perspective? However, before going any further, it is useful to define the main concepts grounded in OM.



### **2.1.7.5. Core Concepts Grounded in OM**

The management of production systems consists of three functions: design, planning and controlling operations and improvement of the system (Bamford & Forrester, 2010; Koskela & Ballard, 2012; Slack *et al.*, 2006).

#### ***Design***

From an OM perspective, the design is the configuration of the shape of the process and product. Often, it is the first step in contributing towards the competitive advantage. There are several decisions linked with the design, such as the choice of location, selection of suppliers, choice of layout and capacity decisions, as well as the design of jobs (Hill & Hill, 2012; Slack *et al.*, 2010). From a strategic perspective, how can the firm or organisation optimise this complex set of decisions?

#### ***Planning and Control***

Once the operations, processes or supply chains have been designed, the roles of the Operations Management function is to contribute towards the optimisation of the product or service delivery, meeting customer demand. In order to achieve these complicated responsibilities, Operations Managers have to check for any deviations away from the production system, which will involve managing the designed capacities, inventories and quality (Bamford & Forrester, 2010; Hill & Hill, 2012).

#### ***Improvement***

The third main dimension of the OM function is the improvement. Creating and sustaining continuous improvement will generate a source of competitive edge. There are different approaches, or methodologies, to improvement. Amongst the most popular are: Total Quality Management (TQM), Lean thinking, Six-Sigma or Business Process Re-engineering (BPR) (Antony *et al.*, 2007; Bamford & Forrester, 2010; Drensek & Grubb, 1995; Hines *et al.*, 2004; Reid & Smyth-Renshaw, 2012).

Therefore, if one of the main roles of Operations Management is to improve the performance of the process, one needs to look towards the Quality Management literature, in order to have a better overview of what it encompasses.

## **2.1.8. Quality Management**

### **2.1.8.1. Definition and Origin**

Dale, van der Wiele and van Iwaarden (2007, p.4) pointed out that, linguistically-speaking, quality comes from the Latin word ‘qualis’, meaning “*such as the thing really is*”. There are several definitions of quality, for instance, Juran (1988) said that it is “*the fitness for purpose*” and Crosby (1979) stated “*it is the conformance to agreed requirements*”. It can be agreed that quality is defined as the conformance to specification. Sliwa and Wilcox (2008, p.97) explained that, with the notion of variability, Shewhart (1931) has become commonly known as the ‘founder’ of the modern quality movement. Williams, Van der Wiele, Van Iwaarden, Bertsch and Dale (2006) argued that there are two eras of Quality Management: classical and modern, both separated by Shewhart’s period.

#### ***The Beginning of the Twentieth Century***

During the early 1900s, Taylor promoted the inspection as one of the main management tasks. However, it is Radford (1922), in his academic publication, who first established the links between inspection and quality control, and promoted quality as a management responsibility. Consequently, quality was recognised as a critical element of any mass production system. Furthermore, Shewhart, in his books ‘*Economic Control of Quality of Manufactured Product*’ (1931) and ‘*Statistical Method from the Viewpoint of Quality Control*’ (1939), then developed a scientific approach to quality, as Williams *et al.*, (2006) explained.

#### ***Shewhart’s Era***

In parallel with mass production, Shewhart was concerned with the ‘economic control’ of quality items produced on a mass scale, and emphasised the need to “*maximise the assurance of quality, minimise the cost of inspection, and minimise loss of rejection*” (Shewhart, 1939, p.47). Moreover, as Anderson, Rungtusanatham, and Schroeder (1994) argued, the application of Shewhart’s ideas allowed to inverse the management trends of deskilling the workforce, tasks specialisation and increased supervision, which opened the doors to the modern era of Total Quality Management (TQM).

## ***Total Quality Management***

Martínez-Lorente, Dewhurst and Dale (1998, p.380) suggested that *“TQM’s origins can be traced to 1949, when the Union of Japanese Scientists and Engineers formed a committee of scholars, engineers, and government officials devoted to improving Japanese productivity, and enhancing their post-war quality of life”*. In the US, the development of the concepts behind Total Quality Management started from the 1960s and 1970s, throughout the writings of the so-called ‘quality gurus’: Deming (1982), Crosby (1979), Feigenbaum (1956; 1961) and Juran (1988), as explained by Bamford and Forrester (2010).

### **2.1.8.2. Evolution of TQM through the American Gurus**

According to Kruger (2001) and Martínez-Lorente, Dewhurst and Dale (1998, p.383), a number of scholars and authors, such as Davis and Fisher (1994), considered Deming (1982) to be the father of TQM. However, it can be argued that Feigenbaum (1956; 1961) was the first to use the term ‘Total Quality Control’. He defined TQC as *“an effective system for integrating the quality development, quality maintenance, and quality-improvement efforts of the various groups in an organisation, so as to enable production and service at the most economical levels, which allow for full customer satisfaction”* (as cited in Martínez-Lorente *et al.*, 1998, p.383). Moreover, English (1996) considered that Juran was related to TQM, even if he did not use the term in his main book *‘Quality Control Handbook’* (Juran *et al.*, 1974; Juran & Gryna, 1988). Finally, it was also considered that Crosby (1979), with his book *‘Quality is Free’*, was a TQM theorist, as Martínez-Lorente *et al.*, (1998, p.383) argued.

If the so-called gurus advocated the total aspect of quality, there were differences in their approaches. For instance, Juran considered that *“quality starts within the design of the product and ends only when the customer remains satisfied”* (as cited in Martínez-Lorente *et al.*, 1998, p.381). Deming and Crosby deemed that quality had to be generated from the production process, respectively, by eliminating variation and targeting the zero-defect.

It is worth acknowledging that differences exist within TQM between countries’, industries’ and even organisations’ maturity levels, which demonstrate its environmental dependability, as detailed in Martínez-Lorente *et al.*, (1998, p.385). It is within Japan where the other major quality gurus and contributors: Ishikawa (1974), Imai (1986),

Taguchi and Shingo (1986), can be found (Asher & Dale, 1989). However, universal commonalities, which have always been the foundation of TQM, will be discussed in the following section, through the assumptions, principles and methodologies.

### **2.1.8.3. TQM Assumptions, Principles and Methodologies**

According to Hackman and Wageman (1995, p.310), and Kruger (2001), there are four assumptions underpinning TQM. First of all, TQM assumes that developing a system, which produces quality products and services, is less costly than the cost associated with poor quality input by inspection, rework and lost customers (Crosby, 1979; Deming, 1986; Juran *et al.*, 1974). Secondly, TQM assumes that the employee is at the centre of the quality system, and needs to be empowered to take initiatives to improve it, using a set of tools and techniques provided by the management teams (Deming, 1986; Ishikawa, 1976; Juran *et al.*, 1974). Thirdly, it is assumed that firms are inter-connected systems; therefore, cross-functional problems will have to be addressed collectively (Deming, 1986; Juran & Gryna, 1988). Finally, TQM is under the prime responsibility of senior management. To be successful, the TQM process has to start at the top, with the senior management's commitment to it (Crosby, 1979; Deming, 1986; Ishikawa, 1976; Juran *et al.*, 1974).

Furthermore, in their publication, Drensek and Grubb (1995) and Hackman and Wageman (1995, p.311) mentioned four principles that guide TQM implementations. First of all, it needs to focus on processes; the quality of the products and services depending on their production processes (Deming, 1986; Ishikawa, 1976; Juran *et al.*, 1974). The second principle is that understanding the variation and variability is critical, as uncontrolled variance in processes is the primary cause of quality problems (Deming, 1986; Ishikawa, 1976; Shewhart, 1931; Van der Wiele, Van Iwaarden, Williams & Eldridge, 2011). The third principle is management by facts, TQM requires the use of systematically collecting and analysing data in order to get to the root-cause of problems. Therefore, there is a need to use statistical tools to monitor and analyse work processes (Deming, 1986; Ishikawa, 1976; Juran *et al.*, 1974; Shewhart, 1931). The final principle underlying TQM is that quality improvement is a never-ending journey. One must appreciate that opportunities to develop more optimum methods for carrying out work always exist, and a commitment to continuous improvement is paramount (Deming, 1986; Ishikawa, 1976; Juran *et al.*, 1974).

Therefore, as Hackman and Wageman (1995, p.312), Dale *et al.*, (2007), and Kruger (2001) mentioned, the TQM foundations rely explicitly on identifying and measuring the customers' requirements, developing strong and reliable relationships with suppliers and ensuring effective cross-functional mechanisms.

### **2.1.9. Conclusion**

In this first section of this literature review, Operations Strategy and Operations Management were defined and analysed from empirical and theoretical perspectives. This has enabled the researcher to start building the foundation for this thesis, and start justifying some of the underlying assumptions. For instance, it is explained that, in Operations Management, several theories have been used to understand related phenomena. RBV was explained in relation to the competitive advantage. The fundamental principle lies primarily in the application of the bundle of valuable resources that a firm dispose (Barney, 2001; Cousins, 2005). It explains that a firm can sustain a competitive advantage by developing unique resources which can be rare, valuable, inimitable and non-substitutable, as well as firm-specific or environmentally dependent. This led the researcher to develop TQM and identify it as an enabler, or being a resource, to develop and sustain a firm's competitive advantage (Miyagawa & Yoshida, 2010). The following sub-chapter of this literature review will build upon TQM to introduce and discuss Lean thinking, which is the extended theoretical concept of the application of TQM. 'Lean' was named during the 1990's, in the West, but carries in its DNA the main component of OM principles.

## **2.2. Lean Thinking**

The previous sub-chapter enabled the setting of the theoretical context and the justification of a set of assumptions. Firstly, Operations Strategy and the RBV were discussed, and then the evolution from the scientific management to Operations Management and Quality Management were presented. This first sub-chapter led the researcher to engage now with a more specific theoretical concept, considered as a body of knowledge on its own: Lean thinking. In this sub-chapter, the origin of Lean thinking will be established, then the systems behind it presented, before the discussion of the different applications of Lean, in the business context, is entered into. It will be argued that there is a degree of Leanness, which can be associated with the maturity level of an organisation or of an industry (Dale & Smith, 1997; Green & May, 2005). Furthermore, it will be suggested that Lean is environmentally dependent, meaning that it must be adapted to fit a specific context (Sousa & Voss, 2001). For instance, Lean in healthcare and Lean in construction will both be detailed in this sub-chapter.

### **2.2.1. Origins and Definitions of Lean Thinking**

The origins of Lean is acknowledged by most experts (Bamford & Forrester, 2010; Bamford *et al.*, 2014; Hines & Rich, 1997; Hines, Holweg & Rich, 2004; Womack & Jones, 1994; Womack & Jones, 1996) as being the manufacturing philosophy deployed by Toyota, in the '50's, and shaped throughout the '60's and '70's under its production system: the TPS (Chakravorty and Hales, 2013). Bendell (2006) noted that the term 'Lean' was first employed by John Krafcik, in 1988, in an article published in the Sloan Management Review, '*Triumph of the Lean Production System*'. The Lean manufacturing system, initiated by Taiichi Ohno and Dr. Shigeo Shingo, was originally developed on the Japanese shop floor, and did not really cross the borders until the end of the 1980s. Ohno (1988) and Shingo (1988) conceived the Lean manufacturing system around the elimination of waste associated with improvement strategies (Pettersen, 2009). Two of the predominant techniques were Poka-Yoke (or mistake proofing), which prevents human error from being transformed into defect and passed onto the customer, and Single Minute Exchange of Die (SMED), which is the reduction and minimisation of change over time, and set up time, to allow reduction in batch size and over-production avoidance (Shingo, 1986; Shingo, 1989). As explained in Dehe (2009), the West awaited the worldwide famous book, written by Womack, Jones and Roos (1990) '*The Machine that Changed the*

*World'*, before starting to embrace the terminology so popular today (Kollberg, Dahlgaard & Brehmer, 2006). Lean thinking was promoted by Womack and Jones (1997, p.12) based on five principles, largely developed in their publications: “*specify the value, identify the value stream, create continuous flow, apply pull concept, and hunt for the perfection*”.

Principle 1	Specify the value regarding the customer requirements
Principle 2	Identify the value streams to realise the final product
Principle 3	Create continuous flows on critical activities
Principle 4	Apply pull systems over theses flows
Principle 5	Implement continuous improvement to reach perfection

*Table 2.5: Lean thinking's five principles (adapted from Womack and Jones, 1997, p.12).*

After Womack *et al.*, (1990) publication the academic and practitioners' Lean literature grew rapidly. Examples, cases and good practices on Lean applications were published, demonstrating the benefits, such as: lead time reduction, teamwork and employee empowerment improved, as well as cost saving and quality improvement. This led industry to start adopting improvement methodologies, such as: TQM, BPR, Lean and Six-Sigma (Demeter & Matyusz, 2011; Ertay, 1998; O'Neill & Sackett, 1994; Reid & Smyth-Renshaw, 2012), as also explained in detail by Bamford *et al.*, (2014). Hines and Rich (1997) and Womack and Jones (1997) agreed that the primary Lean foundation is the elimination of muda (waste), stating that Lean is “*the antidote to muda*”. Wastes had first been classified by Ohno (1988) as the seven Toyota wastes: “*defects, over-production, unnecessary motion, inventory, transportation, unnecessary processing, and waiting time*”. In order to achieve the process perfection, Lean advocates a flexible improvement philosophy, by placing people who add value at the centre of resources, information, process design and decision-making, as well as by increasing customer focus and involvement in product and process development (Bowen & Youngdahl, 1998; Pettersen, 2009; Shingo, 1988). Therefore, kaizen (continuous improvement) events and kaikaku (radical improvement) activities are among the concepts translating Lean thinking to eliminate waste, and eventually, reach the process perfection – a never-ending journey (Arnheiter & Maleyeff, 2005; Hines *et al.*, 2004; Pettersen, 2009) (*as cited in Dehe, 2009*). Dale *et al.*, (2007) recognised that Lean philosophy has been greatly influenced, as well as greatly influencing, all of the improvement approaches, models and frameworks, such as: Total Quality Management (TQM), Business Process Re-engineering (BPR), Six-

Sigma, Soft System Methodology (SSM) and Plan-Do-Check-Act (PDCA), known as the Deming cycle, which have been implemented within numerous organisations throughout the world (Chakravorty & Hales, 2013).

Based on this research, the researcher defines Lean as a pragmatic improvement programme, as opposed to a set, dogmatic principle. This assumption will enable clarification on what is considered to be under the Lean thinking umbrella. This concurs with what Chakravorty and Hales (2013, p.150) said when they stated that, to date, there are not any studies demonstrating a systematic approach for how to develop and deploy successful Lean systems in real-world organisations. Having said that, any successful implementation will have similarities, which are captured in the Shingo Model, the EFQM and the Malcolm Baldrige frameworks, and one of the common characteristics is the use of tools and techniques.

### **2.2.2. Lean Tools and Techniques**

To implement and develop such continuous improvement culture, firms must have tools, techniques and systems in place. Baczewski (2005) reported that Lean is a methodology based on quality improvement techniques. Bamford and Greatbanks (2005) explained that techniques are an association and a collection of tools with a defined purpose. Within the traditional Lean thinking tool box, George, Rowlands, Price and Maxey (2005) stated that a primary tool used is the process mapping, to understand the value chain and spot where the non-added value activities are. Moreover, Lean is associated with the seven quality tools (Q7): check sheet, histogram, graphs, pareto analysis, fishbone diagram, control chart and scatter diagram (Bamford & Greatbanks, 2005). These enable precise data collection and its presentation, which allows for the visualising processes, the identifying of relationships and the support of planning and control activities (Ishikawa, 1976; Juran, 1988). However, to develop flawless processes, more elaborated techniques should be implemented. From the Toyota heritage, key elements are: Just-In-Time (JIT), Processes Standardisation, and Theory of Constraints (ToC), conceptualised by Dr. Goldratt, associated with techniques such as: value stream mapping, 5S, TPM, SMED, Poka-Yoke, Andon, and Policy Deployment (Bunney & Dale, 1997). The idea behind this is to implement a pulling system, and eliminate the unproductive time, defects and movements, instead of pushing the product flow, as in a mass-production process (Shingo, 1986). In other words, these techniques aim to reduce waste, within a particular process, by



smoothing the flow triggered by the customer order, to eventually minimise cost and delight the customer, as summarised in Table 2.6 and stated by Dehe (2009).

Lean Tools and Techniques	Primary Objectives
Seven Quality Tools	Data collection and presentation
Flow and Process Mapping	Visualising a process in detail
Kanban	Support a replenishment pull system
Levelled Scheduling	Optimise the capacity, increase the utilisation and smooth the process
Layout Re-design	Better floor and space utilisation; smooth the flow
Policy Deployment	Align mission, vision and objectives throughout the organisation
Poka-Yoke	Prevent error to be passed onto the customer and becoming defect
Andon	Efficient quality line issues management
SMED	Minimise the change over time
TPM	Synchronise the management of maintenance, equipment and quality
5S	Sorting, straighten, sweeping, standardizing, sustaining

*Table 2.6: Main tools and techniques deployed by Lean (Dehe, 2009).*

Although, Table 2.6 above summarises the original Lean tools, which have been developed mainly in the manufacturing environment, it is far from exhaustive. In this chapter, other techniques sometimes associated with other improvement methodologies, such as: Six-Sigma and TQM programmes, will be presented. Moreover, it is relevant to highlight that if Lean tools and techniques have been mainly developed within large scale production and manufacturing environments, then they have been adapted in low volume and high variety environments; Bennett and Forrester (1994) and Bamford *et al.*, (2014) suggested that Lean adaption was appropriate and extremely valuable, as in the built environment. If this is accepted more widely today, this was not entirely the case in the late '90's, and the shift happened thanks to empirical studies demonstrating Lean application in the craft industries; for instance, in ceramics production (Soriano-Meier & Forrester, 2002), or in complex and low volume transactional, healthcare and construction processes (Arnheiter & Maleyeff, 2005; George, 2003; Kollberg *et al.*, 2006; Kagioglou & Tzortzopoulos, 2010; Koskela, 2004).

As previously stated, the researcher assumed and explained that Lean thinking encompasses other improvement techniques, sometimes associated with Six-Sigma. There is an on-going debate to identify whether Lean and Six-Sigma are different, and whether one is better than the other (Chakravorty & Hales, 2013; Dehe, 2009). Although this argument will not be discussed in greater depth in this monograph, the researcher strongly believes that they are different, but that their overlap is substantial and their synergies

extremely powerful. This argument is in line with the assumption of taking a pragmatic approach to continuous improvement, rather than a dogmatic one. Therefore, techniques originally associated with Six-Sigma, such as Benchmarking, QFD, SPC and FMEA, also have their place under the Lean thinking umbrella.

### **2.2.3. Other Lean Thinking Techniques**

In the following section, a couple of other continuous improvement techniques will be described in more depth. The focus will be firstly upon Benchmarking and QFD, which are key to this research, and then a summary of other techniques will be provided.

#### **2.2.3.1. Benchmarking**

In essence, the Benchmarking process consists of investigating practices establishing metrics, setting up performance levels and comparing them against a specific process (Camp, 1989; Forker & Mendez, 2001). *“Benchmarking is usually triggered by a company's need for information that arises due to: i) internal problems, ii) the need for cost reduction, iii) improve firm productivity, iv) changes in management, processes or products and, v) competitive assaults that require reconsidering the strategies”* (Forker & Mendez, 2001, p.195). Based on this definition, the researcher considers that Benchmarking falls naturally under the Lean thinking umbrella, in line with what Voss, Ahlström and Blackmon (1997, p.1056) explained, stating that Benchmarking has been diffused and rolled-out as part of TQM and JIT initiatives. Adebajo, Abbas and Mann (2010, p.1140) explained that Benchmarking was one of the most popular and widely adopted management techniques of the 1980s and 1990s, after its diffusion from Japan. It started gaining popularity in the west when organisations, such as: Xerox, GE and Motorola, demonstrated market share improvement driven by changes generated from their Benchmarking initiatives (Talluri & Sarkis, 2001). It gained a lot of credit for helping organisations to improve their competitive advantage, hence fit within the RBV rationale, as discussed in the previous section of this chapter.

Moreover, Wong and Wong (2008) even found it to be in the top five management techniques. According to the 2009 Management Tools and Trends Survey, Benchmarking practice was extremely high, with 76% of their respondent organisations having used this technique to initiate a specific strategic improvement (Rigby & Bilodeau, 2009, p.3; Zhang *et al.*, 2012). Research demonstrated the effectiveness of this technique and its

application, when firms sought to improve their processes' performances by using it (Talluri & Sarkis, 2001). It has gained even further exposure since it was included within the three major international Quality Awards: Malcolm Baldrige, EFQM and Shingo Prize for Operational Excellence.

Benchmarking has been implemented in many sectors; not only in the manufacturing (Sweeney, 1994; Voss *et al.*, 1994) and automotive sectors (Delbridge *et al.*, 1995), as often suggested (Adebanjo *et al.*, 2010, p.1140), but also in the food industry (Adebanjo & Mann, 2000), healthcare (Fowler & Campbell, 2001), finance (Vermeulen, 2003) and construction (Love *et al.*, 1999; Sommerville & Robertson, 2000). Despite its popularity and generalisation, it is not well defined, as Talluri and Sarkis (2001) explained. Fong *et al.*, (1998) even suggested that *"Benchmarking suffered from a lack of consensus about its classifications and that some of the models used in deploying benchmarking had significant shortcomings"* (as cited in Adebanjo, Abbas & Mann, 2010, p.1143). In their paper, they noticed that it was difficult to find a universal definition, and almost 50 definitions were reported (Nandi & Banwet, 2000). Having said that, the commonalities, underlying the definitions, were around aspects of operations measurement, comparison of practices and gap analysis (Anderson & McAdam, 2007). Therefore, agreements are built around three notions that Benchmarking is: i) the search process of best practices that lead to superior performance; ii) the activities facilitating the organisation learning and understanding (Camp, 1989) (as cited in Adebanjo *et al.*, 2010, p.1143); and, finally iii) the strategy deployed for implementing change and driving improvement (Freytag & Hollensen, 2001; Marwa & Zairi, 2008, p.59). Benchmarking is an effective business improvement method. It enables performance assessment, evaluation of the current gaps, and suggests drivers to support the innovation for current processes.

Studies, that have criticised Benchmarking, focus on the lack of involvement of employees and associates that own the process being compared (Bhutta & Huq, 1999; Davies & Kochhar, 1999), or state that the prime focus is the financial performance improvement (Maiga & Jacobs, 2004), when other measurements should be considered also, in order to achieve an holistic understanding of the process, as Adebanjo, Abbas and Mann (2010, p.1143) explained. Therefore, it was suggested that robust methodology had to be put in place to achieve successful Benchmarking activities. Several models have been developed and applied in various settings, all with varied steps or stages of the

process (Buyukozkan & Maire, 1998; Delbridge *et al.*, 1995; Zairi & Youssef, 1995). However, the common stages are: i) identification of the partner organisation, ii) data collection and analysis, iii) study of best practices, and iv) recommendations (Marwa & Zairi, 2008, p.60). Figure 2.7 below demonstrates a robust process developed by United Utilities and reported on by Dale *et al.*, (2007). This model supports the overcoming of several of the criticisms made through the years. Zairi and Youssef (1996) explained that the Benchmarking process is divided into four stages: i) plan, ii) analyse, iii) communicate or integrate, and iv) review or act and reflect, for which a great amount of effort and thinking must be undertaken in the planning phase, prior to the Benchmarking visit (Marwa & Zairi, 2008, p.60).

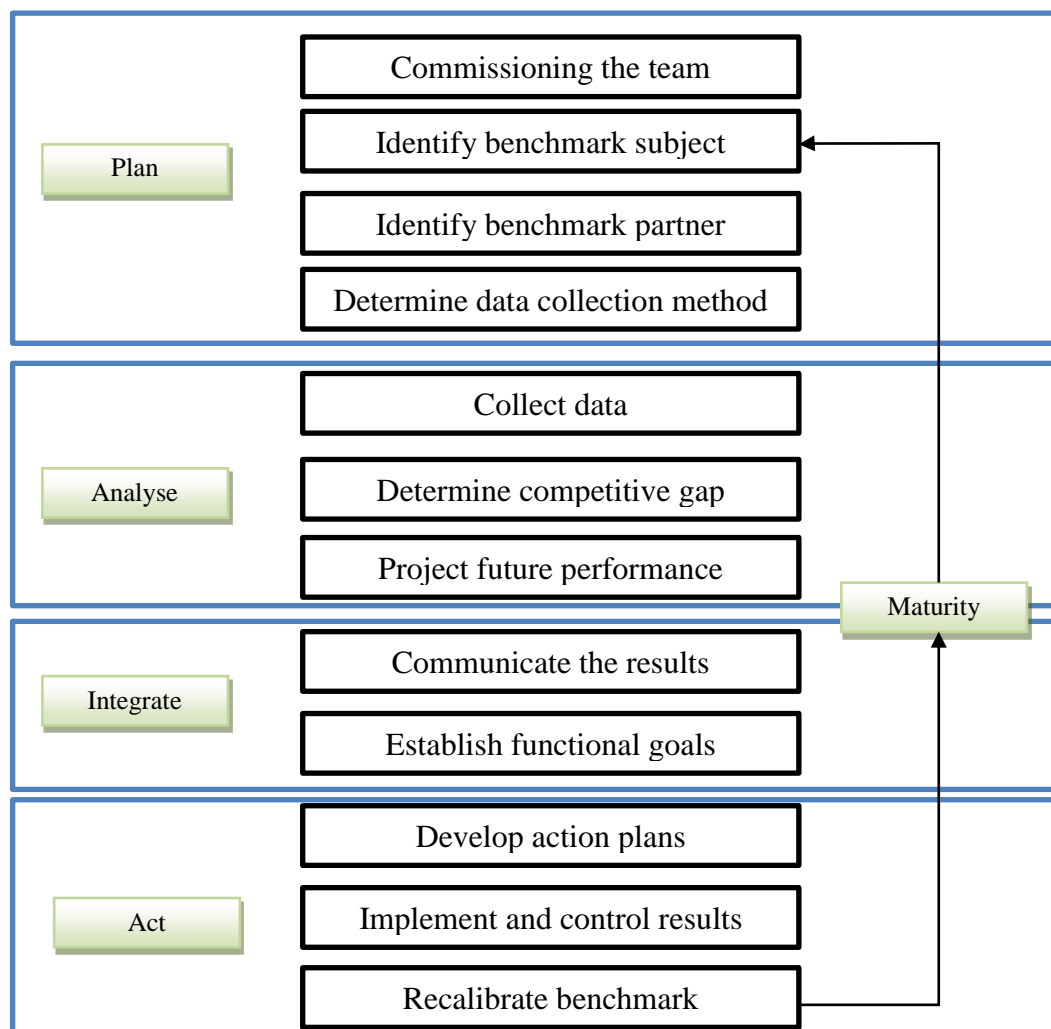


Figure 2.7: The Benchmarking process (adapted from Dale *et al.*, 2007)

Having defined the role of Benchmarking and discussed its process, it is appropriate to note that there are different types of Benchmarking. Adebajo *et al.*, (2010, p.1143) explained that it is often suggested that there are three types of Benchmarking: internal, external and best practice. Marwa and Zairi (2008, p.60) explained that a Benchmarking activity is undertaken by collecting data, both primary and secondary, to develop a deep understanding of the process. Therefore, it is critical that the team has a standard framework in which to collect relevant information and to some extent, develop a uniform collection method to reduce the bias. This can be achieved by developing a robust questionnaire on the measurement framework (Marwa & Zairi, 2008).

Voss, Ahlström and Blackmon (1997, p.1055) clearly demonstrated, both theoretically and empirically, the relationships between undertaking robust and coherent Benchmarking activities and the improvement in performances. Their regression analysis showed that it has an impact on both the financial and the operational results. They concluded that Benchmarking was extremely powerful in terms of organisational learning and knowledge management, which, today, is linked to knowledge transfer and Lean thinking. This goes towards Perez-Araos, Barber, Munive-Hernandez and Eldridge (2006) findings, when they argued that formal knowledge management approach to share ideas, experiences, improvement tools and best practices help organisation to increase their competitiveness. In the following section, Quality Function Deployment will be covered as a Lean thinking technique as well.

#### **2.2.3.2. QFD - Quality Function Deployment**

According to Delano, Parnell, Smith and Vance (2000, p.592) Quality Function Deployment (QFD) originated in 1972, at Mitsubishi's Kobe shipyard. The rationale for implementing QFD was i) the improvement of the cycle time for developing new products, and ii) meeting the customer requirement more closely (*as cited in* Hauser & Clausing, 1988). From the Lean thinking definition previously discussed, it is without doubt that QFD, at its core, also embraced Lean's DNA. It is widely accepted that Dr Yoji Akao (1990) is one of the main contributors to QFD. In the early 1980's, he started to understand the power of integrating different tools and techniques, and he synchronised the result from QFD with value engineering for substantial cost, quality and delivery improvements, notably at Futaba (Abdul-Rahman, Kwan & Woods, 1999, p.591). It is at approximately this time that QFD was introduced outside of Japan, mainly into US

manufacturing (Cauchick Miguel; 2005, p.773). Abdul-Rahman *et al.*, (1999, p.591) suggested that its popularity was generated through Akao's article "*Quality Function Deployment and CWQC in Japan*". Moreover, Deming's contribution should not be disregarded, as he pushed the use of QFD for assuring that quality was built into new products, as Deszca, Munro and Noori (1999, p.614) explained. In summary, QFD facilitates the planning and communication, and supports the co-ordination of skills, competencies and information needed from the design stage to production and sales (Hauser & Clausing, 1988). Andronikidis, Georgiou, Gotzamani and Kamvysi (2009, p.320) stated that QFD is a planning and development structure method, that provides decision-makers and engineers a model with which to collate information to assure that quality is built into the design element of the product, and that customer requirements are taken into account, ultimately to achieve or sustain a competitive advantage by satisfying customers and improving profitability, and, to a certain extent, improving local and new product innovation (Griffin, 1992; Ismail, Reid, Mooney, Poolton & Arokiam, 2007). This is also fitting with the rationale behind the RBV.

In order to allow capturing and meeting customer requirements through the design process, QFD uses several linked matrix diagrams to present and exchange information (Evans & Lindsay, 1996; Waterworth & Eldridge, 2010). These connections of matrices are often referred as the 'House of Quality'; as they form the shape of a house when put together (Waterworth & Eldridge, 2010). Kutucuoglu, Hamali, Irani and Sharp (2001, p.183) explained that, often, a QFD activity may require several iterations of House of Quality to get down to the appropriate level of detail, where, in sequence, the customer requirements will be translated into specific technical characteristics and so on.

As with most of the Lean thinking tools, techniques and concepts – despite their manufacturing grounded origins – QFD has been successfully implemented within other sectors. Deszca, Munro and Noori (1999, p.614) mentioned its application to the service sector, such as hotels and airline, for improving service and process design. It has also been implemented in the e-commerce sector (Waterworth & Eldridge, 2010), education (Koksal & Egitman, 1998; Lam & Zhao, 1998), e-banking (Gonzalez *et al.*, 2004), hospitality (Dube *et al.*, 1999), public sector (Gerst, 2004), retail (Sher, 2006), healthcare (Lim, Tang & Jackson, 1999) and information services (Chin *et al.*, 2001) (*as cited in* Andronikidis, Georgiou, Gotzamani & Kamvysi, 2009, p.321). Furthermore, QFD has

been applied to the construction sector (Abdul-Rahman *et al.*, 1999; Dijkstra, 2001; Rahman & Qureshi, 2008) and healthcare (George, 2003; Lim *et al.*, 1999; Lim & Tang, 2000).

A couple of years ago, Abdul-Rahman, Kwan and Woods (1999, p.591) published a paper describing the concepts and techniques of QFD, applied to a low-cost housing scheme, which was the first example within the construction industry. The application of QFD in the construction industry has, so far, been used mainly in Japan, although the west seems to slowly be moving more towards it, even if its application in other parts of the world still remains infrequent.

The primary difference between QFD and other conventional quality management tools is that quality is being built into a product, and not inspected out of it (Lochner & Matar, 1990) (*as cited in* Abdul-Rahman *et al.*, 1999, p.593). It is emphasised that the main feature of QFD is to collect the voice of the customer (VoC), in order to provide the starting point for the identification of the technical requirements during and throughout a new product or service development, in a systematic manner (Abdul-Rahman *et al.*, 1999, p.591; Sharifi, Ismail & Reid, 2006). QFD is powerful as it provides a framework to break down the objectives and to optimise the trade-offs throughout all stages of the development, from design to productions (Abdul-Rahman *et al.*, 1999, p.592). To work effectively, QFD needs to be developed by a cross-functional team, including research and development, design engineering and production, as well as finance and marketing. When QFD is well implemented, it provides an excellent interdepartmental means of communication that creates a common quality focus across all functions/operations in an organisation (Andronikidis *et al.*, 2009, p.320). Abdul-Rahman *et al.*, (1999, p.593) stated that feedback from the production team will also contribute to the design by developing an efficient and practical design concept. Communication and teamwork, within an organisation, must be greatly enhanced in order to make QFD work successfully (Dube *et al.*, 1999; Gerst, 2004; Griffin, 1992). By integrating the customer demands with the technical aspects, and aligning these with the resources and capability of the organisation, a firm can optimise its products and services as well as its own structure. Hence, QFD is not only a methodological tool, but a universal concept that provides a means of translating customer requirements during each stage of the service development (Chan & Wu, 2002). Typically, the QFD is developed from the upstream end, during the planning

and design phases. It requires firms to work back from the objectives to the means of achieving those objectives, as Abdul-Rahman *et al.*, (1999, p.592) explained.

Andronikidis *et al.*, (2009, p.321) reviewed the benefits of implementing QFD. They explained that it supports the cost reductions of new product development, reduces the rework and design changes, and reduces the risk of failure (Bouchereau & Rowlands, 2000; Gonzalez *et al.*, 2004; Griffin & Hauser, 1993). It was identified that QFD supports the process to speed up the design and lowers cycle times substantially (Griffin, 1992; Xie *et al.*, 2003), as well as bringing stability into the quality assurance planning and increasing the possibility for breakthrough innovation notably (Xie *et al.*, 2003) notably by enhancing cross-functional team communication (Chan & Wu, 2002; Griffin & Hauser, 1993). Ultimately, it improves the firm's overall operational performances by meeting, or exceeding, customer demand and requirements by increasing customer satisfaction (Bouchereau & Rowlands, 2000; Chan & Wu, 2002; Gonzalez *et al.*, 2004).

However, there are issues which have also been reported and summarised by Andronikidis *et al.*, (2009, p.322). They explained that, firstly, QFD can be a long, onerous and cumbersome process (Bouchereau & Rowlands, 2000; Chan & Wu, 2002). A large amount of data must be gathered from customers, competitors and decision-makers, and processed to fit the QFD format. Sometimes, the relationships are difficult to establish and can depend upon the decision-makers' perspectives and subjectivities. It is possible that bias is injected at some stage of the QFD, the correlation amongst the various characteristics can lead to confusion, and the targets can be set imprecisely (Bouchereau & Rowlands, 2000). Moreover, it is extremely important to note that QFD should be undertaken as an on-going process, but that a saturation of data and information needs to be achieved for optimum results and conclusion. More specifically, QFD assumes that there are linear relationships between the customer requirements and the product or service characteristics, which is a simplified version of the reality (Karsak *et al.*, 2002). In other words, QFD assumes that the customer requirements are deterministic, belonging to the known domain and do not change substantially over time (Xie *et al.*, 2003). It needs to be clarified that QFD is a Lean thinking model, which aggregates both qualitative and quantitative data, but remains an overall qualitative method (Bouchereau & Rowlands, 2000) (*as cited in* Andronikidis *et al.*, 2009, p.322). Therefore, some authors explained that QFD could be improved by using more quantitative techniques, such as the Analytical



Hierarchy Process (AHP), to compensate for some of the weaknesses. Integrating pairwise comparison would bring in a systematic process to overcome some of the disadvantages and reduce the subjectivity; for instance, to determine the intensity of the relationship between the requirements and the characteristics (Karsak *et al.*, 2002).

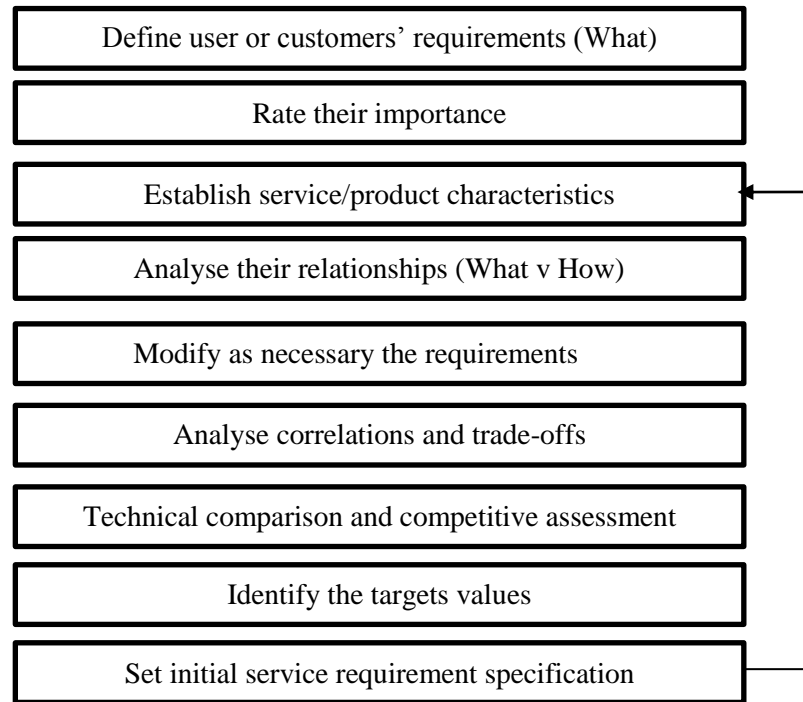
To sum up, Crowe and Cheng (1995, p.37) explained that “*QFD enables organisations to be proactive rather than reactive during design. Through the structured QFD process, the design team is forced to consider what the customer wants, then identify possible ways of achieving that end rather than concentrating on technical aspects of design. There are four phases in a QFD exercise: design, detail, process and production*”.

Rahman and Qureshi (2008) and Dale *et al.*, (2007) developed a nine stage framework, as shown in Figure 2.8, that illustrates the QFD process step by step in detail.

- *Define user or customer requirements (What)*: The starting point of the QFD is to pinpoint client, customer, user or patient needs. This can be achieved using questionnaires, focus groups, workshops, interviews, or consultation activities. The requirements are then sorted into different categories. To do this, affinity and tree diagrams can help to categorise the requirements.
- *Rate their importance*: In this second step, the decision-makers will aim to identify the weight associated with the requirements. This can be achieved by asking the users what the relative importance of each of the identified requirements is, through workshops, questionnaires and interviews. This will allow the focus to be on the features that the customers perceive as being a priority, ultimately to increase their satisfaction.
- *Establish service/product characteristics (How)*: The QFD team will then develop a set of technical characteristics to deliver user needs in measurable and operational technical features. Affinity and tree diagrams can also be applied to interpret the characteristics.
- *Analyse their relationships (What v How)*: In the main body of QFD, each relationship is being analysed, which can be time consuming. The team will need

to analyse the relationship between each requirement and each characteristic to assess the extent to which there is a correlation, according to a scale predefined. This needs to be agreed between all the decision-makers. As a standard convention: 1 = weak relationship, 3 = moderate relationship and 9 = strong relationship.

- *Modify as necessary the requirements:* The literature mentions that, at this stage, it is relevant to review the service or product characteristics and change them as appropriate, before moving on to the trade-offs analysis.
- *Analyse correlations and trade-offs (How v How):* For each characteristic, the decision-makers identify the correlation; they mark them as being positive, neutral or negative against all the other characteristics. This will allow consideration of the trade-offs, and, ultimately, balance the resources.
- *Technical comparison and competitive assessment:* At this stage, it is useful to self-assess, or benchmark, the demand criteria against the competition. Establishing a benchmark against best performances, and identifying any room for improvement, will enable the decision-makers to calibrate their product or service quality. It is strongly suggested that firms develop a robust process to undertake a steady Benchmarking activity, as extensively detailed previously.
- *Identify the targets values:* In the QFD framework, there is room for setting up measurable objectives. The rationale for identifying target values early on is that it enables the decision-makers to develop and agree on the new design objectives.
- *Set initial service requirement specification – absolute and relative scores:* Finally, to finish the first iteration of the QFD, it is important to quantify the requirements and retain focus on the attributes, which generate the most impact and return on investments.



*Figure 2.8: The QFD 9 stage process (adapted from Dale et al., 2007)*

As previously mentioned, the above is an iterative process to enable cross functional teams to drill down to the products and services design, using the voice of the customer. Therefore, the identified characteristics will be taken and will form the starting point of the new iteration. The following section will briefly present other key techniques that have been linked with Lean thinking and Operational Excellence and are associated with Six-Sigma, such as: Statistical Process Control, FMEA and DoE (Bamford & Greatbanks, 2005; Chakravorty & Hales, 2013).

### **2.2.3.3. Techniques Linked With Six-Sigma**

Many different definitions of Six-Sigma can be found in the literature. However, it is commonly agreed that Six-Sigma is an improvement technique, based on a systematic Operational Excellence framework, relying on data to generate process improvements (Antony, 2006; Chakravorty & Hales, 2013; Kumar *et al.*, 2008; Reid & Smyth-Renshaw, 2012). Definitions can be found in Kumar *et al.*, (2006), Harry and Schroeder (1999), Goh and Xie (2004), and Chakrabarty and Tan (2007). Arnheiter and Maleyeff (2005, p.6) explained that “*Six-Sigma is a broad, long-term, decision-making business strategy rather than a narrowly focused quality management programme*”. Six-Sigma was developed by Motorola, who won the Malcolm Baldrige Award for this accomplishment in 1988. Very

rapidly, Six-Sigma was exploited worldwide in other manufacturing organisations: General Electric, Honeywell and Bombardier (Antony, 2006; Kumar *et al.*, 2006). It quickly became a flourishing methodology to enhance processes quality and productivity, with associated financial return (Dale *et al.*, 2007). Six-Sigma is a statistically-based, quality improvement programme, to minimise process variation and improve the level of process efficiency and effectiveness (Hensley & Dobie, 2005). Eventually, by improving process capability and diminishing defects, the production costs are reduced and customer satisfaction improved (Van Iwaarden, Van der Wiele, Dale, Williams & Bertsch, 2008). This is achieved by merging statistical tools with the structured DMAIC (Define, Measure, Analyse, Improve and Control) approach, very similar to the PDSA (Plan, Do, Study, Act) of Deming (1986), to understand and remove the root-causes of defects, in order to generate financial benefits (Antony *et al.*, 2007; Reid & Smyth-Renshaw, 2012; Thomas, Barton, & Bayard, 2008), as explained in Dehe (2009). A wide range of statistical techniques and problem solving are associated with Six-Sigma and can be found in the literature. Some of the most common are: Benchmarking, QFD and SPC (Statistical Process Control), used to develop an in-depth understanding of the process behaviour and capability, as well as FMEA (Failure Mode Effect Analysis), BPR (Business Process Re-engineering) and DoE (Design of Experiment), as shown in Table 2.7 below (Breyfogle 2003; George, Rowlands, Price & Maxey, 2005; Reid & Smyth-Renshaw, 2012; Waterworth & Eldridge, 2011).

Six-Sigma T&T	Primary Objectives
Seven Quality Tools	Data collection and presentation
Flow and Process Mapping	Visualising a process in detail
Quality Function Deployment	Translating the voice of customer into technical requirements
SPC	Keeping the process under control and assessing its capability
FMEA	Ensuring potential risks and problems are considered
Quality Costing	Monitoring and understanding the cost of non-quality
Design of Experiments	Optimising design parameters to make process immune to variation
BPR	Developing new processes by breakthrough improvements
Benchmarking	Assessing performances and processes internally or externally
SERVQUAL	Measuring service quality based on the expectation 'gap theory'
Kano Model	Defining product and service attributes to delight customer

*Table 2.7: Main tools and techniques deployed by Six-Sigma (Dehe, 2009).*

Having defined and reviewed the definition of Lean thinking and some of the relevant different techniques, with a specific focus on Benchmarking and QFD, it can now be appreciated that the researcher takes a very pragmatic approach to improvement and Operations Excellence philosophies. For instance, Six-Sigma is considered as a robust foundation to Operational Excellence, falling under the wider umbrella of Lean thinking. Therefore, based on this premise and underlying principles, it will be argued that Lean is an environmentally dependent, rather than a dogmatic, improvement philosophy, which favours Chakravorty and Hales' (2013) ideas, when they stated that they have not found a study explaining how to systematically implement these systems in the real world. By going further into the reflection, it can be assumed that Lean thinking is still at the pre-paradigm stage of its evolution, as per Kuhn's (1962, 1970) definitions. However, there are non-rigid methodologies moving towards Operational Excellence, such as the Shingo model that can facilitate Lean thinking implementation within a specific context, as it will be discussed further.

#### **2.2.4. Lean Thinking is Environmentally Dependent**

According to the literature, there are evidences that successful Lean implementations have been dictated and influenced by the cultural aspect of the organisation (Bamford *et al.*, 2014; Van der Wiele, Van Iwaarden, Williams & Eldridge, 2011). There are several elements that impact a Lean implementation such as the work environment, the organisation design and structure, as well as its maturity level (Bamford *et al.*, 2014; Losonci, Demeter & Jenei, 2011). This brings elements of explanation as why it took such a long time for the western organisations to replicate the Japanese production models. Many American firms studied in great depth the Toyota Production System (TPS) without being able to replicate it and generate similar benefits; simply because copying it, was not the solution, it had to be adapted to their local environments and be bespoke to the organisations (Dale *et al.*, 2007; Lillrank, 1995). Alves, Milberg and Walsh (2012), Bamford (2011) and Koskela (2004) emphasised that Lean thinking needs to be tailored to fit a specific process and environment to generate improvements. It has been pointed out that Lean is not always suitable for every business, organisation, or even process, especially with low volume and high variety characteristics (Beard & Butler, 2000). However, Bamford *et al.*, (2014) strongly argued that, in its standard form, Lean thinking will not be always suitable, as it must be adapted to the environment. The lack of

adaptation and contingency is a major reason for implementation failure (Radnor & Walley, 2008; Sousa & Voss 2001; Van der Wiele *et al.*, 2011). For example, Radnor, Holweg and Waring (2012) reported that some healthcare organisations rushed into the attractiveness of Lean without adapting the philosophy to their setting, leading to failure and poor results. Eriksson (2010) also explained that some aspects of Lean production may not be equally applicable in construction. Therefore, Lean in construction has to be developed and modified to fit the project-based context (Hook & Stehn, 2008; Mao & Zhang, 2008). Moreover, according to Alves *et al.*, (2012, p.519): “*Koskela (2004) stressed the need for adaptation when Lean thinking principles are applied to construction. Management concepts and more specifically Lean principles are context specific and depend on culture, local market and business conditions, level of education, and incentive structures, among others (Lillrank, 1995)*”. This justifies the reasons why the researcher argued that there is not a prescriptive receipt to the design and deployment of Lean initiatives – it needs to fit the process, structure and organisation specificities. Nonetheless, Arnheiter and Maleyeff (2005) claimed that Lean thinking can be applied to any businesses and processes in which customers exist. In order to study further the contextualisation, in the following section, Lean thinking literature will be reviewed in service operations, healthcare, and finally, construction, which have all seen Lean implementation successes and failures. These are the sectors in which the greatest adaptation of Lean manufacturing had to be made to fit their context characteristics.

### **2.2.5. Lean Applied within Service Operations**

Even though Lean was developed on the Japanese manufacturing shop floor, it is now implemented worldwide, with several service operations taking a “*production-line approach*” (Bowen & Youngdahl, 1998, p.211). Common examples are: processing applications in the financial sector, directing incoming calls in call centres, optimising resources in operating theatres, designing recruitment processes and organising fast-food retailing (*e.g.*: Taco Bell and McDonald’s). Lean is introduced to minimise the non-added value activities and to focus on the next customer (*as cited in* Dehe, 2009). However, Piercy and Rich (2009, p.54) observed that there is evidence that Lean, in pure service environments, still remains limited compared to the level achieved in manufacturing. It is suggested that a number of practitioners are still reluctant to apply Lean thinking in pure services, arguing that Lean is more applicable to physical product than to customer flow.

On the other hand, Buzby, Gerstenfeld, Voss and Zeng (2002) explained that Lean principles are particularly relevant for some services, such as processing price quotation or loan applications, in order to enhance performance and satisfy the customer. Lean can even be implemented to surpass the competition by promising quicker service, and be the foundation of the competitive edge.

#### **2.2.6. Lean Applied within Healthcare**

According to Al-Balushi *et al.*, (2014), Baczewski (2005) and Proudlove, Moxham and Boaden (2008) the level of Lean in healthcare organisations remains low. Proudlove *et al.*, (2008) identified that too little attention has been focused on Lean thinking within healthcare, compared to other sectors. One of the reasons for this might be the complexity of the environment, the high volume and high variety of processes, making it challenging to implement Lean (Al-Balushi *et al.*, 2014). Moreover, practitioners still remain sceptical, despite the success stories and good practices demonstrating the benefits of Lean within healthcare in the US (*e.g.*: Virginia Masson Hospital) and in the UK (*e.g.*: Bolton Primary care Trust, and Salford Hope Hospital) as Savary and Crawford-Mason (2006), Jones and Mitchell (2006) and Fillingham (2007) reported, and highlighted by Papalexi, Bamford and Dehe (2013) and Timmons, Coffey and Vezyridis (2014). Lean in the healthcare sector has been focused primarily on improving patient safety and clinical efficiencies, as it can be proved to reduce waiting time and also smooth patient flows in the Accident and Emergency departments (Breyfogle & Salveker, 2004; Fillingham, 2007; Radnor, 2011; Radnor & Boaden, 2008; Timmons *et al.*, 2014). Even Womack and Miller (2005) advocated the application of Lean thinking in healthcare, suggesting that repositioning the patient at the centre of any process will allow organisations to focus on value-added activity, eliminate duplication and rework, hence improving throughput time.

Therefore, it is believed and suggested that Lean thinking in healthcare is at an early stage of its development (Al-Balushi *et al.*, 2014; Holden, 2011; Radnor & Boaden, 2008; Radnor, 2011). This means that its maturity level, measured in terms of scope and depth, is still low compared to other sectors. Papalexi *et al.*, (2013) have argued, along with Fillingham (2007) and Young and McClean (2009), that Lean initiatives in healthcare are approximately 20 years behind any world class manufacturing organisations. Nevertheless, when environmentally adapted, Lean has significantly enhanced performances and can be applied in any healthcare context (Bamford & Chatziaslan, 2009;

Bamford, Thornton & Bamford, 2009; Carlborg, Kindstrom & Kowalkowski, 2013; Fillingham, 2007; Radnor, 2011; Zhang *et al.*, 2012).

Having reviewed some of the Lean literature in the service and healthcare industries, it is relevant to highlight that the scope of the initiative often remains at the process level, rather than at the organisation level, which is an indication of the maturity (Bamford *et al.*, 2014; Papalexi *et al.*, 2013). Hence, it can be concluded that Lean in healthcare is appropriate, but needs to be adapted to the sector specificities and cultures (Lim & Tang, 2000). It is also relevant to note that, despite generating great improvement, most publications report only partial Lean implementation, as opposed to total, which confirms a low maturity level (Bamford *et al.*, 2014; Cheng, Bamford, Papalexi & Dehe, 2014; Dale & Smith, 1997; Burgess & Radnor, 2013). Therefore, the researcher strongly believes that there is a need for further empirical Lean thinking implementation in this sector, to consolidate the body of knowledge and support the increase of its maturity level (Burgess & Radnor, 2013; Radnor *et al.*, 2012; Young & McClean, 2009). This deployment must take place within both the clinical environment as well as within the support functions, such as in the commissioning groups, estates, infrastructure development, planning, finance, and human resources.

In the following section, Lean applied to the construction context will be detailed. Construction, like the healthcare sector, has been criticised for its lack of productivity and initiatives to implement Lean thinking.

## **2.2.7. Lean Applied in Construction**

### **2.2.7.1. Lean Construction**

For about 20 years, Lean has been implemented within the construction industry, which is bespoke by nature (Al-Aomar, 2012; Howell & Ballard, 1998; Jorgensen & Emmitt, 2008; Koskela, 1992; Macomber & Howell, 2003; Thomas *et al.*, 2002; Thomas *et al.*, 2003). Both the International Group for Lean Construction (IGLC), founded in 1993, and the Lean Construction Institute (LCI), founded in 1997, work to develop knowledge and adapt Lean thinking within the design, engineering and construction of capital facilities “*to better meet customer demands and dramatically improve the construction process as well as product, by tailoring and developing principles and methods adapted to the construction industry*” (IGLC, 2013). This has been importantly consolidated within the



UK, following the work achieved by Egan (1998) and his report '*Rethinking Construction*' as Jorgensen and Emmitt (2008) summarised.

Howell and Ballard (1998) and Thomas *et al.*, (2003) called for the application of Lean thinking within the construction industry, and to conceptualise it as a new way to manage construction projects. These ideas were initiated by Koskela (1992) and supported by other scholars. At first, many practitioners objected because of Lean's manufacturing background and origin, stating and arguing that construction is different from an assembly line and that it is not possible to make construction more like manufacturing through greater standardisation (Alves, Milberg & Walsh, 2012). However, this is a misconception of what Lean construction is. Alves *et al.*, (2012) explained that it is the opposite of making construction an assembly line, but that Lean thinking should be adapted to the specific context of construction (Ballard & Howell, 1998).

Alves *et al.*, (2012, p.513) and Jorgensen and Emmitt (2008) pointed out that the application of Lean in construction first appeared in 1992, with the work of Koskela. However, there are still many meanings, various understandings and a lack of agreement over what Lean construction is. Due to this lack of consensus, Jorgensen and Emmitt (2008) and Pettersen (2009) explained that there are substantial variations and confusions when it comes to detailed theories behind Lean construction, as well as its applications. This is demonstrated by the lack of consistency and uniformity in terms of implementation (Alves *et al.*, 2012; Ogunbiyi, Oladapo & Goulding, 2014). Eriksson (2010) clearly stated that Lean construction is still relatively immature. This is strengthened by Jorgensen and Emmitt (2009), who explained that there is not any coherent and robust framework or philosophy yet developed behind Lean construction terminology. This is in line with what Kuhn (1962) defined as a discipline being in its pre-paradigm stage. However, there are wide communities of scholars and practitioners who are working towards the development of a set of definitions (Al-Aomar, 2012; Ballard & Howell, 2003; Green & May, 2005; Jorgensen & Emmitt, 2008; Koskela & Ballard, 2006). For instance, Diekmann *et al.*, (2004) defined Lean construction as "*the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project*" (as cited in Alves *et al.*, 2012, p.515). It is relevant to note that this definition is extremely similar to any of the classical and traditional Lean thinking definitions, developed within the manufacturing

environment. In his comprehensive literature review, Eriksson (2010) identified six core components of Lean construction: i) waste reduction, which is linked with the JIT and pre-fabrications concepts; ii) process focus in production planning and control, with The Last Planner System as a key aspect; iii) end customer focus: the suppliers, contractors and designers must understand the final customer requirements, for instance, early involvement of contractors and integration of design and construction in concurrent engineering have been an important aspect in lean construction; iv) continuous improvements aiming to reduce waste and improve productivity over time; v) cooperative relationships: a partnership approach to the supply chain of the construction project; and vi) system perspective to avoid sub-optimisation. It is also explained that failure to successfully implement Lean, even in partial and isolated initiatives, within a construction environment, is due to a lack of comprehensive planning that addresses both the social and the technical parts of the organisation (Alves *et al.*, 2012, p.516). Having said that, it must be reiterated that the Lean construction maturity level remains low, or at a pre-paradigm stage of its evolution, where no real universal rules and focus are applied. Additional evidence is the various levels of understanding of Lean and its application across the world. Alves *et al.*, (2012, p.517) explained that “*additionally to the existence of the several Lean models across the industries and organisations, different countries have understood Lean construction from various perspectives*”. Emmitt *et al.*, (2005) explained that Lean construction was originally interpreted and applied in Denmark, with a very narrow and specific focus, to logistics processes and material flows, when some other countries, such as Japan, the US or Sweden, looked at it more from a supply chain performance angle (Eriksson, 2010), or through the concept of prefabrication, or from a design perspective, or even from the worker productivity side (Egan, 1998).

Therefore, the researcher strongly agrees with Alves *et al.*, (2012) and Eriksson, (2010) when it was explained that the plethora of Lean thinking meanings requires more theoretical and empirical research, in order to develop further understanding throughout applications to explain the concept further. This will support the Lean construction promotion understanding as well as its uniformity.

To summarise, Lean construction is still under development, or at pre-paradigm stage. However, there is evidence-based literature demonstrating the application of JIT practice and pull system, elimination of waste and continuous improvements (Fiedler, Galletly &

Bicheno, 1993; Ogunbiyi, Oladapo & Goulding, 2014). A couple of tools and techniques, more or less specific to construction, have been deployed, such as: Benchmarking analysis, simplification of the operations, 5S, QFD and SPC, as well as Last Planner System and BIM (Abdul-Rahman, Kwan, & Woods, 1999; Issa, 2013; Koskela, 1992; Thomas, Horman, Souza, & Zavrski, 2002). In the next section, Last Planner System (LPS), which has been embraced by many firms to implement Lean construction, will be briefly introduced.

#### **2.2.7.2. Last Planner System (LPS)**

Aziz and Hafez (2013, p.679) explained that the Last Planner System is a planning and control technique. It is an application allowing the materialisation of a pull system during the life cycle of a construction project. The LPS enables some Lean thinking concepts (*i.e.*: JIT, kanban, pull system) to be implemented around a concrete system to enhance construction management. Issa (2013) reminded us that LPS was suggested by Ballard, he exposed its principles in his thesis, but was designed by Ballard and Howell (1998). In their publications, they mentioned that the system is based on the Lean thinking theories, allowing the minimisation of waste by assignment-level planning and detailed look-ahead scheduling. LPS is an efficient schedule planning tool and framework that optimises sequence and rate of work flow. It also supports the reconciliation between the supply and demand by matching work flow and capacity. It is the tool that allows for the development of robust methods for existing activities, and is an effective communication mechanism between the different actors of the project. As Ballard (2000, p.3-14) defined in his thesis, the *“Last Planner System is a mechanism for transforming what should be done into what can be done, thus forming an inventory of ready work, from which Weekly Work Plans (WWP) can be formed. Including assignments on Weekly Work Plans is a commitment by the Last Planners (foremen, squad bosses) to what they actually will do”*. Therefore, LPS aims to improve the quality and the reliability of the planning, look-ahead scheduling and work flow control (Ballard, 2000). As Issa (2013, p.698) explained, the WWP controls the flow and helps ensure that work is done on time, within the budget and meets the specification, by proactively acquiring materials, designing information to be used and monitoring previous work or prerequisites. Therefore, the LPS process supports: i) shaping work flow sequence and rate; ii) matching work flow and capacity; iii) dissecting master schedule activities into work packages and operations; iv) developing detailed

methods for executing work, and; v) maintaining a backlog of ready work (Ballard, 2000; Issa, 2013). From an Operations Management perspective, these are all the major planning and control activities, which require the sort of decision-making that one must make in a production environment. The studies about LPS demonstrated that managing the construction processes with a formal and flexible production planning system reduces variation in the project and helps keep the production environment stable, as Issa (2013) demonstrated. However, even if LPS emulates many principles and tools based on the Lean thinking concepts, it is not the definition of what Lean construction is or should be, unlike many practitioners seem to have believed over the years (Alves *et al.*, 2012). But, it can be used as a first step toward Lean construction implementation by planning, based on demand rather than forecasts, supporting root-cause problem analysis and defining sound assignments (Alves *et al.*, 2012). Another tool often associated with Lean construction is BIM, or ‘building information modelling’.

#### **2.2.7.3. Building Information Modelling (BIM)**

BIM is a developing system within the construction industry (Arensman & Ozbek, 2012). It can be defined as a shared system, or repository, through which all the project data will be gathered, analysed and stored to support effective decision-making (Eastman *et al.*, 2011; Dossick & Neff, 2010). Palos, Kiviniemi and Kuusisto (2014) explained that the popularity of BIM has substantially increased within the past couple of years, especially in the support of the planning and design of complex projects. Kurul, Tah and Cheung (2012) stated that, in the UK, BIM will become compulsory for all public sector projects, above £3m, from 2016. However, “*in the US the General Service Administration has been requiring BIM for all of its major projects since 2007*” (Arensman & Ozbek, 2012, p.147). The rationale is that using BIM can potentially enable costs to be extracted and analysed in real time, as well as facilitating the provision of intelligent information about the project design, on-going performance, and operation planning and scheduling (Wong & Fan, 2013). Azhar, Hein and Sketo (2008) explained that BIM enables the different partners: architects, engineers and constructors, to visualise and simulate the final version of the building and to identify potential design, construction or operational problems. It is critical to appreciate that the key component of BIM is not the 3D images, but the management and integration of the information, which can be shared easily by the different stakeholders. However, if it is to be effective and efficient, it requires a

collaborative approach (Eastman *et al.*, 2011). Moreover, BIM is very effective in reducing the number of errors and rework – two of the major waste factors, as defined by Toyota (Palos *et al.*, 2014). This is the reason why BIM is often associated with Lean. Having said that, it is important to explain that, as with the LPS, firms that are using BIM, even at the planning stage of a project, are not necessarily implementing Lean, as Alves *et al.*, (2012) emphasised. BIM can only be used as a tool or technique to support Lean deployment, but needs to be integrated with other systems and embedded within a wider continuous improvement strategy.

When effectively used, meaning that it is updated throughout the life cycle of a project and that all relevant data needed in the design and construction are included in a shared system, then it is reported that BIM will i) facilitate exchange of information between the different partners and enable their contributions based on standardised data, and ii) considerably increase the efficiency and productivity of the project (Wong & Fan, 2013).

However, some studies have demonstrated that BIM is not always effectively used in practice, where it is still used in silo and does not enhance collaboration (Paavola, Kerosuo & Korpela, 2012). For instance, Paavola *et al.*, (2012) reported that, on several projects analysed, although the designers had used modelling for a long time in their own work, it was these first projects in which they used it for interdisciplinary collaboration. Kurul, Tah and Cheung (2012) explained that they are intending to develop a collaborative BIM, or cBIM, to support, still further, an integrated, collaborative approach to procurement, design and delivery. This cBIM will enable the measurement of process and product performance even further, and create some feedback loops between the construction, design and sub-contractors, in order to minimise waste and achieve cost and time reduction throughout the supply chain. Finally, in their study, Jensen and Johannesson (2013) explored and compared the implementation of BIM in two European, Nordic countries: Denmark and Iceland. They demonstrated the benefits of BIM and developed recommendations at national and organisational levels. They suggested that governments should promote the use of BIM mainly within the public sector, and that organisations should start embracing BIM now, by identifying pilot projects, finding super-users and seeking collaborations.

In this section, Lean thinking applied to the construction industry was presented and detailed. It is important to note that, from the body of knowledge reviewed, academics strongly agreed with the researcher's assumption that Lean is environmentally dependent and that it needs to be adapted to the construction context to be successful. To do so, two of the techniques, specifically designed to support Lean deployment in this context, were reviewed: i) Last Planner System, and; ii) Building Information Modelling. Having said that, Lean implementation, as a phenomenon, can be conceptualised, and it is believed that the process of implementing and deploying Lean, throughout a process or organisation, is subject to certain rules and non-prescriptive frameworks.

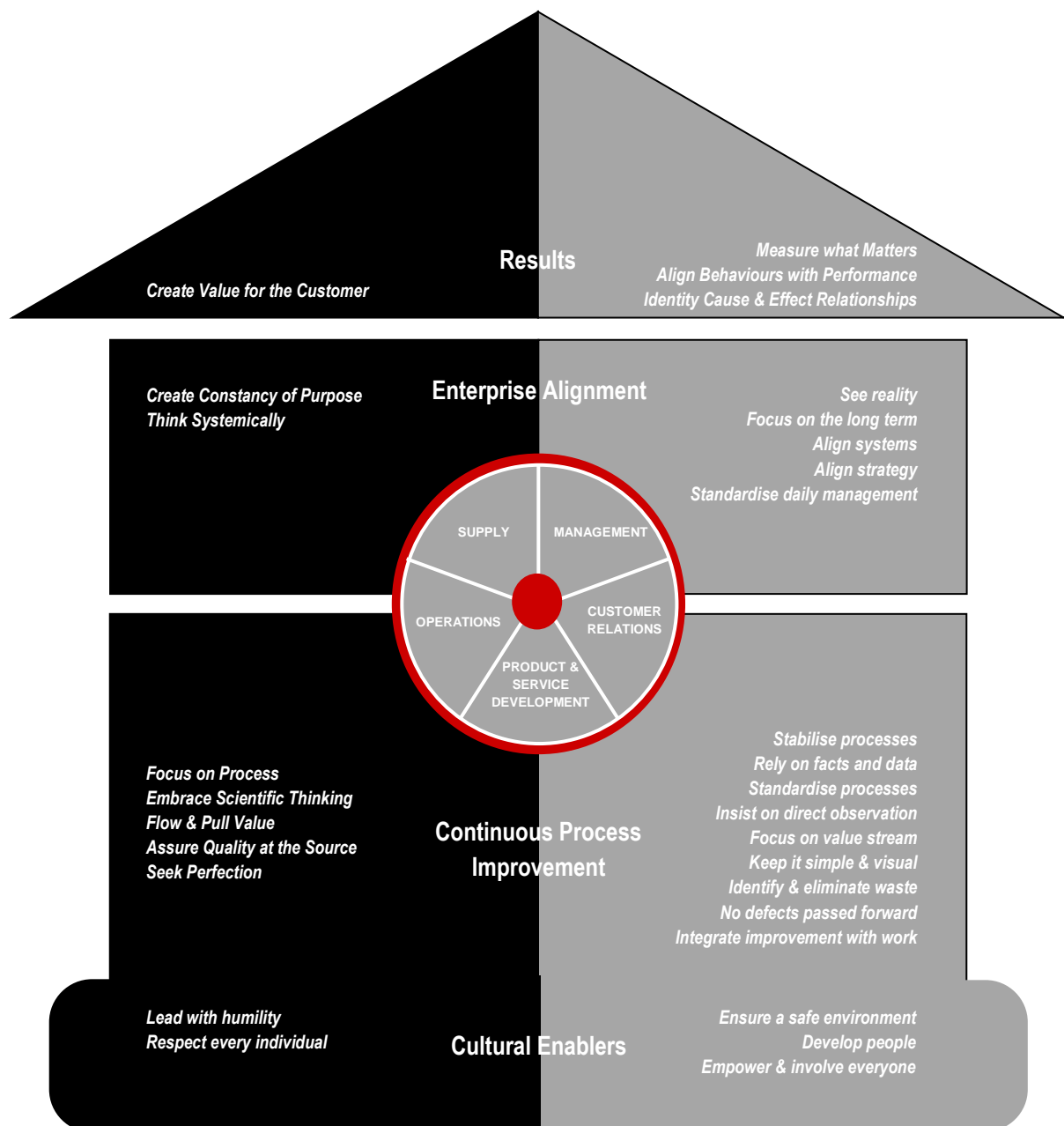
### **2.2.8. Total Lean Implementation**

Having thoroughly explained and justified that Lean thinking is environmentally dependent; Lean implementation mechanisms and principles will now be discussed and detailed further. The best way to understand the different components required to successfully embrace the road towards Operational Excellence and Lean thinking has been captured through years of empirical research, promoted by the three major Quality Award organisations: Malcolm Baldrige National Quality Award (MBNQA), European Foundation for Quality Management (EFQM) and The Shingo Prize for Operational Excellence. In this section, mainly based around the Shingo model, as illustrates Figure 2.9, Lean thinking implementation will be discussed.

In the Shingo model, four dimensions are covered: i) cultural enablers; ii) continuous process improvement; iii) enterprise alignment; and iv) results. This framework serves as a guide and provides examples of the required systems that drive behaviour, and approaches that support Lean thinking implementation. The cultural enablers' dimension is defined by two principles: lead with humility and respect individuals. These can be achieved through ensuring a safe working environment and developing the people skills and competencies, as well as empowering and involving everyone. The continuous process improvement dimension is defined by five principles: focus on process, embrace scientific thinking, focus on flow and pull value, assure quality at the source, and, seek perfection. The framework mentions nine supporting concepts: stabilise processes, rely on data and fact, standardise processes, insist on direct observation, focus on value stream, keep it simple and visual, identify and eliminate waste, no defects passed forward, and, integrate improvement with work. In dimension three, enterprise alignment, there are two

principles, which are to create consistency of purpose and to think systemically. These can be driven by five supporting concepts: see reality, focus on the long-term, align systems, align strategy, and, standardise daily management. Finally, in dimension four, there are four supporting concepts: results, focusing on creating value for the customer through measuring what matters, aligning behaviours with performance, and, identifying cause-and-effect relationships.

Miller (2012), the executive director of The Shingo Prize for Operational Excellence, explained that the framework recognises the application of universally accepted principles of Operational Excellence and Lean thinking, via the alignment of management systems and the wise application of improvement techniques across the entire firm.



*Figure 2.9: Shingo model - a Lean framework (adapted from Miller, 2012).*

The rationale for the researcher to select the Shingo framework, rather than another one, is found in its pragmatic nature and the fact that it is considered to be the most original, in the sense of it being the closest to TPS. Thus, Lean philosophy was driven by Ohno (1988) and Shingo (1986, 1988, 1989). Few individuals have contributed as much to the development of the ideas, labelled TQM, JIT and Six-Sigma, as Shigeo Shingo (Miller, 2012). Finally, this framework reminds us that: i) Operational Excellence, as well as Lean



thinking, requires a focus both on results and behaviours; ii) ideal behaviours are those that flow from the principles that govern the desired outcomes, and; iii) the tools of Lean: TQM, JIT and Six-Sigma, are enablers, and should be strategically and cautiously inserted into appropriate systems to better drive ideal behaviour and excellent results (Miller, 2012).

Interestingly, Bergmiller, McCright and Weisenborn (2011, p.59) explained that “*compared to typical or average manufacturers, Shingo Prize applicants, finalists, and winners are considerably Leaner*”. This statement also justifies the ideas of the degree of Leanness being associated with the maturity level of an organisation.

### **2.2.9. Lean Implementation Maturity**

In this chapter, the concept of maturity being related to the degree of Leanness has been mentioned (Dale & Smith, 1997; Green & May, 2005). It needs to be acknowledged that not every industry or organisation can achieve a total Lean implementation, recognised by the high level of Operational Excellence (OpEx) achieved. It takes time, resources and is an iterative process. The section discussing Lean in healthcare and construction demonstrated these ideas. To further understand the degrees of Leanness, the work of Bamford *et al.*, (2014) Green and May (2005) and Safayeni *et al.*, (1991) is relevant. They discussed the issues of implementation and classified company efforts towards JIT and Lean into four levels: i) education: when maturity is low and the project or intervention scope is low, JIT and Lean are probably only used to overcome a specific problem, or to demonstrate their benefits; ii) pilot project: when both the maturity level and the scope are higher, JIT and Lean can be materialised by several kaizen or Six-Sigma projects, or even by focusing on Lean implementation in a specific line or process of the organisation; iii) modified level is achieved when both maturity and scope are high throughout the organisation, and by going further than the natural firm's boundaries, and iv) total: when Lean thinking and Operational Excellence is the natural way of working, as Figure 2.10 shows.

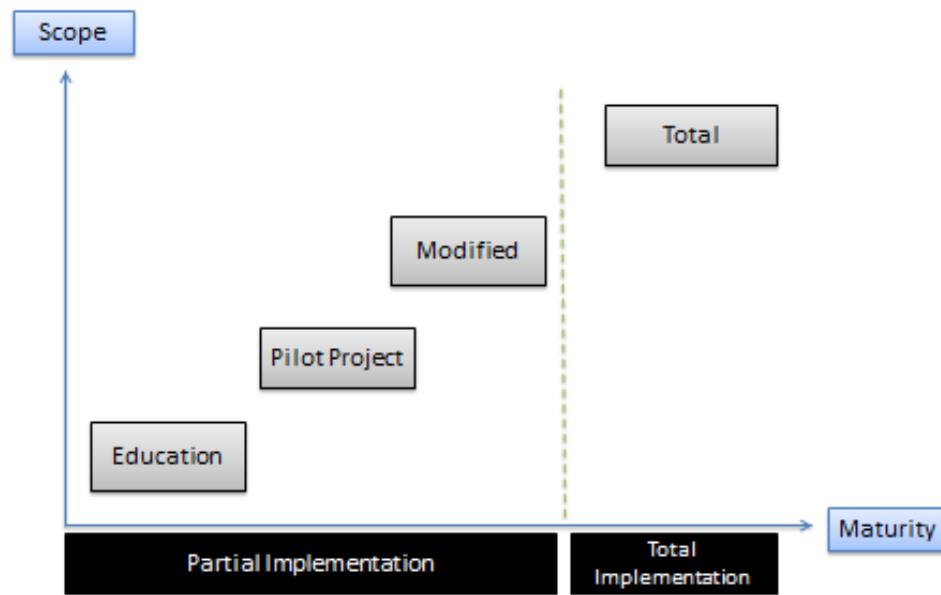


Figure 2.10: Partial Lean implementation model (adaped from Safayeni et al., 1991 and Bamford et al., 2014)

It is suggested that Lean implementation can be modelled as a continuum from minimal implementation (education stage) to maximum implementation (total stage), which indicates the degree of Leanness (Bamford *et al.*, 2014). It can be established that Shingo Prize winners achieved the full adoption, and are able to demonstrate high achievement in all four dimensions. Each level of the model is a discrete category, representing a general state with respect to implementation in an organisation. Therefore, Lean thinking can be implemented at a variety of levels, depending on the maturity of the organisation and the scope of the improvement. Moreover, it is acknowledged that, correlated to the stage at which the organisation is situated, are the difficulties within the implementation and the commitment to Operational Excellence from all employees. This helps us to understand the rationale for a partial implementation, which can be seen by an organisation as a *“reasonable choice since it provides an opportunity to explore the ideas of Lean without changing the overall organisational structure”* (Safayeni *et al.*, 1991, p.34). Furthermore, some academics, such as Harber *et al.*, (1990), explained that the position of a firm and its degree of Leanness is dependent on i) their willingness to embrace Lean thinking, and; ii) their ability to commit and invest in the continuous improvement programmes. The trade-

offs between the risks of failure and the resource and time investment must be balanced with the potential performances' gains in the short term, as well as in the longer term (Green & May, 2005; Yang *et al.*, 2011). Furthermore, there are also more pragmatic barriers to full and total implementation, which are reported by Fiedler *et al.*, (1993). They explained that, because implementing Lean is complex, it cannot be rolled-out at once, but needs to be done throughout several iterations, which would justify an organisation going through the educational stage, the pilot stage and the modified stage.

#### **2.2.10. Partial and Iterative Lean Implementation**

Therefore, as explained in the Bamford *et al.*, (2014) paper, Lean appears to be best implemented as a progression through an iterative process, rather than a once-and-for-all, total adoption (Srinidhi & Tayi, 2004). Despite the wide literature, Lean thinking follows three principal strategic objectives i) gain a strategic competitive advantage; ii) improve operational efficiency; and iii) provide a framework in which to implement change, which all justify the RBV theoretical concept and are in line with its partial and iterative behaviour.

#### **2.2.11. Conclusion: Lean and Decision-Making**

Having demonstrated that Lean is environmentally dependent and must be adapted to the specificity of the organisation or process, it is agreed that tools, techniques, models and frameworks are the foundations of Lean thinking implementation. Furthermore, an aspect associated with both Lean thinking and Operational Excellence is the robustness, rationality and transparency of the decision-making, which is detailed in the next section and forms the second main body of knowledge of this thesis.

## **2.3. Decision-Making Theories**

This third sub-chapter of the literature review presents aspects of a vast body of knowledge: the decision-making theories. It is wide for several reasons. Firstly, from a historical perspective, the roots of decision-making theories can be found within Greek philosophy. The way decisions are and should be taken by individuals, organisations and institutions, was largely described, discussed and theorised by Plato and Aristotle (Tsoukias, 2007). Secondly, because decision-making theories have been studied through many disciplines: Economics (Biswas, 1997; Starmer, 2000), Mathematics (Guha & Chakraborty, 2008), Psychology (Edwards, 1954; Hogg & Terry, 2000; Hogg, 2001; Lichtenstein & Slovic, 1971), Sociology and Behavioural Sciences (Cyert & March, 1963; Miller, Hickson & Wilson, 1996), and Artificial Intelligence (Asady & Zendehnam, 2007; Martel & Zaras, 1995; Pomerol, 2012), it makes it difficult to capture them in their entirety (Miller *et al.*, 1996; Nutt & Wilson, 2010). Therefore, in this section of the thesis, decision-making will be explained mainly from a rationality perspective. The rationality concept will be discussed and it will be assumed that decision-makers are only bounded rational individuals (Simon, 1947); however, that Soft Systems Methodology (SMM) (Basden & Wood-Harper, 2006) and other Operations Research models, can be used to tend towards an optimisation of the outcomes using different techniques, such as MCDA, and resolved using AHP and ER.

### **2.3.1. Origins and Definitions**

In his essay, Tsoukias (2007) provided a very comprehensive history of decision theory from an Operations Research perspective. It is explained that decision-making optimisation emerged just before the Second World War, notably through work led by both the American and British armies (Bowen, 2004; Kirby 2002). Furthermore, in the 1950's, several key contributions appeared due to the enhancement of computer capacity. It became possible to use mathematical and computer-based models to solve complex decision problems, such as: linear programming (Dantzig, 1948), Game theory (Von Neumann & Morgenstern, 1954) and other planning and scheduling algorithms. Academics and scientists quickly realised that these tools and techniques were going to be applied to the business world, in order to support rationalisation of the decision-making. This led to the emergence of new approaches, such as: Soft Systems Methodology (Checkland, 1981; Basden & Wood-Harper, 2006), Strategic Choice (Friend & Hickling,

1987), Cognitive Mapping (Eden, 1988), Robustness Analysis (Rosenhead, 1978), the introduction of fuzzy sets, and, more particularity of possibility theory (Zadeh, 1978) and multiple objectives programming, and multiple criteria decision analysis (MCDA) (Vanderpooten & Vincke, 1989; Ulungu & Teghem, 1994; Yang, 2001), all framing the boundaries of operations research decision theory.

### **2.3.2. Rationality and Logic**

Salaman (2008) and Nutt and Wilson (2010) explained that a central notion to understanding decision-making is the concept of rationality. Rationality is referred to as the quality of thinking behind the decision-making process and outcome. It is relevant to note that rationality has been associated with decision-making that follows various characteristics: thoroughness, logic and systematic. Weber (1964) was one of the first to work on firms' decision-making rationality. According to him, there are three types of rationality, separated into two groups: the formal and substantive rationalities, which are concepts that Simon (1976) later discussed extensively and which were summarised by Pidd (2003). Firstly, formal rationality is less concerned with reality than with appearance. Therefore, it is connected to the linguistics and the expression of the issues (Ren, Gao & Bian, 2013); it is not so much concerned with the efficiency of the processes. Weber (1964) clearly explained that a decision can be formally rational by being exposed and presented in logical language, and by being supported by calculation and statistics, but still be questionable and even seen as irrational by some individuals. Secondly, substantive rationality can be divided into two variants. The first is that it is associated with the 'appropriateness of means to the achievement of chosen ends'. This is often related to common sense. It is focused on the results, or on the relationships, between the methods that decision-makers select to achieve their given goals. However, this type of rationality is environmentally dependent and it is very sensitive to the fact that humans are not free from error, that knowledge is not complete and that truth is not absolute (Salaman, 2008). These issues will be discussed further throughout this sub-chapter. The second type of variant of the substantive rationality is that it "*does not refer to the suitability of means to ends but to the choice of ends themselves*" (Salaman, 2008, p.4). However, because the ends are culturally, spatially and temporally dependent, they may seem irrational to other individuals and decision-makers.

Having established some preliminary concepts of rationality, it is important to appreciate that there are procedures, frameworks and models that can help to structure both the decision-making and the shared cognitive, in order to support the decision-maker's quality of thinking, as well as the appropriateness of choice, as a means to achieve the desired outcomes (Salaman, 2008, p.5). Pidd (2003, p.26) and Rosenhead and Mingers (2001) explained that logical methods and approaches can be developed in this complex business world that is not entirely linear, in order to move towards a rational outcome of the decision-making, by understanding the advantages, disadvantages and consequences of the different alternatives.

### **2.3.3. Decision-Making and Rationality**

Decision-making is a process involving a sequence of tasks, starting with the recognition of a decision problem, and ending with a recommendation (Sharifi *et al.*, 2006). It is a process taking place in the mind of decision-makers to identify the right, or best, decision (Hollnagel, 2007). However, to reach the right, or best, solution, there are three assumptions involved, according to Hollnagel (2007), in line with Salaman (2008), and with what was discussed previously: i) decision-makers are completely informed; ii) decision-makers are entirely sensitive; and iii) decision-makers are rational individuals. Similarly, Simon (1955) explained and described his view on making a rational choice in his books and publications. He mentioned three central concepts involved in making a rational choice: i) the requirement of the identification and clear presentation of a set of alternatives and their courses of action to be given to the decision-makers; ii) the knowledge and the information, allowing the individual to predict the consequences of choosing any of the alternatives, being available and understood by all the decision-makers, or stakeholders, involved; and iii) the decision-makers being able to determine the criteria to justify their preferred options and alternatives (Pidd, 2003, p.27). As one can appreciate, satisfying these notions, or assumptions, is likely to be improbable. Moreover, it is explained that individuals like to think about themselves as rational and informed, but the reality is somewhat different (Pomerol, 2012; Simon, 1976). Hence, these concepts support the fact that decision-makers are mere limited, rational individuals. These barriers prevent decision-makers in being rational in the sense that the outcome of the process is universally logical, objective and measurable. By logical, it is assumed that the decision-making is clear and sound, without bias or being influenced by individuals' emotions

(Pomerol, 2012). Furthermore, by objective, it is supposed that decision-makers are well informed, but it is not probable, or even realistic, to consider that the individuals have a complete knowledge about the choices they have, and what their potential consequences are (Hollnagel, 2007; Pomerol, 2012). Finally, by measurable, it is implied that the value of the various outcomes can be consistently measured to assess the utility, in terms of welfare or of meaningful value (Biswas, 1997; Pidd, 2003). Therefore, in the following section, the issues, behaviours and causes that prevent an individual from being rational are explored further.

#### **2.3.4. Issues and Behaviours Preventing Rationality**

As previously explained, there are issues and behaviours conflicting with the traditional views and theories on rationality. Cohen (2013) and Nutt and Wilson (2010) pointed out the natural behaviours that prevent individuals and decision-makers from leaning towards a rational state. These can be categorised in three groups. Firstly is the non-deliberative decision. This type of decision includes the impulsive actions and decisions that one makes at a certain time. Moreover, there is a tendency for the decision-makers to stop when the results, or outcomes, are considered good enough or satisfactory, based on their worldview, values and cultural assumptions, and, finally, because there is a natural tendency to accept the first decent option (Pomerol, 2012). Secondly, missing information is an issue not to be disregarded. The lack of information, ignorance and information asymmetry, as well as subjectivity, are difficult to assess, can create bias and may skew the decision-making outcomes (Yang, 2001). And, finally, the mental errors that are generated by the decision-makers. For instance, it is not unusual for decision-makers to give disproportionate weight to the first information received, which is called anchoring. Furthermore, it is natural that decision-makers subconsciously favour an alternative which leads to the least amount of change, this is called status quo. And, finally, one needs to appreciate that there are faults in the human cognitive system, leading individuals, or groups of individuals, causing choices to be made in a way that would justify past or flawed choices, also referred to as sunk costs (Cohen; 2013; Pomerol, 2012; Salaman, 2008). All these issues create bias within the decision-making process, and prevent rationality. This is interconnected with the concept of bounded rationality the risks and uncertainty within the decision-making process and the fact that choices can be constrained, as well as the fact that, when a decision-making process needs to be

collective and based on consensus, it might be even more complicated to reach a rational choice.

#### **2.3.4.1. Bounded Rationality**

Simon (1947) stated that humans are intended to be rational but are only limited beings. He explained that individuals do not necessarily make the best or the right decisions, as Hollnagel (2007) suggested. In an early publication '*Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*', Simon (1947) challenged the neo-classical economists' assumptions about the Economic Man. The term 'Economic Man', or 'Homo Economicus', was developed in the 19<sup>th</sup> century, and referred to an individual that endeavoured to maximise their utility by acting rationally. It is assumed that the individual has complete knowledge about the choices and the courses of action (Ferber & Nelson, 1993; Hollis & Nell, 2006). According to the economic theories, the Homo Economicus behaves entirely out of personal concern and only aims at maximising their utility (Miller *et al.*, 1996). However, Simon (1947) established that the notion of the rational Economic Man did not represent a realistic version of human behaviour. As an alternative, he introduced the concept of the bounded rational decision-maker, or the 'Administrative Man', who is subject to cognitive and behavioural limitations, and, therefore, is rationally bounded in their decision-making, as Miller *et al.*, (1996) and Hviid-Andersen (2012) explained.

Moreover, Cousins *et al.*, (2008, p.31) pointed out that bounded rationality is due to the individual's neurophysiologic limits, as well as linguistic restrictions. It is suggested that, as individuals are boundedly rational, therefore to a problem, the best solutions cannot be found. However, a reasonable or satisfactory solution, moving towards the optimum, can be selected by balancing or seeking to satisfy conflicting objectives (Cousins *et al.*, 2008, p.69). It is important to identify the differences between best, associated with the optimal, and satisfactory, associated with the optimum, which is not the best solution as such, but considers the environment, the constraints and the partial, or the asymmetry, of the information, in order to select an acceptable and reasonable alternative. This is in line with what March and Simon (1958, p.141) explained, when they wrote that "*most human decision-making, whether individual or organisational, is concerned with the discovery and selection of satisfactory alternatives; only in exceptional cases is it concerned with the discovery and selection of best alternatives*". The term 'satisfactory', in this context,



means the tendency for individuals, or groups of individuals, to stop searching for better solutions when an acceptable alternative, or solution, has been reached, rather than to pursue optimal performance (Grant, 2010, p.281).

Therefore, the theory of bounded rationality acknowledges the limits preventing the decision-makers in achieving the rational state by considering the quality and availability of information to decision-makers, by recognising the notion that the time available is also a constraint, and by appreciating the individual's cognitive limitations with respect to formulating and solving complex problems, as Sorensen (2012) mentioned (*as cited in* Hviid-Andersen; 2012, p.18). This is also explained by the fact that decision-makers have limited information-processing capabilities, which constrain the set of choices that they are capable of considering (Grant, 2010; Hobbs, 1996). Instead of selecting a choice among all the possible alternatives, as assumed in neo-classical rational choice theory, the bounded, rational decision-maker is satisfied with a choice based on a simplified model of reality (Hviid-Andersen; 2012, p.18).

As Hviid-Andersen (2012, p.18) expressed, the Behavioural Theory provides a valuable standpoint on how individuals, or organisations, scrutinise the alternatives and then make a decision. However, the processes and techniques deployed by organisations, in order to tend towards rational decision-making, remain a relevant phenomenon to explore, but this is dependent on the context. In this section, so far, the ideas and literature regarding rationality have been explored and summarised by explaining the main underlying assumptions, as well as the concept of bounded rationality linked with Behavioural Theory, which was developed by Weber and Simon, as an alternative and a critic to the classical economic theories. Weber and Simon were both concerned with the usefulness and relevance of decision-making application in the real and business world (Pidd, 2003, p.45), stating that men are reasonable, rather than supremely rational individuals. Therefore, decision-makers' rationality is limited, especially in uncertain and complex environments (Hobbs, 1996).

#### **2.3.4.2. Complexity, Risks and Uncertainty**

It is relevant to explain that the world is dynamic and complex, not deterministic. A deterministic environment would allow decision-makers to predict what will happen if a specific action is taken, and to identify the different courses of action (Selten *et al.*, 2012).

Pidd (2003, p.38) explained that a mechanical system can be considered as deterministic, but that this assumption cannot be true in a business or management system, which, ultimately, enhances the complexity element associated with it. Therefore, as opposed to a deterministic system, there is the non-deterministic system, in which an aspect of probability, or statistics, must be taken into account, in order to assess and estimate how likely the occurrence of a particular event may be (Osman, 2010). This is the reason it is associated with uncertainty and risk. According to some scholars (Meredith & Mantel, 2006; Starmer, 2000), decision-making under risks or under uncertainty, can be differentiated. Decision-making under risk assumes that the probability of an event can be known. However, decision-making under uncertainty assumes that the probability is unknown, as Meredith and Mantel (2006) summarised. According to Pidd (2003) some academics argued that, unless the probability is known or objectively estimated, it should not be used. In that case, a pay-off table can be built to show, in terms of utility, the different combinations. Furthermore, there is the concept of subjective probability, which assumes that the probability relates, and is subjective, to the decision-maker's belief and knowledge about a particular event. This will lead the decision-makers to assign the probability based on a subjective, yet informed, notion (Pidd, 2003, p.40). This implies that the probability may change, based on the information and knowledge available. In that case, the assumption is that the principle of decision-making, under risk, includes decision-making under uncertainty, as Pidd (2003) suggested. Moreover, Pidd (2003) and Nutt and Wilson (2010) explained that, in many complex situations, there is considerable uncertainty and risk involved in the consequences of choices. This is due to the lack of available information, and may need to be forecast or modelled. Furthermore, it needs to be appreciated that the external environment, and the actions of other stakeholders, will influence and alter the consequence of an action or decision (Eldridge, Van Iwaarden, Van der Wiele & Williams, 2014). The complexity of many decision-related problems means that decision-makers are unable to compute the best course of action, even if all possible options are known. This is due to the limited capacity of the human brain, even with the use of computer-based analysis (Pidd, 2003, p.46).

#### **2.3.4.3. Constrained Choice**

Another important notion and assumption is the constrained choice. Pidd (2003) explained that the basic idea is that all options are assessed first against the constraints. Only from

within this set of acceptable alternatives, usually called the feasible set, can the optimum, or reasonable option, be obtained, through the use of the decision criteria. This is in line with a pragmatic perspective, suggesting that, if impossible, it can be, or belong to, the best, or right, solution.

#### **2.3.4.4. Collective Process and Consensus**

The last, but not least, critical concept to consider is that, within firms, often the decision-making process is collegial and collective; therefore, a consensus must be found. In the business world especially, very few decisions are simple, or have unique solutions. Modern firms and organisations are increasingly complex and the ramifications and consequences of an action, or event, are not predictable (Miller *et al.*, 1996; Wong, 2005, p.101). Moreover, it is extremely uncommon for the decision to rely on a single decision-maker. Rather, it is a collegial process, involving numerous stakeholders. Valentin (1994) explained that the interactions in a group can either dampen or increase the biases within the decision-making. He pointed out that, according to the groupthink literature and Whyte (1989), group decision-making is worse than the individual making the decision, when the level of political pressure is high and the process for making the decision tacit or informal. Therefore, one must appreciate to what extent this can be overcome in a defined process, aggregating, in an objective manner, the different worldviews and perspectives, in order to establish a group consensus and reduce bias. The final decision outcomes must be built on some sort of consensus, taking into account the multiple stakeholders' opinions, knowledge, values, preferences and assumptions. If the consensus is not reached, the organisation risks to see the decision dragging on forever, and, ultimately, not being made (Hogg & Terry, 2000; Wang, 2005). Furthermore, in the situation where the group of decision-makers have the power and ability to make the decision, it will need to be justified to an extended, or external, group of stakeholders; hence, the process must be traceable and rationalised (Wong, 2005).

It is, however, relevant to highlight some advantages of collegial decision-making. It can be argued that, by having more than two decision-makers working in partnership, more resources can be dedicated to solving the problem. Furthermore, it can be suggested that more information, and even more knowledge, will be utilised to develop a reasonable solution. Moreover, if a consensus is found amongst the decision-makers, it will, ultimately, enhance the legitimacy of the outcomes (Valentine, 1994; Wong, 2005).

However, on the other hand, as the decision-makers forming this group will attempt to reach a consensus, one can wonder about three points; i) whether the consensus is being built fairly, without political pressures and bias, taking into account all opinions equally; ii) whether the outcome will lack logic and robustness by trying to please everyone – the results becoming sub-optimised and even compromised – and; iii) whether, in the end, the consensus will be shared by all the decision-makers (Wong, 2005, p.101). Therefore, the collegial decision-making process can be complex and time consuming. If no robust processes are in place, the outcome can be biased and unequal (Valentin, 1994). This strengthens the need to develop and use of structured processes, tools and techniques to develop a consensus. It gives further credibility to the development of models, allowing transparent mechanisms to be communicated, in order to reach a collective, reasonable and satisfactory solution. These mechanisms are associated with voting procedures, scoring systems and ranking techniques (Pomerol, 2012). In the development of models, brainstorming, mind maps, relation diagrams, affinity diagrams, and rich pictures are often used in early stages, when the group of decision-makers needs to set the boundaries of the problem, generate ideas, identify potential alternatives, think about the different criteria to be considered, and analyse their relationships (Checkland, 1981). Some techniques are more sophisticated and complicated than others. However, they have the same purpose, which is to capture the perception, the information, the knowledge and the feelings of the decision-makers, and to transform them into a useful and meaningful model, in which data aggregation and a quantification process will enable the decision-makers to solve the problem either manually, or with the help of software (Wong, 2005).

### **2.3.5. Approaches and Techniques Used in Collective Decision-Making**

There are three different levels and degrees of formalisation used in collective decision-making process. The first approach, which is the most unstructured and informal, is not represented by any formal models. This is often associated with a simple problem, for which the alternatives are clear to all stakeholders, and where there are no conflicting criteria. Therefore, decision-makers may choose to resolve the problem using a simple voting procedure. It will be seen that this can be associated with the simple domain in the Cynefin complexity framework (*c.f.*: sub-chapter 2.4, Snowden & Boone, 2007). The second level is more structured; the decision-makers require the use of a formal and established model to represent the problem, and to evaluate the different identified options

and scenarios. The decision-makers may choose scoring systems, or ranking techniques, to generate the results, which will then help to inform the outcome (Pomerol, 2012). This can be associated with the decision-maker within the complicated domain, as per the Cynefin framework. Finally, the third level is when the decision-makers participate in the development, based on a consensus, of a bespoke model, which then becomes the foundation for solving the problem. Decision-makers may need to use several tools and techniques, as well as combine voting procedures, scoring systems and ranking techniques, to agree on the weighting and scoring of the different element of the model – for instance, building an MCDA (Multiple Decision Making Analysis) model to solve a site location problem (Pomerol, 2012). This approach offers a greater sense of consensus, not only at the results level, but also at the process level, which becomes much more powerful, in terms of legitimacy and transparency (Wong, 2005, p.102), and will be associated with the complex domain of the Cynefin Framework.

Therefore, in order to build and solve a model, a quantification process will need to take place. This will allow the decision-makers to transform and input their beliefs and judgements, as well as their knowledge and experience, into the model (Belton, 1986; Belton & Stewart, 2002). There are several common weighting and scoring techniques, in varying stages of complexity, to be implemented (Bottomley & Doyle, 2001; Bottomley, Doyle & Green, 2000; Fischer, 1995; Poyhonen & Hamalainen, 2001). First of all, generating a weight from the ranking order is fairly mechanistic and relatively easy to perform – where the most important criteria receives the highest score (Poyhonen & Hamalainen, 2001). Another simple technique is the point allocation – where the decision-makers are required to split the total number of points and allocate them to all the different criteria (Poyhonen & Hamalainen, 2001). Furthermore, the trade-off analysis is also relevant – where the weights can be generated from comparing two elements, in order to make them equally important, in the same way as the QFD's roof assessment (Poyhonen & Hamalainen, 2001). Similarly, pair-wise comparison, used in the AHP technique, allows the decision-makers to express their judgements and knowledge while comparing criteria in linguistic terms, such as: 'strongly more important', 'moderately more important', or 'equally important', which are then converted into ratios, based on the standard scale, as described below (Belton & Stewart, 2002; Saaty, 1980). Other quantification methods, such as the simple, multi-attribute rating technique (SMART),

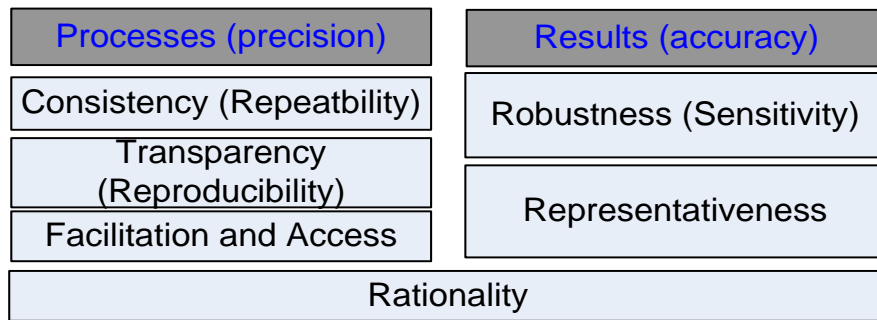
detailed in Poyhonen and Hamalainen (2001); the SWING (Poyhonen & Hamalainen, 2001); and the entropy technique (Eshlaghy *et al.*, 2011), have all been used, as Sureeyatanapas (2013) detailed.

### **2.3.6. Modelling Theory and Role of Models**

Models have been defined differently over the years. For instance, one of the first definitions, stated by Ackoff and Sasieni (1968), was that a model is a representation of the reality. However, Pidd (2003) explained that this simplistic definition did not address several aspects, such as the reason why a model is required, the notion of different worldviews and realities, and, finally, that a model can never be either entirely complete or accurate. Therefore, Pidd (2003, p.12) preferred defining a model *“as an external and explicit representation, part of the reality as seen by the people who wish to use that model to understand, change, manage and control that part of the reality”*. This means that models are an approximation of the reality, and that, according to the specific model used to look at the real world problem, the processes, or outcomes, might be different. As stated by Box and Draper (1987, p.424) *“Essentially, all models are wrong, but some are useful”*. Hence, it can be established that different models might have different characteristics, and one may want to identify the most appropriate model to use. Therefore, it can be argued that, looking at the same world problem through different models, both the process and the outcomes can be different, and, ultimately, one would be more appropriate than the other.

Thus, one may want to look at: i) the robustness and the representativeness of the model results, which are measures of accuracy, and ii) the repeatability and the reproducibility, associated with the consistency and transparency, which are measures of the precision of the model and process (Breyfogle, 2003). In order to evaluate the process, the consistency and transparency will be examined. For instance, will the models allow the decision-makers and participants to be consistent at a different time, based on consensus? And, to evaluate the robustness criteria, it must be asked: how representative of the perceived reality are the results? For instance, by looking at the differences between observed values, gathered from different measurement methods, and the results given by the model, it can be seen that the robustness aspect affects the results generated by the models. Therefore, the rationality and the representativeness of these results can be questioned. It also affects the process: the consistency, transparency and the facilitation, which must be

taken into account when implementing the models. Figure 2.11 illustrates an assessment framework to determine what model would lead towards the optimum solution.



*Figure 2.11: Models comparison framework*

Based on the notion of the bounded rationality and the role of a model, it becomes relevant and appropriate to explore the sub-research question four (*S-RQ4*): *What are the most suitable models to optimise the decision-making processes in this research environment?* The answer will be shaped around Multiple Criteria Decision Analysis (MCDA).

### **2.3.7. Multiple Criteria Decision Analysis (MCDA)**

Multiple Criteria Decision Analysis (MCDA) is a branch of Decision Science that provides a methodology and framework to cope with a multiple criteria situation. The MCDA model allows a coherent and visible decision-making process by structuring the problem, modelling the preferences, aggregating the alternative evaluations, and making recommendations (Belton & Stewart, 2002). Ram, Montibeller and Morton (2011, p.817) stated that, when strategic options are being evaluated, MCDA is the suitable approach when handling conflicting objectives, both qualitative and quantitative. MCDA provides a framework to aid complex decision-making by creating a platform upon which all stakeholders can share information, in order to develop a consensus or to find a compromise. The sequence of tasks becomes logical: firstly, by structuring the problem by defining the goal and generating the alternatives; secondly, by modelling the criteria preference and their importance, and, then, by aggregating the alternatives evaluation; finally allowing the decision to be made by discussing and analysing the ranking of the alternatives (Liao & Xu, 2013; Saaty, 1980).

Ren, Gao and Bian (2013, p.3) pointed out that, from a mathematical perspective, a MCDA model is defined by a set of alternatives, denoted by  $A = \{a_1, a_2, \dots, a_m\}$ , from

which a decision-maker will select the optimal alternative, according to the identified set of criteria, denoted by  $C = \{C_1, C_2, \dots, C_n\}$ . Also, an interval weight vector, denoted by  $\Omega = (\omega_1, \omega_1, \dots, \omega_n)$ , will be given, where  $\omega_j = [\omega_L j, \omega_R j]$  ( $j \in N = \{1, 2, \dots, n\}$ ) and  $0 \leq \omega_L j \leq \omega_R j \leq 1$ . This represents the relative importance of each criterion.

Tavana and Sodenkamp (2010, p.1459) explained that MCDA enables the stakeholders to create a framework to exchange their knowledge and explore their value and belief system, through the use of weighting and scoring mechanisms. Furthermore, Ormerod (2010, p.1768) suggested that different frameworks and mechanisms “*inform the stakeholders’ beliefs about the relationship between the options and the outcomes*”. Belton and Stuart (2002) explained the myths of MCDA, emphasising that there are no right answers, due to the subjectivity of the inputs. The subjectivity is inherent to the choice of criteria, the weighting and the assessment. Therefore, according to the framework selected, the subjectivity might be different, even when the common final aim leans towards a transparent, informed and sensitive decision.

Xu and Yang (2001) wrote that there are many methods available for solving MCDA problems. Amongst the most theoretical and empirically sound techniques, there are ER (Evidential Reasoning) and AHP (Analytical Hierarchy Process) (Saaty, 1980, Saaty & Vargas, 2001; Xu & Yang, 2001; Guo *et al.*, 2007). Other methods which can be found are: TOPSIS: technique for order preference by similarity to an ideal solution (Opricovic & Tzeng, 2004; Yoon 1987); VIKOR, which, translated from the Serbian means: multi criteria optimisation and compromise solution (Opricovic & Tzeng, 2007); PROMETHEE: preference ranking organisation method for enrichment evaluations; ELECTRE: elimination et choice translating reality (Huang & Chen 2005; Roy, 1996; Roy & Berlier 1972); and UTASTAR, which is an improvement on the UTA method (Jacquet-Lagrèze & Siskos, 1982), as Liao & Xu (2013) reported. The literature reports several applications of MCDA. Some applications are associated with a sector of activity; for instance, with manufacturing or with construction. Other applications are related to a specific type of decision. In the following sections, MCDA in healthcare will be reviewed and MDCA, to support site location, will also be discussed.



### **2.3.8. MCDA in Healthcare**

The literature shows a worldwide use of MCDA in the healthcare sector. Its use and application remain varied, to support both clinical and managerial stakeholders and decision-makers during complex problem solving. Academics and practitioners have solved MCDA models using other techniques rather than AHP. For instance: ER, UTASTAR and TOPSIS, have all been used (De Moraes *et al.*, 2010; Grigoroudis, Orfanoudaki & Zopounidis, 2012; Yang, 2001). Therefore, one may wonder if there is one technique more appropriate than another, in a specific context. To support the clinical decision-making process, Tony *et al.*, (2011) tested a MCDA framework for appraising healthcare interventions in the context of chronic non-cancer pain. Similarly, Miot *et al.*, (2012) developed a MCDA model to optimise decision-making in a cervical cancer screening process in South Africa. Moreover, Youngkong *et al.*, (2012) supported the prioritisation of HIV interventions in Thailand, using MCDA. On the other hand, the literature showed that MCDA models were also developed to support managerial and strategic decision-making. De Moraes *et al.*, (2010) developed a MCDA model to identify areas of improvement in terms of healthcare technology equipment utilisation and management. They observed that MCDA was a viable methodology to support adequate clinical engineering. Grigoroudis *et al.*, (2012) combined the balanced scorecard (BSC) approach with MCDA, in order to develop an optimum strategic performance measurement system. Buyukozkan, Çifçi and Guleryuz (2011) showed how a fuzzy AHP model supported the evaluation and the perception of the service quality in a Turkish hospital; they determined the factors and criteria that hospitals should focus on in order to optimise service quality.

### **2.3.9. MCDA in Site Selection**

Site selection is a critically strategic decision as it could potentially make or break a business, independently of the industry, because location decisions involve long term resource commitment and have significant impacts on the Operations Strategy and the key operations performance indicators, such as cost, flexibility, speed and dependability (Ertuğrul & Karakaşoğlu, 2008; Yang & Lee, 1997). The literature is very diverse regarding site selection, or facility location decision-making. Several papers have been published regarding landfill site selection, considering the economic, ecological and environmental issues associated with the decision. Often, the MCDA models were

associated with the use of Geographic Information System (Fatta, *et al.*, 1998; Gorsevski *et al.* 2012; Guiqin *et al.*, 2009; Onut & Soner, 2007). Other papers, less specific, presented MCDA models for other infrastructure locations. For instance, Chen (2006) explained the complexity in the conventional site selection and suggested AHP as a method to support the decision by making sense of the multitude of variables encompassed. They demonstrated the use of their five criteria, and 17 sub-criteria, model within a site selection in Taiwan. Ertuğrul and Karakaşoğlu (2008) chose to demonstrate MCDA application in optimising the facility location of a textile organisation in Turkey. Korpela, Lehmusvaara and Nisonen (2007) used AHP combined with DEA for selecting a warehouse operator network.

However, case studies investigating the healthcare site selection problem, using MCDA, are limited. The researcher identified that, in their paper, only Vahidnia *et al.*, (2009) developed an AHP model to find the best site for a new hospital. Their model has five criteria: distance from arterial routes, travel time, contamination, land cost and population density. Additionally, very few studies comparing results between different models were found. Only Ertuğrul and Karakaşoğlu (2008) compared the AHP method with TOPSIS, and Zhang, Wang, Sun and Wong, (2011) who compare their methods with two different authors Beynon and Hua methods, which lead them to observe contradictory results. This is noted, despite the common recognition of the compensation involved in any aggregation models and the subjectivity incurred in a framework. For example, Grigoroudis *et al.* (2012) explained that results are affected by both the model reference sets and by the decision-makers' consistency and interpretation of the model mechanisms. In their paper, however, Ertuğrul and Karakaşoğlu, (2008) contrasted two modelling techniques: AHP and TOPSIS, and concluded that, despite that both AHP and TOPSIS having their own characteristics, the ranking of the three alternatives was the same. They demonstrated that, when the decision-makers were consistent, both methods could be appropriate, even if they recognised that decision-makers should choose the methods fitting the problems and the situation. However, the study did not address the process differences and preferences of the decision-makers in great depth, and this is the reason why it will be attempted here in the S-RQ4 to compare two methods: AHP and ER, and evaluate the managerial consequences of choosing one or the other.

As previously explained, there are many methods available for solving MCDA problems. However, some methods were criticised for lacking theoretical soundness and empirical evidence (Xu & Yang, 2003). Nevertheless, ER and AHP are both theoretically and empirically grounded (Saaty, 1980, Saaty & Vargas, 2001; Xu & Yang, 2003), and are going to be explored in the following section.

#### **2.3.10. AHP and its Application**

AHP is a general theory of measurement. It is an effective approach to handling decision-making and certainly the most popular MCDA methodology (Belton, 1986; Bozbura, Beskese, & Kahraman, 2007; Kang & Lee, 2007; Partovi, 2007). It was developed by Saaty, in the 1980's, for resolving unstructured problems in any disciplines or business areas (Wu *et al.*, 2007). Saaty and Vargas (2001) explained that it was designed to cope with both the rational and the intuitive, to optimise the evaluation of the number of alternatives available. By undertaking pair-wise comparison, judgments and aggregating the scores, a ranking of alternative is developed. The advantage resides in the fact that it allows inconsistency to be assessed but simultaneously improves the consistency of the decision (Saaty & Vargas, 2001).

The logic behind AHP is in building a three level hierarchy model, with the goal, the criteria and the alternatives to be assessed. Each element in the hierarchy is supposed to be independent, and a relative scale measurement is derived from pair-wise comparisons (Karsak *et al.*, 2002). Similarly, Cousins *et al.*, (2008) explained that, in order to express the relative importance of one criterion over another, AHP uses the pair-wise comparison method. The thorough and robust pair-wise comparison has been used in scientific studies and voting systems. The scale can be selected to accommodate the needs of the decision-makers. However, the fundamental five level scale has been used to offer a wide range of possibilities, as Table 2.8 shows. This fundamental scale was defined by Saaty and Vargas (2001), and has been theoretically justified and its effectiveness validated. This scale is used with reciprocal values when the relationship between two activities is inverted.

Intensity of importance	Definition	Explanations
1	Equally preferred	Two activities contribute equally to the objective
3	Moderately preferred	Experience and judgment slightly or moderately favour one activity
5	Strongly preferred	Experience and judgment strongly favour one activity
7	Very strongly preferred	Experience and judgment very strongly favour one activity
9	Extremely preferred	The evidence favouring one activity over another is of the highest possible order of affirmation

*Table 2.8: Fundamental pair-wise comparison scale (adapted from Saaty & Vargas, 2001)*

Belton and Gear (1983), Chin, Xu, Yang and Lam (2008), and Taround and Yang (2013, p.1222) recognised the excellence of the AHP approach. However, they also explained that it has a number of limitations. Firstly, as AHP treats criteria weights and scores in the same way, applying pair-wise comparison, which, they believed, leads to ranking reversal problems, moreover, one needs to be concerned with the number of judgments required to derive relative priorities, which can create inconsistency issues (Mustafa & Al-Bahar, 1991; Sen & Yang, 1998). Furthermore, AHP lacks the capacity to cope with uncertainty. Finally, the introduction of new criteria, or alternatives, will require the modification of the whole model (Belton & Gear, 1983; Belton & Stewart, 2002). The limitations of AHP do not undermine its usefulness, but have stimulated researchers to develop alternative techniques, such as ER (Taround & Yang, 2013, p.1222).

### **2.3.11. ER and its Application**

The ER approach is amongst the latest of the MCDA techniques, developed to handle uncertainty and randomness (Guo *et al.*, 2007). According to Taroun and Yang (2013, p.1223), ER's capacity to handle incomplete assessments is one of its most powerful features based on the Dempster–Shaffer theory (DST). Xu (2011), Liu *et al.*, (2011) and Wang and Elhag (2008) stated that ER was first developed in 1994, by Yang and Sen (1994) and Yang and Singh (1994), to solve multiple criteria decision problems, taking into account both qualitative and quantitative attributes, as well as the inherent

uncertainty, by combining the Dempster–Shafer theory (DST) (Shafer, 1976) within a distributed modelling framework. DST provides an effective framework for representing the lack of information and analysing uncertainty. The DST allows probabilities to be assigned to any subsets of answers, in order to represent uncertainties or ignorance. Evidence theory acts similarly to probability theory, when the judgement is precise and certain (Sentz & Ferson, 2002; Shafer, 1987; Xu *et al.*, 2006) (*as cited in* Sureeyatanapas, 2013, p.59). According to Bloch (1996), DST is able to handle imprecision and uncertainty by the means of two functions: ‘belief’ (Bel) and ‘plausibility’ (Pla), which are both derived from the ‘mass function’ (m). The mass function represents the portion of belief committed of ‘A’, while ‘A’ is a subset of ‘ $\theta$ ’, and ‘m(A)’ represents how strongly ‘A’ is supported by the evidence (Sureeyatanapas, 2013; Yang & Xu, 2011).

$$\begin{aligned} 0 &\leq m(A) \leq 1 \\ \sum_{A \in \theta} m(A) &= 1 \\ m(\emptyset) &= 0 \end{aligned}$$

The belief function is a probability function, defined as a degree of belief that represents ‘the true answer’ (Wang & Elhag, 2008). It is calculated by the sum of all assigned probabilities, as Taroun and Yang (2013, p.1223) explained. The belief function is represented by:

$$Bel(A) = \sum_{Bi \subseteq A} m(Bi)$$

However, the plausibility function represents “*the extent to which a proposition cannot be rejected; it is the total amount of belief which could be potentially placed in the proposition or the extent to which one fails to disbelieve a proposition*”, as Taroun and Yang (2013, p.1223) explained. The plausibility function is represented by:

$$pla(A) = \sum_{A \cap Bi \neq \emptyset} m(Bi)$$

Taroun and Yang (2013, p.1224) explained that “*ER is based on the DST as a reasoning tool capable of aggregating different types of assessments, handling various forms of uncertainty and representing ignorance and incomplete assessment effectively*”. Thus, the difference with the other, more traditional, MCDA models is that ER uses an extended decision matrix, in which each attribute of an alternative is described by a distributed assessment, using a belief structure (Xu & Yang, 2001; Xu & Yang, 2003). It uses belief structures to assess alternatives against evaluation attributes in distributed forms. For instance, the distributed assessment results of the sub-criteria regeneration impact for alternative ‘A’ can be: {(Best, 33%), (Good, 33%), (Average, 33%), (Poor, 0%), (Worst, 0%)}; whereas, for ‘B’, it can be: {(Best, 0%), (Good, 50%), (Average, 50%), (Poor, 0%), (Worst, 0%)}. ER uses a Simple Additive Weighting, as a scoring method, to calculate the overall score of an alternative, as the weighted sum of the attribute scores or utilities (Xu & Yang, 2001; Xu & Yang, 2003; Xu, 2011; Yang, 2001). The assessment grades are required to be mutually exclusive and collectively exhaustive (Yang, 2001). The general formula for assessing the performance of the alternative ‘Ai’ against the criterion ‘Cj’ is:

$$S(C_j(A_i)) = H_{n, \beta_{n,i}(A_i)}, \quad n = 1, \dots, N$$

$$i = 1, \dots, m, j = 1, \dots, l$$

$$\beta_{n,i}(A_i) \geq 0, \sum_{kn=1}^N \beta_{n,i}(A_i) \leq 1$$

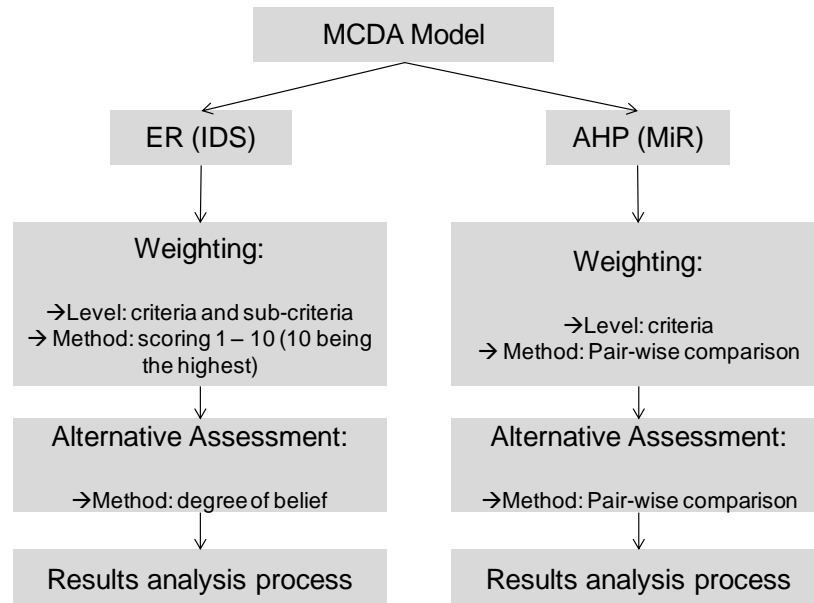
‘N’ represents the number of assessment grades; ‘m’ represents the number of alternatives; ‘l’ is the number of evaluation criteria, and; ‘ $\beta_n$ ’ is the degrees of belief. In the previous example, the sum of the degree of belief is 100%, which represents a complete assessment. However, incomplete assessment, due to a lack of information, can also be handled with ER (Taroun & Yang, 2013, p.1224).

This process can be facilitated by the Intelligent Decision Systems (IDS) software, developed and tested by Yang and his collaborators since 1998 (Wang & Elhag, 2008; Xu, 2011; Yang 2007). Xu and Yang (2001; 2003) also clearly explained that, by using a distributed assessment technique, decision-makers can capture the diverse types of uncertainties and model subjective judgement, hence, they clarified that the ER approach uses the Dempster-Shafer theory (DST) as an aggregation mechanism. Bi, Guan and Bell

(2008) and Guo *et al.*, (2007) explained that DST is an appropriate and suitable approach for dealing with uncertainty and imprecision. It provides a coherent framework to cope with a lack of evidence, and discards the insufficient reasoning principle. ER enables the translation of the relationship between the object and the degree of goodness, or badness, of its sub-criteria, which is measured by both “*the degree to which that sub-criteria is important to the object and the degree to which the sub-criteria belongs to the good (or bad) category*” (Xu & Yang, 2001, p.8). Furthermore, it allows decision-makers’ preferences to be aggregated in a structured and rigorous way, without accepting the linearity assumption (Chin, Wang, Yang & Poon, 2009). To some extent, this makes ER different from other MCDA approaches, such as AHP or TOPSIS (Ertuğrul & Karakaşoğlu, 2008; Seçme, Bayrakdaroglu & Kahraman, 2009; Zhang *et al.*, 2011). Furthermore, ER has been applied in different sectors and industries: construction, security, transport, and IT, with diverse applications, such as: supplier selection, performance measurement, assessment, risk management, new product development, and data aggregation (Chin, Xu, Yang & Lam, 2008; Liu *et al.*, 2011; Wang & Elhag, 2008; Wang, Yang & Xu, 2006). However, not many publications were found detailing this process as used in the healthcare sector; only Tang *et al.*, (2012) used ER in order to assess and analyse the risks in an NHS Trust.

### **2.3.12. General Practical Differences and Similarities**

Evidential Reasoning (ER) and Analytical Hierarchy Process (AHP) were the two approaches presented and selected, because it was considered that AHP was the most popular approach, and ER was an excellent complementary approach. However, the researcher recognises and acknowledges the other powerful techniques, such as VIKOR and TOPSIS. Both ER and AHP enabled the integration of both qualitative and quantitative information, in order to make decisions, and, therefore, they both fitted our environment. Their major practical differences reside in the assessment level and in the assessment technique. ER focuses on the sub-criteria level of the model, uses a degree of belief for the assessment, and the Likert scale for the weighting; whereas AHP focuses on the aggregate criteria and uses pair-wise comparison, as Figure 2.12 illustrates. These differences influence the subjectivity within the modelling process, and may lead to practical and managerial implications.



*Figure 2.12: Differences between ER and AHP*

Both ER and AHP use equivalent hierarchical structures; therefore, one can follow the same process, with the identified group of stakeholders, to satisfy the accountability objectives by engaging with the stakeholders. However, the differences will take place in the weighting and scoring phases, which also impact the robustness and transparency to a certain extent. The assessment of alternatives follows different types of mechanisms. Also, one can wonder whether, by using one or the other method, the interpretation of the results will be influenced, which supports the rationale for the sub-research question 4.

### 2.3.13. Conclusion

In this section, the decision-making process and modelling theory were detailed and explained around MCDA – a powerful modelling technique. It was defined that decision-making is the mental process individuals or a group use to evaluate the options available, and choose the one that best suits their needs. MCDA allows the conceptualisation and formalisation of this process, using statistics and probability to deal with the bounded rationality of decision-makers. Two specific techniques have been reviewed and compared: AHP and ER. Finally, it is relevant to note that MCDA has been associated with Lean thinking and Six-Sigma techniques (Breyfogle, 2003; Brook, 2010). The last section of the literature review chapter will address the built environment, contextualise further the research questions and justify the other theoretical concepts that have been mentioned so far – complexity theory and stakeholder theory.



## **2.4. Built Environment and New Infrastructure Development**

In this final section of the literature review, the built environment body of knowledge, even though considered to be lacking of its own theory (Fernandez-Solis, 2008; Koskela & Vrijhoef, 2001), will be studied with a specific focus on the new infrastructure development in the public and healthcare sector. Associated with the construction industry, the built environment represents between 7 and 10% of the Growth National Product (GNP) (Sutt, 2011), and accounts for an average 12% of the Growth Domestic Product (GDP) of developed countries (Santorella, 2011). Moreover, it is widely acknowledged that the built environment suffers from low productivity levels (Santorella, 2011; Pellicer *et al.*, 2014), especially when compared with its manufacturing counterpart (Egan, 1998; Fairclough, 2002; Latham, 1994). Cain (2004) explained that, for many years, in the manufacturing environment, managers have been focusing on performance improvement and quality, defined by fitness for purpose and driven by customer requirement (Juran, 1988), with great success, notably through the elimination of waste and the application of Lean thinking. However, this shift has not yet taken place entirely in the built environment, as demonstrated earlier, and the level of Lean construction remains low (Ibrahim, Price & Dainty, 2010; Kagioglou, Cooper & Aouad, 2001). One of the reasons mentioned is the degree of complexity involved in a new project, and the dynamism of the supply network and value chains, involving a diverse range of stakeholders (Codinhoto, Platten, Tzortzopoulos & Kagioglou, 2010; Myers, 2008). If there is a concrete call for change, it is also recognised that there are many obstacles that exist when attempting to apply Lean thinking to construction practices (Santorella, 2011). Therefore, in this section, the built environment industry will be described, and the process of new infrastructure development will be discussed to identify the major problems, waste, key decision-making and areas for improvement. The case of healthcare infrastructure will be of a special interest and positioned within the Cynefin conceptual framework (Snowden, 2002; Snowden & Boone, 2007).

### **2.4.1. The Built Environment Industry and its Characteristics**

#### **2.4.1.1. Definition and Structure**

The built environment is composed of different interconnected sectors, such as: architecture, engineering and construction – referred to as the ‘AEC’ sector (Hamzeh, Ballard & Tommelein, 2009). These firms all have different roles and responsibilities

within the infrastructure development process. Too and Too (2010, p.196) defined infrastructure “*as the stock of fixed capital structure in a country*”, including: houses, factories, roads, schools, hospitals, stadiums, airports, universities, and other commercial assets, that have an impact on the economic growth of a region, or of an organisation. It is important to mention that the modern definition of built environment industry is extended to the whole life-cycle of construction, from planning and design through to production, construction, use and management, and even encompasses demolition activities (Myers, 2008; Winch, 2006).

Based on this definition, it can be calculated that this industry is one of the biggest in terms of employment volume across the European Union. There are more than 2.5 million contractors, employing 15 million people, which represents about 10% of total employment (Myers, 2008, p.86). In the UK, about 2.85 million people work within this sector; 1.5 million workers in the traditional construction, around 350,000 engineers, architects, facility managers and surveyors, about 400,000 employed in the manufacture of building products and equipment, and approximately 600,000 workers selling construction materials. In France, it is about 2.36 million, and, in Canada, nearly 1.8 million (Myers, 2008); thus, a huge part of the worldwide working population. This industry also creates a substantial value, according to the Construction Statistics Annual. In the UK, in 2006, the value of the construction output reached £113,569 million (Myers, 2008).

#### **2.4.1.2. Fragmented and Weak Productivity Level**

One of the key characteristics, and probable consequences, of this huge sector is its lack of formal partnership practices, which make the built environment industry extremely fragmented (Vidalakis, Tookey & Sommerville; 2013, p.1194), naturally leading to the fundamental problem of poor and weak productivity levels, as pointed out in many academics’, practitioners’ and governmental publications (Cain, 2004; Egan, 1998; Latham, 1994; Myers, 2008; Pellicer *et al.*, 2014; Santorella, 2011). For instance, according to several reports (Egan, 1998; NAO, 2007), given the existing level of resources available to the industry, the productivity should be at least 10 points higher than its actual level (Myers, 2008). In the US, productivity has been declining for several years. Santorella (2011) reported that, over the past forty years, the productivity in the construction industry, as measured by contract value divided by labour hours, has diminished by an appalling 25%; whereas, in the same period, the productivity in

manufacturing has increased by 100%. This is due to three major factors: i) lack of global competition; ii) being very adverse to change by nature; and iii) its disjointed and strong silo culture (Kiviniemi, 2012). Myers (2008) provided other issues impacting on the productivity level: i) the poor safety record and inability to retain the best staff, creating high turnover; ii) lack of learning from previous projects and best practices; iii) lack of investment in R&D; and iv) lack of the use of technology and innovative methods, such as off-site assembly, pre-fabrication and Lean thinking principles.

Moreover, Cain (2004) and Forgues *et al.*, (2012) regretted that the construction industry is linear and fragmented, when it should be iterative and integrated. To a certain extent, this explains why Supply Chain Management practices and progress in construction have been lagging behind other industries, as the construction industry is also mainly supported by concepts, such as: collaborative procurement, long-term relationships and partnerships, as Akintoye, McIntosh and Fitzgerald (2000), and Cain (2004) suggested, without even mentioning that Supply Chain Management has largely been based on the concepts of Lean thinking (Vidalakis, Tookey & Sommerville, 2013, p.1194).

#### **2.4.1.3. Unique and Bespoke, but can Learn from Manufacturing**

It is important to clarify the uniqueness and bespoke aspects of the construction industry (Cain, 2004; Sutt, 2011). However, this does not mean that the built environment cannot learn, borrow and adapt manufacturing concepts. Despite the fact that Santorella (2011) explained that, in the first instance, manufacturing and construction worlds are entirely opposed, he went on to describe how construction managers view themselves as working in a different environment than that of manufacturing professionals. Fernandez-Solis (2008, p.31) pointed out the systemic and complex nature of the construction industry, which could provide some reasons as to why the industry's ruling models struggle to adopt a manufacturing mind-set. However, other scholars, such as Ballard and Howell (2003), Koskela, Howell, Ballard and Tommelein (2002), Vidalakis, Tookey and Sommerville (2013, p.1194) and Winch (2006) explained that the delivery of a construction project is a typical set of assembly operations, involving several sub-assembly units adding value throughout the supply chain, like in any production operation, with an input, a transformation and an output, in which manufacturing principles can be adapted.

The question that one should consider is, whether the construction characteristics are sufficiently different to warrant not embracing the route towards Operational Excellence, because of: i) its large, heavy and expensive physical nature; ii) the fact that the industry is dominated by a large number of relatively small firms; iii) the uncertainty of demand, which is driven by the state of the general economy; and iv) that most projects are one-offs and bespoke products (Myers, 2008). However, the researcher rejects this assumption, and, as demonstrated earlier, reiterates the fact that Lean can be applied to the construction industry by adaptation, despite these differences, even if these characteristics must be recognised and acknowledged. This is coherent with Alves, Milberg and Walsh (2012, p.513), when they clearly reminded all of the need for change within construction practices. They called for the adaptation of manufacturing principles, which has been supported by some academics and practitioners extensively throughout the past 20 years or so (Egan, 1998; Koskela & Howell, 2002; Latham, 1994; Laufer & Tucker, 1987). They called for a change in the fundamental way the industry operates and invariably focuses on the management of the entire construction process. Ibrahim, Price and Dainty (2010, p.201) also explained that borrowing concepts that have gained acceptance in other industries makes them easier to exploit, rather than inventing new solutions. The industry is clearly facing a change of business model, associated with Lean thinking, and early adopters in the industry are generating benefits by developing a competitive edge. However, this cannot be achieved without a change in the current mind-set (Alves *et al.*, 2012; Miller, Strombom, Iammarino & Black 2009).

#### **2.4.2. An RBV Lens for the Built Environment in line with Lean Thinking**

Too and Too (2010, p.197) claimed the appropriateness of the application of the Resource Based View (RBV) theory to infrastructure organisation, citing Ravichandran and Lertwongsatien (2005). They pointed out that the RBV theory, which focuses on the firm's resources and capabilities, provides a suitable theoretical lens through which to examine how internal factors of the organisation can be a source of competitive advantage. Too and Too (2010, p.199) explained that an organisation will not be able to sustain its competitive advantage, unless new stocks of resources and capabilities are developed. Therefore, internal resources, knowledge and capabilities, such as Lean thinking and Operational Excellence awareness, can provide basic, strategic directions for an

organisation (Grant, 1991). Moreover, Ma (2000) suggested that organisations evolving in the built environment industry must create value throughout their infrastructure development, to justify both their existence to the stakeholders, and that the competitive edge can support a firm in creating better value for the customers, hence contributing towards organisational performance (*as cited in* Too & Too, 2010, p.199). This is the reason why Too and Too (2010, p. 201) demonstrated that RBV was a relevant theory for improving the performance of infrastructure, in terms of quality, speed, dependability cost and flexibility, which are the five Key Performance Indicators monitored in Operational Excellence (Bamford & Forrester, 2010; Shingo, 1988; Slack *et al.*, 2006).

As discussed in the first section of the literature review chapter, the main argument of RBV is based on organisation heterogeneity: unique, difficult to imitate, and within firm specific resources that generate competitive advantages (Barney, 2001); which is in line with the capability of a firm to successfully deploy and implement Lean thinking in its specific environment. This implementation must be independent and adapted to the type of processes a firm is managing. Slack *et al.*, (2006) provided a framework to assess the type of operations, known as the 4V model: volume, variety, variation and visibility. If one can logically assume that the majority of manufacturing processes are high in volume (mass production), low in variety (product standardisation), low in variation (smooth demand) and low in visibility (the customer does not see the manufacturing process), and presume that construction processes are associated with low volume (one-off), high variability (since each project is different and bespoke), high variation in demand and high visibility (customers, workers and suppliers have clear visibility of the project, and construction managers have frequent contact with the stakeholders), as Santorella (2011) explained; and if, as demonstrated earlier, Lean is environmentally dependent; then Lean thinking needs to be adapted and deployed, in a construction process, to generate benefits and to develop, or even sustain, a firm's competitive advantage. This is argued despite the generic problems of the built environment industry, which are going to be developed further in the following section.

#### **2.4.3. Some Generic Problems within the Built Environment**

As reviewed, the built environment is different from other industries. Associated with these differences, there are endemic and generic problems within the planning, design and construction of new infrastructure. In this section, different issues will be analysed and

categorised, such as: supply and demand uncertainty, the lack partnership practices, lack of performance measurement, and the problems related to the decision-making processes, which, to a certain extent, lead to poor and ineffective new infrastructure development. Kagioglou, Cooper and Aouad (2001) pointed out that, within new infrastructure development, efficiency and effectiveness is correlated with higher productivity levels and lower costs (*as cited in* Vidalakis, Tookey & Sommerville, 2013, p.1194).

#### **2.4.3.1. Demand and Supply Uncertainty**

Firstly, the demand for infrastructure is not easy to forecast as it depends on many external and internal factors, which are difficult to control and monitor. For instance, Myers (2008) explained that demand depends on the price of buildings, price of commodities and other goods, current level of income of the firm, and the government policies, as well as customer views and expectations, which are all external factors. If one considers major public infrastructure projects, such as: hospital, roads, schools, tunnels or bridges, then demands are created by large numbers of individuals who, on their own, are neither able, nor willing, to finance and pay for these types of infrastructures (Myers, 2008). Therefore, the government must decide on the capacity and the level of services that should be available. However, the lack of public funds often means that the responsibility, risks and financing have to be transferred to the private sector. Moreover, internal factors must also be considered in order to understand the demand. For instance, the present and the future assessment needs, the availability of finance and level of government subsidy, as well as the age and condition of the existing stock of infrastructure, must be considered. Therefore, as Fildes and Kingsman (2011), and Vidalakis, Tookey and Sommerville (2013, p.1194) explained, the demand uncertainty is seen as one of the key features, and most important factors, affecting the effectiveness and efficiency of the overall operations, as well as adding significant complexity to any new development.

On the other side, there is also the supply uncertainty, which creates other problems affecting the productivity. It is important to understand that, in contrast to manufacturing, the price must be decided before the production starts, even though the producer does not know yet how much the production will cost. Furthermore, the determination of the price is established through some form of competitive tendering (Myers, 2008, p.71). The supply market is fragmented and huge; there are about 186,000 firms in the UK supplying construction product and services (Myers, 2008, p.74). Additionally, the output, which is

determined by thousands of firms, can be transferred between each other; the supply chain is much more complex than in a manufacturing environment, with contractors' and sub-contractors' networks adding supply uncertainty and complexity to the system; and it is not favourable to create strong partnership behaviours. All these factors impact the built environment and must be taken into account.

#### **2.4.3.2. Lack of Partnership**

In this Resource-to-Order industry, as opposed to Make-to-Stock, the client is at the core of the new development process, and is the trigger player for any constructions. However, especially in the public sector, clients are not well informed; they lack of demand understanding, they do not really know what they want and how it can be achieved (Myers, 2008). This lack of information, or ignorance, is strongly associated with the information asymmetry concept, explained previously in the decision theory section, which impacts the process performance (Egan, 1998; Latham, 1994; Myers, 2008). Furthermore, there are no formal means for the client (*e.g.*: an NHS organisation) to become aware of the current best practices in the industry (Kagioglou & Tzortzopoulos, 2010; Myers, 2008). The client must also capture the consumer needs, which modern firms and manufacturing often excel at. Egan (1998) described the construction as an industry that tends to forget about the consumer requirements and expectations, focusing mainly on the next employer in the contractual chain. In all, as expressed by Cain (2004), Sutt (2011) and Santorella (2011), it is widely accepted and recognised that the lack of collaboration and partnership is one of the root-cause problems, as developed by Egan (1998) and other national Audit Office reports, published in 2001 and 2007.

In order to deal with the uncertainty in demand and supply and the lack of collaboration, especially in the public sector, governments created partnership mechanisms. In the UK, the most significant scheme is the Private Finance Initiative (PFI), which is the first systematic programme aimed at encouraging public/private partnerships (PPP), developed in 1992 (Groome, 2010; Ibrahim, Price & Dainty, 2010; Myers, 2008), which will be described in more detail later on.

Overall, these problems have led to a lack of learning from previous projects and best practices, at organisation level, but also from the industry perspective (Kagioglou & Tzortzopoulos, 2010). These issues are associated with the causes of the lack of

technology utilisation and innovative methods, such as: off-site assembly, pre-fabrication LPS, BIM and Lean thinking. Two other problems, which are associated with the above, are lack of performance measurement and lack of effective decision-making processes.

#### **2.4.3.3. Lack of Overall Performance Measurement**

The lack of overall performance measurement and management is a substantial problem in this fragmented and disjointed industry, which remains organised in silo, preventing: i) taking an holistic value chain perspective, and ii) understanding the whole of the development processes (Lawlor-Wright & Kagioglou, 2010; Shohet & Lavy, 2010; Williams, 2000). Hinks and McNay (1999) demonstrated the need to establish Key Performance Indicators (KPIs) for facilities management. Shohet and Lavy (2010) explained that performance measurement and management must be based on quantitative indicators, to monitor and control the infrastructure. Potentially, these Key Performance Indicators (KPIs) could assist with any Benchmarking projects, and drive some continuous improvement activities.

Kagioglou, Cooper and Aouad (2001, p.88) pointed out that the construction industry's core business is either to produce new buildings, or refurbish existing ones, for a variety of clients. Therefore, performance measurement should monitor two aspects: i) the product as the facility, and ii) the process of creating the product. If the literature demonstrates good evidence of measuring the performance of the infrastructure, in terms of hard and soft facility, there is little evidence showing process performance measurement, and it is not considered as important to define the success or failure of a project, which demonstrates a lack of process focus. For instance, in their study, Hinks and McNay (1999) identified a set of appropriate KPIs, which could be used by the infrastructure development organisation to realistically evaluate their performance for their internal customers, and developed a comprehensive list of 23 KPIs, as shown in Table 2.9 below.



Number	Performance	
	dimension	Key indicator
1	<i>Business</i>	Value for money
2	<i>Benefit</i>	No loss of business due to failure of premises services
3		Suitability of premises and functional environment
4	<i>Equipment</i>	Equipment provided meets business needs
5		Correction of faults
6	<i>Space</i>	Effective utilisation of space
7	<i>Environment</i>	Satisfactory physical working conditions
8		Provision of safe environment
9		Energy performance
10	<i>Change management</i>	Effective communication
11		Quality of end product
12		Responsiveness of PD to changes/requirements
13		Achievement of completion deadlines
14		Completion of project to customer satisfaction
15	<i>Maintenance/ services</i>	Management of maintenance
16		Reliability
17		Effectiveness of helpdesk service
18		Standards of cleaning
19	<i>General</i>	Responsiveness to problems
20		Customer satisfaction
21		Management information
22		Professional approach of premises staff
23		Competence of staff

*Table 2.9: List of 23 KPIs (adapted from Hinks & McNay, 1999)*

However, this list is not well adapted to the new healthcare infrastructure development, and does not consider any process performances. Therefore, an adapted framework could be developed, even if the researcher recognised the work from the DoH, with the compilation of the AEDET toolkit to determine and manage design requirements for a new building (Lawlor-Wright & Kagioglou, 2010).

#### **2.4.3.4. Problems with the Decision-Making Process**

A final issue, which must be discussed in this section, is the lack of effectiveness in the decision-making process in the development of new infrastructure. Baker and Mahmood (2012, p.59) explained the need to improve and support the decision-making process, between the large range of actors and stakeholders involved in the built environment. In their paper, they emphasised the importance of using tools enabling communication and data exchange between the stakeholders, which are required to solve complex decisions regarding the planning, design and construction of a new infrastructure. However, it is acknowledged that this is one of the main issues in this sector, and Lean construction tools, as described in the previous section of this chapter, have already highlighted this point (Ballard, 2000; Ballard, 2002). Because the industry is wide and fragmented, there are few tools that support the integration of all the different data and information available to support decision-making, as Baker and Mahmood (2012) pointed out, even if everyone recognises the criticality aspect of effective and efficient decision-making impacting the performance of a project. Therefore, it is essential to develop an interactive planning support system that can model infrastructure scenarios, providing a sound tool for governance (Baker & Mahmood, 2012; Van der Wiele *et al.*, 2011).

In their paper, they stated that the traditional way of doing business is no longer appropriate (Appold & Baker, 2010), especially considering the complexity involved within the new public infrastructure, such as within hospitals and airports. A more integrated approach is required to provide synergies between infrastructure decision-makers, providers, contractors, clients, customers, users, operators and shareholders. However, it is recognised that, due to the diversity of the stakeholders, their interests, assumptions and values, it is challenging to collect their voices and collate them, in order to support decision-making, as soon as the strategic planning phase starts. One aspect that the built environment can improve on is its ability to determine client requirements, successfully transforming these requirements into plans and specifications to support the decision-making processes (Abdul-Rahman, Kwan & Woods; 1999, p.591).

Therefore, the question to address is: what are the tools and techniques that can be developed to communicate and share information more effectively, in order to increase the speed and quality of the decision-making processes? Baker and Mahmood (2012)

suggested the use and development of a planning support system (PSS) to aid in the coordination of infrastructure decision-making and support the sharing of visions between the stakeholders, as well as to create a more interactive method of engaging with local communities, throughout the planning processes. Vidalakis, Tookey and Sommerville (2013) suggested and explained that models should be used in order to address the decision-making issues. In the first instance, descriptive models can be developed, and then sensitivity analysis can be run to develop the models and move towards optimisation, which can be facilitated by a simulation model and other MCDA models.

Having reviewed some of the problems and their consequences, one element, which seems to be the recurrent cause, is the complexity. Therefore, in a following section, the complexity element will be discussed, from a theoretical perspective, around the Cynefin conceptual framework, developed by Snowden (2002). However, before that, it is important to contextualise the built environment still further, by reviewing the literature of new healthcare infrastructure development.

#### **2.4.4. New Infrastructure Development within Healthcare and the NHS**

Passman (2010) summarised that, since 1948 and the creation of the NHS, a large and diverse collection of healthcare infrastructures have been transferred into the public ownership, which have needed to be managed. In 1962, a national plan proposed the creation of the district general hospital (DGH), meaning that hospitals would serve a population of 100,000 to 150,000, and contain a standard capacity of about 800 beds. Typically, this large and inflexible healthcare infrastructure would provide A&E and general secondary care services to the local population (Passman, 2010). However, in the '70's, the global economic situation had changed the pretensions towards large-scale capital investment in the NHS, and, thereafter, most of the buildings that the NHS inherited were no longer fit for purpose (DoH, 2006). Moreover, although the condition of the estates was a real concern, it was not considered a key priority on the government agenda, and a large stock of buildings was left. Therefore, in the '80's, with the improvement of the economic climate, more capital investments were available, which led the Regional Health Authorities to develop and design major projects. However, it was established that, generally, the NHS had more buildings than it required (Passman, 2010). Hence, from the mid-90's, the rationalisation process started, with the trend of developing smaller hospitals closer to the communities (Bamford, 2009; DoH, 2006). As Francis

(2010) mentioned, since the launch of the NHS Plan in 2000, the strategy was to build 100 new hospital by 2010, 500 new one-stop primary care centres, and more than 3000 modern GP centres. Another factor, adding a further layer of complexity, was the changing way of the healthcare services' provision, with more of a holistic approach to health and well-being (Francis, 2010). Nowadays, the model aims at the integration between health and social care services, which will have a substantial impact on future infrastructure developments (Kagioglou & Tzortzopoulos, 2010).

Having briefly summarised the historical context, it is critical to appreciate the role of healthcare infrastructure before describing and detailing the project life cycle, the planning and design processes, the different schemes, and the problems.

#### **2.4.5. Role of New Healthcare Infrastructure**

Infrastructures are one of the key assets of a healthcare organisation. They are a strategic asset, allowing the NHS to provide and deliver health and social care effectively. Infrastructures are the interface, allowing patients to receive healthcare services; hence, they have a substantial impact on the organisation's service quality and productivity (Kagioglou & Tzortzopoulos, 2010; Liyanage & Egbu, 2004). However, in order to produce quality services within fit for purpose infrastructure, their development processes must be robust and efficient. The infrastructure development processes are subject to high variation, as well as high defect and rework rates (Barlow & Köberle-Gaiser, 2008).

The process of developing new healthcare infrastructure is pressurised by the fact that healthcare organisations have an increased accountability for the use of public resources (DoH, 2008). This has heightened demands for improved efficiency and value for money, both of which can only be achieved by improving the management of fit for purpose infrastructures. From an Operations Management perspective, the fitness for purpose state will be reached via effective and efficient planning processes, in which: i) the needs and requirements are captured; ii) robust delivery processes are in place, which ensure quality; and iii) the control processes enable correction of any deviations from the plans (Alexander, 1994; Meredith & Mantel, 2006).

At a time of fundamental change in the public sector, recognising the role of new infrastructure, and how it impacts the overall performance, is critical (Alexander, 1994;

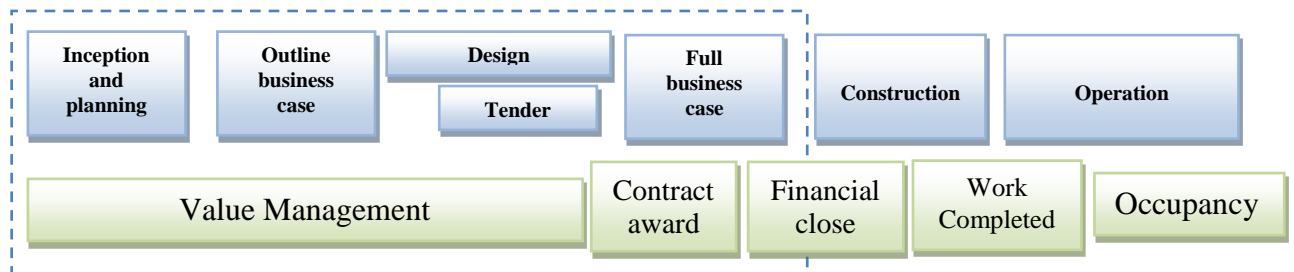
Kagioglou, Cooper & Aouad, 2001). It is accepted that organisations rely on their infrastructures as a major resource to gain or sustain their competitive advantage (Too & Too, 2010). This can be true from either a Resource Based View or a Total Cost Economic approach. While, in the healthcare sector, it is suggested that the aim is not based exclusively on gaining a competitive advantage, one could accept that these principles apply nonetheless, because the healthcare organisation needs to optimise its infrastructure to make sure that the services provided are meeting patient and customer expectations. This is reinforced by the right of patients and users to choose which hospital to be treated in, resulting in a more dynamic and competitive market, making it very similar to the private sector (Barlow, Bayer, Curry, Handy & McMahon, 2010). Therefore, pressure for rationalisation and optimisation, from a strategic perspective, become inevitable. The organisation needs to reduce costs and improve the flexibility of its infrastructure, and create innovative approaches for managing its facilities (Alexander, 1994).

If this shift happened in the mid-90s in the private sector, it has only more recently occurred in the public sector and the NHS (Darzi Report, 2008). Some of the factors were driven by the government and national reports, following a top-down perspective; others have come from a bottom-up approach, driven by the local populations and the patients that are advocating fit for purpose infrastructure.

From an organisation perspective, it is recognised that the infrastructure has the potential for increasing quality, and is a powerful vehicle for its identity (Codinhoto *et al.*, 2009; Liyanage & Egbu, 2004,). Many healthcare organisations are in the process of reviewing the way in which their infrastructures are developed and managed, in order to identify opportunities for improvement and measure the potential impact (Kagioglou & Tzortzopoulos, 2010). Codinhoto *et al.*, (2009, p.145) explained that the role of healthcare infrastructures is to provide stable environment conditions that would avoid disturbance to the healing process of the patients. They demonstrated the importance of effective and efficient planning and design processes for new healthcare infrastructures and the role they have in the future management, as well as within the health outcomes.

#### 2.4.5.1. Project Life Cycle and Value Management

Figure 2.13 presents a typical project life-cycle and it is argued that, in theory, the earlier the value management study is undertaken, the more opportunities arise and the more benefits are generated (Myers, 2008). It is important to involve most of the stakeholders earlier in the planning process, as this will help in building the consensus on the key decision-making areas, such as the location of the new infrastructure, the size, capacity and the service portfolio. Moreover, it is relevant for all the stakeholders to buy into the vision of the project, and discuss how efficiency and value for money can be increased. When the value management is undertaken early, there is an opportunity to discuss and evaluate the different options: refurbishing or building, 3PD or LIFT, as well as to examine the outline business case, seek better solutions, accommodate design changes and eliminate unnecessary cost by identifying synergies, as was explained by Myers (2008, p.95). Unfortunately, the NHS lacks formal and robust mechanisms to sustain this process and focus on adding value activities. Another element regarding the cycle time is that it seems to be related to the size and the complexity of the projects, which seems, at first, to be logical (Cain, 2004; Myers, 2008).



*Figure 2.13: Project life cycle (adapted from Myers, 2008, p.95)*

In this piece of research, the focus remains at the planning and design stages, as shown in Figure 2.13. They will be investigated and detailed further in the following section.

#### 2.4.5.2. Planning and Design Processes in the NHS

As previously highlighted, healthcare organisations are responsible for planning, designing, building and managing their healthcare infrastructures, such as: hospitals, polyclinics, healthcare centres and GP practices, in which the services are delivered to their local populations (Francis, 2010). Generally, after a restructuration process of a geographic area, a healthcare organisation would inherit, from several other different NHS

organisations, a large array of legacy assets and infrastructure, some obsolete and others not fit for purpose, requiring informed decisions as to their future disposition (CIAMS, 2010; DoH, 2000). These situations have led healthcare organisations to redevelop their future network of infrastructure by planning new development schemes (DoH, 2000).

Groome (2010) described a generic planning and design process. He explained that, often the local organisation and the strategic health authorities, in line with the local authorities, will need to recognise the requirement for a new infrastructure. This can take the form of replacing or renovating a current real estate, or building a brand new infrastructure; the justification and rationale will be detailed in a strategic service delivery plan (SSDP). This document must be demand-driven and fit in with the overall strategy of the organisation; hence, public health is involved to support the case and justify, from a demand perspective, the need for a project. Inevitably, decisions will have to be made around the project prioritisation, identifying which project will go through the procurement pipeline first (Groome, 2010). This can be settled by the organisation once the health impact assessment or need analysis is completed, allowing the service model and the regeneration outcomes to be clearly identified. However, to be able to develop these outputs, an organisation will need to engage with the local communities during the public consultation period – a critical activity of the planning process. At the end of this stage, both the site location and the service portfolio should be defined, informing the size and the complexity of the future infrastructure. Only after that can the project be set up, defining the roles and responsibilities, the risks, the cost and the supply chain, which should link the planning phase to the design phase.

The design of the building is the opportunity to think innovatively about the service provision and delivery, as well as to provide efficient and safe environments meeting the needs of the users (Francis, 2010, p.45). Moreover, it is through an efficient layout that the service quality can be sustained. During the design phase, the tenant's requirement document, including the design philosophy, should be drafted. The design of the services and operations should also be taken into consideration at this stage, but these are often neglected (Kagioglou & Tzortzopoulos, 2010). At this stage, there are formal milestones sanctioned by the NHS and local authority boards. These outline and full business cases are submitted in order to demonstrate value for money, affordability and the cost plan associated with the life cycle of the project, as shown Figure 2.13 above.

Once these stages are complete, the legal documents will proceed to codify the agreements and lead to the financial close, which will then trigger the construction work to begin. Obviously, these stages can differ according the schemes selected, but this paragraph has highlighted the key aspects and issues of the planning and design phases. However, Groome (2010, p.71) explained that the general consensus regarding these phases is that they take too long and are too adversarial, too restrictive and too risky for the public sector, leading to the problems and inefficiencies discussed earlier. Hence, one of the options was to develop privatisation of the financial processes, such as: PFI, Procure 21 and LIFT. It is argued that taking a process perspective to planning and design throughout a partial Lean implementation is an alternative, which also strengthens the rationale for the *S-RQ3: What Lean tools and techniques should be implemented to improve the planning and design phases?*

#### **2.4.5.3. The Procurement Schemes: LIFT**

As the infrastructure development is complex by nature, and as it follows a long process which has to be managed by healthcare organisations, through the Department of Health (DoH), the government released guidance and procurement models to support the healthcare organisations in their development activities. Procurement models have been developed with the collaboration of the private sector. Improving the new healthcare infrastructure development has been on the radar of the government for about 15-20 years. Their answers to the above issues were the development of PPP (Private Public Partnership) and PFI (Private Finance Initiative) schemes, to support meeting the local needs through building public infrastructures in partnership with the private sector, and, therefore, transferring the risks (Groome, 2010). For instance, the LIFT buildings are an efficient alternative to the third party development (3PD), and illustrate the Private Finance Initiative (PFI) and Public Private Partnership (PPP) models. These procurement models have recently been the preferred solution to develop complex healthcare centres, polyclinics and other GP practice facilities in several areas (Smith, Bower & Aritua, 2010). PPP is not a new concept to transfer and manage the risk in the construction industry (*e.g.*: Suez Canal, and Trans-Siberian-Railway), and has been practiced in the NHS since the mid-90's. It is also attractive to the private sector organisations, as it creates business opportunities with a potential substantial return on investment (Myers, 2008; Smith, Bower & Aritua, 2010). However, it needs to be recognised that the LIFT



procurement model is more costly, and the trade-off between quality and cost must be carefully appreciated from the healthcare organisation's point of view. With the current PFI procurement model, the private sector would design, build, finance and operate the new facilities. These infrastructures would be owned by the private sector and leased back to the NHS on a long term basis, for 25 or 30 years. At the end of the contract period, two different options are available: extending the lease, or taking it back under public ownership (Ibrahim, Price & Dainty, 2010; Passman, 2010). This model is expensive and leads one to question whether it results in the optimum value for money.

Although, this system has been successful to some extent, it faces criticisms. It has been argued, by Barlow and Koberle-Gaiser (2008), that the decision-making processes have slipped away from the NHS decision-makers, development costs have substantially increased, and the designs are still not free from defects. Hence, might this not be the optimum solution? Furthermore, within the current economic and social climate, healthcare organisations' decisions are carefully scrutinised by the public and local populations, with organisations becoming increasingly accountable to local communities and needing to have processes in place to demonstrate the rationale behind such important capital investment (DoH, 2010). However, even by operating within these procurement models for developing new healthcare infrastructures, the decision-making processes are still opaque, lengthy and complex. It can take up to 10 to 15 years to develop new infrastructure and, even then, it still does not always meet local requirements entirely (Kagioglou & Tzortzopoulos, 2010).

#### **2.4.5.4. Challenges within Healthcare Infrastructure Development**

As previously discussed, infrastructure development is not an easy process and its complexity often creates uncertainty and variation, which prevents the planning and design process from being effective and efficient (Pellicer *et al.*, 2014). Kagioglou and Tzortzopoulos (2010) pointed out that research has demonstrated that the current design of healthcare in the built environment does not effectively meet the users' or consumers' needs or desires. These infrastructures do not have the ability to provide and deliver efficient healthcare services.

In their report, commissioned by The Nuffield Trust, Francis and Glanville (2002) explained that organisations need to engage further in a stimulating and creative dialogue with the different group of stakeholders; for instance, between the design decision-makers and the external design experts, in order to foster and develop quality buildings. In the report, it is suggested that the planning and design processes must be seen as catalyst processes for change, encouraging innovative approaches. Moreover, it emphasised that a framework for the iterative exchange of information between the different stakeholders needs to be put in place to explore and trigger innovation. However, according to Francis and Glanville (2002), the reality is that the vast majority of the design provision is disengaged from the needs of the healthcare system. They even go further, explaining that there is little opportunity to specialise in healthcare design and that there is a worrying shortage of skilled professionals to build new hospitals and healthcare centres. Moreover, Barlow and Köberle-Gaiser (2008), who investigated the effects of planning, finance, construction and operation on the project delivery system for new hospitals, from the perspective of design innovation, suggested that new public procurement models do not automatically provide efficiency and innovation benefits. Therefore, certainly at local level, there are inefficiencies throughout the development process, despite advice, guidance and support from the Estates and Facilities directorate in the procurement and management of healthcare infrastructures, facilities and services (DoH, 2006).

Schraven, Hartmann and Dewulf (2011) reported that the key challenges to achieving effective infrastructure management are: i) to align the infrastructure objectives with the context and the intervention; ii) to formulate coherent aims and strategies between the different functions or group of stakeholders; and iii) to manage accordingly the multiple actors with different interests.

Therefore, collaborative work, certainly at the planning and design stage, must be undertaken between the healthcare and construction industries to achieve the objectives. According to Francis and Glanville (2002), there are four strategic directions to follow: i) development of new forms of procurement based on partnering and long-term relationships; ii) agreement on the mechanisms with which to achieve a greater integration of design and construction; iii) agreement on how to manage and measure the increased levels of performance, and; iv) development of information frameworks and systems to support the strategic planning and design programme for the healthcare environment, as

well as mechanisms with which to effectively pass on the lessons (Kagioglou & Tzortzopoulos, 2010).

#### **2.4.5.5. Key Decision-Making**

During the planning and design processes, the leaders and senior managers will have a set of decision-making critical in the success or failure of any project. Considering the complexity perceived, the decision-makers have substantial responsibilities regarding the design philosophy, impacting the size and layout, the operations and services integration, the site location, and the service quality aimed for. All of these issues must be transparent, rational and inclusive for the large range of stakeholders.

##### **2.4.5.5.1. Size, Layout and other Design Decisions**

Francis (2010) and Trant (2010) explained how important the design is within healthcare infrastructure, as it impacts staff performance, patient health outcomes and users' safety. Francis (2010) pointed out that effective design will provide efficient layout, supporting productive workflow, making best use of staff and technology, and will naturally impact on the reduction of waiting times and improve user experience by making pathways clear. Hence, some research has been undertaken to apply Lean thinking within the design. One of the most successful examples is in the US, with Sutter Health (Chambers, 2010). Moreover, Trant (2010, p.61) identified eight key attributes that make a good design: i) the building needs to make a contribution to its local environment by being suitably integrated; ii) the design should take advantage of open space; iii) logical and clear pathways with one main reception is essential; iv) the building needs to take advantage of the natural environment to create a sustainable infrastructure and utilise environmentally sensitive material and technology; v) the design needs to consider a well-planned waiting area with fit for purpose finishes and furniture; vi) the building should take advantage of natural light and have appropriate ventilation systems; vii) the building needs to have effective, well located storage space; and, finally viii) the design should have the potential to be adapted easily for future changes and modifications.

Codinhoto *et al.*, (2010, p.151) explained that evidence based design (EBD) is a tool that supports sharing vast amounts of information in order to optimise design decisions between the architects, engineers and healthcare planners. Malkin (2008) pointed out that EBD is an approach to assist decision-makers in making design decisions regarding the

size design of the room, and the equipment within it, based on the available knowledge and information. Although Codinhoto *et al.*, (2010) recognised its potential, they also acknowledged that the use of EBD for all decisions would be considerably challenging, given the timescales and variety of decisions required. Therefore, it should only be used to support critical decisions (Codinhoto *et al.*, 2010, p.152). Furthermore, they pointed out that, as EBD is relatively recent, it lacks descriptive evidence. Therefore, only few applications are available in the context of new infrastructure development, and practitioners will need to develop their own models until EBD has been implemented within an effective interface, such as the Cochrane Collaboration. Therefore, the researcher would consider QFD as a relevant and reliable alternative, in order to optimise design decisions (*c.f.*: see QFD in construction). Having established some of the design issues, it is clear that site selection, decided in the planning phase, will massively impact all the design decisions.

Adding to the complexity, a new model of integrated health and social care has been introduced into the UK, within the past five to seven years. Considering the overlap of these two systems, it is only logical and relevant to attempt to integrate them to a certain extent, in order to generate efficiencies, economy of scales, and, above all, improve the service quality for the consumers. However, too many organisational, cultural, and technical issues must be taken into consideration to achieve this service integration, leading the healthcare organisation into difficulties defining and implementing this new model of care. Thus, the trend and potential solution would be to consider this integration as part of new developments, in which the design of these integrated operations can be synchronised with the infrastructure planning and design. However, Codinhoto, Tzortzopoulos, Rooke, Kagioglou and Koskela (2008, p.427) explained that the *“lack of clarity regarding management roles and responsibilities creates problems with the decision making process related to service and building design”*, and mechanisms should be put in place to facilitate both the clarification of roles and communication, as well as the synchronisation of design decisions.

#### **2.4.5.5.2. Site Locations in Healthcare**

For any organisations, infrastructure location is a highly regarded decision and is often considered among the most important. Whitener and Davis (1998) explained that selecting a site is becoming increasingly complex, costly and problematic, because optimum

locations are either already developed or extremely expensive. Thus, techniques and models need to be developed to support decision-making and to understand the impact of the decision on the overall activity. Cook and Hammond (1982) explained that, within the private sector, a poorly chosen location for a business can lead to its failure; whereas a good location leads to its economic success. Moreover, Yang and Lee (1997) noticed that location problems have been increasingly investigated by academics and practitioners, within both the public and private sectors. Yang and Lee (1997) explained that facility location problems have attracted researchers within several disciplines, including: economics, industrial engineering, logistics and geography.

Site selection decisions are deemed strategic, due to their long lasting business impact. For instance, manufacturers and retailers try to locate their facilities in such a way that the entire network's total cost is minimised, or the profit is maximised, by supporting Just-In-Time strategies with their suppliers, and optimising the market penetration by meeting the customer demand with short delays (Christopher, 2005; Cousins *et al.*, 2008). However, within the public sector, the objectives are likely to be different and often not as distinct as in the private sector (Rahman & Smith, 2000). For a public healthcare facility, the location decision has to consider criteria, such as: the distance for the population to travel to it, service availability and the overall equity (Smith, Harper, Potts & Thyle; 2007, Rosero-Bixby, 2004). Therefore, models need to be used to support the decision-making process.

Ghosh and Harche (1993) and Rahman and Smith (2000, p.437) reviewed the role and utilisation of location-allocation models, to support the location of healthcare facilities in developing countries, and demonstrated the *"usefulness of such methods in the site selection decision-making process"*. The aim of these models is to identify the set of optimal locations for a new healthcare facility, by, essentially, minimising the distance or the cost of transportation between the node of demand and the facilities (Tao, 2010). This optimisation would improve the accessibility. The p-median models have proved an attractive method to resolve location problems by calculating the smaller total weighted travel distance, or time, from the user to the facility (Rahman & Smith, 2000). Moreover, Salhi and Al-Khedhairi (2010, p.1619) developed a model *"to solve p-centre problems aiming to locate p facilities and assign demand nodes to these p facilities so that the maximum distance between a demand node and the facility is minimised"*. By developing such models, the redesign of the whole system is likely to be improved. However, the

mathematical methods are quite sophisticated and complex to implement. This is in line with what Rahman and Smith (2000) remarked; that, to a certain extent, most health centre locations disregard the implementation stage. Other popular methods have used Geographic Information Systems (GIS) to predict and analyse the consequences of positioning a facility in a specific location (Rosero-Bixby, 2004, Ramani, Mavalankar, Patel & Mehendiratta, 2007). The major criticisms with linear regression, GIS or p-median solutions, are that the system is optimised based on the accessibility and distance. Moreover, there are several other qualitative aspects that are not taken into account. For instance, these approaches would not facilitate the capture of the voice of the local population. Additionally, although these mathematical models help to optimise the location, a large number of criteria would not be expressed; for instance, the risk associated with the site, the size available to support a specific design, or the potential for regenerating the district. Thus, one may question to what extent the solutions generated from these models will be transparent and traceable. For these reasons, a Multiple Criteria Decision Analysis (MCDA) model is thought to be the solution. This was reinforced by Erkut and Neuman (1989, p.288), who asserted that *“real world location problems are clearly multiple objective and multiple attribute decision-making problems that shall be solved using multiple criteria decision-making tools such as AHP”* as written in Dehe et al., (2011).

#### **2.4.5.5.3. Quality, Continuous Improvement and Performance Measurement**

The quality aspect is linked with the fitness for purpose (Juran, 1995). Francis (2010) wondered how one can ensure that what is being built now will be fit for purpose in the future. Moreover, Too and Too (2010, p201) explained that the quality in an infrastructure is ultimately linked with the continuous improvement activities that are taking place. The quality of the infrastructure can also be measured in terms of effectiveness of the service delivery. Does the infrastructure enable services to be effectively integrated?

Ibrahim, Price and Dainty (2010, p.198) explained that the systematic gathering of project experiences can enable organisations to develop project competences, that lead to sustainable competitive advantage through documentation of its most effective problem solving mechanisms. In addition, documentation of the mistakes should also help organisations to reduce risks associated with similar projects. However, they also

recognised that no such mechanisms are in place. A systematic appraisal framework for healthcare has been developed with the aid of a toolkit called ‘AEDET evolution’. According to the NHS confederation (2004), this framework was developed by the construction industry council as a standard for evaluating the design. However, it is not consistently used and some healthcare organisations do not know of it. Moreover, it may be difficult to define the quality level, and, therefore, make decisions based on a national standard performance measurement framework. This is why the researcher strongly believes that a coherent and bespoke model, assessing the infrastructure holistically, would be extremely relevant to measure performance and to be at the centre of the continuous improvement of infrastructure development.

This section emphasised the decision-making process issues, hence justifying the *S-RQ1: are the decision-making processes the main issues within the new infrastructure development?* The following two sections, in which the literature review will be wrapped up and concluded, will introduce the two remaining theoretical concepts mentioned and discussed throughout the whole of the literature review, which are deeply interconnected with two underlying issues: i) the notion of large stakeholder base, and; ii) the complexity.

#### **2.4.6. Stakeholders Framework**

Too and Too (2010, p.197) explained that the need to satisfy multiple stakeholder demands results in huge performance problems for government-owned infrastructures. A key issue, that increases the complexity of the problems, are the groups of stakeholders, which are large in number, involved within the processes; all with diverse agendas, objectives, practices and even world views, which need to be understood and taken into account by the decision-makers. Interestingly, McManus and Wood-Harper (2007) argued that the different perspectives of the stakeholders involved in software development will influence how quality is seen and measured; and the researcher assumes the same principle applies in the healthcare infrastructure development.

In the management sphere, stakeholder theory has been used when challenging the traditional shareholder framework, by re-positioning stakeholders at the centre of any decision-making and actions (Friedman & Miles, 2002). If this shift of position creates debate within the private sector, where is it believed that “*the well-being of the shareholders is served if the strategy leads to higher share price and higher dividends*”

(De Wit & Meyer, 2010, p.608); in the public sector, where profit is not the ultimate outcome, stakeholder theory can take all its meaning. For the stakeholder value perspective, the organisation should not be seen as an instrument of shareholders, but as a coalition between various groups of stakeholders, with the intention of increasing their common wealth (De Wit & Meyer, 2010). However, an organisation needs to create trust between all parties involved within a project. In this specific example, taking the NHS stance, it is assumed that the project is the development of a new healthcare infrastructure, in which four groups are identified as affecting, and being affected by, the project: i) decision-makers, who are directly employed by the organisation and have the power of decision, they are the executors and owners of the infrastructure; ii) providers, who are employed by the organisation and will be providing the services within the future infrastructure, they will be the infrastructure's main users and are considered to be the internal customers; iii) suppliers and contractors, who are the experts and will work closely with the decision-makers during the development, they are the partners, working in collaboration with the decision-makers in order to procure and build the new infrastructure their power is tacit; and iv) the public, patients and local population, who are becoming more and more involved in this type of project, and are considered to be the external customers. Figure 2.14 below shows a model, in which the four groups could be mapped, according to their power and involvement within a project. Hill and Hill (2012) explained that, in the business context, it is extremely important to understand the power and interest or involvement of each of the stakeholder groups, in order to optimise the communication and the decision-making. They developed a categorisation model, suggesting as the four different strategies: 'to manage closely', 'keep satisfied', 'keep informed', or 'manage with minimal effort'.



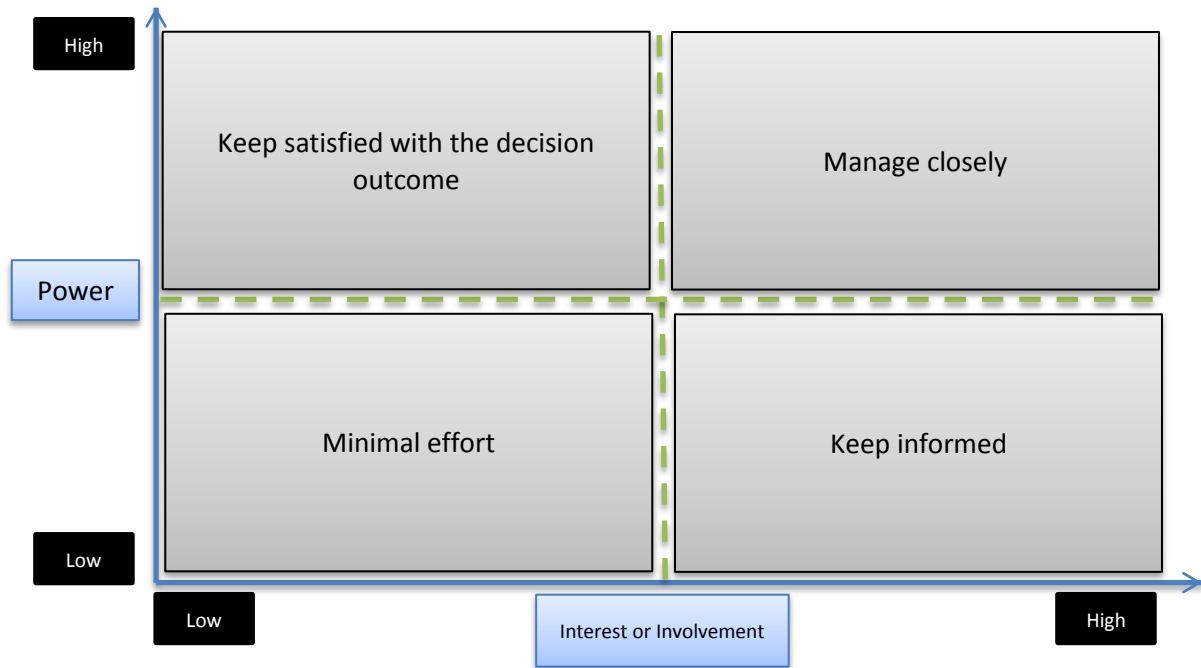


Figure 2.14: Stakeholder model (adapted from Hill & Hill, 2012)

A part of the study seeks to i) map the different groups of stakeholders, and ii) identify whether or not these different groups have a common understanding and perception of the new infrastructure development processes, problems and performances. This is a critical issue when starting to develop improvement. This will potentially support the process owners to gain an insight and develop evidence-based assessments to improve the effectiveness and efficiency of the infrastructure development processes. It is materialised by *S-RQ2: is there a common understanding of the process issues and performances amongst the different groups of stakeholders?*

#### 2.4.7. Complexity Theory

Complexity theory is not always considered as one of the grand theories (Godsell *et al.*, 2013) in the OM discipline; however, it is from the system thinking and OR perspective (Pidds, 2003; Snowden, 2002). As the complexity is a recurrent underlying issue associated with new infrastructure development, it must be looked at from a theoretical perspective. Chu, Strand and Fjelland (2003) mentioned that there is not a widely accepted definition of the complexity; there is not a unified grand theory of complexity, and Fernandez-Solis (2008) pointed out that complex systems are too diverse to share any profound common causes and characteristics. However, a conceptual framework can assist

in making sense and defining the complexity concepts (French, 2013; Snowden & Boone, 2007).

Hamzeh, Ballard and Tommelein (2009, p.165) explained that processes in the built environment are intrinsically variable and uncertain, which makes them complex, as is emphasised in great length throughout this literature review. Too and Too (2010, p.197) explained that the development of infrastructure is highly capital intensive, and encompasses several more layers of complexity than other industries. Hamzeh *et al.*, (2009) pointed out that the uncertainty and complexity have a negative impact on the performances, leading to circular, iterative and unproductive interactions between the different groups of stakeholders and decision-makers. To a certain extent, this phenomenon explains the problems discussed in this sub-chapter and must be handled appropriately, otherwise the key built environment performances, such as the cycle time, cost and quality, cannot be improved. Furthermore, as Fernandez-Solis (2008) detailed, complexity in building construction has been defined from different perspectives; from the stakeholders' angles, *i.e.*: the client, contractors, and other stakeholders, as well as from a production process perspective.

According to the knowledge and legacy left by the quality gurus (Deming, 1982; Juran *et al.*, 1974; Shewhart, 1931; Shewhart, 1939), managing variation and uncertainty – hence, complexity – in the production of a project, is critical to get the processes under control and to improve performances. The fundamental question to address here is: what can be done to avoid or to deal with complexity and uncertainty? Scholars, such as Alarcón (1997), Ballard (2002) and Koskela and Howell (2002), have suggested Lean thinking, Last Planner, JIT and BIM as effective mechanisms, as Fernandez-Solis (2008) reported. Many authors and researchers, from the Lean construction body of knowledge, have demonstrated that the application of the Lean thinking can help to deal with this uncertainty and complexity. The researcher believes that avoiding complexity is not always possible, as it is inherent within the system. However, managing it, in the first instance, can be a more realistic and relevant aim. These ideas will be expressed below, through the S-RQ5, after having conceptualised the complexity phenomenon, based on the Snowden and Boone researches.

In their paper presenting the Cynefin Framework, Snowden and Boone (2007) stated that “*wise executives tailor their approach to fit the complexity of the circumstance they face*”. According to French (2013), the framework offers a perspective on the relationship between scenario thinking and decision analysis in supporting decision-makers, by: i) characterising various forms of uncertainty; ii) helping to structure statistical thinking about decision analysis and decision support; and iii) appreciating the self-knowledge of the decision-maker values, which are “*the driving force of any decision making*” (Keeney, 1992).

Figure 2.15 shows the Cynefin conceptual framework, composed of four main domains: two belonging to the ordered system (simple and complicated), two belonging to the unordered system (complex and chaotic), and a central area called ‘disorder’. Snowden and Boone (2007) explained that complexity needs to be understood in relation to three other domains: simple, complicated and chaotic.

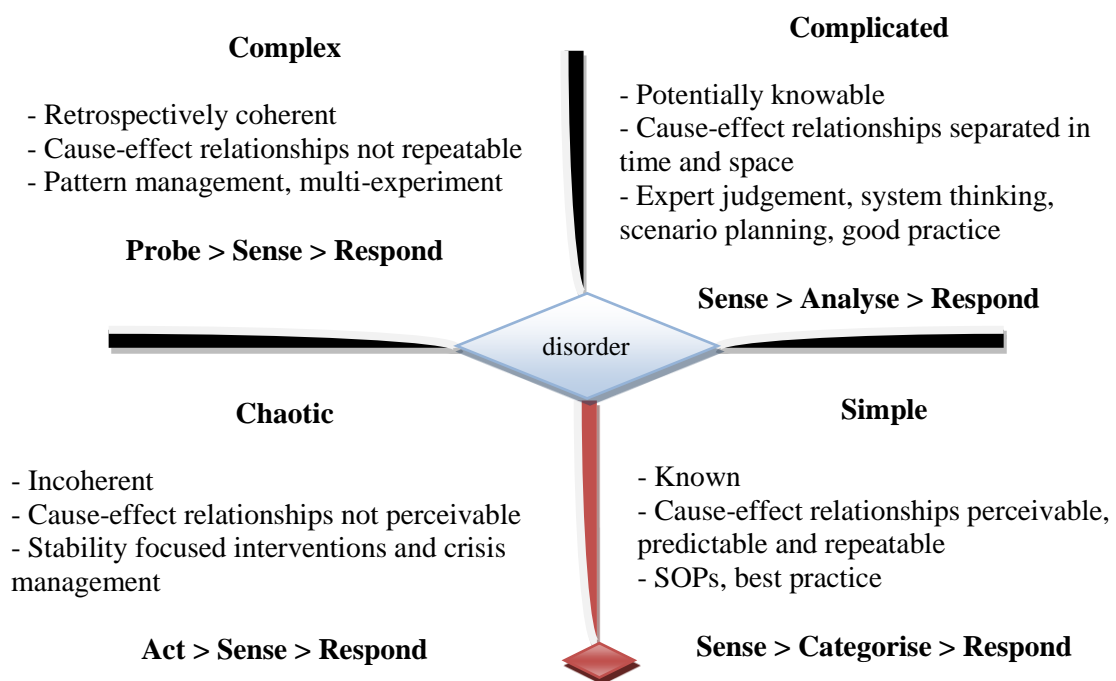


Figure 2.15: The Cynefin framework (adapted from Snowden and Boone, 2007)

Snowden and Boone (2007) defined a complex system, in which there are large numbers of elements interacting with each other in a non-linear manner, making the system dynamic and very sensitive to small changes. This is specifically relevant when defining the new healthcare infrastructure development. Moreover, it is explained that, when one is

dealing with complex problems for which there are not any obvious solutions that can be imposed upon, this causes the decision-making process to appear lengthy, as described previously in the literature review. French (2013, p.548) also pointed out that, in a complex system *“decision-making situations involve many interacting causes and effects. Knowledge in this space is at best qualitative: there are too many potential interactions to disentangle particular causes and effects [...] there are no precise quantitative models to predict system behaviours such as in the known and knowable spaces”*. However, he expressed that decision analysis is still possible and recommended, perhaps with an holistic and interconnected perspective, using a model such as MCDA, in order to explore judgement from the decision-makers (Belton & Stewart, 2002; Saaty & Vargas 2001). In this complex domain, Snowden and Boone (2007) suggested that decision-makers should adopt the following behaviour: probing, sensing and responding.

On the other hand, in the simple domain, or the known space, the correlation between cause and effect is formalised and understood by all of the decision-makers. This occurs when they are dealing with a familiar and repeated problem, which has perhaps occurred because the volume of activity is high (*i.e.*: certain basic manufacturing processes). French (2013) explained that decision-makers can easily create a deterministic model, and be able to predict the outcome of the system (*i.e.*: a mechanical system). Therefore, Kurtz and Snowden (2003), and Snowden and Boone (2007) suggested that the decision-makers sense, categorise and respond.

Within the complicated domain, *“or the Realm of Scientific Inquiry, cause and effect relationships are generally understood, but for any specific decision there is a need to gather and analyse further data to predict the consequences of a course of action with any certainty”* (French, 2013, p.548). According to Snowden (2002), this is when the decision-making can be made by sensing, analysing, and responding; where decisions require the use of models to forecast the course of action and manage the uncertainty level. In this domain, standard modelling and frameworks can prove very powerful in managing the trade-off between the different possible decisions. However, French (2013, p.548) stated that *“when the right answer is elusive, one must base a decision on incomplete data, his/her situation is probably complex rather than complicated”*.

The chaotic domain defines situations involving events and behaviours beyond current experience, with no obvious cause and effect. Snowden (2002) and French (2013) pointed out that decision-making cannot be based on analysis as no concepts apply. Therefore, decision-makers will need to act, sense and respond, which are trial and error tactics.

Finally, the disorder area is the space of not knowing which domain the decision-makers are in. According to Snowden (2002), the danger is to interpret the situation according to personal preference for action, increasing the risk of failure.

Having described and explained the four different domains of the Cynefin conceptual framework, one must appreciate that the boundaries are subtle. As French (2013, p.549) wrote *“the interpretation is soft, with recognition that there are no clear-cut boundaries and, say, some contexts in the knowable space may have a minority of characteristics more appropriate to the complex”*. More precisely, Snowden and Boone (2007) explained that boundaries allow for transitions, except the boundary between simple and chaotic, where transition is easy when decision-makers become complacent, which will lead to failure of the system and crisis. Therefore, this discussion has enabled the positioning and justification of the *S-RQ5: How can a Lean methodology reduce and help to manage the level of complexity in the new healthcare infrastructure development environment?*

#### **2.4.8. Conclusion**

This sub-chapter completed the literature review by discussing the context of the built environment and the roles, challenges and processes of new healthcare infrastructure. This sub-chapter also contextualised and justified the purpose of the sub-research questions, notably, by presenting the two remaining theoretical concepts: stakeholder theory and complexity theory.

Finally, this section allowed the creation of the conceptual synergies between Lean thinking, the process of new infrastructure development, and the decision-making behind the planning and design, as summarised Figures 2.16 and 2.17. They represent the literature review's conceptual models. In order to bring clarity as how these three main bodies of knowledge interact, the researcher started to develop a structured mind map with the main concepts associated with Lean thinking, decision theory and built environment. The direct and secondary interactions between the concepts have been identified,

respectively by a 'line' or a 'dotted line' (or alternatively with the '\*' symbol). It is the secondary connections linking the bodies of knowledge together as shows Figures 2.16, which have not been fully researched yet and represent the gaps in the literature. Additionally, to be more comprehensive, the literature map was replicated and mirrored indicating some of the influential authors used to build the foundation of this thesis, as Figures 2.17 illustrates.

In the following chapter, the methodology will be presented, and the pragmatic paradigm borrowed to undertake this mixed-methodology empirical action research explained.

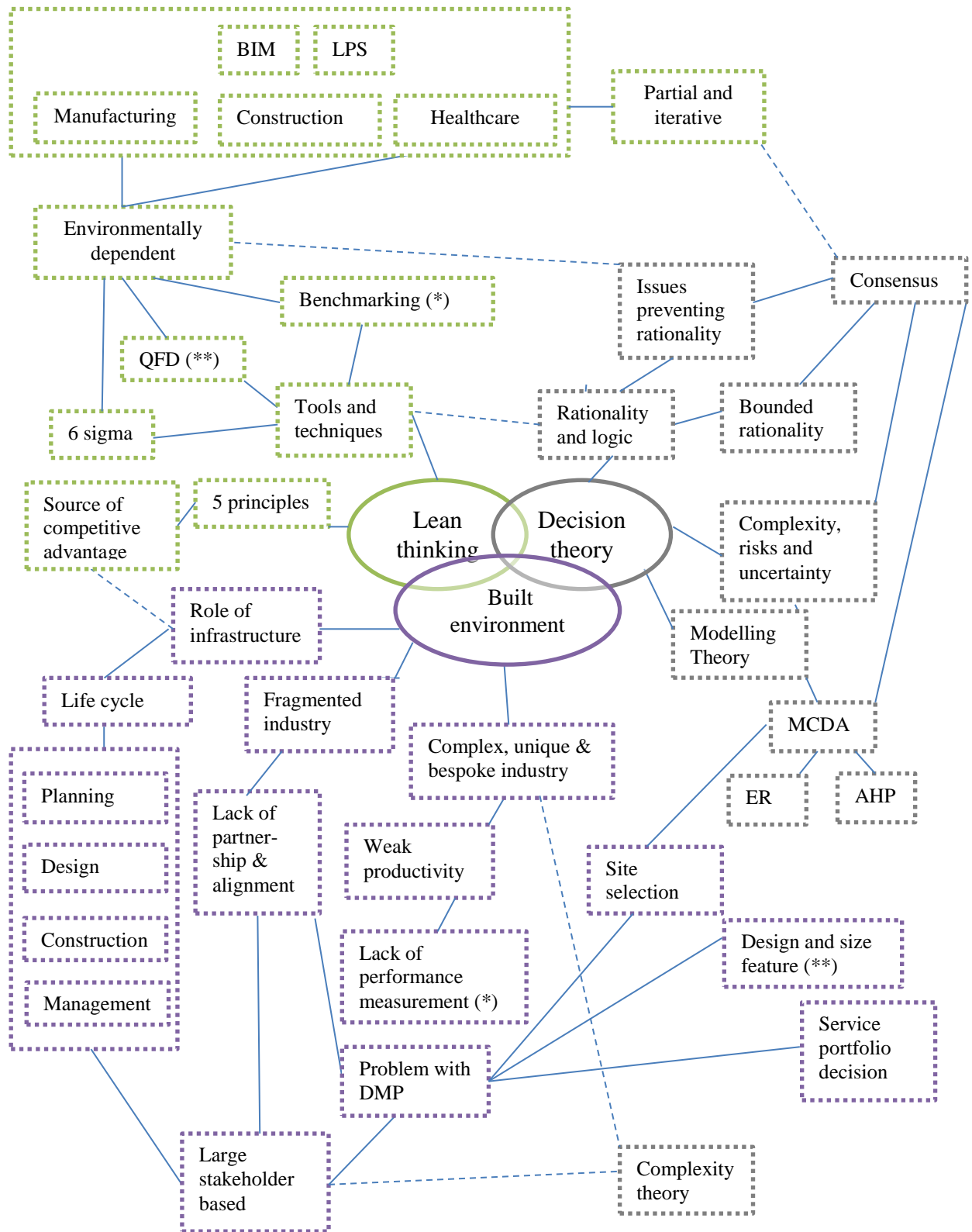


Figure 2.16: Conceptual model of the literature themes

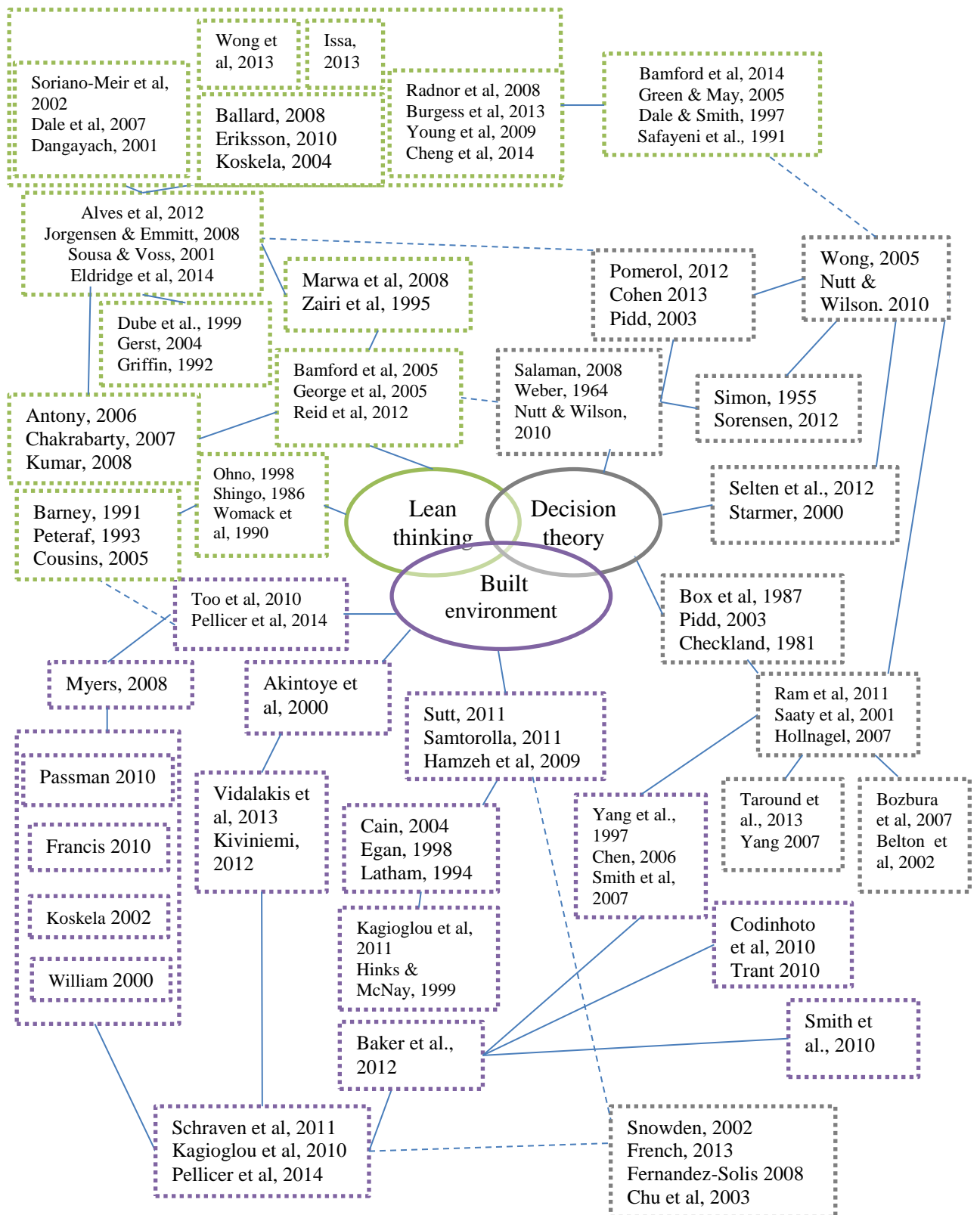


Figure 2.17: Conceptual model of the key authors



### **3. Chapter 3 – Research Methods**

In this chapter, the methodology will be detailed in depth. After an introduction, the research philosophies, the associated assumptions, the research strategy and the mixed-methodology, designed to address the research questions, will be discussed and presented.

### **3.1. Introduction**

Amongst others, Tomkins and Groves (1983) and Guba and Lincoln (1994) clearly explained that the choice of appropriate research methodology is dependent on the different paradigms or research philosophies. The research design and approach should take into account the nature of the phenomenon being researched, as well as two philosophical issues: ontology and epistemology. The first is the researcher's assumptions regarding the nature of the reality; the second is related to the means by which the knowledge is gained (Ryan, Scapens & Theobald, 2002). These elements interact with each other, affecting the designed methodologies and applied methods. Based on the work of Burrell and Morgan, published in 1979, Ryan *et al.* (2002) emphasised that, in Social Science, these dimensions are distinct, yet related, and can be collapsed into an objective-subjective continuum. However, before exploring further the paradigm selected to undertake the research that this thesis is based upon, it is both relevant and critical to re-position the research into context and re-establish the research questions and sub-research questions.

#### **3.1.1. Context Definition**

As it has been written and demonstrated in Chapter Two, healthcare organisations are responsible for planning, designing, building and managing their infrastructures and facilities, from which services are delivered to the local populations in the UK (Darzi, 2008; Kagioglou & Tzortzopoulos, 2010). These built environment processes are long and complex, involving a large range of stakeholders. Moreover, it has been explained that healthcare organisations are lacking in models and frameworks to support their infrastructure development optimisation and decision-making (Barlow & Koberle-Gaiser, 2008; Kagioglou & Tzortzopoulos, 2010). It was suggested that ad-hoc methods used led to inefficiencies in the planning, design, construction and management, as illustrated by the long development cycle time, the non-fitness for purpose, and the lack of innovation (CIAMS, 2010). Hence, in collaboration with a healthcare organisation, this mixed-methodology research was designed to study this complex phenomenon, testing and verifying the emerging issues, as well as assisting the organisation in improving the speed and quality of new infrastructure developments, using Lean thinking. This has been achieved through a system thinking perspective and multiple view-points to a certain extent (Bennetts, Wood-Harper & Mills, 2000) as it will be describe in this chapter.

### 3.1.2. Research Questions

These defined problems led to investigate in great depth, using a mixed-methodology research, two overarching research questions: *RQ 1: What are the root-cause problems associated with new healthcare infrastructure development? RQ 2: How should Lean thinking concepts be implemented to support the decision-making processes for new healthcare infrastructure development?*

Furthermore, driven by the theory and the literature, sub-research questions were also developed, each belonging to the domain of one of the overarching research questions:

- *S-RQ1: Are the decision-making processes the main issues within the new infrastructure development?*
- *S-RQ2: Is there a common understanding of the process issues and performances amongst different groups of stakeholders?*
- *S-RQ3: What Lean tools and techniques should be implemented to improve the planning and design phases?*
- *S-RQ4: What are the most suitable models (ER or AHP) to optimise the decision-making processes in this research environment?*
- *S-RQ5: How can a Lean methodology reduce and help to manage the level of complexity?*

The sub-research questions were justified in the literature chapter, and are interconnected with the following theoretical concepts: RBV, stakeholder theory, modelling theory and complexity theory, as previously detailed. This is important in order to set the foundation for this research and support its contributions.

### 3.1.3. The Research Plan

This section will describe and justify the plan for undertaking this mixed-methodology research under a pragmatic paradigm. It will include the strategies for data collection (inductive-deductive-inductive empirical action research), the mechanisms used to collect the qualitative and quantitative data (interviews, survey, observations, and workshops), as well as the data analysis (thematic analysis, survey analysis). Moreover, the rationale will be explained for selecting these particular techniques, and a description of its coherence with the pragmatic philosophical stances borrowed will be given. However, this chapter is organised in a top-down manner, from the ontology assumption down to the tools used for

analysing the data, in order to answer these specific research questions. The researcher recognises that a study does not systematically follow a linear development, but is a dynamic and iterative process. Nevertheless, the researcher decided to structure this research methodology chapter in a conventional manner for the purposes of clarification and easy reading. Therefore, this chapter will aim to justify the use of the five following elements, to study the nature of Lean thinking deployment into new healthcare infrastructure in order to optimise the planning and design decision-making processes. These five elements are: i) pragmatism as the research paradigm; ii) a multiphase design composed of an exploratory sequential phase and an embedded-experiment variant phase; iii) mixed-methodologies to address the research questions; iv) semi-structured and structured interviews, survey, observations and workshops, to collect the data; and, v) template analysis, matrix analysis, statistical analysis, modelling and experiments to analyse the data.

## **3.2. Research Philosophy**

### **3.2.1. The Ontology Position and Assumptions**

As aforementioned, in Social Science, hence, also in Business and Management studies, the debates about research strategies should be closely linked with the ontology assumptions and epistemology positions held by the researcher (Morgan & Smircich, 1980, p.491). The ontology is defined as the way the reality is perceived by the researcher. For Guba and Lincoln (1994, p.108), the ontology assumption conceptualises the form and nature of the reality. Therefore, researchers need to question whether they consider social entities as either objective or subjective systems, as both are socially constructed by the agents constituting them (Bryman, 2004; Sayer, 1992). From this explanation, a continuum of six assumptions detailed by Morgan and Smircich (1980) have been established and summarised in Table 3.1. This table provides a framework, representing six different views that researchers can hold about their world perspective. It is relevant to understand that each of these assumptions are associated with specific streams of thought, leading to substantial methodological and research design implications, as it will be described further at a later stage (Ryan *et al.*, 2002).

<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center; margin-right: 10px;"> ↑ ↓ </div> <div style="border-left: 1px solid black; padding-left: 10px;"> 1  2  3  4  5  6 </div> <div style="border-left: 1px solid black; padding-left: 10px;"> Reality as a concrete structure   Reality as a concrete process   <b>Reality as a contextual field of information</b>   Reality as a symbolic discourse   Reality as a social construction   Reality as a projection of human imagination </div> </div>	
Subjective	

*Table 3.1: Six ontology assumptions (adapted from Morgan & Smircich, 1980, p.492, and Ryan et al., 2002)*

Therefore, as Ryan *et al.*, (2002) explained, these six ontological assumptions suggest that there is a full spectrum and several possible ways in which to view the world, each affecting the researcher’s epistemological position. However, it is worth noting that juxtaposition between each assumption, within this objective-subjective continuum, is both possible and natural to a certain extent. The first assumption, ‘reality as a concrete structure’, is the most objective, “*where the reality of the external world is taken for granted and is characterised by objective ‘facts’ about the world, which can be discovered and then defined by an appropriate set of variables and tied together by general laws*”. The last assumption, ‘reality as a projection of human imagination’, is the most subjective, in which “*the reality exists only in the individual consciousness in his imagination*” (Ryan, *et al.*, 2002, p.10-12).

According to Ryan *et al.*, (2002), researchers define their ontology assumptions based on their perceived nature of the reality – these assumptions are associated with the worldview borrowed and the way in which the social systems are considered. However, Creswell and Plano Clark (2011) also explained that the ontology assumptions have to be coherent with the research questions. Hence, to answer the defined research questions, and to understand the phenomenon of how Lean thinking can be implemented to improve the efficiency and effectiveness of the new infrastructure development process, the researcher assumes the

‘reality as a contextual field of information’, which is a position in the middle of the continuum and can be related to Simon’s definition of a firm, *i.e.*: an information processing system, as discussed in the literature review (Koskela & Ballard, 2012). Ryan *et al.*, (2002, p.10) explained that, with ‘reality as contextual field of information’ as the main ontological assumption, the researcher “*acknowledges that human beings and organisations are continually processing information, learning, and adapting to their environment.* [This is also in line with the environmental dependability element, argued in Chapter Two]. *As a result, the artificial distinction between the 'subject' and the 'environment' is replaced with a more cybernetic perspective*”, based on the information exchange. It is associated with the possibility to model and map the context based on the available information, as in the soft system methods (Basden & Wood-Harper, 2006). This might involve, or lead, the decision-makers to process information, in order to develop models of the interconnections between the environment and the practices to solve established problems. Hence, the researcher assumes the ability to collect data, which will allow the simulation of both the behaviour and the elements of the system, to support the agents’ decision-making. The research will aim to capture the way in which Lean thinking models can be developed, within this specific environment, and applied to allow the emergence of good practices to overcome a recognised set of unresolved problems, and to make a contribution towards the Lean construction body of knowledge. The following section will consider the epistemological stance associated with this ontological assumption.

### **3.2.2. The Epistemology Position and Assumptions**

Bryman (2004) stated that the epistemological issues are primarily concerned with the means of gaining and justifying the knowledge. The critical question here is to establish whether, in Social Science, researchers should study the open systems, as one would in order to undertake research in natural science; while, Guba and Lincoln (1994) summarised epistemology as the nature of the relationship between the researcher and the system being researched.

Therefore, one can appreciate the close links between these two philosophical issues (Sayer, 1992). If a researcher assumes that reality is ‘real’, as in a concrete structure, he/she will need to be detached from the system being researched. Thus, generally

speaking, holding an objective ontology will lead and encourage the researcher to adopt ‘scientific’ perspectives and methodologies, associated with a positivism epistemological stance; whereas, if the researcher has a more subjective view of the reality, at the other end of the continuum, he/she is more likely to use a ‘naturalistic’ approach, following an interpretivism or constructivism epistemological position (Ryan *et al.*, 2002; Bryman, 2004). There is another major worldview, which has been articulated by many scholars, such as: John Dewey, William James, C.I Lewis and Charles Sanders Peirce, valuing both objective and subjective perspectives, portraying the multiple facets and arguing the complexities of the reality; formally known as ‘pragmatism’ (Creswell & Plano Clark, 2011, p.43).

In other words, a positivist position will encourage the social researcher to adopt and apply methods used within the study of natural science to study a social phenomenon. Often, large sample surveys, statistical analysis and covariance analysis will be used as a means by which to collect and analyse the data, within a quantitative methodology. An interpretivist or constructivist position will consider that, in order to study the social world, different logics of research are required to appreciate and assess human interactions, actions and behaviours, which would be appropriate in a qualitative study in which observations and interviews are the main means of data collection (Bryman, 2004). Whereas, a pragmatism position may combine deductive and inductive thinking, and use mixed-methodologies to address the research questions (Creswell & Plano Clark, 2011, p.42).

In the following sections, positivism, interpretivism or constructivism and pragmatism will be discussed further to demonstrate how distinctive epistemological positions influence research designs and strategies.

#### **3.2.2.1. Positivist Position**

Morgan and Smircich (1980, p.493) explained that, by holding an objective view of the world ‘as a concrete structure’, the researcher is encouraged to hold an “*epistemological position that emphasises the importance of studying the nature of relationships among the elements constituting the structure*”. Thus, it seems logical that the researcher needs to understand the social structure, in order to build up and justify the knowledge generated through a “*positivism approach with a possible emphasis on the empirical analysis of*

*concrete relationships in an external social world, encouraging an objective form of knowledge that specifies the precise nature of laws, regularities and relationships amongst phenomena measured*” (Morgan & Smircich, 1980, p.493). To achieve this, the researcher might develop hypotheses expressed as mathematical equations, and identify a set of variables to be tested, verified or falsified, for the phenomena being studied (Guba & Lincoln, 1994). As Popper (1959) suggested, the aim is to test a hypothesis and prove it wrong to get closer to the truth. This type of research can be associated with a deductive strategy, in which the theory allows the research to build up the hypothesis and identify the variables. To do this, the researcher might collect the data through a survey, with pre-defined variables, targeting a large sample and analysing it with statistical tools and techniques throughout extensive research (Bryman, 2004; Sayer, 1992).

For instance, if one wanted to empirically study Lean implementation within the construction industry in order to measure the correlation between successful Lean implementation and the generated profit and other financial performance, he/she might take a deductive approach to test the suggested theory. Hypothetically, it can be imagined that the primary data collected will have come from the pre-defined, theoretically driven survey, which would have been sent to a statistically significant number of carefully selected organisations in the construction sector. Questions would have been asked to enable statistical analysis and to generate results, which would be as objective and representative of the population as possible. The findings would then help in predicting and forecasting the impact of Lean implementation onto the bottom line.

#### **3.2.2.2. Interpretivism or Constructivism Position**

On the other hand, if the researcher holds a highly subjectivist view of the reality as a ‘projection of individual imagination’, this ontology assumption will lead to a complete disagreement with a positivist epistemology position, as the key focus would be on *“understanding the process through which human beings concretise their relationship to their world”* (Morgan & Smircich, 1980, p.493). In this instance, the focus of the Lean research would alter, becoming inductive and qualitative by nature, as opposed to the previous example. The epistemological assumptions would be associated with the interpretivism or constructivism position; the researcher would try to understand the causal mechanisms through observations and in-depth interviews, to develop a thorough



understanding of the phenomenon, in order to generate findings that will lead to the building of a theoretical contribution (Sayer, 1992). The researcher might only focus on one or two firms to get the depth required; whereas, using the positivism position, a substantial number of organisations would have been targeted in order to make a contribution. Moreover, based on our previous example, the constructivist researcher would argue that the *“quantitative research excluded the meaning and the purpose attached to the human behaviour”*. Also, he/she could argue that, although *“the quantitative research was statistically significant, the generalisation of the findings would have no significance on a particular case and that a qualitative research would avoid this confusion”* (Guba & Lincoln, 1994, p.106). For instance, the researcher would be interested in studying how the implementation of Lean thinking occurred within the organisation, and why and how the profits generated have improved. This will lead the researcher to an inductive strategy, in which he/she collects the data to generate a theory or conceptual model. The scientific approach relies on a deductive logic, meaning that the researcher collects the data to test a theory, as previously explained (Maylor & Blackmon, 2005, p.152).

### **3.2.2.3. Pragmatism Position**

The third position developed here is pragmatism. Sliwa and Wilcox (2008, p. 100) explained that the foundations of pragmatism are associated with Charles Saunders Peirce *“who developed pragmatism as a theory of meaning, based on information, arguing for the existence of an intrinsic connection between meaning, information and action, and proposing that the meaning of ideas is best discovered by subjecting them to an experimental test and then observing the consequences (Murphy 1990)”*. This is in line with the ontological assumption: ‘reality as a contextual field of information’. Moreover, William James (1907) and C.I Lewis (1934), two other main contributors to this paradigm, argued that pragmatism was a philosophy oriented towards practice, action and relative principles, through experiments, experiences and perceptions grounded within empirical research, as opposed to the abstractions and the absolutes (Sliwa & Wilcox, 2008, p.100). Shewhart (1939) was a pragmatist, and he argued that knowledge cannot be developed without interpretation. According to Sliwa and Wilcox (2008, p.100), Shewhart *“demonstrated that he conceived knowledge not as objective and absolute, but as depending upon a specific conceptual frame used by the investigator or the agent”*.

Moreover, he considered that the process of data collection is central to the acquisition and development of knowledge, and did not entirely associate knowledge with truth.

Furthermore, it can be argued that empirical characteristics lean towards the subjective end of the ontological spectrum, but this is not necessarily true as it would depend on the nature of the research questions (Creswell & Plano Clark, 2011). Plano Clark and Creswell (2008) mentioned that, instead of searching for metaphysical truths and realities, pragmatists consider truth and real, what works based on using the information available. Therefore, pragmatists stepped away from the research paradigm war, considering all the research methodologies as incommensurable (Kuhn, 1962; 1970), and arguing that both qualitative and quantitative methods are compatible. Furthermore, they mentioned that several research designs could be possible and that having different inductive and deductive cycles could be suitable and relevant, in order to address the research questions.

Hence, to study this phenomenon and address the main research questions regarding the root-cause problems associated with the new healthcare infrastructure development, and the ways in which Lean thinking should be implemented to support the decision-making processes for planning and designing healthcare infrastructure, both qualitative and quantitative data was collected and analysed, within a multiphase design. Furthermore, three different modelling tools, associated with Lean thinking, were developed and empirically tested to support and resolve the established issues. This research was conceptualised through an empirical action research, involving the researcher taking an active role in the research process and development.

In this section, major differences between the three paradigms: positivism, constructivism and pragmatism, were highlighted, and some of their differences and implications, in doing research in Business and Management, were detailed. This enabled the introduction and justification of the pragmatism paradigm borrowed. The following section will focus on the research strategies, designs and methodologies.

### **3.3. Research Strategies, Designs and Methodologies**

Bryman (1984) and Sayer (1992) explained that, since the '70's, academics have been debating about the two types of research in Social Science: quantitative and qualitative. In the '50's and '60's, it was current practice to keep the level of analysis focused upon the

tools and techniques. Hence, at that time, methodologists compared the social survey against the participant observation or interview, and most of the social scientists greatly favoured quantitative methodologies; the majority disregarding the qualitative approach (Tomkins & Groves, 1983). However, reflection has been undertaken by academics and researchers to discuss the advantages and disadvantages of qualitative research at a philosophical level, which led several methodologists to consider qualitative researches differently when developing a theory. Therefore, disagreements about the “*consideration of the superiority or appropriateness of the methods in relation to one another*” have largely evolved during the last three decades, and are not critical issues for the pragmatists (Bryman, 1984, p.75).

These two types of research are commonly referred to as ‘quantitative or qualitative methodologies’. However, terminologies for these two approaches have also been used interchangeably and may lead to some confusion. For instance, Sayer (1992) and Lowe (2001) refer to extensive and intensive research strategies, explaining that each directly influences the selection of either a quantitative or qualitative methodology. Bryman (2004) stated that the research strategies can be either deductive or inductive, and that quantitative methodologies are more often used in a deductive research strategy; whereas, qualitative methodologies are used within an inductive strategy. However, a study can have some element of both, which would also support the pragmatism argumentations of mixed-methodology. This introduction has set the scene and presented a few concepts and ideas, which will be developed further in this chapter.

### **3.3.1. Research Strategy: Inductive and Deductive**

Sayer (1992, p.242) and Bryman (2004) made a clear distinction between two strategies, or logic, when they referred to inductive and deductive researches. They explained that there are two alternatives and that the distinction is also a question of the depth, or breadth, of the study, establishing the boundaries of the research. Moreover, this largely influences the type of research questions, and the techniques applied to collect and analyse the data.

Inductive researches are concerned with understanding how the causal processes work, in a particular case, to generate a theory or conceptual model; whereas, deductive researches are concerned with discovering some of the common proprieties and general patterns of a

population as a whole, by testing a general rule or theory (Sayer, 1992, p.242; Maylor & Blackmon, 2005, p.150).

Table 3.2 below presents the comparison between the two research strategies, or logic, based on seven criteria: research question, role of theory, types of user groups, type of account produced, typical methods, limitations, and tests.

Research Strategies	Inductive	Deductive
Research questions	How and why does the process work? What produces change? What do the agents do?	What are the factors? What is the distribution of characteristics? How much is each factor contributing?
Role of theory	Generation of theory through pattern analysis	Testing of theory through development of hypothesis and verification
Types of user groups	Predominant in human resources, organisational behaviour, organisational science	Predominant in economics, operations research, and marketing
Types of account produced	Causal explanation	Descriptive representative generalisation
Typical methods	Qualitative analysis	Quantitative analysis
Limitations	Unlikely to be generalizable, representative or average	Limited explanatory power, generalizable to one population in a certain time and place
Tests	Corroboration (where the findings are confirmed with other individuals)	Replication (where the generality of properties is determined in the population)

*Table 3.2: Comparison of inductive and deductive research strategy (adapted from Sayer, 1992, p.243 and Maylor & Blackmon, 2005, p.153)*

As Becker (1996) mentioned, according to the research strategies selected – inductive or deductive – the investigated questions will be different, which will have a considerable impact on the research design. Moreover, it can be argued that the data collection activity and the generalisation of the findings will not be the same according to the strategy chosen. The epistemological position will influence whether the researcher will have an iterative process, leading to the alteration of the data collection, during the development of the new findings; or whether all the variables are determined in advance and unlikely to evolve overtime (Maylor & Blackmon, 2005). This can be linked back to the ontology assumption and how the world is seen by the researcher.

By definition, the qualitative research is closely linked with the inductive strategy, and quantitative research with deductive strategy. Qualitative research assumes that the researcher has a close involvement with the subject or phenomenon being studied, and that the researcher sees the world from his/her perspective, it is subjective by nature; whereas, in quantitative research, the agent and the structure are separated and should not interact on each other.

In the research upon which this thesis is based, elements of both have been borrowed and mixed to study the phenomenon, and address the research questions in line with the pragmatic paradigm; naturally, keeping a certain consistency and coherence with both the ontological (reality as a contextual field of information) and epistemological (pragmatism) stances adopted. The researcher has developed an inductive-deductive-inductive research strategy, using both qualitative and quantitative approaches, as Figure 3.1 demonstrates.

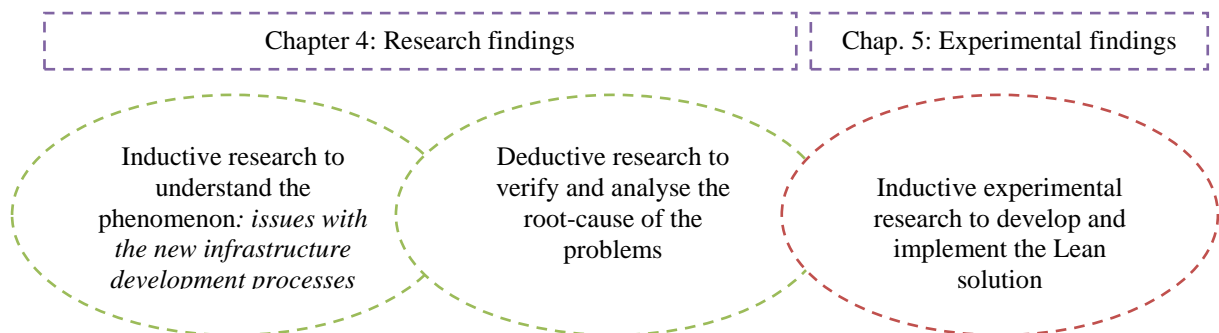
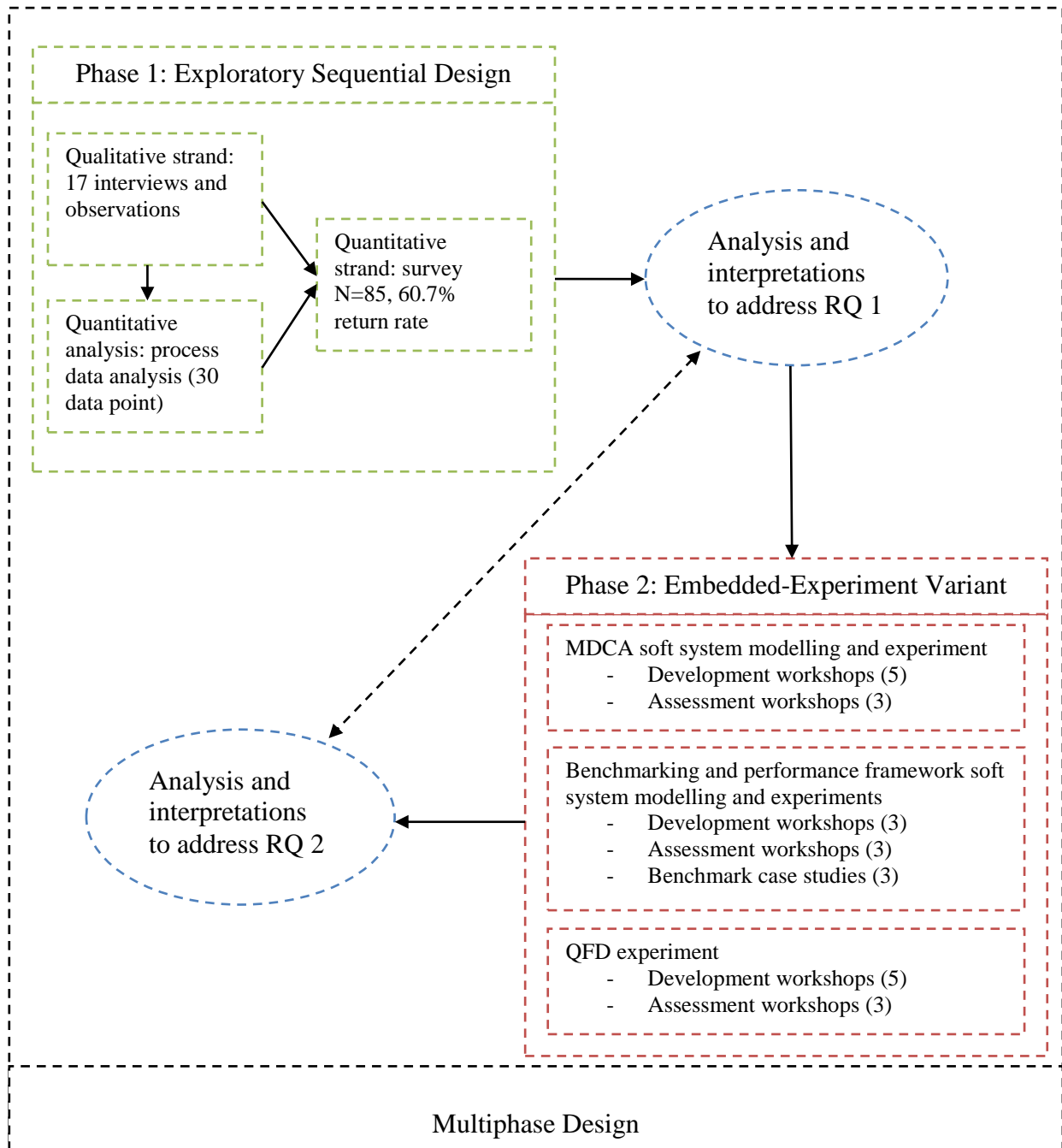


Figure 3.1: Inductive-Deductive-Inductive cycle

According to Sayer (1992, p.243) and Bryman's (2004) definitions, the inductive research strand will be the investigation of the nature and reasons behind the issues within the new infrastructure development process in the specific environment, and the deductive research strand will be used to prove or disprove the generated hypothesis, and analyse the root-cause of the problems. Then, the study will focus on the experimental research, using qualitative and quantitative data, to develop and understand how Lean thinking models can be developed and implemented within this specific environment to improve the decision-making processes, which has an underlying inductive logic. The findings will be extensively presented in Chapter Four and Five of this monograph, as Figure 3.1 suggested. However, the next section will present and justify this multiphase design.

### **3.3.2. Research Design: Multiphase Design**

This thesis is split into two phases, referred to as a 'multiphase design', as Figure 3.2 illustrates (Creswell & Plano Clark, 2011). The first phase is an exploratory sequential design, addressing the first research question and its associated sub-research questions, 1 and 2; whereas, the second phase is an embedded-experiment variant, designed to address the second research question and its sub-research questions, 3, 4 and 5 (Creswell & Plano Clark, 2011). Both phases have within them aspects of mixed-methodology, and these will be described, in great depth, in the following sections. Phase 1 is associated with the inductive-deductive cycle, which aimed to establish the problems and then verify, and test, the generated hypothesis. This was achieved through an exploratory sequential design, composed of both qualitative and quantitative elements. Phase 2 is associated with the development and experiment of the solutions overcoming the root-cause issues identified and measured in phase 1. This was achieved through an embedded-experiment variant design (Creswell & Plano Clark, 2011).



*Figure 3.2: Multiphase design*

### 3.3.2.1. Phase 1: Exploratory Sequential Design

The exploratory design is a two-phase, sequential design, started off by a qualitative strand, in order to appreciate the context, its singularities and explore its issues, before building a second quantitative phase to test the generated hypothesis. The purpose of this exploratory study was to build the instrument and generalise the findings, as the variables were unknown. Multiple worldviews, and/or pragmatism, are the logical philosophical

assumptions behind this type of exploratory design (Creswell & Plano Clark, 2011). If the main design was sequential, as suggested in Figure 3.2 above, a concurrent process data analysis was performed, for triangulation purposes, throughout this exploratory phase (Modell, 2005; Modell, 2009). The details of this data analysis will also be provided later on, in Chapter Four.

Figure 3.3 below provides further details about the sequence of activities. Firstly, a set of structured and semi-structured interviews (N=17) were undertaken; the coding and data analysis enabled the researcher to develop five themes. Along with this qualitative study, the new infrastructure development process data was collected and analysed. These two elements led to the development of the survey instrument (N=85). Analysis and interpretations of these three components enabled the researcher to address research question 1 and its associated sub-research questions, 1 and 2, as well as to develop the solutions to overcome the identified root-cause issues.

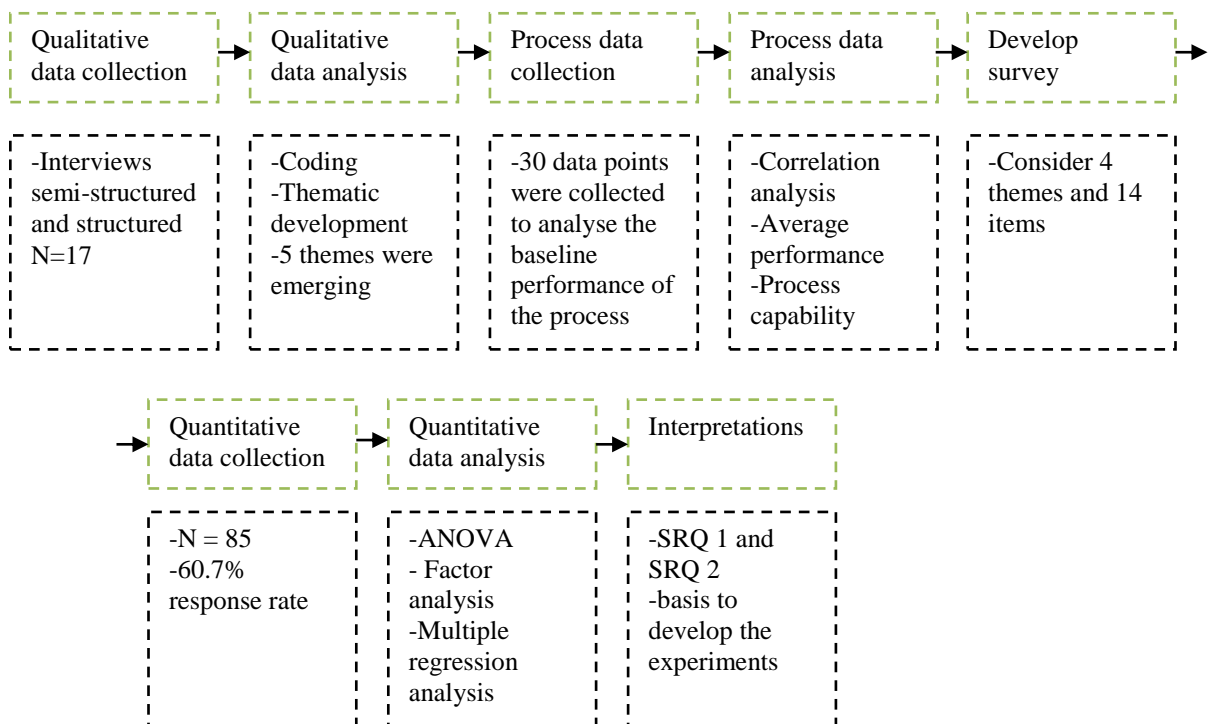


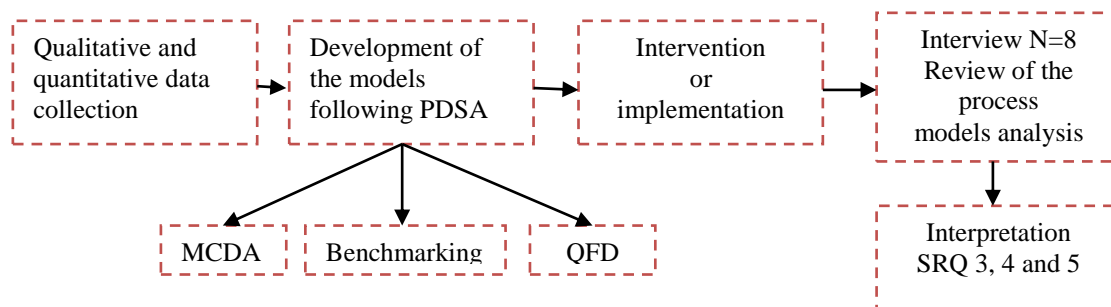
Figure 3.3: Steps within the exploratory sequential design

### 3.3.2.2. Phase 2: Embedded-Experiment Variant Design

According to Creswell and Plano Clark (2011, p.71), the embedded design occurs when the researcher collects and analyses both quantitative and qualitative data, within a



traditional quantitative or qualitative design. The most common example is the embedded-experiment variant, which occurs when the researcher embeds both qualitative and quantitative data within experiments (Creswell & Plano Clark, 2011, p.95). Here, the developments of the three models (MCDA, Benchmarking and QFD) have been approached as experiments, following a structured technique, developed by the pragmatist, Shewhart (1931): Plan – Do – Study – Act (PDSA), and advocated by Deming (1986) and other soft system thinkers.



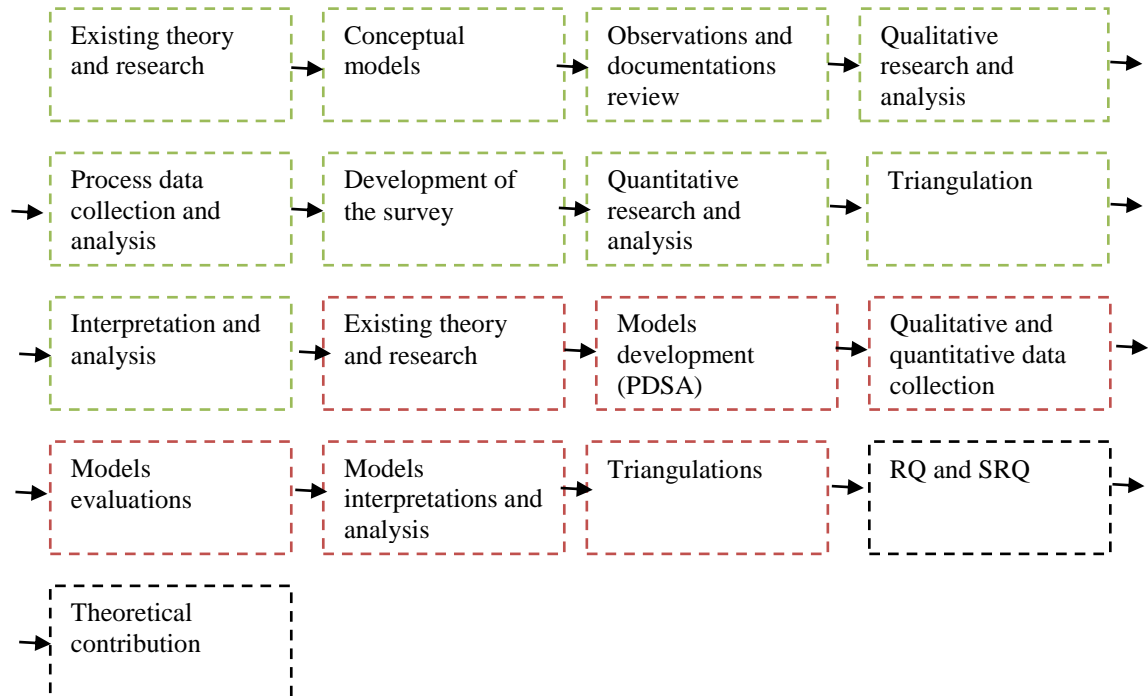
*Figure 3.4: Steps within the embedded-experiment variant design*

After having collected and reviewed the data, Lean thinking techniques and models were developed to address the root-cause issues. A systematic approach to the models' development has been followed: i) Plan, by defining the problems and identifying how the model could be developed and implemented; ii) Do, by collecting both qualitative and quantitative data, both primary and secondary, to develop a bespoke model; iii) Study, by testing and validating the model, through workshops with the key stakeholders, and evaluating its strengths and weaknesses, and; iv) Act, by implementing and controlling the model's impact. By reviewing the models with the decision-makers and interpreting the results, the second research question was addressed, along with its associated sub-research questions 3, 4 and 5.

### **3.3.2.3. Bi-Phase Design**

In this section, the research design was presented. It can be understood that this thesis relies on two studies: an exploratory sequential study feeding into an embedded-experiment variant study. According to Creswell and Plano Clark (2011), this is referred to as 'multiphase', or, in this instance, a 'bi-phase' mixed-methodology design, which will be modelled in the discussion as follows, and presented in Figure 3.5. It needs to be

recognised that, despite the linear description and visualisation of this design, the research process was rather iterative and dynamic (Maylor & Blackmon, 2005).



*Figure 3.5: Steps within the bi-phase design*

### 3.3.3. Research Methodology: Mixed-Methodology

Creswell and Plano Clark (2011, p.61) and Bryman (2006) explained the reasons and advantages of mixed-methodologies. They developed a comprehensive taxonomy, composed of 16 reasons. Below are the major points used to justify the utilisation of mixed-methodology research in this thesis. First of all, to fully explore and address the research questions, the researcher considered appropriate and relevant to design the study around an iteration of inductive and deductive logic. Thus, qualitative and quantitative elements were required to satisfy the aims and objectives. Additionally, mixed-methodologies support powerful triangulation of findings, enabling corroboration (Modell, 2005). They allow the offsetting of the strengths and weaknesses of both qualitative and quantitative elements, especially within the experimental findings, making the research more comprehensive and credible (Modell, 2009). For instance, the researcher recognises that using mixed-methodology has both helped in explaining further some of the findings, and enhanced their quality.

In this piece of research, the two types of methodologies have been considered, equally, and have been given equal priority when addressing the research problem, despite their different roles and responsibilities. The researcher was confident in this approach, as it is consistent with the incommensurable argument (Kuhn, 1962) and the pragmatism paradigm borrowed (Murphy, 1990). Nonetheless, the challenges behind mixed-methodology, in terms of access, time and analysis, had to be considered.

In the following section, further details about the research methods will be provided. It will be explained how this multiphase study, started in January 2010, emerged within an empirical action research, and how case studies have been used as a vehicle to develop, experiment and test the Lean models.

### **3.4. Research Method: Empirical Action Research**

Having presented and analysed the research paradigm, philosophy, strategy and design, this section will detail the research methods used. There are three interconnected elements that characterised this piece of research, associated with this multiphase design: i) its empirical nature; ii) its action research component; and iii) the use of case studies to test and develop the modelling.

#### **3.4.1. Empirical Research**

According to Forza (2002), undertaking empirical research, in the field of Operations Management, can increase the usefulness of the research output for practitioners, especially when the phenomenon being studied has a process-based perspective, such as a new infrastructure development process. Moreover, as a key assumption behind this research was the consideration that Lean thinking, in the construction setting, is still at a pre-paradigm stage, as defined by Kuhn (1962; 1970), it is, therefore, relevant to undertake an empirical study, in order to contribute to the body of knowledge by developing conceptual models generated from the applications. There is no dominant theory established or ruling the research community in this field. Therefore, initiatives designed to understand, and allow concepts to emerge, are appropriate. The method, or mechanism, used to undertake this empirical research, was action research.

### 3.4.2. Action Research

French and Bell (1990) defined ‘action research’ as the process of collecting research data within an on-going system, feeding this data back into the system, and taking action to alter a number of variables based on the information and findings generated, as well as evaluating the results, as Bamford, Thornton and Bamford (2009, p.144) summarised. Zimina, Ballard and Pasquire (2012, p.384) explained that “*action research was introduced by Kurt Lewin to describe a process of organisational change that uses a spiral of steps, each of which is composed of a circle of planning, action, and fact finding about the result of the action*”, which is also in line with the Plan – Do - Study – Act cycle. Baskerville and Wood-Harper (1996, p.235) suggested that, by merging research and praxis, action research generates a large amount of data and produces relevant findings. In Information System (IS), as in Operational Research (OR) and Operations Management (OM), action research is an accepted research method (Baskerville & Wood-Harper, 1996; Bamford, *et al.*, 2009; Bamford & Chatziaslan, 2009). Checkland (1981) has contributed towards developing the legitimacy of action research in system thinking and it is now recognised as a method on its own. Baskerville and Wood-Harper (1996, p.236) also explained that action research is a method that perfectly fits within a post-positivist paradigm, “*it is empirical yet interpretive; experimental yet multivariate and it is observational yet interventionist*”. These different elements and notions also seem to fit extremely well with the pragmatic paradigm. In this study, the action research element is mainly linked to the development and experiment of the three Lean techniques: MCDA, Benchmarking and QFD. The researcher played the roles of observer and analyst, which was stretched to include a participative role, within the models development and experimentations (Zimina *et al.*, 2012, p.384). The objective was to develop and test a new embedded practice, designed to address the root-cause problems and to enhance the new infrastructure development processes by altering some of the process variables.

Furthermore, “*from an epistemological perspective, action research is consistent with the Lean thinking philosophy, as they both assume that the most efficient way to acquire and develop knowledge is by participant experiment in a live environment*”, and then to systemically reflect on the successes and failures (Zimina *et al.*, 2012, p.384). Thus, the Plan, Do, Study, Act iterative cycle is highly appropriate, as suggested earlier.

The researcher established long-term collaboration with a specific healthcare organisation, formally and contractually starting in January 2010 and ending in January 2012, as they were willing and keen to experiment with new approaches to improve their new infrastructure development process performance. Hence, the researcher was directly involved and worked within the project teams on a daily basis, totalling 450 working days, acting as an informer of Lean theory, supporting the decision-makers to improve their processes by initiating adjustments, and collecting data (Zimina *et al.*, 2012).

The third element, associated with the research method, is the case study. In this thesis, the case study is used as a vehicle to develop and test the models, working at the infrastructure unit of analysis, not the organisation.

### **3.4.3. Case Study**

Ryan, Scapens and Theobald (2002) defined ‘a case study’ as a research method, not as a methodology on its own. However, it can be used as an effective mechanism by which to study a phenomenon. Yin (1994) explained that a case study can be selected by researchers who are interested in empirically exploring, explaining or illustrating a phenomenon in depth, by capturing a rich understanding of the phenomenon in a real-life context. Thus, to achieve this goal, one can design a single case study or a multiple case study-based research, mainly depending on the developed research questions. It has been noted that the popularity of the case study research method, in Social Science, has recently grown. However, it was perceived as a less desirable form of research method when used exclusively (Yin, 2009). In his book, Yin reported that the main counter-arguments against the case study are its lack of rigour and systematic approach, as well as its lack of basis for the generalisation of findings. Having said that, Voss, Tsikriktsis and Frohlich (2002) agreed with Yin (2009), recognising that the main strengths of the case study research are that both inductive and deductive research strategies can be deployed, where, on the one hand, theories can be generated from the understanding of the phenomenon, and, on the other, theories can be tested, verified or falsified by exploring misunderstandings of the phenomenon. Moreover, it is a powerful research method, involving the researcher collecting empirical, rich data on a particular phenomenon, and then developing a thorough description and analysis of the setting, potentially leading the researcher to make a contribution to knowledge (Maylor & Blackmon, 2005). Although the case study has

often been associated with softer methods and qualitative researches, it can also be suitable with pragmatism and in a more quantitative research too.

Hence, in this monograph, a case study (referred to as the K case) has been used as a vehicle, both to expose and to test the experimental findings. MCDA has been applied to the decision-making process of the K site selection. Benchmarking and the performance measurement framework have been developed and applied to support the planning decision-making of the K infrastructure in the investigation of three cases, as it is reported in Chapter Five. Finally, QFD has been deployed to optimise the decision-making process behind the design of K. The rationale for using a case study was to empirically test the modelling techniques and provide evidence.

This section justified and linked the different concepts underlying this research method. The following section provides further information regarding the tools and techniques used to collect and analyse the data.

### **3.5. Research Tools and Techniques: Data Collection and Analysis**

In order to collect the data robustly, different tools have been used in line with the multiphase design of this mixed-methodology research. These will be presented individually, not necessarily chronologically or in order of importance.

#### **3.5.1. Process Data**

From an OM perspective, it is extremely relevant to analyse the performance and process data (Shewhart, 1939; Deming, 1986). Therefore, the researcher developed a framework to collate cycle time data around the main construction phases of any projects: planning, design and construction. However, this type of data was not readily available; hence, it took a couple of months before the process data could be put together. The information was retrieved from the project managers' logbooks, internal documentations and each of the infrastructure reports. It was possible to track back the cycle time and performance data to the year 2000, leading to the collation of a sample of the last 30 new infrastructures initiated in the area, which was enough to start statistical process analysis (Breyfolge, 2003). At the time of data collation, not all the schemes were completed; hence, forecast data was used. The estimates were re-validated in October and November 2011, by the team of decision-makers and experts. The data was analysed in Minitab; the findings are

provided in Chapter Four. Moreover, the preliminary analysis supported the design of some of the interviews, and, to a certain extent, the survey, which was illustrated in the exploratory sequential design phase.

### **3.5.2. Interviews**

Interviews were one of the main techniques used for the data collection. Both structured and semi-structured interviews were used, at different times, as previously described. In total 25 interviews were undertaken, recorded and used in the analysis, as illustrated in Table 3.3. Two waves of structured interviews were employed to build up a rich understanding of the context and to form the different stakeholders' perspectives.

The first wave of the structured interviews was composed of three sections and 18 questions. The second wave being composed of six questions (*c.f.*: Appendix 1: Structured Interviews Questions). Each section focused on a specific area relating to the understanding of the issues behind the planning and design of new healthcare infrastructure development, and the appreciation of Lean thinking implementation, in order to improve the new infrastructure development processes. The objective was to interview the majority of the people directly involved within this process. In this particular organisation, these individuals were from: Estates, Primary Care, Service Development, Strategy, Finance and Planning, representing about 30 to 35 individuals at the time of the study. The 16 structured interviews undertaken lasted between 60 and 90 minutes, and were digitally recorded and transcribed. The nine semi-structured interviews were usually shorter, between 45 to 60 minutes.

Coding and thematic analysis was undertaken to make sense of the data and to generate categories or nodes. Nvivo was considered for coding. However, after the preliminary analysis, thematic analysis was undertaken using Excel. Chapter Four presents the findings and the structure of the analysis.

From February to April 2010, 17 semi-structured or structured interviews were designed and undertaken to pinpoint some of the major issues, and eight structured interviews took place in September 2011 to form an understanding of the modelling outcomes. These techniques were aimed at collecting primary data from a large panel of stakeholders involved within the new infrastructure development process.

#	Date	Reference	Position	Interview type
1	07/02/2010	CDJC02	Development & improvement manager	semi structured
2	08/02/2010	ABHH01	Director of primary care and public engagement	semi structured
5	12/02/2010	TSJL11	Intelligence and analysis manager	semi structured
9	14/02/2010	XWHB13	Assistant director intelligence and analysis	semi structured
11	15/02/2010	YZSB14	Director of south west commissioning alliance	semi structured
12	18/02/2010	BCDR15	Head of improvement and patient experience	semi structured
13	15/03/2010	EDBL16	Head of community service strategy development	semi structured
15	26/03/2010	GFJH17	Provider estates manager	semi structured
16	12/02/2010	LKJW06	Estates manager	semi structured
3	29/03/2010	FEJW03	Estates manager	structured wave 1
4	11/02/2010	OPJB09	Service improvement manager	structured wave 1
6	13/02/2010	JIMT05	Transformation programme director	structured wave 1
7	13/02/2010	MNMD08	Estates manager	structured wave 1
8	13/02/2010	UVME12	Service design manager	structured wave 1
10	14/02/2010	GHCT04	Deputy director of service development	structured wave 1
14	18/03/2010	QRLH10	Head of primary care	structured wave 1
17	03/04/2010	LJHV07	Estates project manager	structured wave 1
18	05/09/2011	LKJW60	Estates manager	structured wave 2
19	07/09/2011	OPJB90	Service improvement manager	structured wave 2
20	10/09/2011	JIMT50	Transformation programme director	structured wave 2
21	10/09/2011	MNMD80	Estates manager	structured wave 2
22	11/09/2011	UVME120	Service design manager	structured wave 2
23	15/09/2011	GHCT40	Deputy director of service development	structured wave 2
24	15/09/2011	QRLH100	Head of primary care	structured wave 2
25	16/09/2011	LJHV70	Estates project manager	structured wave 2

*Table 3.3: List of the interviews*

### 3.5.3. Survey

A survey instrument was designed to test some of the findings generated from the interviews. The researcher developed the survey empirically, based on a review of the literature, as well as from a series of structured and semi-structured interviews. Four constructs were developed: i) strategic decision-making processes and mechanisms (3 items); ii) public consultation processes (4 items); iii) business cases processes (3 items); and iv) implementation and results perceived (4 items) (*c.f.*: Appendix 2: Survey Instrument).

The survey was developed and piloted by 10 experts from the organisation, who had participated in the interviews. Adjustments to the instrument were made accordingly; the main changes were around item reduction and item aggregation. Reviewers suggested that a shorter survey would be beneficial to increase the chance of return, and, where possible, it was requested that items be combined together. Once the survey had been amended, it



was uploaded onto the local IT system and an invitation was sent, by email, to a list of 140 carefully selected, internal and external individuals, who had recently been involved in new infrastructure development processes. With a ratio of 60.7% completed and returned survey, the response rate was considered high, compared to what the literature reports (Field, 2009). The survey remained open for 1 month, between May and June 2010. Two reminders and a supporting email from a senior management team member enabled the collection of 85 valid responses.

SPSS was used to analyse the data. Items were rated on a 5-point Likert scale (1= strongly disagree to 5= strongly agree). Chapter Four reports the descriptive results, the reliability, validity analysis, ANOVA, Factor Analysis and Multiple Regression Analysis outcomes, to address the associated research questions. According to Kass and Tinsley (1979), the sample size was appropriate; accounting for between 5 and 10 participants, per variable, is acceptable for this type of analysis. Therefore, a sample of between 70 and 140 is suitable.

#### **3.5.4. Observations**

The researcher was granted formal and full access to the organisation for the duration of two years (or about 450 working days) which was spent recording observations, participating in meetings and working within teams involved in the new infrastructure development. This full access also supported the design of the research and the analysis of the findings. Observations form part of the action research data collection techniques; they can be tacit or more formal when recorded and analysed. Over the two years, the researcher kept an extensive diary, developing the richness of the observations. This has helped in understanding the social interactions that could not have been gathered otherwise. However, no findings in this monograph exclusively rely on observations; they have mainly had a data triangulation purpose (Modell, 2009), and, therefore, will not be detailed any further.

#### **3.5.5. Workshops**

As previously mentioned, the development of the models and Lean thinking techniques have followed a Plan, Do, Study, Act systematic cycle. In order to design, validate, populate and solve the models, a series of workshops, or focus groups, were organised with the different groups of stakeholders – similar to the research techniques used by

Waterworth and Eldridge (2010) and Waterworth and Eldridge (2011). In this section, the data collection and analysis of the three different models will be reviewed.

### 3.5.5.1. MCDA

To develop the MCDA model, a series of eight workshops, attended by the different groups of stakeholders, was organised. To reach to the consensus, four iterations of the models were necessary, as is detailed in Chapter Five. Altogether, five workshops were held to identify and agree on the criteria and sub-criteria. Furthermore, three assessment workshops were organised with the decision-makers, to input the data into the model and discuss the outcomes. Table 3.4 below provides further details.

#	Date	Participants	Type	Outcomes
0	12/07/ 2010	Decision-makers	MCDA development	Initial workshop
1	23/07/ 2010	All stakeholders	MCDA development	Model construction
2	05/08/2010	All stakeholders	MCDA iteration	6 criteria and 21 sub-criteria
3	20/08/2010	Team of experts	MCDA iteration	7 criteria and 28 sub-criteria
4	27/08/2010	Team of experts	MCDA iteration	Consensus established
5	08/09/2010	Decision-makers	ER assessment	Initial assessment
6	15/09/2010	Decision-makers	ER assessment	Model solved
7	10/11/2010	Decision-makers	AHP assessment	Model compared

*Table 3.4: List of the MCDA workshops*

To solve the MCDA model, two techniques were used and compared: ER and AHP. ER was facilitated by the IDS software, and AHP with MIR (Make it Rational) software. Further workshops were set up, allowing the comparison of the different modelling techniques and establishing whether ER or AHP was the most relevant.

### 3.5.5.2. Benchmarking and the Performance Framework

To develop the performance framework and undertake the Benchmarking, a series of nine workshops, attended by a group of 10 experts, was organised. To reach to the consensus, iterations of the models were necessary. Furthermore, three assessment days were organised with the Benchmarking partners in the UK and the US. The decision-makers were actively involved in the data collection and analysis. Three other workshops were organised to solve the models and discuss the outcomes. Table 3.5 below provides further details.

#	Date	Participants	Type	Outcomes
1	04/03/ 2011	Decision-makers	Framework	Model development
2	14/03/ 2011	Decision-makers	Framework	4 criteria 39 sub-criteria
3	21/03/2011	Team of 5 experts	Test	Pilot
4	21/04/2011	Team of 10 experts	Benchmark 1	Site visit
5	22/04/2011	Team of 10 experts	Benchmark 2	Site visit
6	10/05/2011	Researcher	Benchmark 3	Site visit
7	05/09/2011	Decision-makers	Assessment	Models solved
8	12/09/2011	Decision-makers	Assessment	Models solved
9	19/09/2011	Decision-makers	Assessment	Models compared

*Table 3.5: List of the Benchmarking workshops*

### 3.5.5.3. QFD

To develop the QFD framework, a series of eight workshops, attended by the different groups of stakeholders, was organised. To reach a satisfying level of detail to support the design decision-making process, two iterations of the models were necessary and the results are presented in Chapter Five. The decision-makers were actively involved in the data collection and analysis. Table 3.6 below provides further details.

#	Date	Participants	Type	Outcomes
1	10/07/ 2011	Decision-makers	QFD presentation	Training & inputs
2	23/07/ 2011	Decision-makers	QFD development	Initial model
3	05/08/2011	Decision-makers	QFD iteration	Iteration
4	24/08/2011	Decision-makers	QFD iteration	Iteration
5	26/08/2011	Decision-makers	QFD iteration	Iteration
6	30/09/2011	Decision-makers	QFD assessment	Assessment
7	21/10/2011	Decision-makers	QFD assessment	Model solved
8	18/11/2011	Decision-makers	QFD assessment	Model solved

*Table 3.6: List of the QFD workshops*

### 3.5.6. Secondary Data

Finally, although the majority of this research relies on primary data, the researcher had access to a substantial amount of secondary data from internal documents and reports, meeting minutes and other surveys collected and generated by the organisation. Minutes from the bi-monthly Strategic Estates Committee (SEC) meetings were used and analysed. Process data was also generated from the reports put together by this committee. Furthermore, data generated by the public consultation (PC) was used and analysed to support the findings. For instance, the results of a large survey (N=3055) were used to support the assessment of the alternatives within the MCDA models.

### 3.6. Conclusion

Maylor and Blackmon (2005, p.156) said “*the research approach should always be consistent with the philosophical assumptions, methodology, method and the research questions*”. In this chapter, the multiphase research, composed of an exploratory sequential design and of an embedded-experiment variant design, has been detailed and justified in relation to the research questions. Moreover, the consistency between the different concepts was logically linked and justified. The chapter started by discussing the different philosophical assumptions and analysing how they influence the scientific paradigms. Then, the researcher explained why pragmatism was borrowed and how it is associated with mixed-methodology research. The chapter then ended with the description of the different tools and techniques used to collect and analyse the qualitative and quantitative data. In order to study this phenomenon, which had not been studied before, it was relevant to use mixed-methodology techniques to understand the issues in depth, analyse the root-cause problems and develop appropriate models. Thus, the researcher believes that this methodology was the most suitable to use in order to develop conceptual frameworks, so as to make a contribution, for both practitioners and scholars, within the Lean construction field. Finally, Figure 3.6 below summarises the logic and robustness of the methodology, by linking the interactions between the elements of this research.

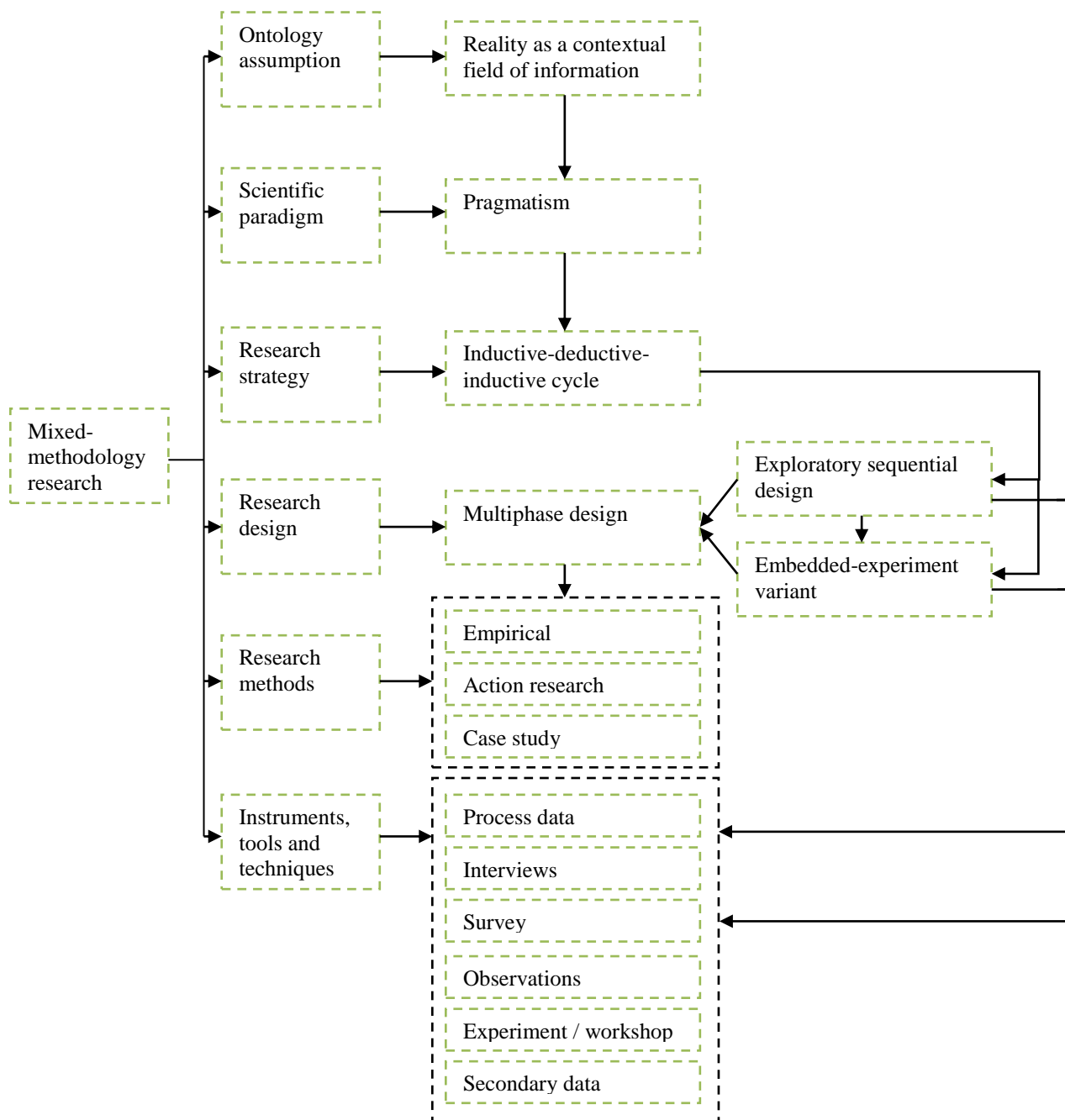


Figure 3.6: Logic of this mixed-methodology research (adapted from De Moraes, et al. 2010)

## **4. Chapter Four – Research Findings**

### **4.1. Introduction**

This chapter sets the scene and boundaries for this research findings and discussions. It presents the first set of findings by exploring the problems associated with the planning and design of new healthcare infrastructure. This is supported and achieved by analysing the semi-structured and structured interviews, process data and the survey, as detailed in Chapter Three. By triangulating the different analyses, the objectives of this chapter are to: i) explain the problems related to new infrastructure development (NID) processes within the healthcare organisation studied; ii) develop the root-cause analysis within the planning and design phases; iii) test whether or not the different groups of stakeholders, involved in the process, have similar perceptions of the problems; and iv) measure to what extent the problems identified impact the infrastructure performances. This chapter will set the foundations for the development and experimentation of solutions, which will be presented and discussed within the experimental findings chapter – Chapter Five. To contextualise the research, firstly, this chapter provides some background on the organisation, explaining in more detail the activities involved within the planning and design processes, using some qualitative findings. Secondly, the chapter reports on the quantitative findings of the process data analysis, and then, develops and categorises the issues by analysing the interviews, which is achieved through thematic analysis. Finally, it quantitatively analyses the survey that was developed based on the qualitative findings, using ANOVA, Factor Analysis and Regression Analysis, to fulfil the aims previously stated.

## **4.2. The Partner Organisation**

### **4.2.1. Strategy and Structure of the Organisation**

At the time of the research and up until April 2013, the partner organisation commissioned a full range of clinical services throughout 58 community-based health services, across 100 sites and within 30 political wards, each of them with a population of around 17,000 inhabitants. The total catchment area represents approximately 500,000 people, living in both urban and rural areas; a significant proportion of the population belonging to disadvantaged, ethnic minority groups (Bamford, 2009; CIAMS, 2010). The organisation had set particular priorities: reduction of health inequalities, improvement of the clinical quality and safety, as well as increasing patient experience, through the enhancement of efficiency and effectiveness performances (Bamford, 2009; Dehe *et al.*, 2011). This could be accommodated by a move towards a more community-based care provision, as specified within Lord Darzi's report (2008). However, to achieve these objectives, the organisation will have to undertake extensive infrastructure development over the next decade, but lacks mechanisms, systems and procedures for overseeing their planning and ensuring that the organisation's future strategic needs will be achieved, as it will be demonstrated in this chapter. Moreover, at the time, no formal planning or modelling tools were available within the organisation, to plan and design infrastructure and to respond to the service integration changes. In an interview, ABHH01 clearly explained that *"we would need to have in place some sort of tools to support the planning and the coordination of the infrastructure design and development, which would improve the delivery and the management of these complex infrastructure programmes. The idea would be to have models and frameworks to optimise the decision-making processes; for instance, models to identify the optimum location, the optimum service portfolio and how the service integration could take form within the new infrastructure"*.

From 2006, as explained by the board of directors, the strategic objectives were clear: i) to reduce the health inequalities; ii) to modernise the services; and ii) to bring the health and social care services closer to the local population. Whilst working towards these objectives, the organisation started to develop several brand new health infrastructures in the most deprived area of the district, with these programmes rapidly becoming an important priority (CIAMS, 2010). The majority of these centres will include: GP practices, end of life care, local authority and third sector services, dental practices,

community services, physiotherapy, elderly day services, cancer support and some of the outpatient, diagnostic and treatment services, currently provided in the acute sector, as reported in internal documentation. These new healthcare centres will serve the whole community by meeting their needs. *“If we have the right cartography and network of infrastructure, we can improve our healthcare services, reduce the number of patients in hospital, so reducing cost and deploying more effective services,”* explained the director of primary care and public engagement (ABHH01).

This organisation encompasses two geographic areas. A couple of years ago, four trusts merged into one organisation. The merger took place to create synergies between the organisations and to start improving the service quality across the region. *“Our roles now are to understand the health and social needs within the two patches and provide the right services, in order to reduce the health inequalities, with the objective to increase quality and reduce costs, at the same time, by developing synergies”* said one of the organisational development managers (CDJC02). However, a direct consequence of this merger was that *“the organisation had inherited an ageing stock of 18 freehold properties and leaseholds in a poor standard of repair. Most of the freehold properties were not designed to accommodate the growing range of services now being delivered in community settings [...] which require urgent attention, despite the past five years of hard work”* explained an estates manager (FEJW03).

The budget for 2009/10 was about £900 million to implement 10 commissioning programmes, identified by the board of directors, in order to support the strategic plans and to buy health services for the community. In 2009, substantial changes took place within the organisation, most notably the separation between the provider and commissioning functions. The rationale was that, in order to improve the quality of healthcare services, the organisation needed to create an internal and formal supplier/customer relationship. *“The objectives are to provide world-class health services that improve the community healthcare and well-being, but to achieve that, the organisation must be equipped with the right organisation and this separation is the natural step [...]. However, we will need the right infrastructure too, which, if you ask me, it is not currently the case”* said an organisation development manager (CDJC02). These findings also give empirical credibility to the assumption made regarding the application



of RBV within the new healthcare infrastructure – without fit for purpose infrastructures to deliver the services, it becomes challenging to develop a world-class organisation.

#### **4.2.2. Current Infrastructure Projects**

At the time of this research, nine priority projects were progressing; all at different stages of the life cycle and all with different issues. However, the site selection was a primary and recurrent issue. For instance, in March 2010, it was reported, by one of the estates managers in the SEC (Strategic Estates Committee) meeting, that *“for the F and M projects, there was a need to start as soon as possible; otherwise, we could be in danger of losing the site identified. [...] NW project had stalled due to an unavailable piece of land. [...] For the C project, a piece of land was bought but there were concerns about the lack of agreement regarding the design between the partners. [...] Finally, for the K project, the public consultation had to be extended by two or three months to improve the transparency of the very sensitive decision-making process regarding the site selection, but also the service design”*.

ABHH01 explained that *“currently, there are a couple of projects, more or less strategic, and P, C, and K are the priorities. Obviously, it is difficult to always run all the projects at the same time, as we are restrained by our available resources (i.e.: people and money)”*. Therefore, there is a need to do things differently. The Strategic Estates Committee (SEC) is responsible for overseeing and making recommendations regarding project selections and progress. At the time, the SEC was the main mechanism to monitor, control and recommend the choice of procurement, the site selection, the planning route and the basic design features, and the board of directors would make the decisions based on the recommendations. However, it was understood that the SEC recommendations needed to be structured around a framework, in order to support the final decisions more effectively. In an interview, it was explained that *“the overarching responsibility for the decision-making sits with the board of directors, and they make the final decisions, but what goes to them tends to be a recommendation, which is well argued, taking into account the views or the interests of the different stakeholders, which, however, unfortunately, is not always done with consistency and robustness”* (GHCT04).

### 4.2.3. Decision Objectives

As suggested in the literature, the NHS needs to increase its engagement with the local population, as there is a push towards more transparency. ABHH01 explained that *“the organisation is trying to involve the public and the local community more and more in the infrastructure development process, and, to some extent, in the decision-making. Recently, we have asked our stakeholders their views on a range of potential services to be deployed in future developments. We asked for views on proposals for a new surgery in the R centre, the creation of a practice and walk-in centre at the HB Centre, and on the improvements made to adult mental health services across the district. However, the plan, in the near future, is to consult the local population about the provision of a new community hospital in the I area, and in the location selection for the health and wellbeing centre in K”*. Therefore, this suggests that there is a need for more consistency, transparency, robustness and engagement in the decision-making process, but that it lacks mechanisms. The involvement of multiple stakeholders, for the site selection and the design decisions, becomes a requirement that needs to be evidenced in the full business case.

### 4.2.4. The Planning and Design Processes through the Business Cases

Any development requiring funding, irrespective of its purpose or procurement route, must be supported by thoroughly robust business cases. It is not possible to prescribe an ideal level of detail for the business case's content, since it depends on the scale and complexity of the scheme. However, there are four key stages within this process: i) the need analysis; ii) development of the outline business case (OBC); iii) development of the full business case (FBC); and, finally iv) the financial close, before construction can start. This encompasses both the planning and design phases and is in line with the model described in the literature.

#### *The Need Assessment and Analysis*

This is the trigger point at which the need for a new service is recognised and demonstrated, through a project inception, a pre-public consultation, a review of the primary care strategy and an assessment of the health impact. The Commissioning Strategy Board will then need to prioritise the sites for redevelopment and identify new potential sites. The decisions will be based on the following key criteria: i) a non-fitness

for purpose of the exciting local infrastructure; ii) a recognition of the under-served local populations; and iii) a desire for an integration of services. For each selected project, an outline business case will then need to be developed.

### ***Development and Submission of the Outline Business Case (OBC)***

The outline business case is the initial report that needs to be submitted to the board of directors. Different parties or stakeholders are required to assess and agree, in principle, on the plans ahead, as part of the planning process. The outline business plan can be established through the design philosophy of the future infrastructure, and the identification of the supply chain. Obviously, the board of directors will look at the results from the need analysis, and, in particular: i) the condition of the current infrastructure; ii) the demonstration that the area is underserved, by mapping the area of health inequalities and identifying the lack of services or quality level; and iii) by assessing the opportunities for co-location of services. Moreover, the OBC could provide further information to enable the board of directors to speed up their decisions, by including: i) a prediction of future population growth; ii) evidence of consultation processes; and iii) the description of the supply chain and its procurement route, demonstrating feasibility.

However, ideally, the OBC could give further information regarding the scheme itself, by: i) detailing the scale of the project; ii) listing the services to be provided; iii) identifying other potential occupants of the new infrastructure; iv) estimating the facility' requirements (size, and number clinical rooms); v) stating the site location and explaining how the decision was made; vi) demonstrating value for money and financial viability of the project; vii) justifying the procurement route, as well as the developers and contractors; and finally, viii) presenting a detailed plan with an expected time frame. Once the OBC has been approved, the full business case can then be developed. However, it was noted and reported, within the particular organisation studied, that the OBC was often submitted without all the details, which led to the decision-makers having to deal with a lot of uncertainty.

### ***Full Business Case (FBC) Approval***

The full business case will confirm and update the details contained within the outline business case, and will also include a number of key processes in the project. At this stage, Estates, Finance, Infection Control, Primary Care, the architects and the main contractors

will need to work together to develop the FBC and to support the design. The full business case needs to: i) confirm the OBC; ii) detail the operational systems considered in the design; iii) confirm that the design takes full account of the healthcare building regulations, fire code and health and safety regulations, as well as the security policy; iv) detail the IT system; v) demonstrate value for money; and vi) provide full details of the public consultation results and outcomes. Once the full business case has been developed, it should be formally submitted to the appropriate board for approval, in order to obtain the final go-ahead through the financial close, and then the construction can begin.

Despite the clear, prescriptive milestones to respect, the process boundaries are weakly defined. The role and responsibilities of the different teams (*i.e.*: Estates, Primary Care, Service Design and Finance) are inadequately set out within the new infrastructure development process, creating barriers to effectiveness and efficiency; there is a lack of synchronisation between the teams, and the departmental strategies mismatch each other. JIMT05 explained *“if we don’t involve Estates and all the partners right at the beginning, I think it is a poor show, because they will have a valid reason why things might need to look a lot different. So, we have to strengthen the relationships between Estates, Service Development and Public Health, as well as to raise the profile of Estates”*. This will be analysed further in this chapter through the thematic analysis.

In this section, the organisation was described and the processes for developing new healthcare infrastructure identified, as Figure 4.1 summarises. There are three clear steps before financial close and the start of construction: need analysis, outline business case and full business case. These processes encompass the planning and design phase. However, they seem to be weakly managed as processes.

Need analysis	OBC	FBC	Financial close
Project inception	Design philosophy	Confirm the OBC	Property sales
Primary care strategy review	Public consultation results	Final design of the infrastructure	Lease plus agreements
Health impact assessment	Roles and responsibilities	Detail the service portfolio	Payment mechanisms
Public consultation	Supply chain identified	Demonstrate value for money	Construction
Site identification	Seek approval	Seek approval	

*Figure 4.1: Process through business cases*

This section has highlighted the processes and some of the issues that the organisation is facing within the new infrastructure development. The following part will present, in more depth, the problems behind the processes. This will be achieved by analysing and triangulating a large set of primary data.

### **4.3. Root-Cause Analysis**

Having established and contextualised the organisation's situation, it is relevant to investigate and discuss the issues further, identifying some of the root-cause problems that this healthcare organisation was facing.

#### **4.3.1. Problem Definition and Measurement**

##### **4.3.1.1. Define Phase**

At the time of this empirical action research, from 2010 to 2012, the organisation had an infrastructure portfolio comprised of 53 properties, made up of 18 freehold properties, 35 leasehold properties and 4 properties occupied under other forms of agreement. These 53 properties provided more than 56,000 m<sup>2</sup> of space. Moreover, the estates had a net book value of more than £41 million, and, in 2009, the capital charges and depreciation costs were estimated at £8 million. During the same period, the organisation spent almost £5 million on rent for the use of leasehold property. Since 2004, the organisation had commissioned 21,000m<sup>2</sup> of new community healthcare accommodation on 11 sites (CIAMS, 2010).

Although there are national mechanisms in place to control these major investments and developments, such as: PPP, PFI, Procure 21 and LIFT schemes (c.f.: Groome, 2010), there were no systematic, transparent processes in place at local level, allowing the different mechanisms to be optimally used, according to the specific nature of a scheme. Furthermore, culturally, the processes were not revised or improved. JIMT05 explained that *“we need people who challenge the status-quo and the system on those kinds of things [the infrastructure development process] and are not afraid to do it to generate some improvement”*.

The national mechanisms, such as: i) Health Building Note (HBN) 11-01; ii) Department of Health guidance; iii) the PFI and LIFT schemes, or; iv) ProCure 21, potentially, are extremely powerful, but needed to be embedded within less prescriptive and overarching bespoke methodology, fitting the local requirements. LKJW06, an estates manager, explained that *“there are different procurement routes that can be taken for developing a new infrastructure or a refurbishment: the Third Party Development (3PD), ProCure 21 and the LIFT route. We must identify which routes will best suit our needs for each project”*. Healthcare organisations face different issues, having diverse types of resources and skills available, and, although it is recognised that national guidance can be extremely effective, this is not always the most appropriate or relevant method for a particular case within a specific setting. *“The national guidance is heavy and does not help in speeding up the process”*, said one of estates project managers (LJHV07). It was felt that the prescriptive guidance from the DoH needed to be integrated with a more flexible and bespoke methodology, supporting the organisation to optimise its development processes.

LIFT is Private Public Partnership (PPP) that was established by the DoH in 2000. It is a joint venture between a private sector consortium holding 60% of the share, and the remaining 40% being equally shared between the local NHS Trust and a national joint venture (c.f.: Kagioglou & Tzortzopoulos, 2010). *“From my point of view, the LIFT buildings allow us to transfer the risks, ensure the degrees of commitment to respect the specifications from the different players, and support us in demonstrating value for money and affordability,”* said an estates manager (LKJW06). However, he also explained that *“it is much more expensive to build than a 3PD, and, during the 25 years of leasing, LIFTco will be responsible for maintaining the infrastructure while the organisation will*

*pay a rent". GHCT04 pointed out that "3PDs don't seem that long in getting to financial close; they don't have as many hoops to jump through".*

However, it was established that whatever the route selected, ad-hoc methods led to inefficiencies in the planning, design, construction and management of the new healthcare infrastructure (c.f.:Alves *et al.*, 2012). LKJW06 explained that *"the main issues are around the time it takes from planning to completion. We need to find a solution to be able to reduce this cycle time"*. This is illustrated by the long development cycle time, *"which can be up to 15 years, from the conception to the completion, for some projects"* (CDJC02).

Following this rationale, the researcher collected data, in order to measure the process performance from planning to completion of new infrastructure development, in this healthcare organisation.

#### **4.3.1.2. Baseline Performance**

To support and triangulate these arguments, quantitative data has been collected regarding the last 30 schemes, developed or under development, in the district. Table 4.1 below shows the cycle time for these 30 schemes, based on internal intelligence, the data available and experience from the Strategic Estates team. Table 4.1 shows some of the expected finish dates that were established in collaboration with the teams involved, considering the information available up to autumn 2011. It is recognised that it may not be entirely accurate due to the uncertainty associated with the restructure of the NHS. However, it was acknowledged as realistic when the table was compiled and verified.

Scheme	Type	m2	Starting year	Completion year	Cycle time *	Planning time *	Design time *	Construction time *
WG	LIFT	5450	2000	2007	7	3	2.75	1.25
LM	LIFT	850	2000	2006	6	4	1	1
TM	LIFT	915	2000	2008	8	5	2	1
CH	LIFT	1400	2000	2015	15	10	3	2
C	LIFT	3200	2001	2010	9	5	2.5	1.5
HMP	LIFT	1450	2001	2007	6	2.5	2.5	1
HB	LIFT	2435	2001	2008	7	3.5	2.25	1.25
UH	LIFT	2100	2001	2008	7	4.5	1.25	1.25
SH	3PD	1200	2002	2011	9	4	3.5	1.5
NW	3PD	800	2002	2017	15	10	4	1
LHL	3PD	900	2002	2007	5	2	2	1
R	3PD	3190	2003	2009	6	2.5	2	1.5
HRM	LIFT	700	2003	2013	10	4.5	4.5	1
M	3PD	670	2003	2012	9	4	4	1
FM	3PD	800	2003	2012	9	4	4	1
WC	3PD	1880	2003	2008	5	2	1.5	1.5
B	LIFT	2300	2003	2014	11	6	3	2
SM	3PD	1000	2004	2010	6	3	1.5	1.5
QH	LIFT	760	2004	2015	11	7	2.5	1.5
RC	LIFT	400	2004	2016	12	8	3	1
P	LIFT	900	2004	2014	10	6.5	2.5	1
F	3PD	780	2004	2007	3	1	0.5	1.5
SM	3PD	2491	2004	2008	4	2	1	1
AS	3PD	1390	2004	2009	5	2	2	1
K	LIFT	5000	2006	2015	9	5	2	2
U	3PD	650	2007	2016	9	6	2	1
CM	3PD	600	2008	2011	3	1.5	0.5	1
NSS	LIFT	1000	2010	2014	4	2	1	1
LG	LIFT	450	2010	2014	4	2	1	1
TM	LIFT	800	2010	2015	5	2.5	1.5	1
		46461			<b>7.63</b>	<b>4.17</b>	<b>2.23</b>	<b>1.24</b>

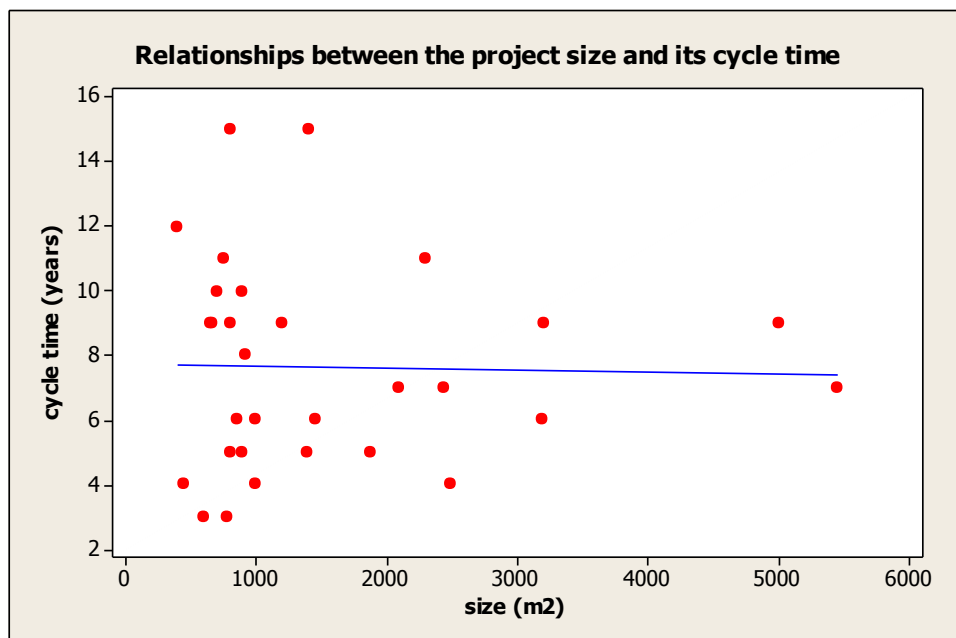
\* Unit of analysis is the time in years with the data available in 2011

Table 4.1: Data of the last 30 schemes

In Table 4.1, two of the assumptions and findings discussed previously are confirmed: i) that the development of new infrastructure is a long and complex process; and ii) that it is difficult to control the process, as illustrated by the high variation (*c.f.*: Deming, 1986).



It is noted that the cycle time is long and subject to substantial variations, which makes the process difficult to control. The planning and design phases are the main variables and the most uncertain phases in any project. The average time spent on planning, in years, is 4.17 and design is 2.23; whereas, the construction phase averages time is 1.24 years, because it is less subject to variation and more predictable, making its performances more satisfying and comparable to the benchmark. Moreover, there are no relevant relationships or correlations between the development cycle time (or construction cycle time) and the building size (in m2), as is generally observed in the construction industry (*c.f.*: Cain, 2004; Myers, 2008). The scatter plot in Figure 4.2 and the Regression Analysis confirm the previous statement.



*Figure 4.2: Relationships between the project size in m2 and the construction cycle time in years*

There is no evidence of a relationship between the two variables, as the  $R\text{-sq} = 0\%$  shows. This fact became useful when challenging the stakeholders and process owners' perception, as they strongly believed that the size of a project and its development cycle time were irrevocably linked. MNMD08, an estates manager, said "*generally, the construction process depends on the complexity and size of the building, but, up to starting to build, I would say, in my experience, it is a three to five year process before you actually start on site.*" This led the researcher to feel reassured that the main

improvements were going to be generated from improving the planning and design phases in the first instance, which corroborates with the findings described earlier in this chapter.

Before investigating the root-cause problems further, understanding the reasons why the planning and design phases are long and vary substantially between projects, and assessing how improvements can be implemented, the average performances of the development process are presented below, and the baselines performances are also established.

#### 4.3.1.3. Average Performance

In Figure 4.3 below, a huge variation between the different 30 schemes can be seen. From the conception to the completion phase, it was recorded that the fastest development was completed in three years and the longest in 15 years (Range=12 years).

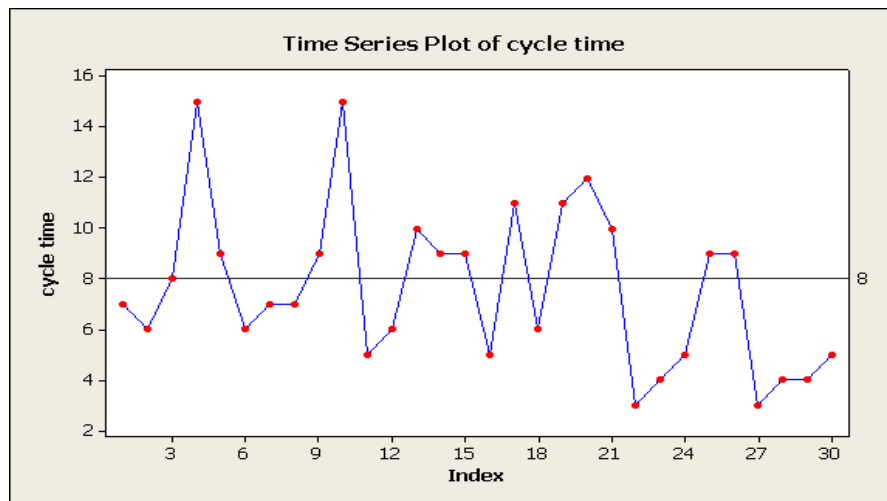
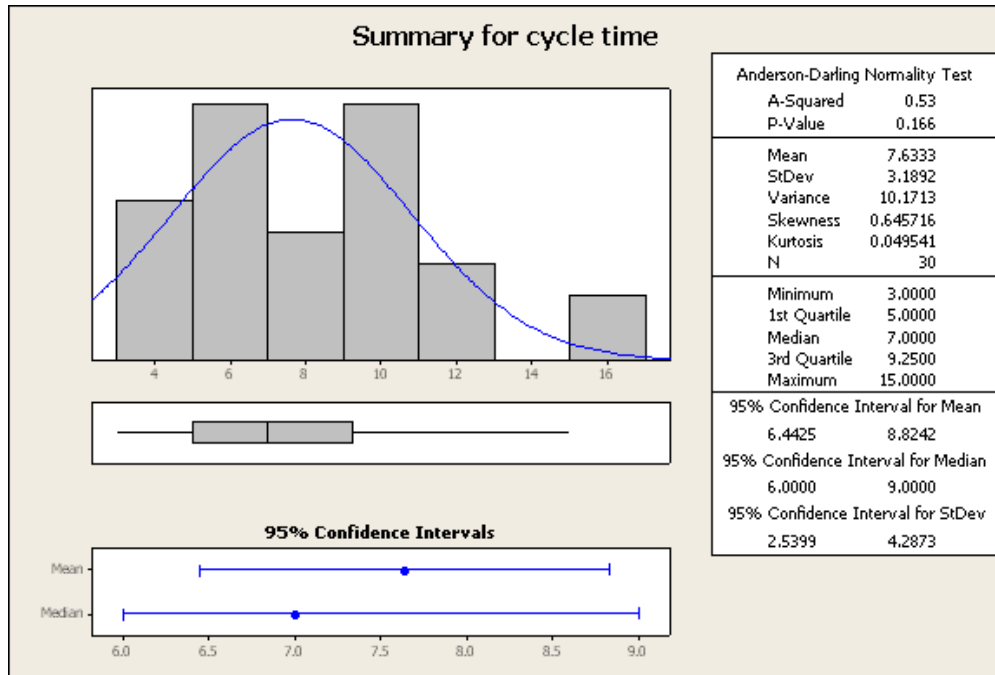
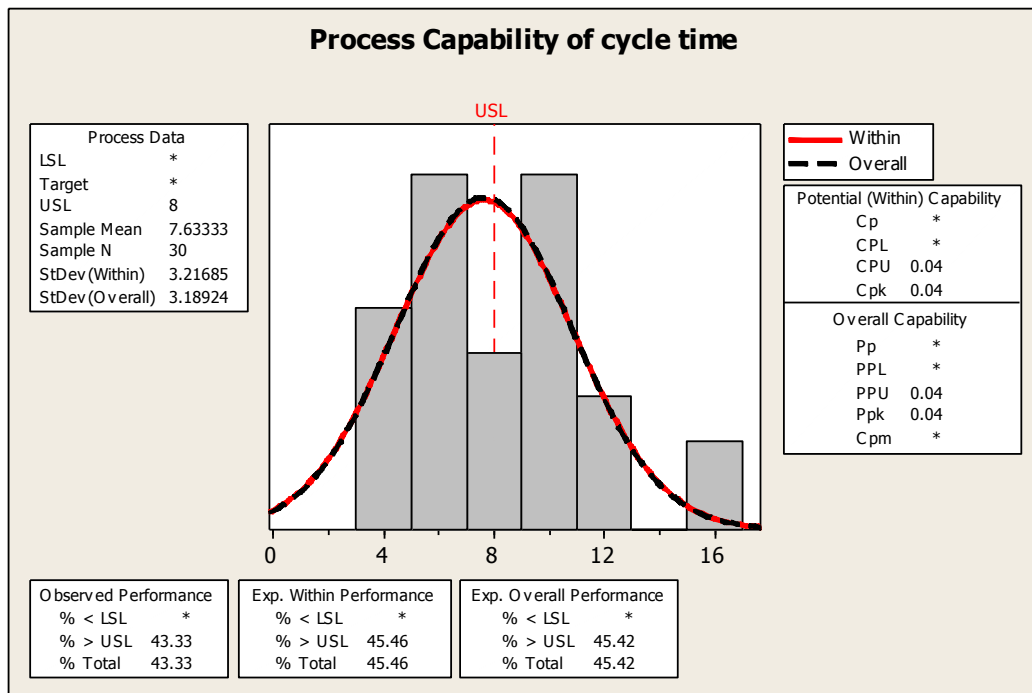


Figure 4.3: Cycle time variation

Based on the available sample of 30 schemes, it has taken an average of 7.63 years (between 7 and 8 years), with a standard deviation of 3.19 years, to complete new infrastructure, as summarised in Figure 4.4 below. It is also relevant to understand that 45% of the schemes have needed more than 8 years to be completed ( $P(X > 8) = 45\%$ ), as is shown in Figure 4.5. From the interviews and secondary data collected, it was clearly recognised that 8 years was considered, by the stakeholders and the public, as the maximum acceptable and reasonable cycle time for developing new infrastructure (upper specification limit), and that, ideally, the total cycle time should be between 3 to 4 years.



*Figure 4.4: Cycle time distribution*



*Figure 4.5: Process capability*

The baseline performance will also help to quantify the improvement and to understand to what extent the implementation of the solutions will, over time, deliver an efficient and

effective output, meeting both the stakeholders' and the public's requirements in terms of cycle time, fitness for purpose and innovation level.

This section presented the process data analysis. By triangulating the results from the interviews and process data, it will enable the researcher to build validity in the root-causes analysis. The following section presents the qualitative findings, exploring further the issues related to the weak process performances in the planning and design phases.

#### **4.3.2. Understanding the Issues: a Thematic Analysis**

In order to grasp further the complexity of the problems, a total of 25 formal interviews took place. The interviews were designed to gain an understanding of the major issues the organisation was facing, preventing effective and efficient new infrastructure development processes. It became rapidly clear that there were no obvious solutions, as it was not an evident problem. As FEJW03 said *"it is difficult to highlight the reasons for the weak performances; otherwise, we would have sorted this issue a long time ago. But, I guess it is about having everyone going in same the direction. Sometimes, projects stall because Finance disagrees, or Primary Care sees it differently, and so on [...]. Sometimes, it is because we have not found a site for the building. Or, we need to wait until the public consultation is finished, or wait for the board approval, and so on [...]. It means that we go ahead when everyone is happy and we can move forward, but it is difficult to predict"*. OPJB09, a service improvement manager, even described the new infrastructure development as the *"poisoned chalice [...] a job too difficult to contemplate, with no comprehensive processes or procedures in place, which had previously led to costly incidents"*. Therefore, the thematic analysis was undertaken to establish a framework, inspired by Ishikawa's categorisation of the root-causes. Analysing the interview data, the researcher was able to categorise the problems under five issues: i) methods; ii) complexity; iii) communication; iv) organisational; and v) environmental.

##### **4.3.2.1. Methods Issues**

The first type of issues identified was associated with the methods. Methods issues are related to the procedures and processes problems, identified during the data analysis. Five key issues have been categorised.

### ***Activity Based Perspective (from an activity based to a process management perspective)***

Firstly, as the theory suggests, in order to gain in efficiency and effectiveness, it is useful to take a process perspective and to move away from activity based management. As previously described, the planning and design processes are not visible; they are hidden within the three steps: need analysis, outline business case and full business case, in which the activities are included, as Figure 4.1 showed. To illustrate this concept, OPJB09 explained *“it takes an inordinate length of time – ten or twelve years – and activities seemed to stop and start, so there would be a couple of months of frantic activity, and then there would be nothing for nine months, and then there would be another couple of months frantic activity”*. In this particular case, as described by the interviewee, the flow of work is not levelled.

Moreover, as it was clearly suggested above, through several quotes from interviewees, there were no standard procedures in place to support the decision-making process within the planning and design of new healthcare infrastructure (other than the national guidance), directly impacting the site selection, service design and infrastructure design, leading to this activity based perspective. OPJB09 said that *“it seemed to consist of small bands of people, sat in darkened rooms, coming up with an idea, and then saying: ‘Right, let’s go ahead with this build and now we will go out and consult people and ask what they want’ [...]. Once they got the information back, they would then possibly hire an architect to actually design the building, based on some limited amount of input from consultation”*. This adequately illustrates the idea of activity based management, in which the overall process is not considered.

### ***Activities in Series not in Parallel***

As a direct consequence of the activity based perspective, it was established that, in both the planning and design phases, all activities are managed in series or in sequence. For instance, an activity would only start formally when its antecedent was achieved and validated. GHCT04 said *“I was just thinking about to what extent we can do things simultaneously. [...] To what extent could we programme an activity, so it was happening at the same time as something else? [...] You know, I already said, the consultation – what can we be doing at the same time if we are doing the public consultation? We don’t just want to be consulting the public; we should, at the same time, be working with the architects to plan and design, or whatever it happens to be”*. Undertaking activities in

series is a prudent approach to planning and designing, but creates massive delays within the system. If it is resource effective, it is far from being flow efficient. The research suggested that the rationale behind working in series is to reduce the financial risks associated with the project. However, it is believed that there are better ways to handle uncertainty and to assess risks, notably by reducing the information asymmetry and by being able to increase the rationality behind the decision-making processes.

### ***Lack of Innovative Thinking within the Process of Built Environment***

The group of stakeholders were aware of the inefficiency within the new infrastructure development process. However, the processes were not challenged to generate improvements. As JIMT05 stated *“the organisation needs innovative, committed people who think differently about infrastructure development and service delivery, and who are naturally good at partnership working”*. This is relevant to the implementation of process improvement. According to the interviewee, the lack of innovative thinking approach is linked with the silo organisation structure and the lack of collaborative practices, both of which will be detailed below. Furthermore, it was confirmed by OPJB09, who stated *“I don’t think we are particularly innovative at the moment. We tend to build whatever the architect tells us to build. We give them a rough specification and he knows roughly what is going in; however, he designs it the way he wants to a great degree, which is why we end up with funny designs, green glass and other odd things. I think we should be a lot more innovative in how we do it; we should also be a lot more strategic in how we do it”*. Moreover, QRLH10 could not agree more, saying *“I don’t think we are really anywhere near being innovative. We are still stuck in the same old [...]”*. This interviewee, however, justified this situation by a lack of money, *“I would ideally like to be as innovative as we can, but recognise that, often, innovation actually costs more. [...] A few years ago, we were cash rich, so we had the opportunity to be more innovative and maybe look at schemes which were environmentally-friendly and more fit for purpose. They cost more initially, but, over a period of years, actually, they would probably end up being cost effective”*.

### ***High Variety and Variations between the Different Routes Leading to Inconsistencies***

Another emerging issue was the fact that there were substantial variations between the different procurement routes, mainly 3PDs or LIFT, as also suggested by the process data analysis, preventing the organisation from developing standards and setting clear

operating procedures. CDJC02 explained *“I have been involved in different projects, often at the beginning or the planning phase, during the public consultation process. I was involved in the B project. This has been quite an exciting and rather successful LIFT project. However, the reality is that infrastructure development is a complex process – it takes us a long time from conception to handover [...]. There are several parties involved and they often have different agendas (i.e.: Primary Care, Estates, Service Providers, Clinicians), which makes it difficult to manage. And, there are several types of developments that do not follow the same route or process, (i.e.: LIFT or 3PD), which also can create confusion”*. This high amount of variety created some confusion for the providers and especially for the contractors. Having said that, OPJB09 suggested developing standard processes across the planning, design and construction of new healthcare infrastructure, irrespective of the procurement route, by working around standard design *“if we are designing standardised buildings, then the planning phase should be a lot quicker, the design phase would be a lot quicker and the construction phase would be a lot quicker, and they should all be cheaper as a result”*. It will be suggested further that, before reaching a full standardisation, the solution could be to reduce the variation through clearer boundaries definition of the process, business cases and roles and responsibilities.

### ***Lack of Ability to Use Information to Support Design Decision-Making***

The organisation had access to a large dataset, which could support the decision-making processes, as explained by TSJL11, *“we have access to a huge range of population data and information; for instance, the demographic profile, the deprivation for the area, and the health profile. We compile this data from the different sources: the GP practice, the Office for National Statistics and other marketing organisations. All this data helps us to understand the population profile”*. However, this was not used appropriately or consistently, as the interviewee admitted, *“we do not always use the set of data optimally. I think it depends on the site, the scheme, the procurement route and the timing. Sometimes, we pick a site very close to the previous healthcare centre. In that case, we do not really have to make many changes in terms of road, traffic, signage and so on. So, we do not really run complex modelling or simulation”*. It was discovered that Geographic Information System (GIS) output, lessons learnt and data collected during the public consultation were not consistently and formally fed back within the decision-making

process. This was due to the lack of non-prescriptive models and frameworks that would allow the decision-makers to gather the information, record it and process it to support any decisions.

In this section, it is argued and established that, as part of the methods issues, there were five main problems impacting upon the inefficiency and ineffectiveness of the planning and design of new healthcare infrastructure: i) activity based perspective; ii) activities in series; iii) lack of innovation; iv) substantial amounts of variety and variation, and; v) lack of ability to use information to support decision-making. Some of the problems could be explained by the complexity of the decision-making involved in the planning and design, or by the bespoke nature of the new infrastructure.

#### **4.3.2.2. Complexity Issues (*i.e.*: K project site selection)**

The second major element emerging from the thematic analysis, explaining the issues within the planning and design of new healthcare infrastructure, was the complexity involved within these processes. In order to illustrate the complexity in more detail, this section reports the case of a site selection of the major £15 million K project. Throughout this case, it will be explained why the high uncertainty and the current decision-making mechanisms add to this complexity, preventing effective and efficient planning and design. Furthermore, the public consultation (PC) has been identified as one of the most critical and complex, as well as added-value activity to optimise the processes (*i.e.*: site selection, service design or portfolio management); hence, it needs to be managed carefully by the organisation. There is a growing amount of pressure related to the increased level of accountability and transparency that the healthcare organisation is expected to achieve. In this section, the site selection will be detailed further and taken as an example.

#### ***Uncertainty and Risks within the Public Sector***

The decisions involved within the new infrastructure development (NID), especially within planning and design, are related to the determination of the building's purpose and priorities, identification of the financing scheme and procurement route, and selection and purchase of the land. Moreover, within the business cases, it is a requirement to provide details regarding the planning utilisation, the service design and the building design features, as previously explained. These decisions are complex and bespoke, with long



lasting consequences, and are associated with a high level of uncertainty. Therefore, making the wrong decisions could be detrimental to the organisation, so it is understandable that the decision-makers become very cautious. ABHH01 justified the complexity involved within the process, explaining that *“infrastructures are here to sustain over time, for 25 or 35 years. We need to be able to build infrastructure that is fit for purpose today, but which will be able to accommodate future health and social care service provision. [...] These are the reasons why it takes time, and we need to be sure before we make the decisions”*. On the other hand, OPJB09 explained that *“we are very afraid of making the wrong decisions, or making an incorrect decision, or making a decision that might be challenged later down the line. And, sometimes, that fear can almost freeze us into inertia, so that no decision is better than a bad decision in this complex environment”*. This could be explained by the lack of mechanisms allowing decisions to be made. As one might suspect, if the organisation was equipped with the right tools and processes to reduce the uncertainty, and had a mechanism to increase the rationality of the output, then the cycle time could be reduced.

### ***Meetings as Mechanisms to Make Decisions***

The most common mechanisms to make and justify the decisions are the meetings. However, it is suggested, in this thesis, that if the decisions are not structured around a model or framework to justify the rationale for the outcome, they might become problematic, due to the issues preventing rationality (*c.f.*: Pomerol, 2012). The organisation struggled in dealing with complex decision-making, and spent a considerable amount of time discussing the issues and postponing the decisions. As recognised by JIMT05, *“public sector decision-making takes a long time. There are so many things we have got to think about for the right reasons, and, sometimes, we are very good at not making decisions, and the number of meetings we go to, where we go round and round in circles and we don’t make a decision, is soul destroying. So, we could be a lot better at that”*. This quote illustrates the effect of complexity. The following paragraph will exemplify these notions, using the public consultation period as an example.

### ***The Public Consultation and Transparency – K Project***

As previously discussed, the transparency aspect must be satisfied because the organisation is increasingly accountable to the local population, which creates another layer of complexity and uncertainty, which, theoretically, is satisfied through the public

consultation. The public consultation is a requirement by law, and must last for at least three months in the case of new infrastructure development. The rationale behind it is that the organisation needs to engage with the public and local communities, in order to communicate the changes and collect the public voice. *“Our aim is to increase the engagement activities with the local population to improve health and well-being. The local population need to be further involved in the decision-making process. The NHS has to be more and more inclusive and transparent [...]. The planning phase of infrastructure development is a very good example, where the organisation needs to consult the local population, during at least three months, to identify the future service portfolio and the location of the new build,”* said CDJC02. In principle, this is an extremely powerful mechanism for collecting the ‘voice of the customer’ (VoC) and for being able to input their views into the planning and design phases (*c.f.*: Abdul-Rahman, *et al.*, 1999; Sharifi, Ismail & Reid, 2006). However, in its current form, it appeared prescriptive and too heavy for the organisation. During the public consultation, the organisation has two major sets of decisions to optimise and communicate: i) the site selection; and ii) the service selection and design. As one can imagine, it is this first decision which can lead to substantial problems and disagreements, thus slowing down the overall planning process. As long as the site selection has not been approved, it becomes difficult to move further on in the development process. Therefore, for clarification purposes, the following section will describe the site selection process for a strategic project run in 2010/2011.

The site selection for the K project had been a really complex issue within the planning process. First of all, the local population was genuinely concerned about the location of the future healthcare centre – this became the most important element of the project for them, and led to unconstructive debates during the public consultation and meetings, away from the subject of other core elements, such as the development and design of the future services provided. The organisation had become unproductive, unable to carry on with the planning and design processes whilst, for practical reasons, the location had not yet been determined. The project was losing pace and momentum, delaying the completion time. Four months of public consultation were set up to engage with the local communities using questionnaires, focus groups, meetings and presentations, in order to select between three sites. When surveyed, 92.6% (N=3055 responses) of the local population preferred Location A, compared with Locations B and C. However, at the beginning, decision-

makers firmly believed that Location A was the least optimum choice. Although Location A was the site of a current health centre, it was extremely limited in its potential compared to B and C. According to the feedback, the local communities were concerned about travelling difficulties, lack of public transportation to sites B and C, and with the element of safety. Although these issues were valid and had to be taken on board, they could not be appraised as rational, because improvements to the public transport system, the environment and safety would be expected if the new healthcare infrastructure was built in those places. Therefore, the questionnaire sent out by the organisation could not help in optimising the location decision, and could not be considered as either a rational or an informed process, this will be discussed further in Chapter Five and Six (Dehe, *et al.*, 2011).

According to the discussions held during the public consultations and several meetings, it was clear that the local population felt threatened by this substantial project, and felt that their health services were going to be taken away from them. This could explain why 92.6% chose Location A when asked for their preferred location choice between A, B and C. Moreover, in such decision-making, a large number of stakeholders were directly involved: the organisation's decision-makers, the provider's staff, the contractors, the council and local authorities, as well as the local communities and patients. All of those stakeholder groups had different personal and political interests leading to a conflicting site selection, which, in the past, has considerably slowed down the whole decision-making process, as some of the quotes from the interviewees suggested. This also justified the need to build a process to enhance the robustness and transparency of the decision-making by being inclusive, based on the consensus of the stakeholders, and to move towards an optimum and rational decision, as part of the overall improvement of the new infrastructure planning and design process (Dehe *et al*, 2011).

Through this example, elements of the complexity of the decision-making were illustrated. It was also suggested that, without a framework or model, it was difficult for the decision-makers to use the meeting as the main mechanism by which to deal with complex, bespoke and long lasting decisions with the associated high uncertainty (*c.f.*: Pidd, 2003). The following section provides further insight, explaining another set of problems that emerged from the data analysis, which are found within the communication.

#### 4.3.2.3. Communication Issues

From the research and the data collected, it was apparent that communication was an issue preventing the organisation in gaining efficiency and effectiveness during the planning and design of healthcare infrastructures. This section demonstrates that the lack of synchronisation between the different group of stakeholders and the lack of cross functional understanding of the process were barriers to improvement.

##### ***Lack of Synchronisation from the Different Groups of Stakeholders***

Earlier, it was suggested that lack of innovation was an issue, which could be a consequence of the lack of communication and synchronisation between the different groups of stakeholders involved within this complex processes. GHCT04 explained that *“if you talk to any of the departments or the groups of individuals within the organisation, or within the LIFT company or within property developers generally, everyone would be in favour of a process which made infrastructure development quicker, but it comes back to what I said earlier about when things get out of balance, the whole process gets skewed, so one individual, who jumps in with their big feet, and says: ‘No, I want it this way’, and has the power to be able to make that decision, is always going to be a cause of delay in the process”*. This is also associated with the lack of the alignment of strategies between the different functions (c.f.: Slack *et al.*, 2006; Boyer *et al.*, 2005).

##### ***Lack of Cross Functional Understanding of the Process***

It is suggested that the organisation works essentially in silo, and that there is a lack of understanding of other department processes, as several earlier quotes illustrated. Emphasising the project management and leadership could help in resolving this issue. UVME12 suggested that *“first and foremost, we need to have a programme manager, or a leader, who is going to be there for the whole duration of the project. So, I think, we have got to first identify how long the process is going to take and develop your programme team around that [...]”*. Here, it is recommended that it is the leader’s role to start developing cross-functional, working groups, and, to do so, a process perspective can be extremely relevant. Furthermore, UVME12 explained that *“we have got to get everybody in there starting from the same story; it has got to be consistent, it has got to be clear, it has got to be concise, and, within that, we need to have a very formal governance approach to it with set timetables”*. However, embedding this within the new

infrastructure development is a complicated process, as it touches upon not only process improvement, but elements of cultural change also.

In this section, two issues relating to the communication domain were discussed – lack of synchronisation between the different groups of stakeholders and lack of the cross functional understanding, which is directly linked with organisational issues: the fourth theme identified.

#### **4.3.2.4. Organisational Issues**

Another element impacting the effectiveness and efficiency was the structure and design of the organisation. For instance, QRLH10 did not think that the internal and external organisations' structures were in favour of, or designed appropriately enough, to deliver complex projects, explaining that *“there are barriers, organisational barriers, at the lower level, which actually stop us delivering complex projects”*. It was felt that much stronger roles and responsibilities, embedded within a project management approach, could be defined within the new infrastructure development processes, to prevent and overcome some of the structural and silo issues.

#### ***Lack of a Project Management Approach***

Despite the fact that several employees were PRINCE 2 trained, the project management principles were not applied within the new infrastructure development. QRLH10 explained that *“going back a few years, PRINCE was the hot topic in terms of project management [...] but, to be honest, it was never really embedded throughout the organisation, because, although some training was given, people just didn't have the time to actually implement that way of working. It was never embedded throughout the organisation, although there were attempts to do so. [...] but no – as an organisation we never really embedded that, and, I think, although I was quite resistant, I can actually see the benefits, especially within the new infrastructure development”*. Another interviewee thought that project management would be relevant. OPJB09 said *“I think project management techniques would help – they would have to be fit for purpose though, [...] because there was a danger, with project management, that all you do is manage projects; you don't actually deliver what you are due to deliver, but I would rather go down a bit further that way than where we are at the moment, which is no performance or project management, no robust planning, no holding to account when milestones aren't met, and*

*those kinds of things*". This interviewee suggested that working within a project management framework could support a process perspective and move away from the exclusive activity base work practice, generating some improvements.

### ***A Silo Organisation***

The 'silo organisation' is often referred to when describing the healthcare sector. However, this has led to a lack of process understanding at the organisation level. OPJB09 explained that *"silo working is evident in healthcare at every level, so, within the organisation, sometimes the functions don't work together as well as they could have done, particularly if we are looking at a cross departmental project, like infrastructure development, when you have got people from Estates, from Primary Care, from Finance, from Public Health and so on. They all have their own agendas and are looking after their own interest to an extent. Each of those groups of stakeholders will also work at their own pace and have their own conflicting pressures. [...] What we are very, very bad at, in this organisation, is getting a matrix style of working together, where people come and form a project team and they identify themselves as part of that team"*. The silo structure is clear within the organisation. The main consequences are related to process improvement. Unless there is a consensus and agreement on both, the problems and potential solutions, change and improvement are extremely difficult to start undertaking. Therefore, integration or synchronisation is needed, as ABHH01 explained *"I consider the main challenges to be the facilitation of a new model of integration. We have to consider it since the beginning; this was a key problem we had with the previous schemes. During the planning and design, we need to involve the different parties and we must take a patient perspective approach, if that makes any sense. It is by the integration that we will achieve more effective and efficient services, and improve the quality of our service and the fitness for purpose of our infrastructures"*.

### ***Lack of Definition of Roles and Responsibilities***

Another element which emerged from the analysis was the lack of definition of roles, responsibilities and boundaries within the new infrastructure development, which could be a direct consequence of the lack of project management practices and the silo structure described earlier. OPJB09 explained that *"roles tend to be quite vaguely defined within health, I think, apart from if you are looking at places like the estates team. You would think we would have pretty defined roles in infrastructure development. However, the*

*other stakeholders tend to have slightly less defined roles, particularly the internal ones. Primary Care team and Public Health, and those kinds of places, have different perceptions of what the roles are, especially when it comes to new infrastructure development*". This was felt, in most projects, as leading to ineffective and inefficient decision-making processes.

In this section, it was argued that lack of project management, the silo organisation structure and the lack of clear roles and responsibilities were barriers to effective and efficient new infrastructure developments. The last group of issues identified were related to the environment.

#### **4.3.2.5. Environmental Issues**

The last theme, but by no means the least that emerged to explain the issues related to new infrastructure development, was to do with the environment. The political aspect, the lack of cash available and the constant changes, led by the government, prevented the organisation from building longer term strategic and innovative processes.

##### ***Political Issues***

Political issues are everywhere and without doubt when an NHS organisation is planning to develop a new healthcare infrastructure. ABHH01 explained "*we always need to identify and decide what project must take priority. Having said that, there are political issues involved, and there are pressures coming from different parties, in some cases, which make our job more complicated (i.e.: C project)*". This interviewee recognised that the political issues are important external barriers, leading to long and uncertain cycle times.

##### ***Lack of Cash Available***

On several occasions, it was mentioned that projects could stall due to changes in the amounts of funds available. QRLH10 explained that "*up until recently, from this organisation's perspective, if we were cash rich and there was more money to be innovative and to invest, we would focus less on financial efficiencies and probably be more productive*".

### ***Lack of Stability***

The nature of the NHS is so that constant structural changes happen, which prevent gaining effectiveness and efficiencies within secondary processes, such as the development of new infrastructure. QRLH10 explained that *“if we were just assuming that things were as they were a couple of years ago, and we hadn’t gone through all this organisational change, then I think we would have definitely seen a shift towards improving the planning and design of new infrastructure – definitely!”* This interviewee also argued that *“it comes back to a cultural thing – constant change. There is a re-organisation, and then all of the various committees and processes are re-designed, and new people arrive, which often leads to a lack of understanding and creates confusion”*.

Having identified three environmental issues, they are believed to be national, structural problems and must be dealt with and resolved differently, and at a different level than that of this organisation. Therefore, although identified and acknowledged here, the researcher will not be considering them further in this thesis. Having identified five groups of issues emerging from the qualitative data analysis, and detailed the specifics of the problems, the next section will summarise these sets of findings.

#### **4.3.2.6. Summary of Qualitative Findings**

To sum up, in this section, five types of issues emerged from the qualitative, thematic analysis, categorised as follows: methods, complexity, communication, organisational and environmental. 16 issues were discussed and categorised, as Table 4.2 illustrates.



Understanding of the issues				
Method issues	Complexity issues	Communication issues	Organisational issues	Environmental issues
Activity based perspective	Uncertainty and risks within the public sector	Lack of synchronisation from the different group of stakeholders	Lack of project management approach	Political issues
Activities in series	Meetings, mechanisms to make decisions	Lack of cross functional understanding of the process	A silo organisation	Lack of cash available
Lack of innovative thinking	The public consultation and transparency		Lack of roles and responsibilities definition	Lack of stability
High variety and variations				
Lack of ability to use information				

*Table 4.2: Categorisation of the emerging issues*

Having established and categorised the problems using the process data collection and interviews, the researcher needed to consolidate and validate the findings by collecting quantitative data. Thus, a survey was designed based on these findings. The aims were to: i) measure whether there were common understandings of the problems between the different groups of stakeholders; and ii) establish any relationships between the fitness for purpose and the high performances of the healthcare infrastructure with effective planning and design decisions. To achieve these two aims, a survey instrument was designed and data analysed, using statistical techniques: ANOVA, Factor Analysis and Regression Analysis. The results are presented in the following section, in order to validate the assumptions and conclusions generated from the first qualitative study.

*H1: There is a different understanding between the groups of stakeholders that prevents the organisation from implementing improvements.*

*H2: There is a relationship between effective planning practice and the fitness for purpose and performance of new infrastructure.*

Hence, the next section will present the survey results needed to achieve the objective stated. Firstly, the descriptive results are presented; secondly, the results from the one way ANOVA; thirdly, the Factor Analysis; and, finally, the Regression Analysis.

#### **4.3.3. Survey Analysis – Verification and Corroboration**

The researcher's rationale was that, before designing and implementing any improvements, the organisation needed to assess whether there was a common understanding of the problems amongst the different key stakeholder groups. Four groups are identified as affecting and being affected by the NID projects, as defined in Chapter Two: i) decision-makers, who are employed by the organisation, they are the executors and owners of the new infrastructure development processes; ii) providers, who are employed by the organisation and are the infrastructure's main users; iii) suppliers and contractors, who are the external organisations and partners working in collaboration with the organisation, in order to procure and build the new infrastructure; and iv) the public, the patients and local population, who are the potential service users and final customers.

Figure 4.6 below maps out the four groups, according to their power and involvement within a project. The decision-makers have high power and take a high level of interest and involvement, they are accountable. Therefore, they all have to be managed closely and take part in all the major decision-making processes. The providers, as end users, take a high level of interest and can have fairly high power by having access to information and being able to influence some of the decision-makers. The suppliers and contractors have a direct involvement within the process, and, from a business perspective, their interest is medium-high level; their power is tacit, discrete and indirect. Finally, the members of the public, as customers and consumers, must be kept satisfied with the decision outcomes; their power can become higher if they are disappointed with the outcome.

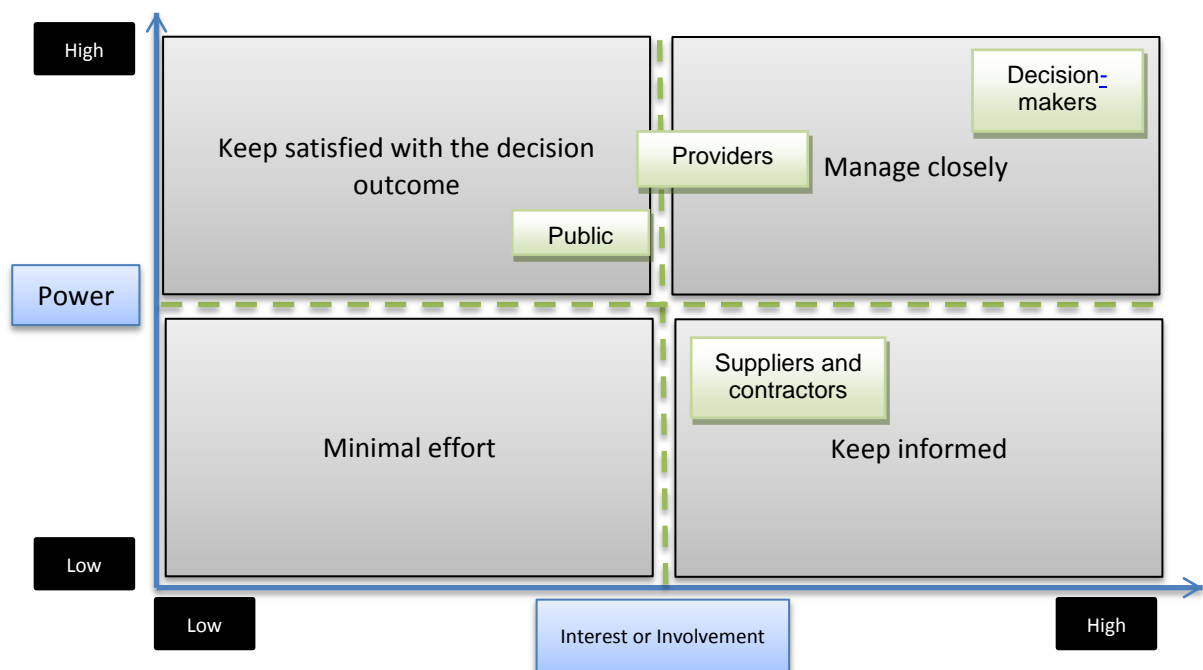


Figure 4.6: Stakeholder model (adapted from Hill & Hill, 2012)

Before any interventions or process improvement, it is important to get the buy-in from the different groups of stakeholders; otherwise, the risk of sub-optimisation is very high. Therefore, it is assumed that if there is an agreement on the nature of the problems, the organisation will be able move forward, by experimenting with new models and implementing strategic changes in the way the healthcare infrastructures are being developed. Furthermore, it was relevant to test whether there is a positive relationship between the effort put into the planning and the performance of the infrastructure, as theories suggest (*c.f.*: Meredith & Mantel, 2006). Both hypotheses are tested in the following section.

#### 4.3.3.1. Descriptive Results

Table 4.4 provides relevant information regarding the participants of the survey. Out of the 85 responses, 37 were decision-makers (43.5%), 11 were providers (13%), 21 were contractors or suppliers (24.7%), and 16 were members of the public (18.8%). Furthermore, 52% of the respondents were male and 48% female.

<b>Gender / role</b>	<b>Frequency</b>				<b>Total</b>
	<b>Decision-maker</b>	<b>Provider</b>	<b>Contractor or supplier</b>	<b>Public</b>	
<b>Male</b>	16	2	15	11	44
<b>Female</b>	21	9	6	5	41
<b>Total</b>	37	11	21	16	85

*Table 4.4: Respondents' frequency table*

The new infrastructure development scale developed contains 14 variables, numbered from 3 to 16. Each item was operationalized on a 5 point Likert scale: from 1 being strongly disagreed to 5 being strongly agreed with the statement. The means and standard deviations for each item are reported in Table 4.5 below. The variables were derived from the findings and they are related to the issues previously discussed in this chapter.

Variables	Mean	Std. deviation	Skewness
3_The different departmental strategies are sufficiently aligned	2.48	1.019	0.291
4_Consistent and robust need analysis is performed	2.68	1.082	0.322
5_GIS could be used in a more systematic manner	3.29	1.173	-0.236
6_The site selection is sufficiently transparent for the local population	2.80	1.067	0.171
7_The PC could be carried out in a more systematic manner	3.94	0.956	-0.97
8_The PC outcomes are representative of the local population	2.84	1.100	0.335
9_The public consultations capture the service needs and contribute to the service design	2.45	1.041	0.501
10_The outline business case can be developed further	3.60	1.157	-0.391
11_One process can be designed to accommodate the different procurement routes	3.80	1.213	-0.752
12_The land purchase can be postponed until the feasibility study is completed	3.36	1.317	-0.323
13_The latest NIDs are fit-for-purpose	3.24	1.054	0.073
14_The latest NIDs are well managed	3.44	1.005	-0.538
15_ In the latest NID the service integration is successfully implemented	2.62	1.046	0.047
16_ In the latest NID continuous improvement activities are successfully implemented	2.35	1.020	0.272

*Table 4.5: Descriptive results*

It is relevant to note that the items' average scores were between 2.35 and 3.94. The standard deviation illustrates the spread, or variation, of the data around the mean and is comprised between 0.95 and 1.31. On the 5 point Likert scale selected, the value '3' is the middle point – the respondent is 'neither agreed nor disagreed' with the statement. Seven items have a mean of above 3 and seven items have a mean below this threshold, as illustrated in Table 4.6 below.

<b>Variables</b>	<b>Mean</b>	<b>Std. deviation</b>
7_The PC could be carried out in a more systematic manner	3.94	0.956
11_One process can be designed to accommodate the different procurement routes	3.80	1.213
10_The outline business case can be developed further	3.60	1.157
14_The latest NIDs are well managed	3.44	1.005
12_The land purchase can be postponed until the feasibility study is completed	3.36	1.317
5_GIS could be used in a more systematic manner	3.29	1.173
13_ The latest NIDs are fit-for-purpose	3.24	1.054
8_The PC outcomes are representative of the local population	2.84	1.100
6_The site selection is sufficiently transparent for the local population	2.80	1.067
4_Consistent and robust need analysis is performed	2.68	1.082
15_In the latest NID the service integration is successfully implemented	2.62	1.046
3_The different departmental strategies are sufficiently aligned	2.48	1.019
9_The public consultations capture the service needs and contribute to the service design	2.45	1.041
16_In the latest NID continuous improvement activities are successfully implemented	2.35	1.020

*Table 4.6: Items sorted by agreement*

Before analysing the survey further, it is relevant to test whether there were differences in perceptions between the groups of stakeholders. To explore the following hypothesis, ‘there are no differences in the perception’, a one way ANOVA test was performed.

### 4.3.3.2. ANOVA Analysis

One way between groups ANOVA was used as the statistical technique to compare the differences in perceptions of the problems and the performances within the new development of healthcare infrastructure processes, amongst the four groups of stakeholders identified: decision-makers, providers, contractors and suppliers, and the public. The results were compiled into Table 4.7 below.

<b>Variables</b>	<b>Decision-makers</b>	<b>Providers</b>	<b>Contractors and suppliers</b>	<b>Public</b>	<b>Overall</b>
3_ The different departmental strategies are sufficiently aligned	2.68	1.91	2.67	2.19	2.48
4_ Consistent and robust need analysis is performed	2.76	2.82	2.76	2.31	2.68
5_ GIS could be used in a more systematic manner	3.73	2.91	3.1	2.81	3.29
6_ The site selection is sufficiently transparent for the local population	3.11	2.73	2.67	2.31	2.8
7_ The PC could be carried out in a more systematic manner	4.08	3.64	3.86	3.94	3.94
8_ The PC outcomes are representative of the local population	3.11	2.45	2.71	2.63	2.84
9_ The public consultations capture the service needs and contribute to the service design	2.65	2.36	2.29	2.25	2.45
10_ The outline business case can be developed further	3.57	3.27	3.9	3.5	3.6
11_ One process can be designed to accommodate the different procurement routes	3.73	3.91	3.9	3.75	3.8
12_ The land purchase can be postponed until the feasibility study is completed	3.14	3.55	3.67	3.38	3.36
13_ The latest NIDs are fit-for-purpose	3.59	3.27	3.05	2.63	3.24
14_ The latest NIDs are well managed	3.68	3.09	3.24	3.38	3.44
15_ In the latest NID the service integration is successfully implemented	2.78	2.36	2.76	2.25	2.62
16_ In the latest NID continuous improvement activities are successfully implemented	2.68	2.00	2.24	2.00	2.35

*Table 4.7: Items mean per group of stakeholders*

Table 4.8 below reports the ANOVA results, with the homogeneity of variance, the p-value, the F statistics and the ETA squared.

<b>Variables</b>	<b>Homogeneity of variance</b>	<b>p value</b>	<b>F</b>	<b>ETA sq</b>	<b>Mean</b>
3_ The different departmental strategies are sufficiently aligned	.565	.074	2.390	0.081	2.48
4_ Consistent and robust need analysis is performed	.670	.514	0.77	0.027	2.68
5_ GIS could be used in a more systematic manner	.223	.020*	3.48	0.114	3.29
6_ The site selection is sufficiently transparent for the local population	.408	.076	2.38	0.081	2.8
7_ The PC could be carried out in a more systematic manner	.384	.564	0.68	0.024	3.94
8_ The PC outcomes are representative of the local population	.460	.220	1.5	0.052	2.84
9_ The public consultations capture the service needs and contribute to the service design	.061	.476	0.84	0.030	2.45
10_ The outline business case can be developed further	.052	.485	0.82	0.029	3.6
11_ One process can be designed to accommodate the different procurement routes	.017	.943	0.13	0.004	3.8
12_ The land purchase can be postponed until the feasibility study is completed	.101	.494	0.81	0.029	3.36
13_ The latest NIDs are fit-for-purpose	.302	.013*	3.79	0.123	3.24
14_ The latest NIDs are well managed	.000	.235	1.45	0.050	3.44
15_ In the latest NID the service integration is successfully implemented	.557	.296	1.33	0.047	2.62
16_ In the latest NID continuous improvement activities are successfully implemented	.107	.063	2.53	0.085	2.35

*Note: \* -  $p < 0.05$*

*Table 4.8: Results of ANOVA*



The assumptions were tested: i) the independence of observation assuming that the respondents were not influenced by each other, ii) the results are normally distributed, and iii) the homogeneity of variance assuming that the variability of score for each of the groups is similar (non-significant result,  $p\text{-value} > 0.05$ ) were all verified.

The analysis reports the statistical differences at  $p < 0.05$ . One-way between groups ANOVA and Post-hoc using the Tukey HSD test were conducted to explore the differences that lie between the perceptions of the different groups of stakeholders involved in the NID process. As aforementioned, the respondents were divided into four groups: decision-makers, providers, contractors and suppliers, and the public.

There was a statistically significant difference at  $p < 0.05$  in the perception that ‘(5) GIS could be used in a more systematic manner’,  $F(3, 81) = 2.38$ ,  $p = 0.020 < 0.050$ . The effect size was calculated,  $\eta^2$  was 0.114, which showed a medium effect ( $< 0.14$ ). Post-hoc comparisons, using the Tukey HSD test, indicated that the mean score for the decision-makers (3.73) was significantly different from the public (2.81).

There was also a statistically significant difference at  $p < 0.05$  in the perception that the ‘(13) Latest NIDs are fit-for-purpose’,  $F(3, 81) = 3.79$ ,  $p = 0.013 < 0.050$ . The effect size was calculated,  $\eta^2$  was 0.123, which showed a medium effect. Post-hoc comparison, using the Tukey HSD test, indicated that the mean score for the decision-makers (3.59) was significantly different from the public (2.63).

It can be noted that, amongst the different groups of stakeholders, only two items show differences between the decision-makers and the public. Therefore, decision-makers, providers, and contractors and suppliers have a similar understanding and perception of both the problem and the performance of the processes within the new infrastructure development, and the members of the public agree with them on 12 out of the 14 items. This is an important element to consider in understanding and interpreting the survey results. To explore the data further, another statistical method was used, the Factor Analysis.

#### **4.3.3.3. Factor Analysis**

As Field (2009) explained, the method used depends on what generalisation the researcher wants to make from the data. Here, the data is not intended to be extrapolated to all of the

new healthcare infrastructure development process, but to gain a deeper understanding of this phenomenon. Therefore, the principal component was selected. Thus, the Factor Analysis (FA) was conducted, in order to identify a simple structure among the 14 items that were developed. The Keiser-Meyer-Olkin (KMO) is a measurement of sampling adequacy,  $KMO = 0.773 > 0.70$ , which is the recommended threshold, indicating that the degree of common variance is estimable (Field, 2009, p.647). Moreover, the Barlett's test of sphericity (BTS) was significant (Chi-square = 376.34,  $p < 0.05$ ), demonstrating its correlation magnitude significantly differ from a given identity matrix, "*indicating that the hypothesis of the variance and co-variance matrix of the variables as an identity matrix was significantly rejected*". It was concluded that the sample size was acceptable for the Factor Analysis (Byon *et al.*, 2010, p.149).

The Principal Component Analysis (PCA) was employed to explore the correlation coefficients among the items, and to identify the most parsimonious scale upon which to preserve the measurement property (Chen, 2004).

The direct Oblimin rotation was performed based on the rational that, from a theoretical point of view, the factors are correlated. From the Pattern Matrix, Figure 4.10, the items with a factor loading of  $>0.50$  were kept.

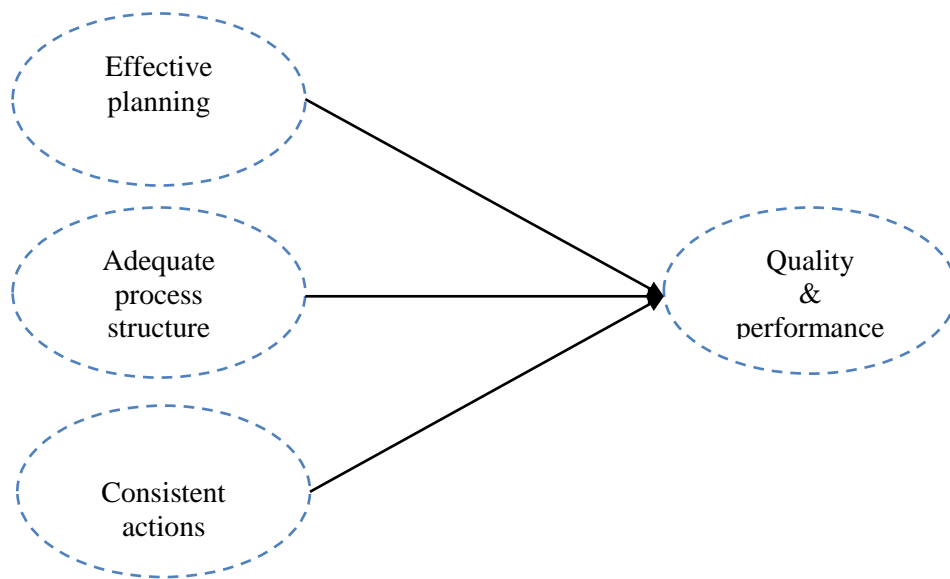
The factors were determined with the scree plot, the eigenvalue (greater than 1), the percentage of variance explained, as well as the consideration of the meaning of the solutions, as Table 4.9 reports. The four factors identified accounted for 62.41% of the total variability. A five factor solution could also be reported, but a four factor solution was more meaningful.

	<b>Factor 1</b>	<b>Factor 2</b>	<b>Factor 3</b>	<b>Factor 4</b>
Eigenvalue	4.347	1.893	1.409	1.089
% of variance	31.047	13.521	10.062	7.78
Cumulative %	31.047	44.569	54.631	62.41

*Table 4.9: Factor identification*

By interpreting the Pattern Matrix, reported in Table 4.10, the factors were named: 'Factor 1: Effective Planning', 'Factor 2: Adequate Process Structure', 'Factor 3: Consistent Actions', and, 'Factor 4: High Quality and Performance'. This has been consistently

interpreted as being in line with the literature (*c.f.*: Cain, 2004; Meredith & Mantel, 2006; Santorella, 2011; Sutt, 2011). According to Operations Management theories, it is believed that effective planning increases the speed and quality of the process output (*c.f.*: Slack *et al.*, 2006; Bamford & Forrester, 2010). Moreover, adequate process structure and consistent actions reduce the variation of the systems, allowing for greater standardisation, which directly impacts the process performances (*c.f.*: Deming, 1986). This is illustrated in Figure 4.7, through the model.



*Figure 4.7: The Factor Analysis model*

<b>Pattern Matrix</b>				
	Factors			
	1	2	3	4
<b>Effective planning (5 items)</b>				
4_ Consistent and robust need analysis is performed	<b>.736</b>	.060	-.169	.103
6_ The site selection is sufficiently transparent for the local population	<b>.732</b>	.068	-.176	-.049
8_ The PC outcomes are representative of the local population	<b>.667</b>	-.149	.103	.001
3_ The different departmental strategies are sufficiently aligned	<b>.646</b>	-.041	.151	.214
9_ The public consultations capture the service needs and contribute to the service design	<b>.589</b>	-.018	.502	.073
<b>Adequate process structure (3 items)</b>				
11_ One process can be designed to accommodate the different procurement routes	-.189	<b>.810</b>	-.101	.092
12_ The land purchase can be postponed until the feasibility study is completed	-.028	<b>.727</b>	.025	-.008
10_ The outline business case can be developed further	.173	<b>.712</b>	.194	-.156
<b>Consistent actions (2 items)</b>				
5_ GIS could be used in a more systematic manner	.072	.232	<b>.701</b>	.168
7_ The PC could be carried out in a more systematic manner	-.315	-.105	<b>.664</b>	-.220
<b>Quality &amp; performance (4 items)</b>				
14_ The latest NIDs are well managed	-.116	-.025	.122	<b>.857</b>
16_ In the latest NID continuous improvement activities are successfully implemented	.045	-.154	-.016	<b>.821</b>
15_ In the latest NID the service integration is successfully implemented	.094	.207	-.176	<b>.704</b>
13_ The latest NIDs are fit-for-purpose	.364	-.088	.052	<b>.607</b>

*Table 4.10: Pattern Matrix*

In this section, using the factor reduction techniques, a model was developed. In the following section, the Multiple Regression Analysis will be testing the relationships between the model's components. However, in the first instance, it is appropriate to investigate the reliability scale.

#### 4.3.3.4. Reliability Scale

Cronbach's alpha represents an internal reliability and consistency measurement and is the most common of its type used in Business and Management studies (Field, 2009). It is associated with the consistency and repeatability of the scale (Tabachnick & Fidell, 2007). It is widely accepted that the value of alpha should be above 0.6, in empirical research, and 0.7 otherwise, for the scale to be considered reliable (Field, 2009). However, there are many parameters, such as the sample size and number of the items, within the scale which impact its accuracy. If alpha is lower than 0.6 for an empirical research, it is an indication of inconsistency issues within the specific factor.

Factors	Factor 1 (5 items)	Factor 2 (3 items)	Factor 3 (2 items)	Factor 4 (4 items)	All items combined
Cronbach's Alpha	0.771	0.647	0.23	0.813	0.711

*Table 4.11: Cronbach's alpha table*

Factor 1 and factor 4, respectively, with Cronbach's alpha = 0.771 and 0.813, are considered as reliable factors, measuring each construct appropriately. Factor 2, with an alpha = 0.647, is acceptable in empirical studies (Field, 2009). However, the relatively low reliability score for consistent action (alpha = 0.23) means that the results involving this variable must be viewed with caution, and should, perhaps, be discounted altogether. This can be explained by the fact that the factors are only composed of two items, when, ideally, this technique is more suitable when the factors are composed of at least three items. It is noteworthy to highlight that the combined alpha of  $0.711 > 0.70$ , which is reassuring.

The following section describes the Multiple Regression Analysis and reports upon the findings. This statistical method was performed in order to explore the relationships between the different factors, or components, forming the model.

#### 4.3.3.5. Multiple Regression Analysis

Multiple Regression Analysis (MRA) is a statistical technique used to assess the relationships between one independent variable (IV), in this case: the quality and performance of the new infrastructure, with several dependent variables (DV), in this case:

effective planning, adequate process structure, and consistent actions, which were the results of the Factor Analysis, as previously analysed. In this section, the researcher reports on the results of the MRA, which represent the best prediction of how to achieve high quality and performance for the new infrastructure development (NID), according to the three DVs. Before being able to evaluate the results, it is critical to check the assumptions involved within the Regression Analysis: the multicollinearity, and the outliers, normality, and linearity. Then, the evaluation and the significance of the model are reported upon.

In Regression Analysis, the multicollinearity evaluates to what extent the predictors, or the dependent variables, are correlated. The multicollinearity occurs when multiple factors are correlated and is an indication of redundancy in the model. Also, if the multicollinearity is high, it can impact upon the significance levels of the variables (Tabachnick & Fidell, 2007). One way to measure multicollinearity is with the variance inflation factor (VIF), which assesses how much the variance of an estimated regression coefficient increases if the predictors are correlated. If no factors are correlated, the VIFs will all be 1. According to Table 4.12, which shows the Tolerance and variance inflation factor (VIF), the multicollinearity assumption is respected; there is no evidence of multicollinearity within the regression. The VIF is about equal to 1, indicating that the predictors are unlikely to be correlated. It can be noted that, when the VIFs are greater than 10, it indicates a high correlation, and the researcher should then remove one of the predictors to refine the model. Now that it is established that the results will be reliable, it is important to verify the other assumptions of the Regression Analysis (*i.e.*: the normality and linearity).

Model	Coefficients											
	Unstandardized coef		Standar dized coef	t	Sig.	95.0% Confidence interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower bound	Upper bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	6.641	1.976		3.360	.001	2.708	10.573					
Effective planning	.501	.077	.582	6.485	.000	.347	.654	.582	.585	.581	.998	1.002
Adequate process	-.020	.106	-.017	-.187	.852	-.230	.190	-.052	-.021	-.017	.981	1.019
Consistent actions	-.196	.186	-.095	-1.054	.295	-.565	.174	-.096	-.116	-.094	.983	1.017

Table 4.12: Multiple Regression Analysis results

As part of the MRA, it is relevant to test whether the assumptions of normality and linearity are also respected. The normality can be checked by looking at whether the residual errors are normally distributed in the P-P plot (SPSS), or the residual Plots (Minitab), as Figure 4.8 illustrates. The linearity assumption can be checked by determining whether the relationships between the independent variable, or predictors, and the dependent variable, or the outcome variable, are linear.

In the Normal P-P plot, the results should lie in a reasonably straight, diagonal line from bottom left to top right. In the Scatterplot, the residuals should be distributed, with most of the scores concentrated around 0. The outliers would be the points outside the +3.3 and -3.3 range (Tabachnick & Fidell, 2007). Therefore, it is assumed that the assumptions are respected in this model, and that we can be confident in the validity and reliability of the results.

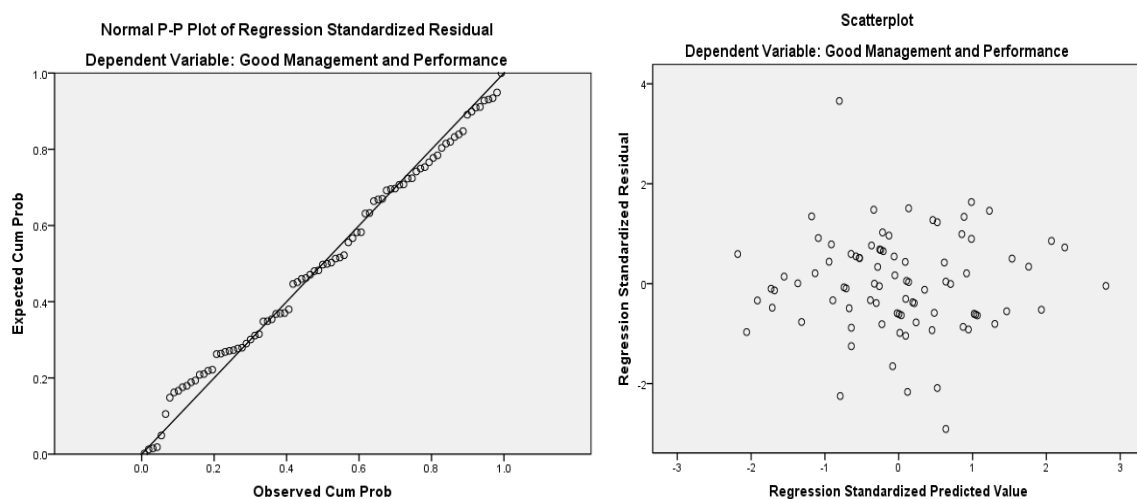


Figure 4.8: Normal P-P plot and scatterplot

### ***Evaluation of the Model***

According to Table 4.13, the three independent variables (effective planning, adequate process structure and consistent actions), included within the model, explain about 35% of variance ( $0.349 \times 100\%$ ) in dependent variables (the quality and performance of the new infrastructure).

Model Summary				
Model	R	R square	Adjusted R square	Std. error of the estimate
	.591	.349	.325	2.71256

Table 4.13: MRA model summary

### ***The Significance of the Model***

The ANOVA table indicates the significance of the model:  $F(3, 81) = 14.47$ ,  $p < 0.05$ .

ANOVA					
Model	Sum of squares	df	Mean square	F	Sig.
Regression	319.416	3	106.472	14.470	.000
Residual	595.996	81	7.358		
Total	915.412	84			

Table 4.14: MRA model significance

### ***Evaluation of Each Independent Variable (IV)***

From Table 4.12 above, the evaluation of each independent variable is possible by looking at the standardised coefficients and the sigma values. It can be understood that the best predictors of the quality and performance for the new infrastructure are the effective planning (Beta = 0.582). Both adequate process structure (Beta = -0.017) and consistent actions (Beta = -0.095) do not predict the quality and performance of the new infrastructure, as one could interpret from the theory.

	R-squared	Beta	B	SE	CI 95%
Model	0.35 ***				
Effective Planning		0.582 ***	0.501	0.077	0.347 / 0.654
Adequate Process Structure		-0.017	-0.02	0.106	-0.230 / 0.190
Consistent Actions		-0.095	-0.196	0.186	-0.565 / 0.174

Note: \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$

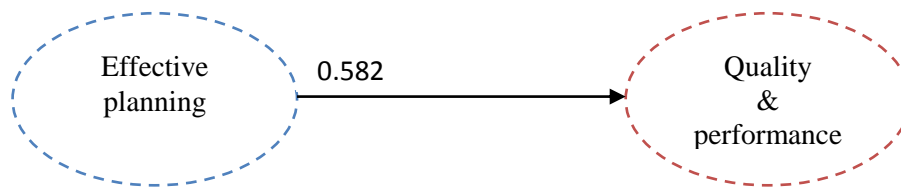
Table 4.15: Multiple Regression table

### ***Results presentations***

Multiple Regression Analysis (MRA) was performed to investigate the capacity of effective planning, adequate process structure and consistent actions to predict the levels of quality and performance of new infrastructure. Preliminary analyses were conducted to



ensure that the assumptions of normality, linearity and homoscedasticity were not violated. Additionally, the correlations between the predictor variables, included in the study, were examined. The three independent variables explained 35% of variance in the quality and performance of the new infrastructure ( $F(3, 81) = 14.47, p < 0.001$ ). However, the only variable that was statistically correlated with the quality and performance of the new infrastructure was effective planning. Therefore, in the final model, one predictor variable was statistically significant, recording high coefficient ( $\text{Beta} = .0.582, p < .001$ ), as is shown in the model below, Figure 4.9.



*Figure 4.9: Effective planning impacts the performance of the NID*

#### **4.3.3.6. So what are the Areas for Improvement?**

Therefore, from the set of statistical analyses and findings, the researcher is confident that the different groups of stakeholders each have a similar perception of the problems and issues regarding the new infrastructure development processes. Moreover, thanks to the Factor Analysis and the Multiple Regression Analysis, it was possible to focus exclusively on the most important and meaningful issues within this process. According to the MRA, it was established that effective planning was highly correlated to the performance and the quality of the new infrastructure development. Therefore, the areas for improvement can be identified by the items constructing this factor: i) (4) more consistent and robust need analysis could be performed; ii) (6) the site selection was not sufficiently transparent for the local population; iii) (8) the public consultation outcomes were not representative of the local population; iv) (3) the different departmental strategies were not sufficiently aligned (*c.f.*: Francis & Glanville, 2002; Schraven, Hartmann & Dewulf, 2011); and v) (9) the public consultations did not entirely capture the service needs and contribute to the service design.

These components can be resolved and addressed with more effective planning processes in place. Finally, as it was demonstrated that there is a common understanding of the issues and performances, it is believed that the organisation is ready to improve its

processes for the planning and design of its infrastructure. The researcher will introduce and experiment with these changes through an implementation of Lean thinking tools and techniques that have been deployed within the organisation.

#### **4.4. Conclusion**

This research findings chapter has: i) explained the problems related to the new infrastructure development (NID) processes within this healthcare organisation, via the thematic analysis and the process data analysis; ii) demonstrated the root-cause analysis within the planning and design phases, and confirmed the results via the survey analysis; iii) tested whether or not the different groups of stakeholders involved in the process have a similar perception of the problems, by performing ANOVA; and iv) measured to what extent the problems identified impact the infrastructure performances, thanks to the Factor Analysis and the Regression Analysis.

Therefore, it is now suggested that Lean thinking models and techniques can bring an element of support in improving the new infrastructure development processes, and, ultimately, enhance the quality and performance of the new infrastructure, in this healthcare organisation, by focusing on effective planning.

The following chapter will provide an explanation of the solutions selected and implemented: MCDA, Benchmarking and QFD. It is suggested that MCDA can be applied to improve the site selection transparency, and to enhance the representativeness of the public consultation. Benchmarking will be tested to improve the consistency and robustness of the need analysis, as well as to support the alignment between the different strategies. Finally, QFD will be applied to support the capture of the service needs, to contribute towards the design decisions, and to enable the alignment of the strategies. Figure 4.10 represents the conceptual model of this chapter. These Lean techniques have been specifically designed to support the new infrastructure development process of this organisation, to respect the environmentally dependent aspect. These Lean approaches to process improvement allow the reduction of waste and the resolution of some of the identified issues.

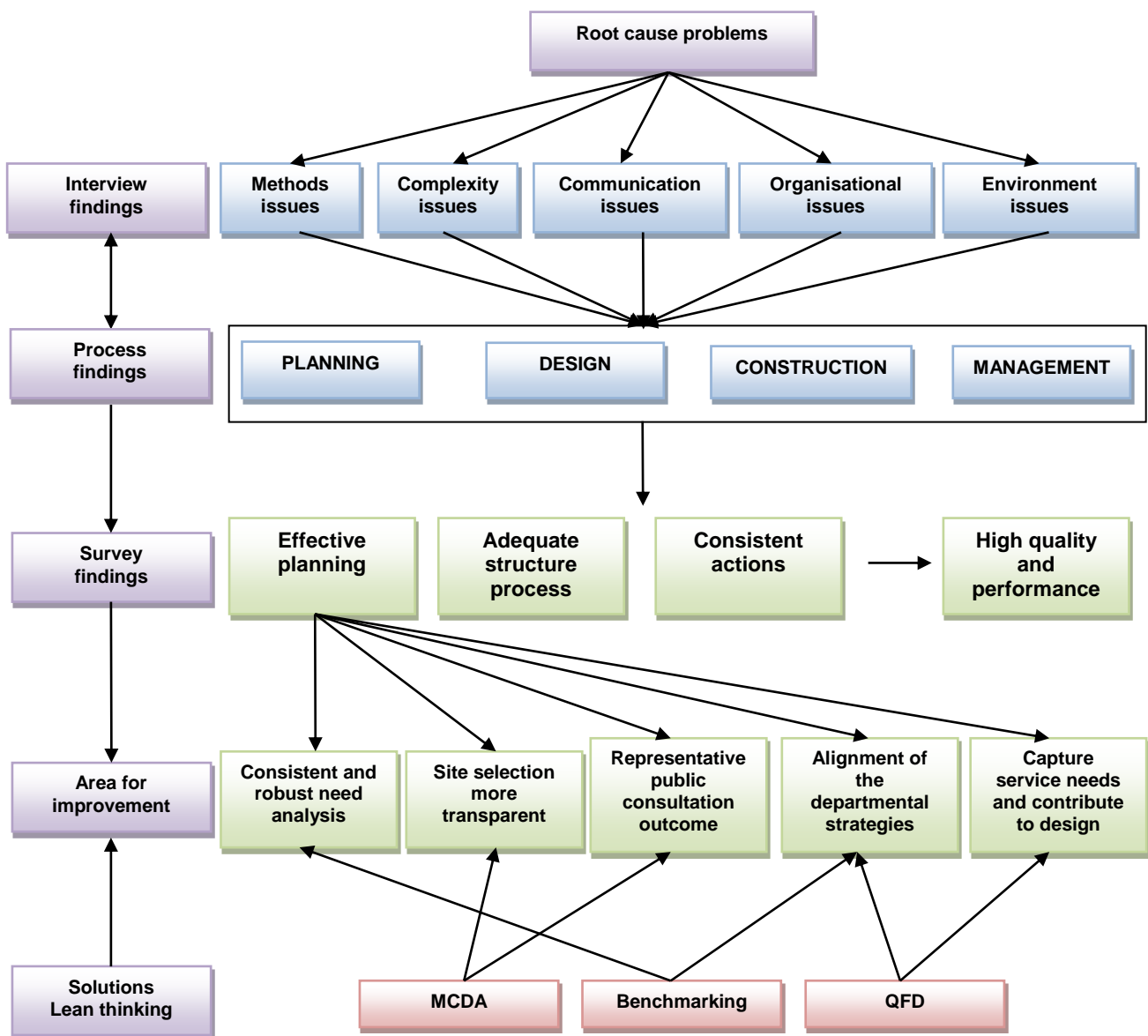


Figure 4.10: Research findings conceptual model

## **5. Chapter Five – Experimental Findings**

While Chapter Four described the case and identified the issues responsible for the weak performances associated with the new healthcare infrastructure development, Chapter Five will present the Lean solution designed and adopted to solve the underlying problems and improve the performances of the processes.

## **5.1. Introduction – Improvement**

Based on the analysis and triangulation of the interviews, process data and the survey, Lean tools and techniques have been developed to overcome the underlying problems. Through Chapter Four's interpretation of the data, it is established that the complexity of the decision-making was the common underlying issue within both the planning and the design phases. To overcome the nature of this issue, the new infrastructure development (NID) processes needed to be redesigned in such way that: i) the overall speed, transparency and rationality of the decisions are improved, ii) the strategic alignment between the different groups of stakeholders are enhanced, with a more consistent and robust performance assessment, and, finally, iii) the design decisions are less subject to reworks and defects. This chapter will describe the three Lean techniques that have been developed to support the strategic decision-making processes, within the planning and design of new healthcare infrastructure: Multiple Criteria Decision Analysis (MCDA) has been experimented to improve the decision-making process rationality and transparency for site selection and scheme prioritisation; Benchmarking and a performance framework have been designed and implemented to improve the strategy alignment between the different groups of stakeholders, so that they can learn from practice and generate a mechanism for continuous improvement and innovation, and, finally; Quality Function Deployment (QFD) has been implemented to support the design decisions, as well as to enhance the strategic alignment by synchronising the infrastructure design with the service design. This experimental findings chapter will present the ways in which these three Lean techniques have been adapted and implemented within this specific, bespoke and complex context.

Firstly, the MCDA model will be presented and the site selection problem be solved using Evidential Reasoning (ER), followed by Analytical Hierarchy Process (AHP). Secondly, the bespoke performance framework and three Benchmarking cases will be presented and compared. Finally, two iterations of the Quality Function Deployment (QFD) results will be shown.

## **5.2. MCDA for Site Selection**

In the previous chapter, it was demonstrated that a key issue, within the planning phase, was the site selection. It was not a sufficiently transparent process and had severe consequences, impacting upon the whole public consultation (PC). In this section, the introduction of MCDA, to optimise site selection decisions, will be explained, based on an experiment conducted on the £15 million K project. Firstly, the background will be provided; secondly, the construction of the MCDA model will be presented and defined throughout two iterations; thirdly, through the use of ER and AHP, the model will be resolved, and, finally; both models – ER and AHP – will be compared.

### **5.2.1. Background**

After the four months of public consultation (PC) were completed and analysed for the K project, it was necessary to reopen the PC as no final, rational solution or clear consensus had been established regarding the site selection. Therefore, the board of directors were keen to engage further with the key stakeholders and the local community. However, instead of engaging in a traditional manner, it was agreed that the consultation would be structured around the building of an MCDA model. In essence, instead of consulting with each other on the potential solutions, the stakeholders would develop a consensus regarding the set of criteria and sub-criteria to consider when searching for the optimum solution. Therefore, a series of workshops were organised, allowing the stakeholders to take part in identifying the criteria that the decision-makers would need to consider when assessing the alternatives. The main objective and rationale were to improve both the transparency and the robustness of the decision-making process. The intention was to bring together key stakeholders including: decision-makers; providers, such as health and social care professionals and representatives from the district town council and the voluntary sector; and patients and service users, in order to ensure that a wide range of views were included within the criteria and sub-criteria selection and weighting. Therefore, after an initial workshop, two workshops were organised, with all the groups of stakeholders, to determine the criteria and attributes, which would then be considered in order to make the site selection decision. The workshops were aimed at assessing what were the criteria, which stakeholders considered paramount when selecting the optimum site location and quantifying their importance. This enabled the development of an aggregated model, which takes into account multiple criteria to assist the decision-makers

in making a transparent and evidence based recommendation for the site selection. This section reports on both the experimental findings from building the MCDA model and the identification of the optimum site location for the K project. Both sets of results from the ER and AHP modelling will be presented.

### **5.2.2. Building the MCDA Model**

As discussed in Chapter Two, an MCDA model is defined by the set of criteria and their associated weightings that are considered in order to assess the different alternatives (*i.e.*: Locations A, B and C). In order to build the model, the set of criteria and the weightings needed to be agreed by the selected stakeholders. The researcher developed the model construction through two iterations. The iterations are composed of a series of workshops and meetings.

#### ***First Iteration: Workshops 1 and 2***

The first iteration started on 23<sup>rd</sup> July 2010. 16 people participated; mainly members of the public, plus some of the service users. The outputs from the earlier public consultations were made available to all participants. The outcome was the identification of six criteria, with their individual weightings, which the decision-makers needed to consider when selecting the optimum site location. Another workshop was held on 5<sup>th</sup> August 2010. 20 people attended but only 14 members of the public and the service users participated – four decided not to be involved further within the process. To ensure continuity, two people from the first workshop attended as observers. This allowed the validation of the findings from the previous workshop, expansion of the sub-criteria list and the redefining of the identified weightings (*c.f.*: Figure 5.1). The following figure, Table 5.1, illustrates the outcomes of the two workshops and the criteria weighting aggregation, based on the 30 participants' opinions.

Workshop 1 (16 active participants)			Workshop 2 (14 active participants)			Participants' Weighting	
	Weighting	Rank		Weighting	Rank	Weighting	Rank
			Environment				
Safety	7.38	2	& safety	6.75	5	7.09 (7)	5
Size	6.13	6	Size	9.55	2	7.73 (7.7)	2
Cost	7.13	4	Total cost	5.67	6	6.45 (6.5)	6
Access	8.94	1	Accessibility	9.64	1	9.27 (9.3)	1
Design	7.25	3	Design	7.92	4	7.56 (7.5)	3
Time risks	6.25	5	Time risks	8.18	3	7.15 (7.1)	4

*Table 5.1: Workshops 1 and 2 – outcomes for the criteria (Dehe et al., 2011).*

The same process was undertaken with the sub-criteria. This enabled the development of the following model, presented in Figure 5.1. It represents the aggregated version of the model developed by the 30 participants, composed of six criteria and 21 sub-criteria.



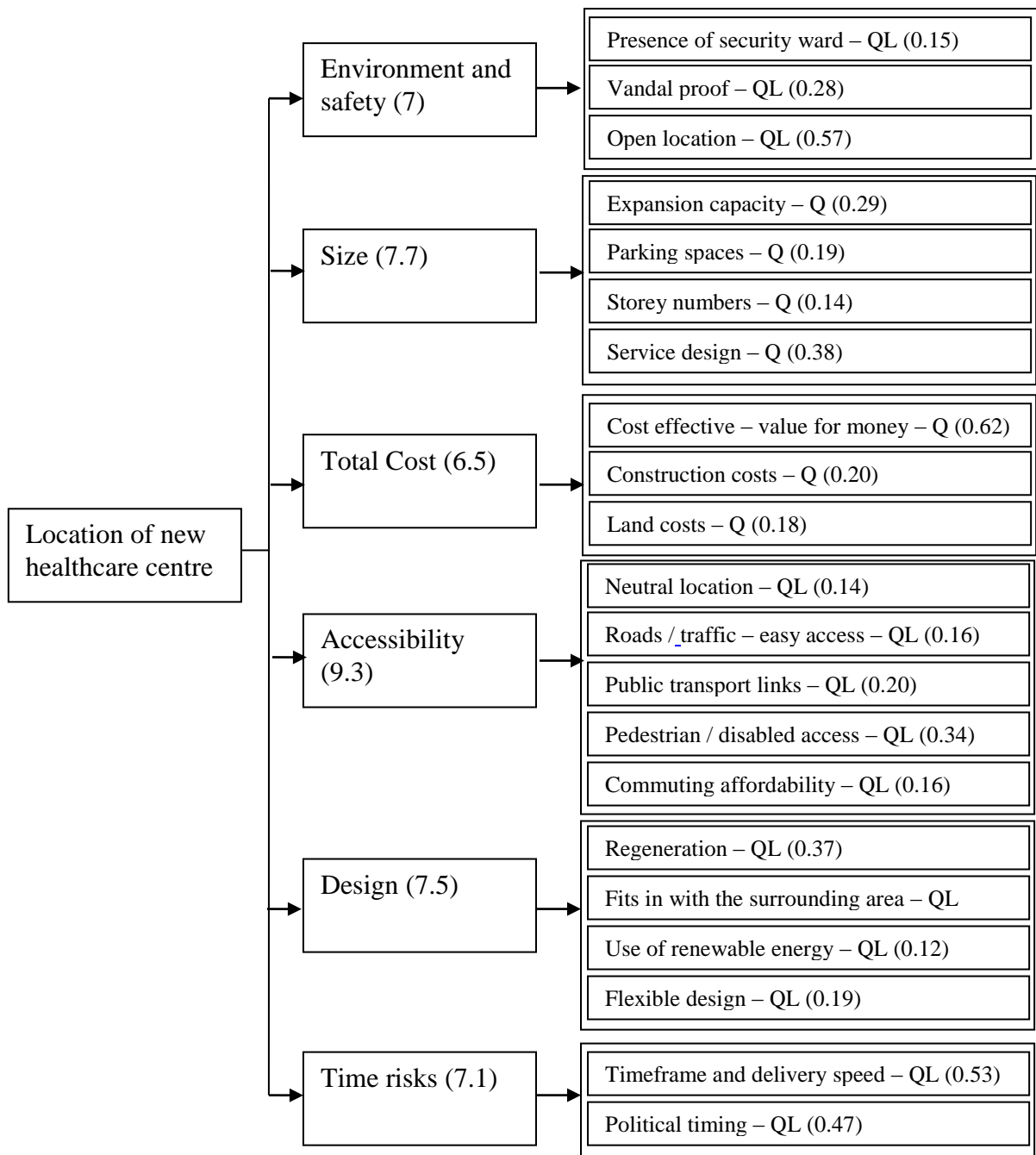


Figure 5.1: MCDA model structure after the first iteration

### Second Iteration: Workshops 3 and 4

This process could go no further without first inputting the knowledge of the 15 experts. The experts' opinions were gathered through a series of meetings and two workshops: 3 and 4, which led to the addition of extra criteria and sub-criteria to the model. This enabled the development of a thorough and robust model, as shown below in Figure 5.2,

designed to assess the alternatives. In the final model, as presented in Figure 5.2, the weightings took into account the workshops and the public consultation outcomes, as well as the expertise of Estates, the architects, Primary Care and Service Development, Intelligence & Analysis, and the senior managers. The final weightings were developed upon the foundation of the consensus and agreement amongst the decision-makers. This final model is composed of seven criteria and 28 sub-criteria, as described below. This iterative process was critical in order to refine the model and to build the consensus. The following section defines the different criteria identified and agreed upon by the stakeholders.

### ***Criteria Definitions***

The ‘environment and safety’ criterion is related to the safety of the surrounding area and the potential for regenerating this part of the district, through the building of a new health and well-being centre. The neutrality of the location, according to the different communities, was also taken into account.

The ‘size’ criterion is linked to the number of square meters available to accommodate the future health centre. Logically, the expansion capacity, number of parking spaces and the square meters allocated to the clinical space and the administrative space, has to be considered.

For the ‘total cost’ criterion, both variable and fixed costs had to be taken into account. Thus, construction costs, land costs, rates and taxes, as well as value for money, which can differ from one alternative to another, were considered. Although, this criterion had received the lowest score from the participants, it is deemed to be the most important factor for consideration when making the location decision, especially within the current financial and economic climate.

The ‘accessibility’ criterion was, without doubt, the most important criterion to emerge from the public consultation and the workshops. Therefore, decision-makers would need to consider and assess the alternatives against the different types of access: public transport, road and traffic, pedestrians and disabled accessibility. Another sub-criterion was identified – commuting affordability for both the staff and the patients.

The ‘design’ criterion needed to be taken into account also, as this impacts the choice of location too. The number of floors, presence of a pharmacy, potential for a flexible design, potential use for renewable energy, and the way in which the health centre would fit in with the current landscape (planning regulation, design style), are all relevant issues to consider.

The ‘risk’ is a criterion which had not been clearly identified throughout the workshops and the public consultation. However, such strategic and long lasting decisions must consider the risks involved. The following risks were highlighted: construction risks, land risks, intensity of other health and social services provision in the area (to help in reducing the inequalities), timeframe and the delivery speed risks (also a concern from the point of view of local communities).

Also, the ‘population profile’ has proved important to look at, via the demographic, geographic and epidemiologic profiles of the different parts of the district, even if, in this case, this did not influence the final outcome.

Once the model was built, agreed upon and validated, the assessment of alternatives and interpretations of the results took place – this process was referred to as ‘solving the model’ and is presented in the following sections. As discussed earlier in this thesis, there are several methods, or techniques, available to solve the model. In the first instance, ER was selected to resolve the final model, composed of seven criteria and 28 sub-criteria. As mentioned in the literature review, in the Evidential Reasoning (ER) approach, assessment takes place at the sub-criteria level. Therefore, the identification of whether the sub-criteria were evaluated quantitatively (noted Q), or qualitatively (noted QL), as shown in Figure 5.2, was required. Once the weightings were identified and validated, they were normalised. In the second instance, the model was solved by applying the AHP technique, through which the assessment takes place at the criteria level. The following section will present both findings.

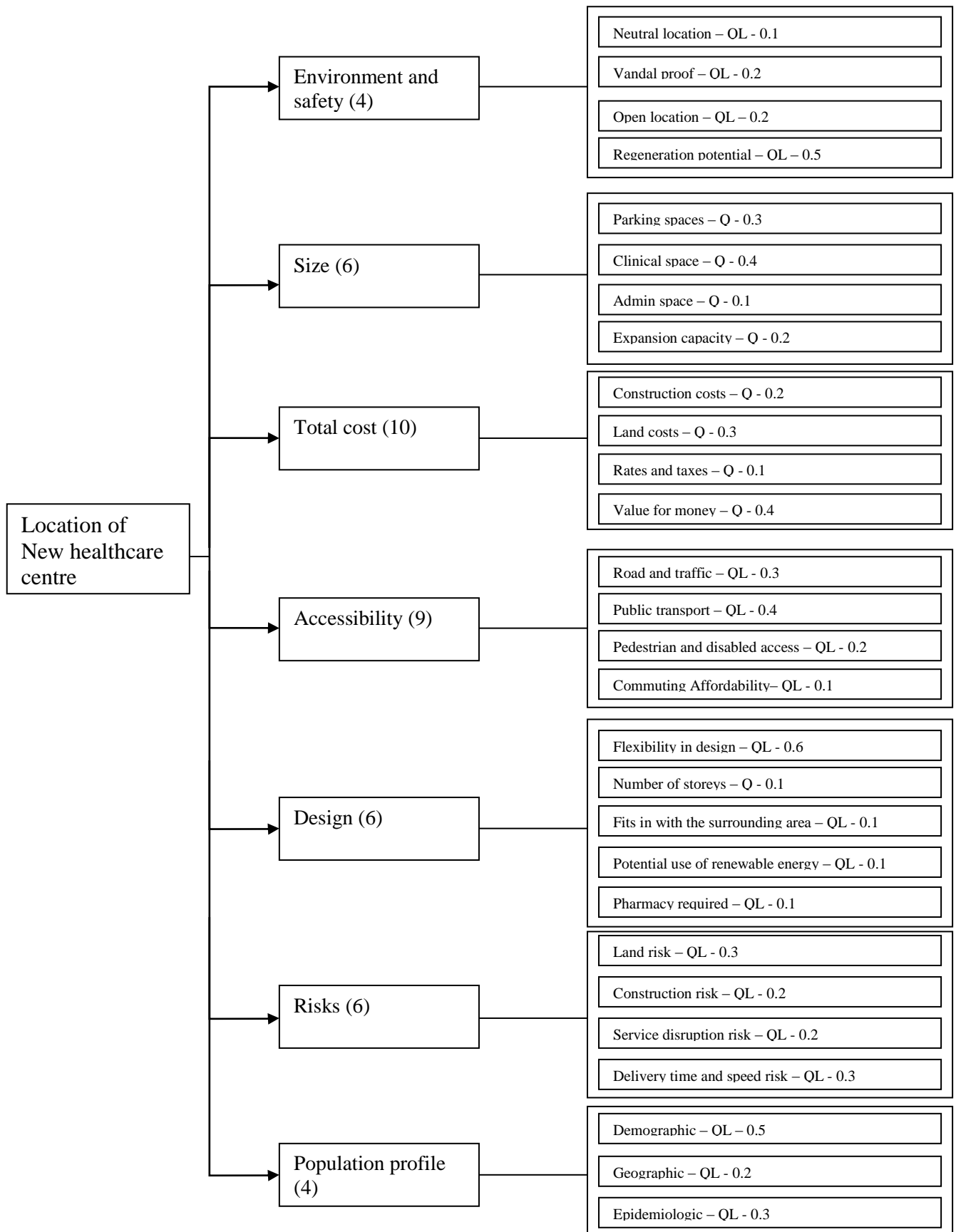


Figure 5.2: MCDA final model structure with criteria and sub-criteria weightings

### 5.2.3. Evidential Reasoning (ER) to Solve the MCDA Model

To resolve any defined MCDA model using ER, in which the weightings of criteria and sub-criteria have been agreed, there are two main steps: i) assessing the alternatives, meaning to evaluate each potential solution against each sub-criteria, and; ii) analysing the results. In this section, both steps are presented.

#### 5.2.3.1. Alternative Assessment

At the beginning of the public consultation, three location alternatives were being considered: A, B and C. However, within the assessment process, Location C had to be discredited, due to external political pressures and considerations. Thus, the following section describes the assessment of Locations A and B (Appendix 3: Location A & B information summary). A team, formed by experts and decision-makers, assessed alternatives A and B against each criteria and sub-criteria in IDS (Intelligence Decision Software). It needs to be noted that, in IDS, the weights have been normalised in percentages, as Table 5.2 reports, which is the convention. Table 5.3, below, shows the assessment, indicating the inputs of each criterion, including both the weights and assessments for Locations A and B.

#	Criteria	Original weight	Normalised
		(1-10)	weight
1	Environment and safety	4	8.9
2	Size	6	13.33
3	Total cost	10	22.22
4	Accessibility	9	20.00
5	Design	6	13.33
6	Risks	6	13.33
7	Population profile	4	8.9
<b>Total</b>		<b>45</b>	<b>100</b>

*Table 5.2: Normalised criteria associated weighting*

Table 5.3 shows the assessment results for Location A and Location B, and the score for each sub-criteria. The qualitative sub-criteria are assessed through a scale of degree of belief; {Worst, Poor, Average, Good, Best}. The distribution was discussed, case by case, with the team of experts. For certain sub-criteria, GIS (Geographic Information Systems)

inputs were considered as appropriate; for instance, to assess the ‘accessibility’ and the ‘population profile’. Thus, this process supported the reduction of the information asymmetry, by making sure that both alternatives were assessed as objectively as possible; something that would not have been possible without this process.

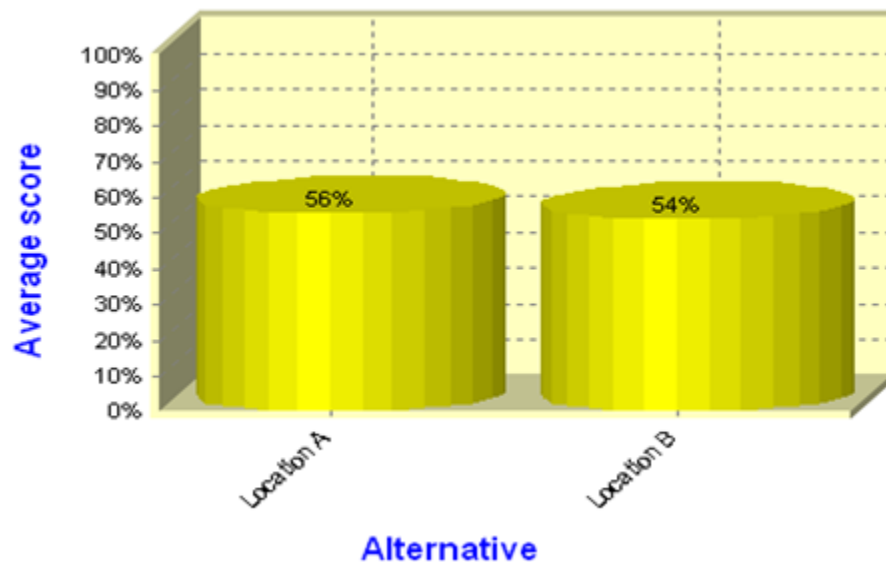
Top-Criteria	Sub-Criteria	Weight	Overall Weight	Assessment A	Score A	Assessment B	Score B
Env. and Safety 8.90%	Neutral Location	10.00%	0.89%	Worst-10%; Poor-10%; Ave-20%; Good-50%; Best-10%	60.00%	Poor-60%; Ave-10%; Good-20%; Best10%	45.00%
	Vandal Proof	20.00%	1.78%	Ave-100%	50.00%	Ave-100%	50.00%
	Open Location	20.00%	1.78%	Ave-50%; Good-50%	63.00%	Ave-100%	50.00%
	Regeneration-Positive Impact on the Surrounding Area	50.00%	4.45%	Ave-33%; Good-33.3%; Best-33.3%	75.00%	Ave-50%; Good-50%	63.00%
Size 13.33%	Parking Space	30.00%	4.00%	150/250	50.00%	175/250	63.00%
	Clinical Space (Serv design)	40.00%	5.33%	4000/5000	50.00%	5000/5000	100.00%
	Admin Space (Serv Design)	10.00%	1.33%	500/500	100.00%	500/500	100.00%
	Expansion Capacity	20.00%	2.67%	10%/25%	25.00%	25%/25%	100.00%
Total Cost 22.22%	Construction Cost	20.00%	4.44%	Poor-50%; Ave-50%	38.00%	Poor-33.33%; Ave-33.33%; Good33.33%	50.00%
	Land Cost	30.00%	6.67%	0/2000000	100.00%	2000000/2000000	0.00%
	Rates / Taxes	10.00%	2.22%	150000/200000	25.00%	150000/200000	25.00%
	Value for Money	40.00%	8.89%	Ave-50%; Good-50%	63.00%	Poor-33.33%; Ave-33.33%; Good33.33%	50.00%
Accessibility 20%	Roads Traffic (Easy access)	30.00%	6.00%	Worst-33.33%; Poor-33.33%; Ave-33.33%	25.00%	Worst-33.33%; Poor-33.33%; Ave-33.33%	25.00%
	Public Transport Links	40.00%	8.00%	Ave-100%	50.00%	Ave-100%	50.00%
	External Pedestrian and Disable Access	20.00%	4.00%	Ave-33%; Good-33.3%; Best-33.3%	75.00%	Ave-50%; Good-50%	63.00%
	Affordability for the Local Community to Commute	10.00%	2.00%	Poor-33.33%; Ave-33.33%; Good33.33%	50.00%	Poor-50%; Ave-50%	38.00%

<b>Design 13.33%</b>	Flexible design	60.00%	8.00%	Ave-50%; Good-50%	63.00%	Good-50%; Best-50%	88.00%
	Number of Storey	10.00%	1.33%	3 (Best: 4)	33.00%	2 (Best: 4)	67.00%
	Fit with the Surrounding Area	10.00%	1.33%	Good-100%	75.00%	Good-100%	75.00%
	Potential Use of Renewable Energy	10.00%	1.33%	Ave-100%	50.00%	Ave-100%	50.00%
	Presence of Pharmacy Required	10.00%	1.33%	Ave-100%	50.00%	Ave-100%	50.00%
<b>Risks 13.33%</b>	Land Risk	30.00%	4.00%	Good-50%; Best-50%	88.00%	Worst-33.33%; Poor-33.33%; Ave-33.33%	25.00%
	Construction Risk	20.00%	2.67%	Poor-50%; Ave-50%	38.00%	Ave-50%; Good-50%	63.00%
	Services Provision (Intensity of practices in the area)	20.00%	2.67%	Ave-100%	50.00%	Good-100%	75.00%
	Timeframe and Delivery Speed	30.00%	4.00%	Ave-100%	50.00%	Poor-50%; Ave-50%	38.00%
<b>Pop. Profile 8.89%</b>	Demographic	50.00%	4.45%	Ave-100%	50.00%	Ave-100%	50.00%
	Geographic	20.00%	1.78%	Ave-100%	50.00%	Ave-100%	50.00%
	Epidemiologic	30.00%	2.67%	Ave-100%	50.00%	Ave-100%	50.00%

Table 5.3: Weighting and assessment for Alternatives A and B



Based on this model and the presented inputs, Figure 5.3 shows the ranking of alternatives A and B. From the assessment, Location A scored 56% and Location B scored 54%.



*Figure 5.3: Ranking of the alternatives*

From this assessment, the preferred option turned out to be Location A, with a score of 56%, whilst Location B scored 54%. By looking at Figure 5.4, it can be seen that Location A outstrips Location B in the following four criteria: ‘environment and safety’ by 11%, ‘total cost’ by 32%, ‘accessibility’ by 2% and ‘risks’ by 12% (meaning that A is believed to be less risky than B). Whereas, Location B outstrips Location A fairly substantially in the following two criteria: ‘size’ by a huge 41% and ‘design’ by 21%. Although, according to this assessment, Location A is the preferred option, it is relevant to understand the consequences of altering the weightings and inputs by undertaking sensitivity analysis.

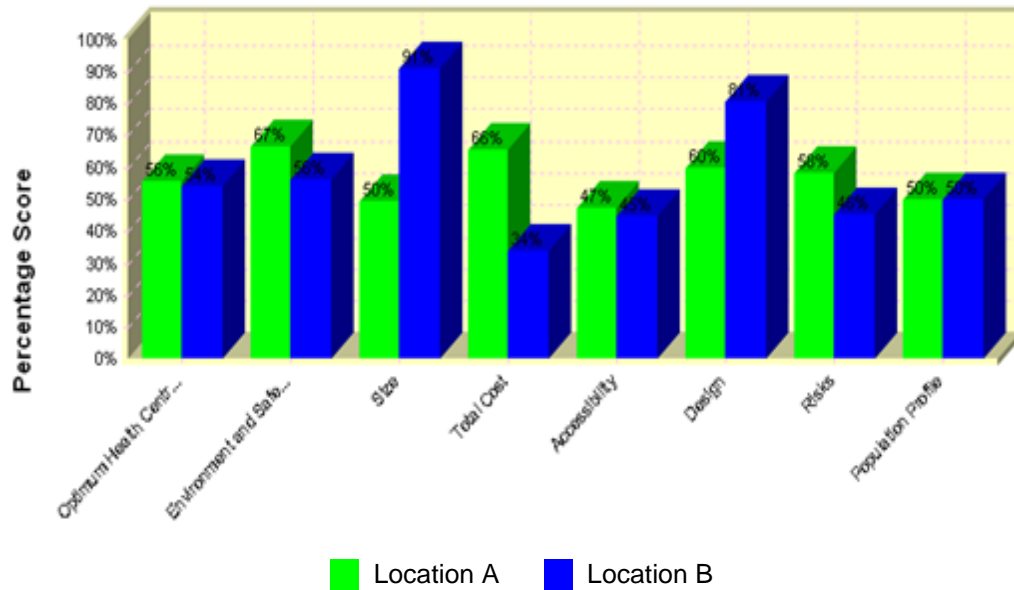


Figure 5.4: Criteria performances

#### 5.2.3.2. Results Analysis

This analysis was conducted to inform further the decision-makers and help them appreciate the meaning of the results. The difference in weighting, between the model compiled by the public during the first iteration and the final model (second iteration), is shown in the Table 5.4 below.

Criteria	1 <sup>st</sup> iteration		2 <sup>nd</sup> iteration	
	Weight	Rank	Weight	Rank
Environment & safety	15.52%	5	8.90%	6
Size	17.07%	2	13.33%	3
Total cost	14.41%	6	22.22%	1
Accessibility	20.62%	1	20.00%	2
Design	16.63%	3	13.33%	3
Risks	15.74%	4	13.33%	3
Population profile	N/A	N/A	8.89%	6

Table 5.4: Iterations models weighting comparison

From Table 5.4, two key points need to be explained further. Firstly, the ‘population profile’ criterion was not considered in the first iteration. This is potentially very important as one of the key issues to tackle here is the reduction of inequalities; hence, the

location selection should assess these issues. In this particular case, the population profile was assessed equally, as none of the demographic, geographic and epidemiological elements were different in this area. Secondly, the other difference appears in the 'total cost' criterion. In the first iteration, the public considered 'total cost' to be the least important criterion; a fact which may seem surprising within this tough economic climate. From discussions with the participants, they did not see a big cost difference between building the healthcare centre in Location A or in Location B. However, 'total cost' has proved the most important weight in the final model, simply because, from the organisation's perspective, value for money, the affordability and the other financial features are fundamental aspects of the project, and of paramount importance when making the final decision on location. Moreover, there are important differences between Location A and Location B, particularly in terms of the 'land costs' criterion. The land for Location A would not have any direct associated costs as the organisation owns it. The land for Location B would need to be purchased and its costs negotiated, involving a higher element of risk as well as costing more. During the assessment, the cost of the land for Location B was estimated at £2,000,000 by the experts. This will be analysed further.

IDS was used to assess the model and to undertake the analysis. Thanks to IDS, the researcher was able to carry out sensitivity analysis for the weighting of the criteria. Three of the criteria could affect the final outcome: 'size', 'total cost' and 'design'. This is useful information because, as previously mentioned, 'size' and 'design' were the two criteria for which Location B outstripped Location A. 'Size' had an associated weight of 13.33%. However, as seen in Figure 5.5 below, if the weight associated increased to 16%, Location B would reach a higher score. This has helped the decision-makers to discuss to what extent the 'size' criterion could become a more important criterion, but it was identified as appropriate. Thus, Location A still remained the preferred option.

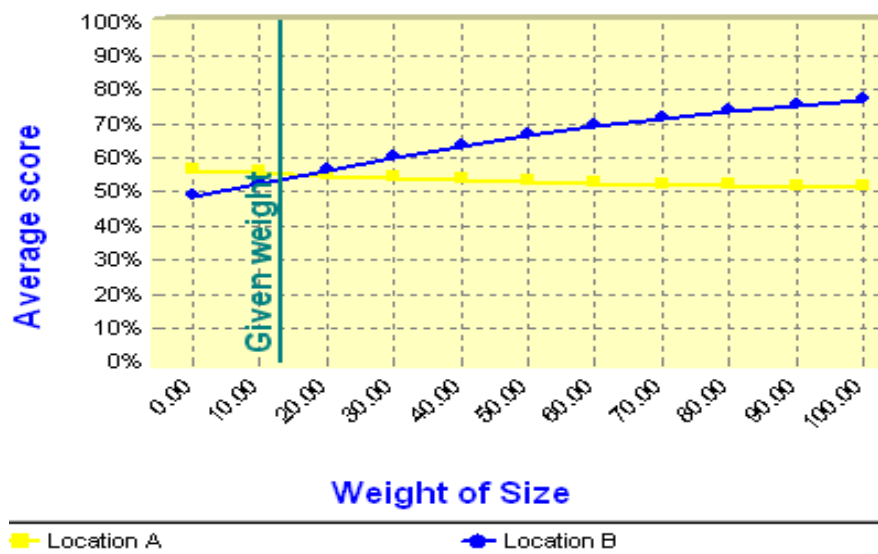


Figure 5.5: Sensitivity analysis for the weight of 'size'

'Total cost' has a weight of 22.2%. However, according to Figure 5.6, what is relevant to consider is the case in which the weight is reduced to 20%. That way, Location B would be the preferred option. This has raised the issue of the public not considering 'total cost' as the most important criterion. However, the decision-makers agreed that it was the most crucial criterion. Therefore, its weight would not be diminished, under any circumstances.

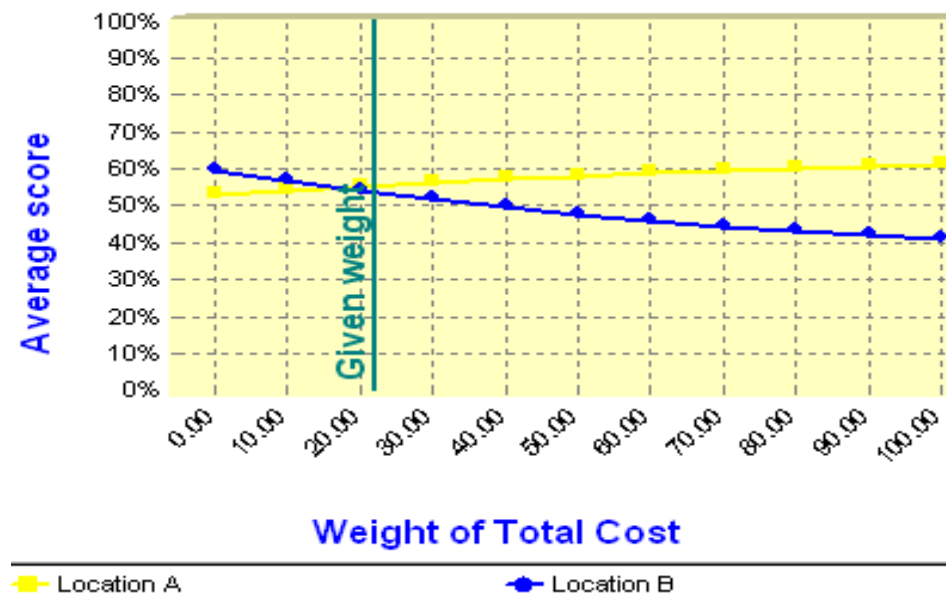


Figure 5.6: Sensitivity analysis for the weight of 'total cost'

‘Design’ weight has also been identified as a sensitive criterion. According to Figure 5.7, if ‘design’ was deemed more important when selecting the optimum site, and had an associating weight of 20%, then Location B would outstrip Location A, becoming the preferred option. Therefore, discussion around to what extent ‘design’ should be more important in the final decision took place, and, again, the decision-makers agreed that this was the right weight for this particular case.

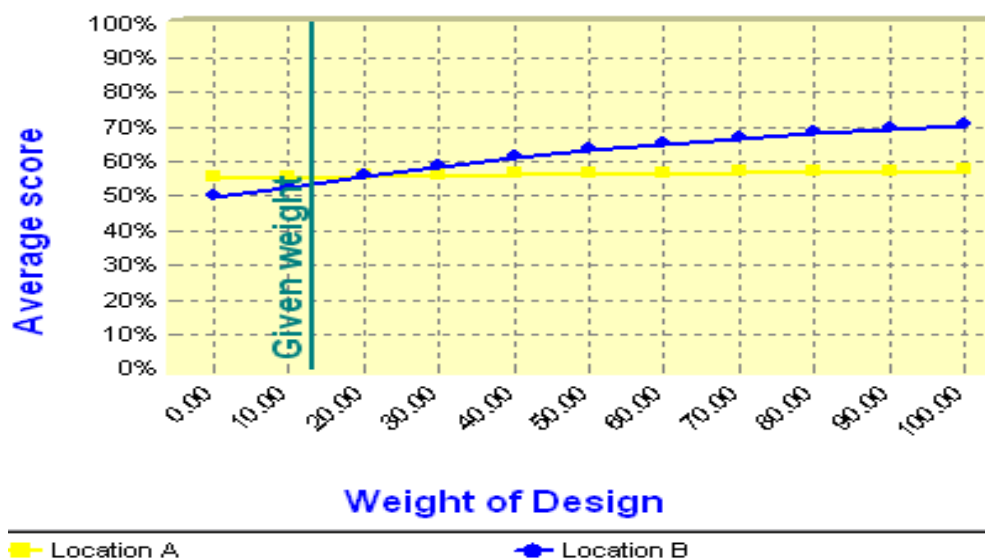


Figure 5.7: Sensitivity analysis for the weight of ‘design’

Therefore, this analysis was useful for the decision-makers when appreciating the sensitivity of the weightings. This also enabled the decision-makers to challenge to what extent the weightings were relevant for this site selection – discussions around these issues had taken place in the final workshop. This was when the opportunity to validate the final models was given. It was agreed amongst all the decision-makers that these weightings were based on a consensus in line with the strategy and the public consultation outcomes. However, it was appropriate to carry out further analysis to measure the sensitivity of the inputs, which were based on the knowledge and expertise of the cross-functional team of experts. ‘Size’ was a sensitive criterion and its key sub-criterion was ‘clinical space’, a quantitative sub-criterion assessed in square meters. Based on both the internal knowledge and the planning at that stage, Location A would have offered available clinical space of approximately 4,000 m<sup>2</sup>, allowing some space for the provision of services identified through the need analysis, but with little room for flexibility; whereas, 5,000 m<sup>2</sup> could

have been available easily in Location B. Therefore, any improvements to the clinical space in Location A would have strengthened it as the preferred option, as shown Figure 5.8 below. This finding will be taken further within the design phase, to improve the overall quality of the infrastructure.

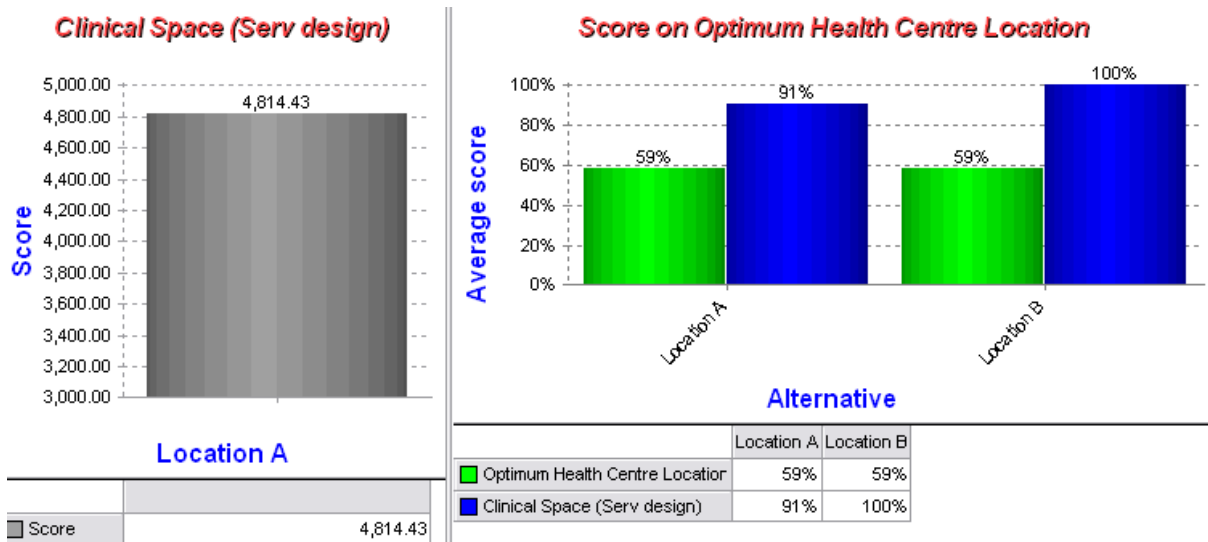


Figure 5.8: Input sensitivity analysis for ‘clinical space’

The same reasoning was applied to the qualitative ‘flexible design’ sub-criterion. Location B had been assessed as the most flexible location, with a distribution of the degree of belief of {50% Good, 50% Best}; whereas, the distribution of the degree of belief of Location A was {Average 50% and Good 50%}, according to the experts. However, by improving the flexibility through design features, the distribution of the assessment could be improved so that it could reach a distribution of {Average 33%, Good 33% and Best 33%}, for example. In this case, Location A would boost its score and strengthen its preferred position.

This was discussed by the decision-makers as a key aspect for further consideration when trying to establish how to improve Location A and confirm it as the optimum option.

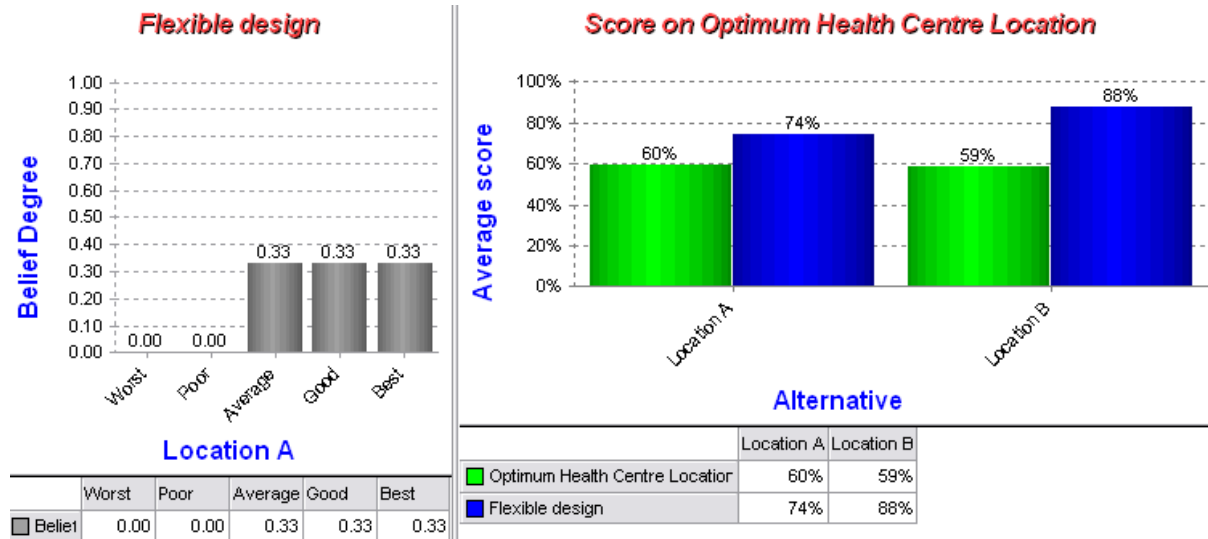


Figure 5.9: Input sensitivity analysis for 'flexible design'

Having said that, the other crucial issue for consideration was 'land costs'. From the sensitivity analysis, it was calculated that this sub-criterion had a considerable impact on the final decision. As stated previously, Location A was owned by the organisation; hence, no direct cost would have been charged for its acquisition. On the other hand, Location B is privately owned, with a business running next-door to it. The cost for acquiring the land was estimated at £2,000,000. Different scenarios were tested and a break-even point identified. If the cost associated with the acquisition of the land was down to £1,380,952, then, based on this assessment, both Location A and Location B would have had the same score, as illustrated in Figure 5.10 (c.f.: Tao, 2010). Furthermore, if the land could be acquired by the organisation at about £604,000, then Location B would outstrip Location A as the preferred option by 3%, as shown in Figure 5.11. There was another scenario discussed also, as it was implied that the organisation might be able to generate some cash from selling land for Location A, if A was not the selected option, in order to finance the land for Location B.

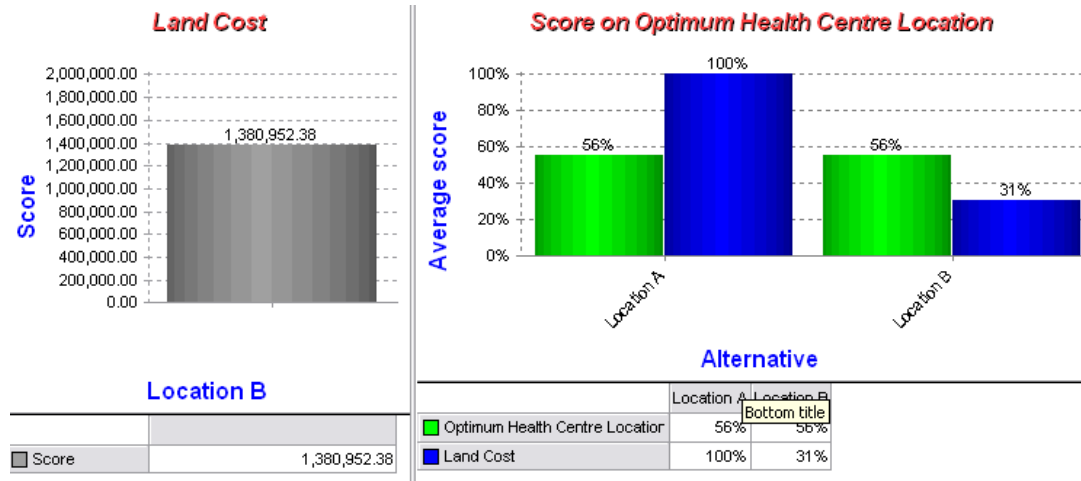


Figure 5.10: Input sensitivity analysis for 'land costs'

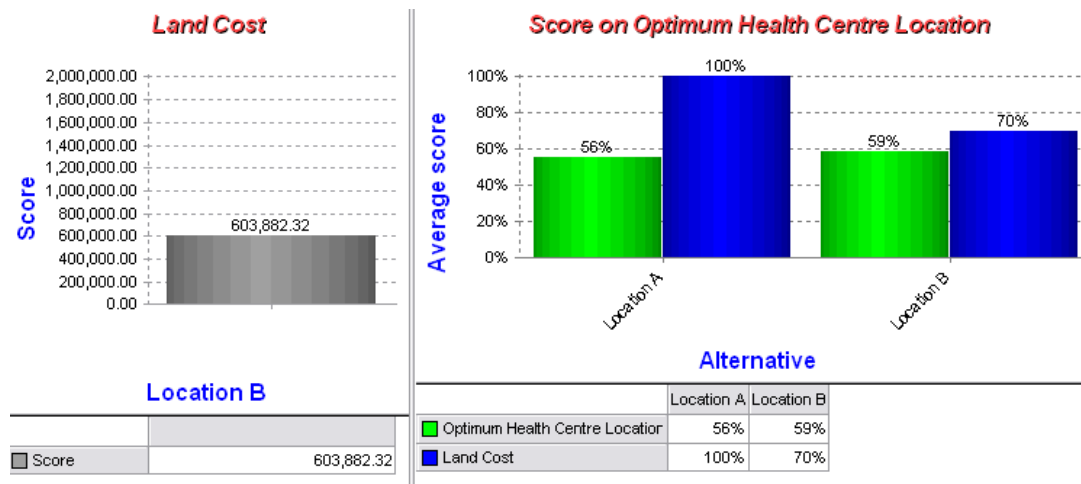


Figure 5.11: Input sensitivity analysis for 'land costs'

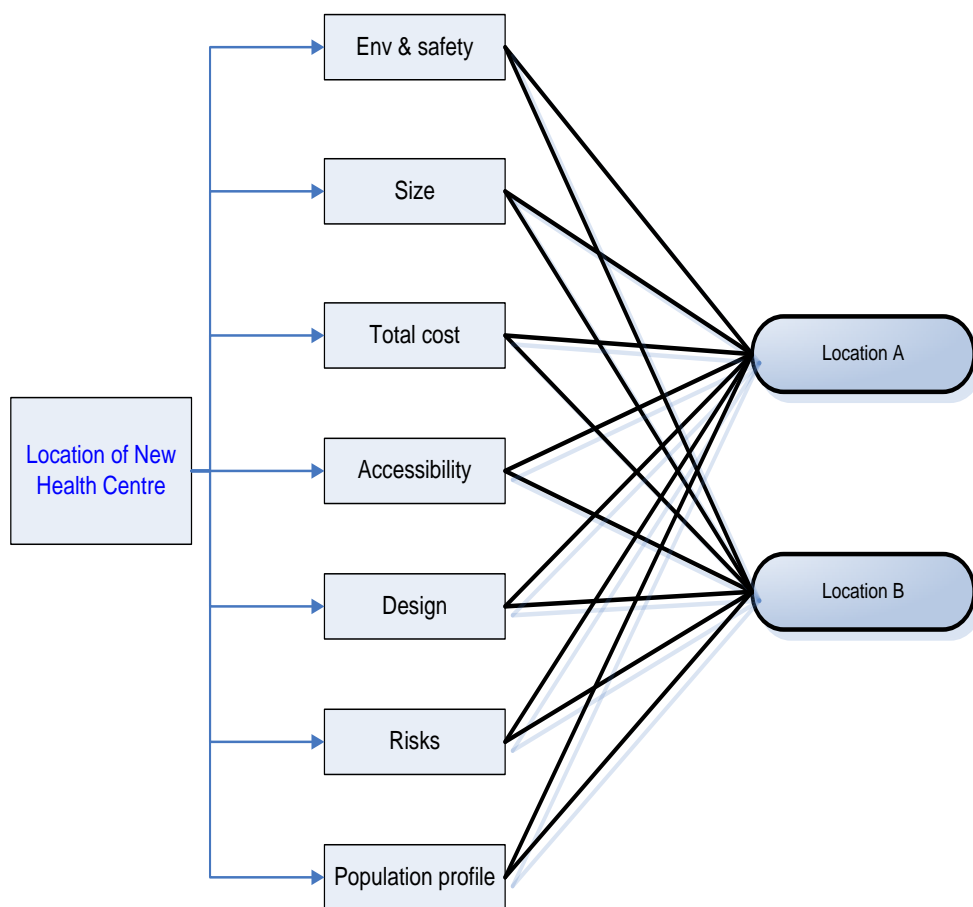
This model demonstrates how the site selection decision-making process has been optimised. However, as specified in the literature, the technique used to solve the model might impact the final results. As Location A and B were extremely close in terms of results, AHP was used as an alternative technique to solve the model and the comparison results are presented in the following section.



#### 5.2.4. AHP Used to Solve the MCDA Model

The rationale for solving the MCDA model with AHP was simply to gain even more confidence in the solution and in Location A. As with ER, the results were similar – AHP was used as a way to verify these results. Since it was such an important decision, AHP was a relevant alternative at the time.

The AHP model traditionally has three levels: the goal, the criteria and the alternatives, as illustrated in Figure 5.12. The set of seven criteria used below is the common structure, as these criteria are independent from the selected modelling techniques.



*Figure 5.12: AHP model structure*

#### 5.2.4.1. The Criteria Weightings

In the AHP model, the weightings of the criteria are pair-wise compared and the results are shown in Table 5.5 below. The pair-wise comparison was established by the group of decision-makers and is consistent with the weightings determined by the ER model.

Criteria	Total						
	Env & safety	Size	cost	Accessibility	Design	Risks	Pop profile
Env & safety	1	1/3	1/7	1/7	1/3	1/3	1
Size	3	1	1/5	1/5	1	1	3
Total cost	7	5	1	3	5	5	7
Accessibility	7	5	1/3	1	5	5	7
Design	3	1	1/5	1/5	1	1	3
Risks	3	1	1/5	1/5	1	1	3
Pop profile	1	1/3	1/7	1/7	1/3	1/3	1
Sum	25	13.667	2.219	4.886	13.667	13.667	25
Weights (%)	3.53	8.44	38.89	28.75	8.44	8.44	3.53

*Table 5.5: AHP pair-wise comparison table for the criteria weightings*

Whilst ER uses the Likert scale, from 1 to 10 (10 being the highest), to identify the weighting of each criterion, AHP uses pair-wise comparison. This means that, for instance, if ‘environment and safety’ is equally preferred to ‘population profile’, then a value of 1 is captured, and if ‘size’ is strongly non-preferred to ‘total cost’, then a value of 1/5 is captured. This is also automatically recorded within the reciprocal cell. As ‘total cost’ is strongly preferred to ‘size’, a value of 5 is registered. Once this has been averaged out and normalised, the weightings can be obtained.

#### 5.2.4.2. The Alternative Assessment

Within the AHP framework, the pair-wise comparison was applied in the same way as in the criteria weighting process. Table 5.6 presents the alternative assessment for Locations A and B, using the seven criteria. From this assessment, a normalised score was generated for Locations A and B. From the results obtained, it can be seen that A outstrips B in three criteria: ‘environment and safety’ (A=75 and B=25), ‘total cost’ (A=87.50 and B= 12.50) and ‘risks’ (A=75 and B=25). On the other hand, Location B outstrips A in two criteria: ‘size’ (A= 12.50 and B=87.50) and ‘design’ (A=16.66 and B=83.33). The two remaining

criteria, ‘accessibility’ and ‘population profile’, were both assessed as equal. These results are consistent with the ER assessment.

Env & safety	A	B
A	1	3
B	1/3	1
Sum	1.333	4.000
Weights	75.000	25.000

Size	A	B
A	1	1/7
B	7	1
Sum	8.000	1.143
Weights	12.500	87.500

Total cost	A	B
A	1	7
B	1/7	1
Sum	1.143	8.000
Weights	87.500	12.500

Accessibility	A	B
A	1	1
B	1	1
Sum	2.000	2.000
Weights	50.000	50.000

Design	A	B
A	1	1/5
B	5	1
Sum	6.000	1.200
Weights	16.667	83.333

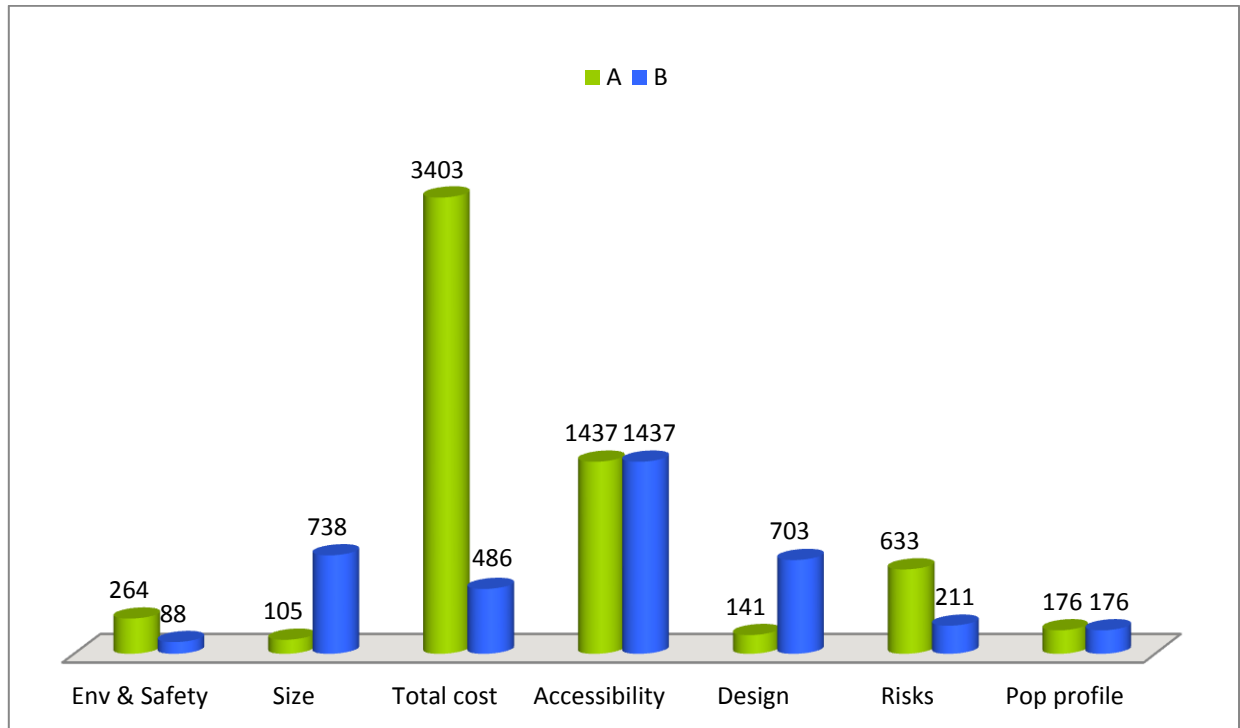
Risks	A	B
A	1	3
B	1/3	1
Sum	1.333	4.000
Weights	75.000	25.000

Pop profile	A	B
A	1	1
B	1	1
Sum	2.000	2.000
Weights	50.000	50.000

*Table 5.6: Alternative assessment results using AHP*

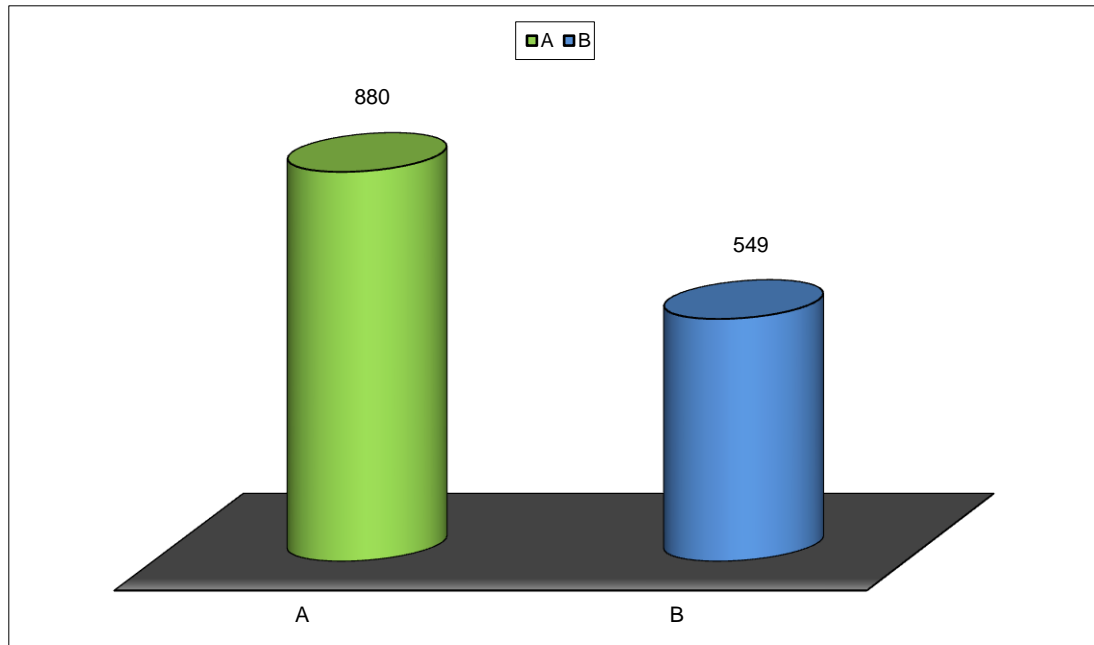
Furthermore, Figure 5.13 shows the results, at the criteria level, by considering both the importance of the criteria and their performances. The results are generated for each location by multiplying the weights of the criteria by their performances. For instance, it was established that ‘environment and safety’ has a weight equal to 3.53, based on the pair-wise comparison, and that, for this criterion, Location A had a score of 75; hence ( $3.53 * 75 = 264$ ). This provides a deeper understanding of the assessment using the AHP model.



*Figure 5.13: Aggregated criteria score and performances*

#### **5.2.4.3. Results Analysis**

The first point to note is that, with AHP as with ER, Location A remained the preferred option. However, from the AHP assessment, the results were more significant than with ER, as Figure 5.14 below shows. Location A had a total score of 880; whereas, Location B had a total score of 549. The most significant criterion impacting upon this difference is ‘total cost’. This is clearly visualised in Figure 5.13 above, and corroborates the sensitivity analysis conducted previously.



*Figure 5.14: Results from AHP*

Having presented the results for both the ER and AHP models, demonstrating that they were both consistent but different, it was relevant to compare them. The comparison is presented in the following sections.

## **5.2.5. ER and AHP – the Comparison**

### **5.2.5.1. Comparing the Weightings**

In Table 5.7 below, the weightings assigned to both models are presented. It can be noted that the weightings' ranges are different, depending on whether ER or AHP was the selected framework used to solve the problem. With ER, the weightings are included into a range from 8.90% to 22.22%; whereas, with AHP, the range is wider, from 3.53% to 38.89%. From the assessment, it was established that, when stakeholders use a Likert scale from 1 to 10, the likelihood is that little difference will be perceived between the criteria, but that the uniformity will be respected as it is highly transparent. However, when using pair-wise comparison, the difference is amplified, but there is room for inconsistency when criteria are being compared against other criteria, and stakeholders might have a less transparent perception of the weightings phase. The second relevant point to mention is that, in this case, using ER or AHP led to the same rankings, which is positive and translate that the decision-makers were consistent in their approach, and provide confidence to proceed with the comparison.

Criteria	ER		AHP	
	Weight (%)	Rank	Weight (%)	Rank
Environment & safety	8.90	6	3.53	6
Size	13.33	3	8.44	3
Total cost	22.22	1	38.89	1
Accessibility	20.00	2	28.75	2
Design	13.33	3	8.44	3
Risks	13.33	3	8.44	3
Population profile	8.90	6	3.53	6

Table 5.7: Criteria weightings and rankings comparison

#### 5.2.5.2. Comparing the Assessment

The next step, in this case, was the assessment of Locations A and B, which allowed the ranking of the criteria for both alternatives. With ER, the degree of belief for each sub-criterion is established independently; whereas, AHP remains at the criteria level and assesses both locations against the other, using pair-wise comparison. Table 5.8 compiles the results from both assessments at criteria level. It has been noted that, even if the results provided show that Location A is significantly the preferred option across three criteria, and Location B in two criteria, and that, overall, A is the preferred option, the quantification differences, which are the most paramount indicators for the final decision, are substantially different, according the selected modelling approach. Therefore, for this reason, a statistical test was undertaken – a two-proportion test.

*Hypothesis testing: is there any significant difference between the scoring ranges of the results obtained using ER compared to those obtained using AHP?*

H0: proportion [ER(a-b) = AHP(a-b)] – there are no differences between the proportions.

H1: proportion [ER(a-b) ≠ AHP(a-b)] – there are differences between the proportions.

P value = 0 < 0.05 (with  $\alpha = 0.05$ )

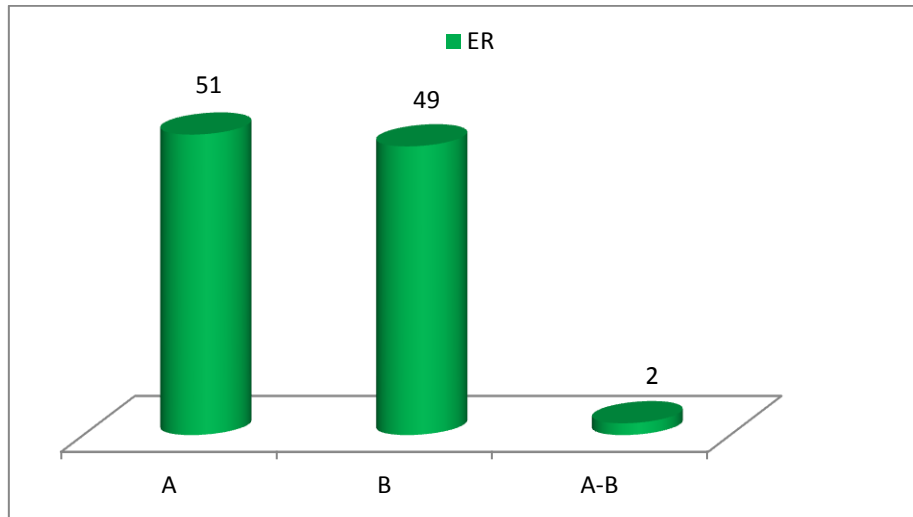
P value is lower than  $\alpha$ ; hence, H1 can be accepted. This means that there is a difference between the results obtained using ER compared to those obtained using AHP.

With ER, it is suggested that both locations reach similar normalised scores (A=51 and B=49). Therefore, it can be interpreted that Location A and B are performing similarly. However, when using the AHP model, there is less doubt that Location A significantly outstrips Location B (A=61.6 and B=38.4). Having said that, these results do not indicate which model provides the optimum solution in this example and context.

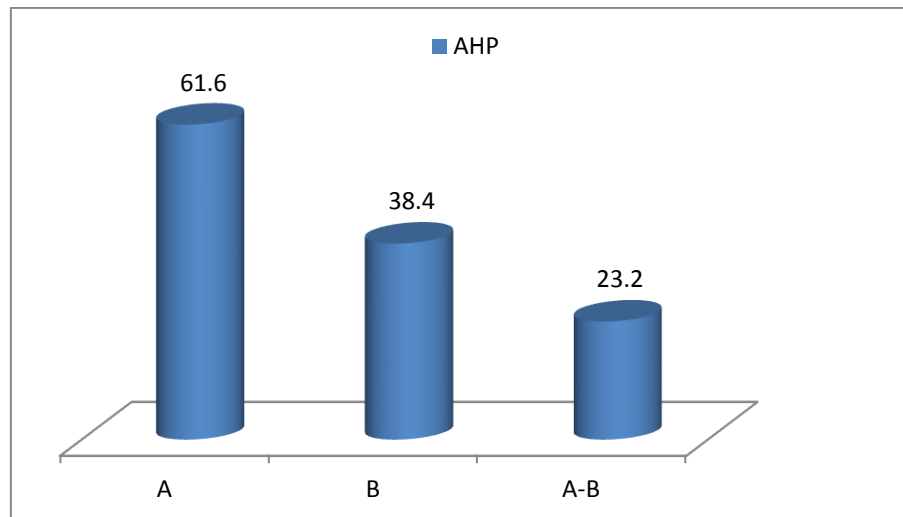
	Scoring			
	ER (IDS)		AHP (MiR)	
Criteria	A	B	A	B
Env & safety	67	56	75	25
Size	50	91	12.5	87.5
Total cost	66	34	87.5	12.5
Accessibility	45	45	50	50
Design	60	81	16.67	83.33
Risks	58	46	75	25
Population profile	50	50	50	50
Aggregate	56	54	880	549
Normalised	51	49	61.6	38.4

*Table 5.8: Scoring differences between ER and AHP*

The aggregated results, communicated to the decision-makers, are shown in Figure 5.15 and 5.16 below. The questions are: i) would the final recommendations change based on the ER or AHP results, and; ii) S-RQ4: what is the most suitable model (ER or AHP) to optimise the decision-making processes in this environment? This question will be addressed in Chapter Six.



*Figure 5.15: ER score summary*



*Figure 5.16: AHP score summary*

### 5.2.6. Summing up MCDA

In this section of the experimental research findings, it was explained how the implantation of MCDA, as a Lean technique, was achieved in order to increase the transparency and rationality of the decision-making process. This was demonstrated using the site selection, which, as discussed in Chapter Four, was one of the most critical and problematic decision-making processes. In this section, the researcher showed how the model was built and solved using two techniques – ER and AHP. The results were then compared and it was discovered that the results ranges were significantly different. The ER technique shows that there is only a very small difference in Location A compared to B; whereas, AHP suggests that the difference is significant. However, both models



generated the same answer – that Location A is the preferred option. This analysis led the researcher to investigate which model is the most suitable in order to improve the speed, rationality and transparency of the decision-making process. This will be discussed in Chapter Six, under sub-research question four: S-RQ4: what is the most suitable model (ER or AHP) to optimise the decision-making processes in this environment?

MCDA was the first Lean technique used to overcome two major root-cause problems, as identified in Chapter Four. These were that the site selection was not sufficiently transparent for the local population and the public consultation outcomes were not representative of the local population. The next section presents the Benchmarking and the performance framework designed to overcome the requirement for a more consistent and robust need analysis, and to align the departmental strategies.

### **5.3. The Performance Framework and Benchmarking**

As discussed during Chapter Four's analysis, an evident lack of alignment between the different departments has been discovered, hindering the performance of the new infrastructure. Moreover, it was become obvious that more consistent and robust need analysis could be performed, in order to improve the decision-making processes. To overcome these two substantial issues, a Lean inspired technique was developed and implemented – Benchmarking. However, in order to be effective, consistent and relevant, a bespoke performance framework had to be designed and agreed upon. Firstly, the following section will present the performance framework and detail the Benchmarking processes, before reporting the results from three external infrastructures, assessed by the team of stakeholders, to demonstrate the benefits.

The purpose of the performance framework was twofold: i) enable the organisation to measure and compare the infrastructure internally and externally, and; ii) use this framework as the foundation upon which to carry out solid Benchmarking activities and identify a strategy to support innovation and continuous improvement. Firstly, the background will be provided; secondly, the framework will be explained; thirdly, the Benchmarking partners will be presented; and, finally, the results will be reported.

#### **5.3.1. Background**

In order to develop a robust Benchmarking process, a cross-functional team was set up, representing the different groups of stakeholders and included eight people, five of whom were decision-makers from the organisation; the other three of whom were providers – a GP practice manager and two senior managers from the council and social services, all involved in the K project. It was considered that members of the public were not part of this equation, but that it could have been useful to have a contractor as part of the team. However, this was not possible at the time of the research. The rationale behind this Lean technique was to take different perspectives and assess the infrastructures and their services, based on the organisation's strategies. The cross functional team was briefed and had a clear vision of how the Benchmarking was going to be managed, which enabled them to agree on the Benchmarking partners. Three healthcare infrastructures were identified as potentially relevant, according to their characteristics. Two infrastructures in the North West of England were selected, as well as one in the US, considered best in

class. These cases will be described in this section, after the framework has been presented.

### **5.3.2. The Performance Framework**

As aforementioned, no suitable models or frameworks were available at the time of this research. Therefore, the team of experts used the research workshops as brainstorming sessions, to identify what aspects of the infrastructure would be important to measure and assess. The rationale was to develop a model that could be used by the decision-makers, to support the assessment of both internal and external infrastructure, and to inform them, in a consistent manner, on the performance level. Moreover, the framework will be used to initiate continuous improvement activities, as well as becoming a trigger for innovation. Hence, the final framework agreed was composed of four themes: i) 'estates and premises', which represents the hard facility aspects; ii) 'service provision', which provides an indication of the strategy selected to deliver and to design services; iii) 'operations management', which allows the assessment of the efficiency and effectiveness within the infrastructure, and, finally; iv) 'processes', which records and assesses the criteria referring to the planning and design activities and decision-making and development processes. Each theme is further detailed and subdivided into criteria. In total, 39 criteria were defined, which shows the multi-faceted nature of this framework and the complexity involved with new infrastructure development, a recurrent theme in the thesis.

Using this framework, the team was able to assess three sites. The data was collected through interviews with local GP practices managers and staff, on-site observations and discussions with specialists (Estates and other service providers). The team spent a day together on each site for both of the UK projects in April 2011. This was appropriate in order to gather the required set of data. For the US project, only the researcher visited the sites, due to a lack of financial resources available, in San Francisco and Sacramento.

To allow for the quantification process, the framework was specially designed by the researcher to accommodate for a weighting and a scoring mechanism for each criterion, or KPI, according to their respective scales. The weighting refers to each criterion's importance and has a number allocated to it, from 1 to 5 (1 = not important, 2 = moderately important, 3 = important, 4 = very important and 5 = extremely important).

The scoring refers to the performance of a particular criterion and has a number allocated, from 1 to 9 (1 = very poor, 3 = poor, 5 = average, 7 = good and 9 = very good). This mechanism allows the comparison of the projects, the identification of the gaps and enables improvement targets to be set up. The following section describes the framework in detail.

### 5.3.2.1. Estates and Premises

This first theme looked at the key estates' attributes, as detailed below in Table 5.9. These have been defined further by a statement to demonstrate precisely what was assessed. The definitions were based on the different departments' strategies and targets. The definition process allows the focus to be on the major points and has proved itself very beneficial, overcoming several of the issues discussed in Chapter Four, in terms of communication and lack of synchronisation. Table 5.9 presents the 11 criteria that have been identified, and their matching, agreed descriptions, in line with the functional strategies.

Ref	KPI	Description
A1	Design	There are clear ideas behind the design reflecting the NHS' values
A2	Size	The premises have a human scale and feel welcoming
A3	Capacity	The capacity of the premises suits the catchment area demand
A4	Resources utilisation	The resources are thoughtfully used
A5	Space utilisation	The space is thoughtfully used
A6	Equipment utilisation	The specific equipment is well used
A7	Estates running costs	The total, yearly premises cost is acceptable and meets the target
A8	Eco-friendliness	The total, yearly energy consumed is acceptable and meets the target
A9	Building layout	The interior of the building is logical, aesthetic and appropriately signposted
A10	Building facilities	The building offers good facilities to the staff and the consumers
A11	quality	General and durable finishes

*Table 5.9: Estates and premises criteria*

### 5.3.2.2. Service Provision

This second theme looks at what services are provided within the infrastructure. The organisation's strategy is to develop infrastructure in which both health and social services are provided, in such a way that synergies are developed throughout service integration and co-location. Therefore, the measurement framework needed to translate this aspect, as the eight criteria, composing this theme, show, summarised in Table 5.10.

Ref	KPI	Description
B1	Services provision	The right services are suitably provided to the consumers
B2	Level of integration	Intra and Inter organisation integration is successfully deployed
B3	Service culture	There is a clear service culture, in which the consumer is at the centre
B4	Implementation	The cultural change has happened effectively
B5	Service planning	The co-location of services have been achieved through effective planning
B6	Business results	The number of hospital admissions has dropped, and the inequalities reduced
B7	Impact on the community	The services and the building have a positive impact on the community
B8	Financial mechanism	The financial mechanisms have been clearly defined and are respected

*Table 5.10: Services criteria*

### 5.3.2.3. Operations Management

The operations management theme establishes the way in which the infrastructure was run at an operational level, but also at a strategic level. There are 11 crucial criteria to ensure the successful delivery of the services that have been identified, as shown in Table 5.11. These sets of data are relevant in order to link the previous two themes, and gain a better understanding of implementation issues.

Ref	KPI	Description
C1	Opening hours	The infrastructure offers a flexible range of opening times
C2	Consumer pathways	There are clear designed pathways
C3	Staff integration & mgt	Clear and effective staff activities and allocation of responsibilities
C4	Leadership	There is an effective and non-ambiguous senior management
C5	Staff satisfaction	The staff satisfaction is assessed and corrective actions are taken
C6	Consumer satisfaction	The consumer satisfaction is assessed and corrective actions are taken
C7	User involvement	Improvements are based on the Voice of the User / Consumer
C8	Conflict resolution	Conflicts are effectively resolved by senior managers
C9	Engineering systems	The engineering systems are well designed and efficient in use
C10	Accessibility	Public transport, roads, parking and pedestrian access are assessed
C11	Health & safety	Waste management and a fire planning strategy is in place

*Table 5.11: Operations management criteria*

#### 5.3.2.4. Processes

Finally, it seemed useful to capture the way in which the healthcare organisations have managed the planning and design of their new infrastructures, and decision-making processes, under a generic umbrella called ‘processes’. While the previous themes assess and consider output criteria, this theme focuses on the processes. Potentially, correlation analysis could be performed in order to assess the relationship between high performing processes and infrastructure performances. This is the rationale behind this theme, comprising nine criteria, as Table 5.12 below shows.

Ref	KPI	Description
D1	Alignment of strategies	The different partners’ strategies are logically aligned
D2	Need assessment	The need assessment outcomes have helped to design the services
D3	Development cycle time	The planning and construction cycle time have been under control
D4	Site selection	The site location has been optimally selected
D5	Decision-making process	The decision making process is robust and transparent for all stakeholders
D6	Public consultation	The local community participated enthusiastically in the public consultation
D7	Business cases	The business cases were handled effectively by the team
D8	Transition phase mgt	The services relocation was run smoothly
D9	Construction process	The construction took advantage of standardisation and pre-fabrication

*Table 5.12: Processes criteria*

In the following section, the utilisation and implementation of the framework will be demonstrated, based on the three different cases. Two cases, the P project and the W project, were selected locally and are similar types of infrastructures to the K project. However, the third case was selected in order to collect data from a project that is considered best in class – the Sutter Health organisation from the US. Both primary and secondary data was collected to support the assessment, and the findings are described in the following section.

#### 5.3.3. The Benchmarking Cases

##### 5.3.3.1. Case 1: The P Project

This healthcare infrastructure opened in November 2009. Its building is the largest of the region’s current phase and was a joint venture by a healthcare organisation and a city

council. The infrastructure offers a broad range of health services, together with community and council services. The centre, developed by a LIFT Company, cost £17 million, and, within its 6000 m<sup>2</sup>, accommodates two GP practices, a specialist children's facility and a library. The centre, also known as the 'gateway', won an award in the North West Region in 2010. *'The Awards recognise the best in the built environment, from architecture to planning, townscape to infrastructure, and reward projects that make a difference to local people and their communities'* (Britain's Best Building, 2012). This achievement was made possible via the coordinated efforts from the architects, Austin-Smith and Lord LLP; the contractor, Laing O'Rourke; the structural engineer, Shepherd Gilmour; the services engineer, Hoare Lea; and, obviously, the procurement team. Finally, according to the chairman of this LIFT company: *"The P gateway demonstrates enhanced, integrated public services in a stunning fit for purpose facility, leading the way in innovation. The response of the community, through significantly increased usage numbers from improved accessibility, is a justification of the investment in this joint service facility."* Hence, this was a relevant benchmark for the organisation, and, in March 2011, a day's full access was granted to the whole team; the visit itself taking place on 21/04/2011.

#### **5.3.3.2. Case 2: The W Project**

As part of the government's ten year plan to modernise and reform the NHS in this area, published in July 2000, this infrastructure was developed and then opened in September 2008. The W gateway was the first of three similar buildings planned in this area. This £12 million project was aimed at bringing key facilities, such as community health care services, council and library services, into one building of 3000 m<sup>2</sup>, making them as accessible as possible to the local population, and offering new services, which previously were hospital-based, such as X-rays. From within this building, users also have access to information about housing and council tax benefit. To ensure the best quality of provision for the city, the council and the healthcare organisation combined their efforts and resources to create this multi-functional centre, under a LIFT partnership venture. The organisation's chief executive said: *"This new, state of the art facility offers our people the opportunity to access both health and social care facilities, right on their doorstep. It also brings some services that were previously only available at the Royal Hospital, into the community and closer to where they live. This is one of the first centres of its kind in*

*the UK, which offers fully integrated working between the council and the healthcare organisation. It's a fantastic development for this area"* (Britain's Best Building, 2012). The W gateway offers many services, including: physiotherapy and occupational therapy; GP and dental services; community health services, including podiatry; community paediatrics and district nursing, among others, plus an advice and information area next to the library. Hence, this was also a relevant benchmark for the organisation and a day's full access was granted to the whole team in March 2011, with the visit taking place on 22/04/2011. Having detailed the UK Benchmarking cases, the next section will provide both the assessment results and a comparison, using the Benchmarking framework previously described.

#### **5.3.3.3. Comparing the P and W Gateways' Performances**

As previously explained, the team, made up of eight experts, undertook the assessment, following the framework in a structured and objective manner. For each criterion, the assessment consisted of capturing and recording the relevant pieces of information, weight, score and the provision of further qualitative information regarding this specific indicator. These factors were based on the consensus of the team. Although the two gateways differed in many aspects, it has been noted that, fundamentally, they are actually quite similar. This can be explained by the fact that the centres were developed within similar structures, and, to some extent, with the same vision and strategy. However, the results were relevant so that the healthcare organisation could compare itself with similar local organisations, set up targets based on the gap analysis, engage in a continuous improvement journey and support its strategy alignment.

The fact that the two gateways were similar was clearly translated by the framework results. The same patterns of results for both projects were established, with 'service provision' as the strongest theme, then 'operations management', then the 'estates and premises' theme, and, finally, the 'processes' theme. Moreover, it needs to be noted that the weightings remained the same; only the performances were changed so as to become consistent with the organisation's strategy. The disadvantage is that the overall results turned out to be very close to each other, meaning that, at first, the learning can be limited for the K project. However, this reflected the reality.



The following Figures, 5.17 and 5.18, present the results. Although, from the assessment, the P gateway was the award winning facility, with 10.52 points, , the team rated the W project as being slightly better , with 11.09 points. This was explained by the different set of criteria chosen in the bespoke performance framework, designed to holistically assess the effectiveness and efficiency of the infrastructure. Having clarified this, the following section justifies and explains the scoring, as well as discussing each theme in more depth.

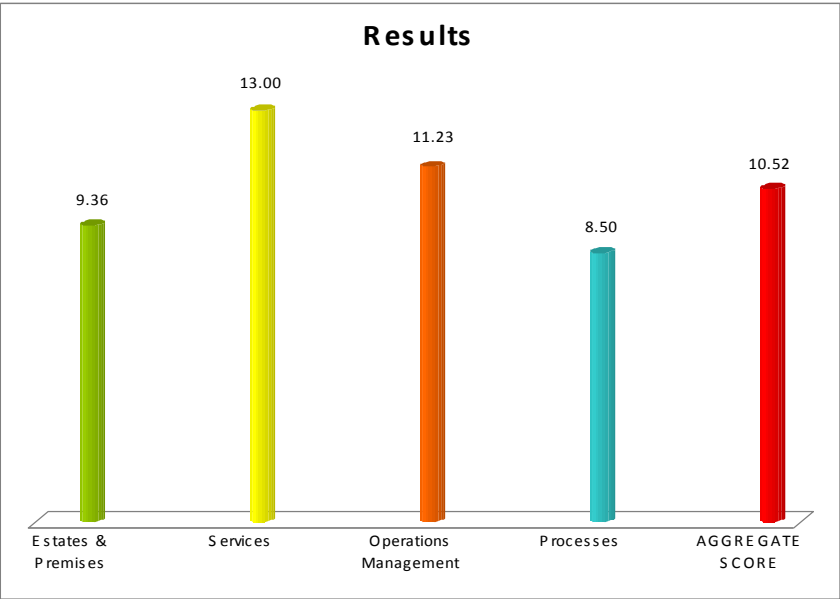


Figure 5.17: P gateway aggregated results

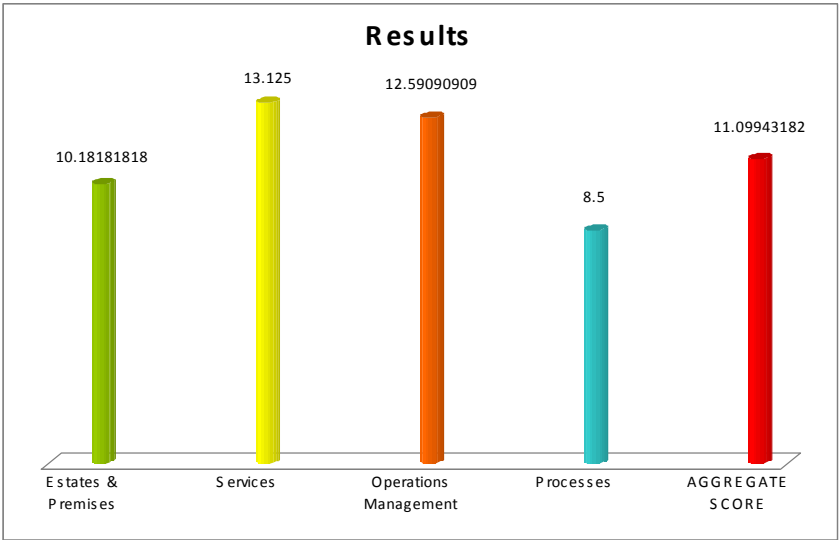


Figure 5.18: W gateway aggregated results

### ***Estates and Premises***

In this theme, the W project achieved a score of 10.18 points, which meant that it was rated slightly higher than the P project's 9.36 points. The quality of both buildings achieved high standards and the facilities available were very much appreciated by the users and staff. The P project has a 6000 m<sup>2</sup> foot print over three floors, receiving an average of 30,000 customers per month (360,000 visits per year), and has a running cost of £1,800,000 per year. However, the W project has a 3000 m<sup>2</sup> foot print, over 2 floors, receiving an average of about 22,000 customers per month (or 264,000 visits per year), and has a running cost of £900,000 per year. By extracting the two ratios, the comparisons become much more meaningful. Both infrastructures have an average running cost of £300/m<sup>2</sup>, which was considered very efficient. However, while the P gateway has a running cost of £5/visit/year, the W gateway is more efficient, with an average of £3.4/visit/year, which explains a slightly better score in the framework.

From the assessment, it was discovered that, in both buildings, the library, on the ground floor, has proved a successful '*catch*' to attract the local population (the library membership increased by 200%, according to the practice manager). The clinical services are provided in the higher floors. Although, in both buildings, the design and layout of the ground floor was very clear and open, it was felt that the higher floors were quite closed in, with many corridors, and did not provide easy navigation access through the building. However, overall, it was thought that the W gateway had a more effective design and layout.

The resources, space and equipment utilisation was very low, below 60% in both facilities. Therefore, the size of the infrastructures was challenged and the question of whether 6000 m<sup>2</sup> was required was posed. The estates strategy was to take advantage of the site availability instead of planning for further 10 or 20% extension, as is currently the norm. The decision to directly build a bigger facility was taken in both cases. This is extremely useful information, as this is not current practice in other healthcare organisations, which often opt to build a smaller infrastructure first, with the possibility of expanding it. However, this strategic decision has often been made without formally assessing the risks and cost associated with such an extension.

### ***Service Provision***

In both infrastructures, the strongest theme was 'service provision'. 13.00 points were allocated to the P gateway, and 13.1 to the W gateway. The team believed that, within both healthcare infrastructures, the co-location of services and their implementation had been successful. One of the key factors in their success was the strategy alignment and collaboration between the council and the healthcare organisation, as both entities had a similar vision for the centres and had managed to work closely to deliver the co-located services. This implementation had been made possible via the centre managers' team, which was the cornerstone of the success. There were five centre managers responsible for the implementation of the common strategy. The centre managers rotated across three gateways and had a complete understanding of these complex, public infrastructures. The centre managers were empowered to interface with all the different organisations and service providers. This helped to develop the cross-functional culture required for running a 'one stop shop' health and social care facility. Moreover, using the title 'gateway' for the centres is an efficient way to support the integration, as the staff were not labelled 'NHS' or 'council', and both the medical and admin staff were all part of the same team structure in the P or the W gateway. This was a completely innovative and efficient way of managing the infrastructure and services.

However, for the K project, the team and decision-makers believed that the road to achieving an ideal, true integration, as the organisation conceives it, remained long. For instance, it was felt that the GPs were apart from the rest of the staffing structure, with their own processes and independent receptions. Although good efforts were made around the IT systems, the P and W gateways were still running on different operating systems that were not all compatible with each other. In terms of service provision, although both gateways were good examples of successful coordination, full-integration had not yet been achieved.

Finally, to conclude these encouraging results, the cultural changes amongst the staff had been implemented without strong reluctance to change, which, again, was extremely positive.

### ***Operations Management***

The second strongest theme in both gateways was ‘operations management’, achieving a score of 11.23 points for the P gateway, and 12.59 points for the W gateway. Thanks to the centre managers, a strategy was in place to improve the facility and to manage the operations. For example, there were processes in place to measure staff performance, with improvements in user satisfaction being achieved based upon feedback collected; something that very few other healthcare organisations were successful in. It is considered that, within such integrated and complex infrastructure, roles and responsibilities must be clearly defined and identified in order to effectively resolve potential conflicts between different partners. It was felt that this was carefully thought through during the planning phase, and that the lessons gained from this were useful ones to learn.

The collaborative agreement between the healthcare organisation and the council was based upon the foot print utilisation. The current financial commitment in place was based upon the space allocated – 80% to healthcare services and 20% to council services in the P gateway, and 60% to healthcare services and 40% to council services in the W gateway. This system had worked thus far, but was being revised at the time of the research. This also proved to be a clear and simple model that the healthcare organisation could replicate in the K project.

The main differences between the P and W gateways were to be found in the customers’ pathways and accessibility. From the team’s feelings and judgements, both of these criteria were rated better for the W gateway, which goes towards explaining the final results.

### ***Processes***

This was more difficult to assess retrospectively. However, through discussions with the estates manager, who had been involved in both projects since the beginning, it was established that the planning, design and construction processes had been steady and efficient. However, there were no key innovations to learn from. Both the P and W gateways took between seven and 10 years to be completed, with a period of 18 months for the construction. It was felt by the estates manager: *“that the need analysis could have been improved to support the service design further”*. Interestingly, these issues around the processes of planning, design and construction are also the main issues faced by the

healthcare organisation producing the K project also. As the processes to plan and build both infrastructures were almost identical, they were equally rated; the team allocated an 8.50 points score for each, based on the data and judgments made.

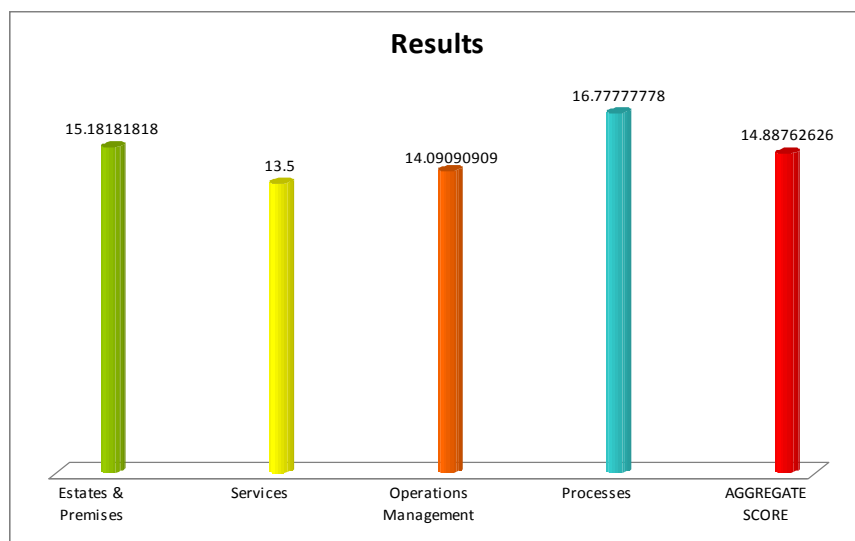
Having explained the performance framework and reported the findings for two carefully selected infrastructures, the Benchmarking seemed to have achieved its objectives in that it had: i) identified innovative practices, and; ii) supported the different functions in aligning their strategy. To satisfy other objectives, such as initiating the continuous improvement and increasing the innovation within the process of planning, designing and building healthcare infrastructure, the framework needed to be used regularly. Therefore, the decision was taken to assess a US infrastructure; one considered best in class. The researcher collected substantive secondary and primary data, in order to apply the performance framework and analyse the results. The following section will present the outcomes.

#### **5.3.3.4. Case 3: Sutter Health – Best in Class**

As part of the Benchmarking experimental findings, a US based organisation was identified who demonstrated advanced techniques in planning and designing healthcare infrastructures – Sutter Health. A large amount of data and information had been collected, in order to build up an understanding of the reasons why and how Sutter Health had successfully managed to implement Lean thinking in order to improve its infrastructure development and management. This not-for-profit healthcare organisation owns 27 hospitals and healthcare centres in Northern California (Sutter Health, 2012). In 2004, Sutter Health embarked on a long and challenging journey, the goal of which was to apply Lean principles to the design and construction of their infrastructures, so as to develop state of art hospitals and other healthcare centres (Lichtig, 2010). The drivers were to cope with the changing demand, and to improve their performance and innovation by building flexible facilities, to cope with the dynamic healthcare environment. Hence, the organisation was allocated \$5.5 billion (Lichtig, 2005; Hamzeh, Ballard & Tommelein, 2009). Based on secondary and primary data collection, the researcher was able to complete a concrete assessment of Sutter Health infrastructures, considered as an example of best practice in healthcare infrastructure development. The assessment compiled the data into the performance framework and was made with objectivity. However, one needed to acknowledge that the performance framework may not have been entirely

designed to suit the Sutter Health strategy, as it was specifically designed for NHS organisation infrastructures in the UK. However, despite the differences between the US healthcare system and the British system, in terms of the different resources and objectives to satisfy, this assessment still proved legitimate and relevant for the organisation. It is still useful to note that, within such a different environment, similar problems occur regarding the decision-making processes. Therefore, solutions can be transferable from one system to the other, in order to further improve the infrastructure development processes.

The findings were compiled into the developed performance framework. In the following sections, the Sutter Health infrastructure is described and analysed against the four themes: ‘estates and premises’, ‘services’, ‘operations management’ and ‘processes’ (Appendix 4: Sutter Health Benchmarking Assessment). Based on the collected data, the assessment confirmed that Sutter Health was among the exemplars of best practice encountered in healthcare so far. They have achieved the highest score compiled, performing better than any other infrastructure assessed internally and externally, with an aggregate score of 14.8 points, as illustrated in Figure 5.19. The points system was established to assist the decision-makers in comparing and benchmarking the different infrastructure performances, based on the same measurement system, and to help them to focus on innovation and to drive improvements. As explained and defined above, the points are based on two factors: the weighting, which considers the importance of the criteria, assessed on a 1 to 5 scale; and the scoring, which considers the performance of the criteria, assessed on a scale from 1 to 9.



*Figure 5.19: Assessment results for Sutter Health*

### ***Estates and Premises***

To better understand the best practice Sutter Health exhibits within this category, San Francisco's Cathedral Hill hospital has been the main source of information. This 15 storey building was validated in 2007, and is expected to be completed in 2014. Its size will be approximately 100,000 m<sup>2</sup> (including underground car parking facilities). This enormous infrastructure, located right in the middle of San Francisco city, will facilitate the current California Pacific Medical Centre (CPMC) and accommodate services from St Luke Hospital, both of which are located in San Francisco also. The design and construction phases have integrated Lean principles and concepts (*i.e.*: Just-In-Time, evidence based design methods, decision-making modelling, the focus upon value for users/consumers, and integrated supply chain partners), successfully implemented thanks to the collaboration of the different partners involved. The Smith Group, as an architecture and engineering planning partner, who provided their experience of managing change processes; the Lean Construction Institute (LCI), as body of reference; and the University of California, in Berkeley, as a laboratory of research (Hamzeh, Ballard & Tommelein, 2009; Lichting, 2010). There are also several other partners that have been involved, such as Capstone Consulting and Lean Project Consulting, to deploy the enterprise wide solution to support all the contractors and sub-contractors in working with Lean principles. It is believed that this result would not have been achieved without the support and collaboration of all the partners. The results of this collaboration, and the efforts put into the design, are reflected within the assessment of the 'estates and premises' category, scoring 15.1 points. For example, this 15 storey building will accommodate 555 beds, established as the optimum capacity, according to the demand of the catchment area, forecasting the attraction of patients from the whole of San Francisco. The layout has been designed according to the potential patient flows and routes. It is organised around comprehensive centres of care rather than the traditional departments, which will enhance the delivery of services whilst improving space, capacity, service efficiencies, streamlining the workflow, and optimising the utilisation of resources and equipment. This layout design is a direct application of Lean principles, created with the input of the users and clinicians to minimise wasted space, while supporting service delivery. Other innovations achieved in the infrastructure are related to the eco-friendliness and engineering systems, which were cited as key features for optimisation at the beginning of

the project, when considering the choice of material, building quality, natural lighting and ventilation and heating systems.

As is to be expected, this project has a huge cost attached to it, compared to the budget available to the NHS – it was reported that almost \$2 billion were allocated to this US project. However, Sutter Health observed and claimed that the development costs are under control, thanks to the application of Lean principles, and expects the infrastructure running costs to be optimised, thanks to the fitness for purpose achieved (reduction of back-log maintenance, rework, efficient energy consumption and service quality).

### ***The Services' Culture and Organisation***

Within the performance framework, the rationale for capturing and assessing the 'service' theme was to assess the service culture, service integration implementation and establish the link between the service delivery and the infrastructure itself. Having said that, the framework was used slightly differently to accommodate the Sutter Health strategy and model. Sutter Health provides healthcare services to more than 100 communities throughout Northern California, thanks to 27 acute care hospitals, medical research facilities, region-wide home services, hospices and occupational health services, and long-term care centres, employing over 3,500 physicians and 41,000 staff (Capstone, 2005). The selection and development of the service culture was identified and defined by the Sutter Health headquarters, and is translated into the different facilities, according to the communities served. However, it appears that Sutter Health promotes good integration between the different services and partners, which is facilitated by the manifesto and collaborative agreements, which need to be signed by all partners after having established the strategic roles and responsibilities. This type of agreement is a key support in implementing their Lean vision; firstly, for the infrastructure development, but also in order to provide the healthcare services (Lichtig, 2010). Once Cathedral Hill is fully operational, it will be expected that the CPMC Pacific and California campuses will close, and that the transfer of specific services from St Luke Hospital will take place, so as to optimise the service quality and generate financial benefits, by pooling resources into one infrastructure. The transition phase started early in the process to make sure that the transformation of the services runs smoothly. Sutter Health considers service planning to be an integral part of the infrastructure design – it is of paramount importance to overlap the two when integrating fitness for purpose into the design. They achieved this result by



including the decision-makers, services planners and providers within the core team, which also helped to enhance the Lean culture deployment throughout the organisation. Sutter Health believes that, by centralising services, the healthcare outcome will be improved. However, it was acknowledged that, even though 'services' achieved a high score of 13.5 points in the framework, this is the category from which what could be learned was of the least importance out of the four.

### ***Operations Management***

To assess the way in which the operations are being managed by Sutter Health, Sacramento Medical Centre and Pacific Campus were the main sources of information, but it was relevant to link them to Cathedral Hill too. Sacramento Medical Centre and the Pacific Centre are tertiary, referral centres – they provide a wide variety of services, including acute, post-acute and outpatient hospital care; home care and hospice services; preventive and complementary care; and health education, and are very complex systems to manage. Hence, Sutter Health has developed several procedures, relying on clear management bodies to support the operations management, whereby they manage operations according to the patient. Within the visited sites, it appeared that consumer pathways are an integral part of the design and management of the operations. This is why co-locating all of the services within one infrastructure has proved a major advantage. Sutter Health considers that the patients' route through the system and services needs to be flexible enough to meet their requirements. To some extent, this can be associated with the service integration concept. This will be clarified using the Cathedral Hill design and the modular layout achieved; the rationale being to use a flexible design to meet different pathways' needs. Moreover, strong leadership was key in achieving this – the organisation relies on strong leadership and Sutter Health has set up a system with clearly defined roles and responsibilities. For instance, the conflict resolution protocol, part of the construction operations management, is well defined; this is also applicable to the different parties at the planning and design phases, and for managing the services. Sutter Health has developed clear procedures to manage any conflicts and always promotes consensus or compromise (Lichtig, 2005). Potentially, this is the cornerstone upon which to start managing the operations effectively. At Sutter Health, an incentive programme was put in place to manage the operations – the organisation developed incentive programmes to encourage superior performance, based on the strategy. It was clear that the organisation

engaged with its patients and staff to encourage general improvements on a regular basis, and developed this as part of the organisation culture. This explains the rationale for the high score and justifies the 14 point aggregated score, based on the assessment of the 11 criteria belonging to this category.

### ***Processes***

Out of all the categories, Lean thinking has made the greatest impact on the ‘processes’ theme, which justifies the 16.7 points allocated to it in the framework. Implementing these innovative approaches has challenged the status quo, encouraging change in the processes of traditional infrastructure development. Sutter Health has successfully managed this transition and has been through a substantial change process. The partners recognised that this has not been easy. It has, however, been very beneficial. Firstly, they had to work collaboratively with the whole of the supply chain, aligning their different strategies – this was also facilitated by the Integrated Project Delivery Agreement. These documents enabled the establishment of the strategies at the corporate level, intra and inter organisations, but also at the operational level for the planning, design and construction phases. What was important to note is that the Cathedral Hill infrastructure was started in the 2000’s. However, four years later, the project had to stop – it was not going to be successful, and, at that time, was expected to come in \$400 million over budget (Tommelein, 2011). Therefore, in 2004, Sutter Health decided to re-group and implemented a Lean perspective, by collaborating with the Lean Construction Institute (LCI) and the University of California, Berkeley. It was claimed that, with the help of this new organisation, 90% of the initial programme could be delivered within 70% of the total cost. The Lean Construction Institute worked with the Sutter Health partners to establish and streamline the decision-making processes that were identified as problematic. They developed a decision-making technique called ‘Choosing by Advantage’ (CBA) to optimise each of the decision-making processes (Parrish & Tommelein, 2009). Interestingly, this can be associated with the MCDA work (presented earlier in this chapter) in terms of improving planning decisions. However, Sutter Health systematically implemented this decision-making technique at the design stage, to make sure that they had explored all alternatives and made the optimum choice, which will relate to the following section and the application of QFD to design decisions. It was reported that up to a 30% reduction of the cost, associated with design features, could be generated by

making the right decisions at the right moment, based on the consensus. Their communication processes have evolved. The A3 communication tends to be the norm; this helps the planners, engineers and architects to work collaboratively and communicate effectively. The A3 format enables the implementation of Lean thinking to facilitate improvements and set up control mechanisms. The visual display is the model adopted to support the transparent sharing of information across the different parties. The co-location of offices, between the different teams, seems to be efficient too, in terms of sharing information across the different organisations. A major challenge was to enable corrections and modifications during the construction design, linking both design and construction. To do this requires a reliable information system, which has the necessary visibility to make the changes on time. Finally, Sutter Health recognised the importance of the lessons learnt process during and after each programme, setting up mechanisms and a feedback loop to constantly improve processes and products.

The Sutter Health example was extremely relevant to benchmark, their approach to new infrastructure development is very innovative and challenges the pre-conceived ideas. Their Lean thinking approaches have generated huge benefits and are now used as an example to the construction world.

#### **5.3.4. Summing up the Benchmarking Findings**

In this section, the Benchmarking findings were reported. Firstly, the bespoke performance framework was explained, and then three relevant cases were described and assessed. Both the P and W gateways studied were extremely relevant benchmarks, due to their similarities, in terms of scope, size, budget and strategy, to the K project; hence, they are compared. The third case was selected so that data could be collected from what the researches consider to be best in class, and was described separately. The Sutter Health case was an eye opener in terms of room for improvement and innovation potential. Substantial learning took place through challenging the status-quo. The framework made the team think in a different and more innovative way; for instance, in terms of design and layout, or regarding the management of their infrastructure. But, most of all, this inspired Lean thinking technique (*i.e.*: Benchmarking) allowed the different functional strategies to be aligned, through agreement on the key criteria, evaluation of their importance and having the ability to establish a performance assessment. This performance framework has been extremely useful in terms of challenging the current practices and helping the

decision-makers to explore different models for planning and designing healthcare infrastructure. This was relevant as it allowed the need analysis to be performed in a more consistent and robust manner. By focusing on the framework, the decision-makers were able to ask about and communicate what data was required to make the decisions, in a very transparent manner. From the experimental findings, the need analysis team appreciated the ability to work under a framework. However, to be used optimally, it was felt that the performance framework should be linked with the planning and design decision-making processes. Therefore, it was important to use another Lean technique, which would support the design decision-making (*i.e.*: QFD). Quality Function Deployment (QFD) was identified as appropriate and, consequently, implemented. The following section will show the use of QFD based on its standard model – the House of Quality (HoQ).

## **5.4. QFD**

In this final section of the experimental findings, Quality Function Deployment (QFD) implementation will be presented, based on the K project. The main objectives of this implementation were: i) to capture the voice of the stakeholders, customers and patients, and translate them into the design of both the infrastructure and the service operations; ii) to further increase the alignment of the different departmental strategies, and; iii) to support the decision-making process at the design phase. At the end of the planning phase and the start of the design phase, this Lean thinking technique enables the decision-makers (DM) to explore the relationships between the decision-makers' vision and the local population's requirements, within the constraints of budget, cost, and construction methods. The idea is to develop the design phase around a design process, in order to generate possible design features and evaluate them against alternatives in a transparent and rational manner.

Firstly, a brief overview of the QFD process is presented, and then the vision and expectations of the decision-makers, for the K project, are detailed, with the findings from the public consultation. Afterwards, the description of the QFD application in the K project will be discussed around the findings of the two first iterations, using the House of Quality (HoQ).

### **5.4.1. QFD Information Translated into Design**

Quality Function Deployment (QFD) methodology was first developed by the Japanese manufacturing companies, in order to capture their customers' requirements and translate them into design and manufacturing specificities. These principles and concepts have been applied so as to understand the 'voice of stakeholders and customers', during the public consultation, in order to build quality into the infrastructure and service operations. As mentioned in the literature, QFD relies on a framework, often referred as the 'House of Quality' (HoQ), which has been used in its standard form for the K project. This approach has been introduced within the design phase of the new infrastructure development (NID), in order to transform the requirements of the decision-makers, providers, patients and local communities into both service and building design for the K project.

#### **5.4.2. The Case Background – the Decision-Makers' Vision for the K Project**

The K project had a strategic and innovative focus. The healthcare organisation aimed to develop a state of the art building, in order to create an environment in which the local authorities, the council and the social services organisations could cohabit, under one roof, to offer and provide an integrated service to their local communities. This was part of the transformation programme, through which the decision-makers realised how important their infrastructure will be in the future as a vehicle, both to achieve their vision and to support the development of a competitive edge, or to become a world class organisation.

The aim was to develop a range of innovative care packages, in collaboration with the aforementioned partners, in order to provide an optimum care service for the patient. One of the objectives was to reduce hospital admissions, by being able to provide a fast diagnosis from a specialist's opinion when required, and to have a pro-active approach to healthcare. To achieve this model of excellence of care, it was clear that, firstly, the infrastructure needed to be adequately designed. After all, it is the interface and the physical resource from which to provide the services. Furthermore, a new clinical services portfolio needed to be developed for creating the innovative care package; this would be achieved through suitable service and operation design. The organisation's ambition for the K project was to design a patient centred approach, so as to create a sustainable local health economy for the local population and to change the current healthcare model, which is dominated by hospital delivery.

It was clear that developing this infrastructure was a real challenge for the organisation as this type of infrastructure had not been planned or designed before. The researcher identified that QFD could offer an established framework, which would allow the decision-makers to conceptualise their ideas for the K project by integrating the voice of the local communities, and considering the financial and physical constraints. This was achieved with a team of 10, composed of eight decision-makers and two providers; three members came from the estates team, two from primary care, three senior managers and deputy directors, and two service providers at senior level.

Having summarised and captured the vision of the decision-makers for the K project, it is now appropriate to sum up the findings regarding the local population's requirements, in terms of design.

#### **5.4.3. The Public Consultation Findings for Design**

Throughout the four months during which the local population engaged with the decision-makers and providers to discuss the K project, a list of key requirements was developed. These are reported in this section, using some of the quotes collected.

It was important to the local population to have a: *“bright and welcoming building with lots of space”*, possibly with: *“multi-functional areas, ensuring maximum flexibility and some extra space for people to meet”*. Moreover, they said that they were expecting: *“a building designed around people and their movements to ensure that it is cohesive”*. It was recorded that the users also required good communication and clear signage. They said: *“the internal walls and static display should be used to provide information about where to access services”*. It was also mentioned that: *“signs should be written in several languages and pictures provided, so that everyone can understand them”*. Some users explained that it would be important to have: *“friendly guides, or buddies, to help people to find their way around the building”*.

Furthermore, the aspects of sustainability and eco-friendliness were also specific requirements that the local population were keen to have: *“a purpose-built, efficient and eco-friendly building, using technologies to minimise the building's environmental impact”*. Also, it was mentioned that: *“having an external area with wildlife and trees instead of shrubs”* would be beneficial.

Of course, as one can imagine, the accessibility was a recurrent theme. The public were expecting: *“lots of free car parking, a dedicated space where people can be picked up or dropped off for appointments, and good bus routes, ideally with a bus stop outside the building”*.

Other issues, such as security and safety, were raised. It seemed important to have: *“security teams and cameras to help people feel secure”*, plus: *“first-class hygiene and infection control procedures”* were expected.

Therefore, in the first instance, the vision and requirements from the decision-makers were established, then the findings from the public's expectations were summarised. This is where QFD added value to the process of supporting design decision-making. The process is detailed below.

#### **5.4.4. The QFD Process – 1<sup>st</sup> Iteration**

As mentioned and explained in Chapter Two, QFD is used to assess the stakeholders' key elements and requirements, by following the nine standard steps process (Rahman & Qureshi, 2008), which is detailed below. However, before the nine steps could be applied, it is relevant to explain that, after having compiled and summarised the vision for the building and the key requirements that the organisation had, as well as having consulted the users and agreed on the criteria that they were expecting, the team of decision-makers was able to input these sets of information into the HoQ model, in order to support the decision-making process at the design phase. This enabled the decision-makers to discuss and agree on the key design features for the future healthcare infrastructure, from a top-down approach. Without QFD, this process would not have happened.

##### **5.4.4.1. Define Service User and Stakeholders' Requirements**

At the beginning of the QFD process, the decision-makers needed to define both the user and stakeholders' requirements, based on their strategy and vision. This information was collected through the analysis of the patient needs' questionnaires, focus group feedback, and, especially, from the consultation activities reports. Within the QFD core team, the consensus was established and 10 main demands of quality, or stakeholder requirements, were identified. Therefore, the new infrastructure would need to meet the following requirements: i) have very good accessibility; ii) ensure minimum waiting time; iii) have an effective workforce; iv) demonstrate good communication; v) provide an aesthetic environment; vi) provide excellent customer service; vii) have multiple, integrated services; viii) respect patient security and privacy; ix) achieve a design which is easy to navigate through, and; x) be the main and unique healthcare point of contact for the local population.

These requirements can be sorted into different domains, such as clinical versus non-clinical, or infrastructure versus services. However, as it can be seen, these requirements translate the strategy and vision of the decision-makers, as well as the users' expectations.



As with the MCDA and the performance framework, QFD supports the decision-making processes; hence, a quantification process is also facilitated in the House of Quality (HoQ).

#### 5.4.4.2. Rates of Importance

During a dedicated QFD workshop in mid-2011, which included 22 associates, they were asked to rate the importance of each of the 10 requirements, on a scale from 1 to 5 (1 = neutral, 2 = important, 3 = quite important, 4 = very important, 5 = extremely important). The mode for each of these 10 requirements was then selected, as it can be seen in Table 5.13 below. This process allowed the decision-makers to focus on the features that the stakeholders perceived as being a priority, in order to increase the customer, or user, satisfaction.

5.0	Very good access to the centre
4.0	Minimum or no waiting time (capacity mgt)
4.0	Workforce effectiveness
2.0	Good communication
2.0	Aesthetic environment
5.0	High quality customer service
3.0	Multiple services
3.0	Patient security and privacy
4.0	Easy navigation in the building
3.0	Main point of contact for healthcare

*Table 5.13: Requirement weightings*

It can be seen that ‘very good access to the centre’ and ‘high quality customer service’ were the most important criteria agreed by the decision-makers to be ‘extremely important’, with an associated weighting of 5. Then, ‘minimum or no waiting time’, ‘workforce effectiveness’ and ‘easy navigation of the building’ were allocated a weighting of 4 and thought to be ‘very important’. ‘Multiple services’, ‘patient security and privacy’ and ‘main point of contact for healthcare’ had a weighting of 3, meaning that they were ‘quite important’. Finally, ‘good communication’ and ‘aesthetic environment’ had a

weighting of 2, which means that they were rated as ‘important’. Logically, it was agreed that none of the identified and selected requirements were considered simply ‘neutral’. Having established the top 10 requirements and their associated weightings, the team then needed to identify the service and product characteristics to satisfy these requirements.

#### **5.4.4.3. Establishing Service and Infrastructure Characteristics**

In this, the third stage, the decision-makers identified a set of 15 technical characteristics. These technical characteristics helped to define how it would be possible to deliver both patient and service users’ needs within measurable and operational features. The decision-makers identified and agreed on the following: i) a modern and flexible design; ii) suitable car parking; iii) specific transport links; iv) an effective and transparent waiting time with queuing systems in place; v) to provide extended opening hours; vi) a successful service integration; vii) deployment of an efficient communication culture and processes; viii) an aesthetic interior decor ix) to have an integrated IT system and to provide DIY technology; x) to achieve top quality healthcare service; xi) to provide multi-lingual support; xii) to have complying disabled access inside and outside; xiii) to have different types of consulting rooms; xiv) to have good signage and a clear layout, and; xv) to be a single point of access with a pharmacy, physio and hot desk clinical specialist services.

Following the technical characteristics, the HoQ facilitated the analysis between the requirements and the technical characteristics by analysis of each relationship, establishing a coefficient.

#### **5.4.4.4. Analysing the Requirements’ Relationships with the Characteristics**

This is the main body of HoQ and can be time consuming. The team of decision-makers needed to analyse the relationships between each requirement and each characteristic in order to assess to what extent there was a correlation, according to a pre-defined scale. This needed to be agreed between all the stakeholders so as to build a consensus (1 or  $\Delta$  = weak relationship; 3 or  $O$  = moderate relationship; 9 or  $\Theta$  = strong relationship), as shown in Figure 5.20.

<div>Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")</div> <div>Demanded Quality (a.k.a. "Customer Requirements" or "Whats")</div>	modern and flexible design	Car parking	Transport links	waiting time and queuing system	extended opening hours	service integration / appropriate service design	communication culture and processes	aesthetic interior decor	IT system and technology DIY	Top healthcare service Quality	Multi-lingual support / council services	disable access inside/outside	different type of consultancy rooms	good sign postage and clear layout	single point of access (pharmacy, physio, hot desk specialist services)
very good access to the centre	▲	⊖	⊖		○	▲			▲		▲	⊖			▲
no or minimum waiting time (Capacity mgt)	○			⊖	⊖	⊖	▲		○				▲		▲
workforce effectiveness					▲	○	⊖		○	▲			▲		▲
good communication						⊖	⊖		▲	▲	▲			▲	
aesthetic environment	⊖							⊖				▲	▲	○	
high customer services quality	○	▲	▲	⊖	⊖	○	▲	○	○	⊖	▲	▲			○
multiple services	⊖				○	⊖	○		▲		○		▲		⊖
patient security and privacy	▲			▲		○	▲				▲		○		○
easy to navigate in the building	⊖					▲		▲	▲			○		⊖	▲
main point of contact with Healthcare					○	⊖			○	⊖			▲		⊖

Figure 5.20: Relationships analysis

As discussed previously, the two most important requirements identified were ‘very good access to the centre’, and ‘high quality customer service’. These two requirements will be discussed below, and their relationships with the characteristics explained.

### ***Very Good Access to Centre***

In this matrix, it can be seen that, for instance, the decision-makers considered and agreed that ‘very good access to the centre’ had a weak relationship with ‘modern and flexible design’, ‘service integration / appropriate service design’, ‘IT system and DIY technology’, ‘multi-lingual support / council services’, and ‘single point of access’. The decision-makers deemed that ‘very good access to the centre’ would be achieved through the use of different aspects, and they did not think of it as external accessibility alone. Therefore, it was discussed that the use of performing IT systems and technology would support improvements in the access (*i.e.*: use of telecare and providing an online booking website). Moreover, the decision-makers thought that providing ‘multi-lingual support / council services’ would increase access to a non-English speaking population, which happened to be high in this area. Furthermore, it was believed that, if the infrastructure was modern, patients would be more likely to use the services there instead of going to

hospital. Lastly, if the service portfolio was to be integrated and the infrastructure had a single point of access strategy, then the patients would have greater access to the right care.

Furthermore, ‘very good access to the centre’ had a moderate relationship with ‘extended opening hours’. It is logical to understand that, if the centre is open until 9 p.m. instead of 5.30 p.m., then more patients will have a greater access to care.

Finally, it was established that ‘very good access to the centre’ had a strong relationship with ‘car parking’, ‘transport links’, and ‘disabled access inside/outside’. The decision-makers agreed that these three characteristics would have a strong, positive impact on accessibility.

### ***High Quality Customer Service***

Within their vision, the decision-makers wanted to consider patients and users as customers. This was deemed an extremely important aspect of the culture for the future healthcare centre, and needed to be part of the design features.

In the matrix represented in Figure 5.20, it can be seen that ‘high quality customer service’ had a weak relationship with the ‘car parking’, ‘transport links’, ‘communication culture and processes’ (within the infrastructure), ‘multi-lingual support / council services’ and ‘disabled access inside / outside’. This is because the decision-makers considered that service quality is complex and seen completely differently by diverse groups of users. However, they agreed that ‘high quality customer service’ would be perceived if ‘car parking’ was available on site, and if the ‘transport links’ were effective. Moreover, it was decided that ‘good communication’ with the patients, inter and intra the infrastructure, would be extremely important, but, also of equal importance would be the customer perception of the effectiveness and efficiency of the communication between the different services or organisations. Hence, processes would need to be designed and put in place right at the start. Also, it was established that designing excellent disabled facilities would be seen as supporting ‘high quality customer service’.

Moreover, it was agreed that ‘high quality customer service’ had a moderate relationship with ‘modern and flexible design’, ‘service integration / appropriate service design’, the ‘aesthetic interior decor, the ‘IT system and DIY technology’, and the ‘single point of

access'. It is extremely relevant to note that, throughout the infrastructure and services, fitness for purpose is built into the design; therefore, 'high customer service' can be achieved.

Finally, it was agreed by the decision-makers that 'high quality customer service' had a strong relationship with the following characteristics: 'waiting time and queuing system', 'extended opening hours' and achieving 'top quality healthcare service'. It is relevant to note that the decision-makers agreed that, firstly, 'top quality healthcare service' was dependent on the core business providing excellence in healthcare, but that it could also be achieved by using some simple design features, such as 'extended opening hours' and by providing fast services while managing waiting time and queues, which are related to capacity management issues.

Obviously, the researcher facilitated each intersection of the matrix during the workshops, in order to build a complete agreement with the decision-makers. However, the remaining details won't be explained further in this thesis, but it is believed that, by now, the matrix in Figure 5.20 has become more self-explanatory. This terminates step 4 of the QFD process.

#### **5.4.4.5. Modifying the Requirements as Necessary**

At this stage, a revision of the service / product characteristics may be appropriate, although the decision-makers made few amendments at this point in the process. However, the researcher presents here the final version, as very small and insignificant changes were made. Having said that, what is critical to report is that this step created the opportunity to challenge the QFD results and the data input within the framework. It was the opportunity to step back and try to make sense of this process. It is at this stage that the decision-makers agreed on the consensus, and aligned, even further, their strategies and processes, in order to achieve the objectives which had started to emerge from the QFD, especially between Estates and Primary Care.

#### **5.4.4.6. Analysing Services Correlations and Trade-offs**

For each of the 15 characteristics, under the standard HoQ framework, the decision-makers needed to identify the correlation – either positive, neutral or negative – between all the other characteristics. This was facilitated by the 'roof' of the framework. It allowed

for consideration of trade-offs and balances the resources at the design phase, as Figure 5.21 below illustrates. To evaluate the correlations, there is a standard notation: ‘++’, means that there is a strong, positive correlation between the characteristics; ‘+’ means that there is a positive correlation; ‘-’ means that there is a negative correlation; and, finally, ‘- -’ means that there is a strong, negative correlation.

To illustrate these correlations, some of the findings will be explained. The decision-makers considered and agreed that ‘modern and flexible design’ had a negative correlation with ‘car parking’, as they were thinking that the car parking will consume space that could be otherwise utilised. However, they thought that ‘modern and flexible design’ had a positive correlation with ‘transport links’, ‘waiting time and queuing system’, ‘IT system and DIY technology’, ‘top quality healthcare service’, ‘disabled access inside / outside’, ‘good signage and clear layout’, and ‘single point of access’. The decision-makers also identified a strong, positive correlation with ‘service integration / appropriate service design’ and ‘aesthetic interior design’. It shows that, by achieving one of the characteristics i.e. ‘modern and flexible design’, other characteristics will also be impacted positively. In terms of the decision-making process, it is the negative correlations that must be looked at carefully, and, where necessary, trade-offs will need to be considered. It is relevant to note that, out of the 105 possible correlations, only 12 were marked with a negative coefficient and 38 marked with a positive, or strongly positive, coefficient, which left 55 uncorrelated characteristics.

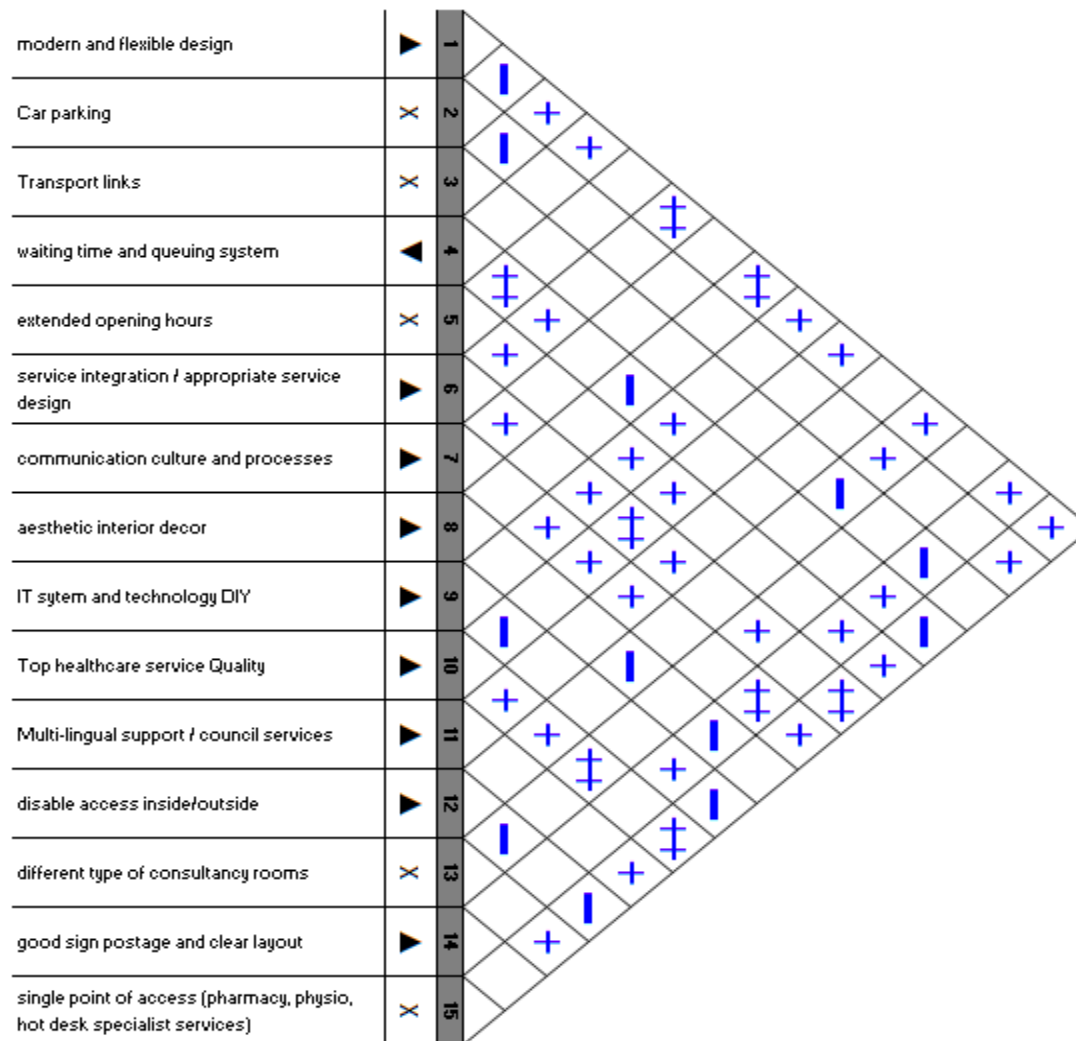


Figure 5.21: Trade-off analysis

Therefore, in terms of investment, the possible, negative trade-offs, which will need to be considered further, are between ‘car parking’ and ‘transport links’ – is it worth having extensive car parking if there are opportunities to work in collaboration with transport providers to add to services and change a few routes, so as to facilitate the new health centre? There might be a negative correlation between ‘transport links’ and the perception of ‘disabled access inside / outside’ the infrastructure, as well as a negative correlation with ‘good signage and clear layout’, because these might be outside of the scope of the healthcare organisation, but, if not included within the design phase, these factors will still prove detrimental to ‘top quality healthcare service’, and, therefore, must be considered, so as to reduce risks in the future. Furthermore, there is a negative correlation between ‘waiting time and queuing system’ and ‘single point of access’, as, logically, ‘single point of access’ would create more demand for the healthcare’s services; hence, ‘waiting time

and queuing system' can be affected if suitable processes are not designed effectively. The same rationale applies to 'extended opening hours'. Moreover, the decision-makers identified that 'aesthetic interior decor' could have a negative correlation both with 'good signage and clear layout', as well as with 'disabled access inside / outside', even if this could prove a controversial issue, as was mentioned by the decision-makers. 'IT system and DIY technology' could be perceived as being negatively correlated with 'top quality healthcare service', as, normally within the service industry, DIY technology emerges only within the low cost organisations. Also, 'IT system and DIY technology' could have a negative correlation with 'single point of access', through having to deploy a much more complicated IT infrastructure than is usually planned. Finally, the last of the negative correlations lay between 'disabled access inside / outside' and 'different types of consultancy rooms' and with 'single point of access', which would probably increase the cost substantially, and, therefore, needs to be given careful consideration during the design phase.

This step was extremely powerful in starting to identify potential issues and make the decision-makers think about the challenges associated with the design decision-making process. It was also noted that every trade-off would impact either the cost of the design or the quality of the service delivery. Having said that, it was satisfying to notice that most of the relationships had positive correlations, through which synergies would be generated if the design proves fit for purpose and innovative. In other words, there are more strengths and opportunities to gain from the design, as opposed to weaknesses and threats.

#### **5.4.4.7. Technical Comparison and Competitive Assessment**

Within the framework, the seventh stage is used to self-assess the demand criteria against the competition, or against identified benchmarks. This was ideal, since, based on the developed performance framework and the presented Benchmarking results, this assessment was made possible and reliable. The HoQ framework enables the decision-makers to rate and compare the 10 stakeholders' requirements against identified schemes, by allocating a score ranging between 0 and 5: 0 = worst and 5 = best. Five schemes were identified as appropriate benchmarks; two were internal Benchmarks (the current K centre and the B centre) and three of the schemes were external (the P and W gateways and Sutter Health, as described earlier in this chapter). Whilst in the previous section of this



chapter, extensive information was provided for the external schemes no information has been provided regarding the current K centre and the B centre, as yet.

Currently, the services in the area of the K project are provided by three main infrastructures, all of which are reaching the end of their service life, which is one of the main reasons for building this new, innovative centre that will replace these three buildings. The decision-makers wanted to take these as benchmarks in order to evaluate the improvements made in the future. The second, internal benchmark selected was the B centre, which was developed and opened in 2010, as part of a regeneration project. This project was considered successful but the decision-makers agreed that there was still room for improvement.

To populate this section of the HoQ framework, the decision was taken to establish the performance rating for each requirement, based on the consensus between the decision-makers. Instead of looking at each individual requirement, the overall analysis will be presented here.

Firstly, it needs to be noted and explained that the scores allocated to the current centres, within the area of the new K project, were the lowest. In the K area, the healthcare services were not performing at an acceptable standard (the scores for which ranges between 0 and 3), which was one of the reasons for this new development, and this was clearly translated into the framework. These centres will be replaced by the new K project. On the other hand, as previously discussed, Sutter Health was the best performing scheme, with scores ranging between 4 and 5. Finally, in the middle, the internal B scheme and the external P and W gateways were comparable, with scores ranging between 3 and 4, as shown in Figure 5.22 below.

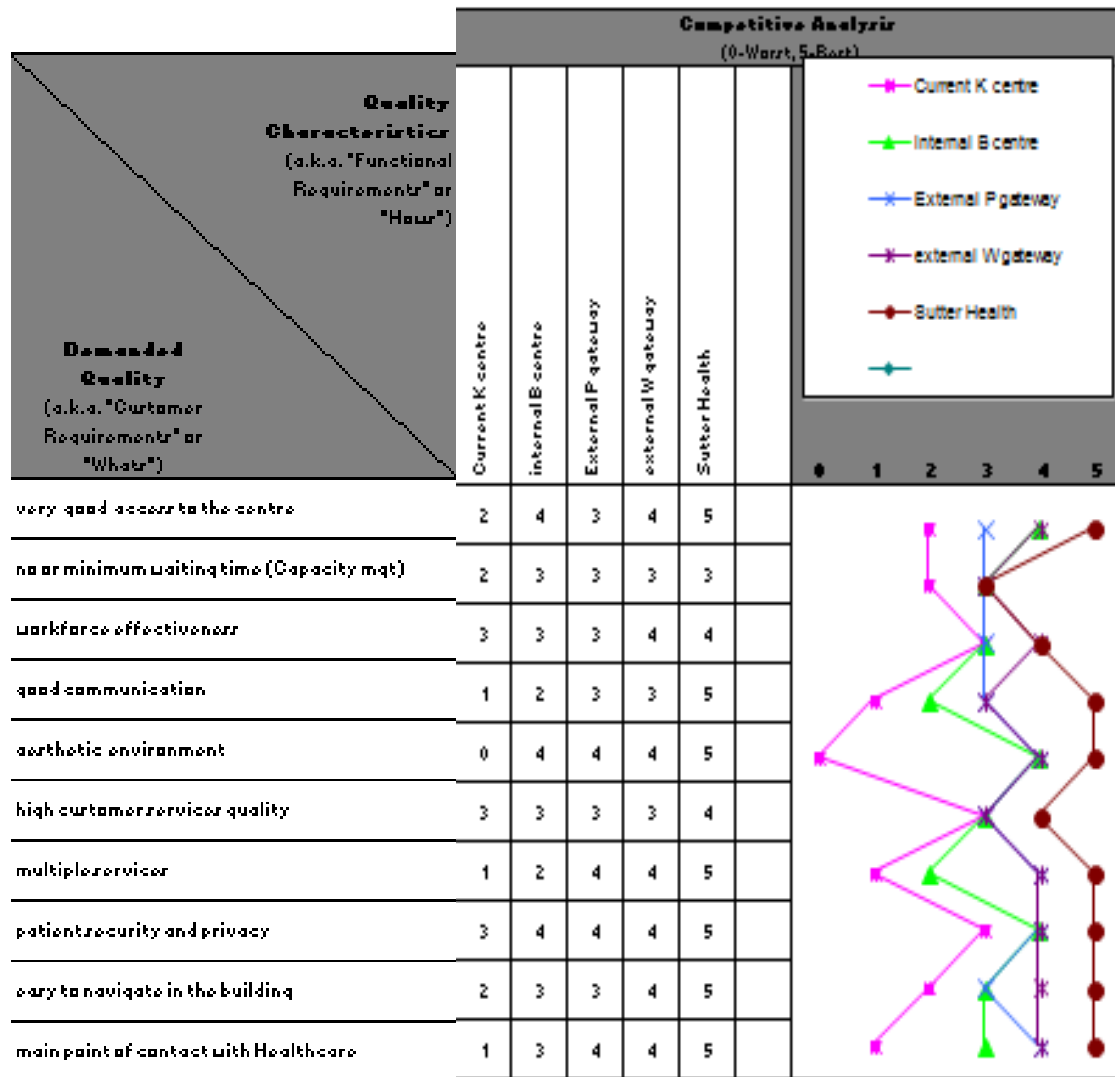


Figure 5.22: The comparative analysis

#### 5.4.4.8. Identify the Targets Values

The following step of the QFD process is designed to establish a measurable objective for each technical characteristic, whenever possible and coherent. The rationale for setting up objectives is associated with the old principle: *'what gets measured gets achieved'* (c.f.: Kaplan, 2001a,b,c). Therefore, the decision-makers agreed on the design objectives, as Table 5.14 shows. The team agreed that 11 out of the 15 technical characteristics should be associated with a key target value. This also supports the decision-making process at the design stage. For instance, it was established that 150 car parking spaces were going to be the minimum target value, to ensure that the accessibility element was met. In terms of accessibility and 'transport links', it was suggested that four bus routes should service the future healthcare centre. Moreover, the decision-makers agreed that, when patients are

given appointments, 90% should wait 10 minutes or less, and that a process would need to be designed to monitor this target. To satisfy ‘extended opening hours’, it was decided that the centre should be open until 9 p.m. at least three days a week. To monitor and make sure that ‘service integration / appropriate service design’ is working, the decision-makers decided that no unproductive conflict between partners should be dealt with by the parents’ organisations; the partners would need to set procedures in place to resolve potential conflicts themselves. Standard operating procedures (SOP), in terms of ‘communication culture and processes’, would be required to be in place and available to users. DIY technology and online services will be promoted; hence, a target of 50% of customers using online appointment booking systems and self-check-in was set. To measure ‘top quality healthcare service’, the decision was taken to use the developed performance framework, meaning that, based on the Benchmarking established, an overall amount of 13 points should be achieved. The decision-makers decided to over-comply with current regulations regarding ‘disabled access inside / outside’. To assess ‘good signage and clear layout’, it was decided that the aim would be to reduce the number of queries regarding direction, as compared against other schemes, which would need to be recorded. Finally, it was decided that less than 20% cases should be referred elsewhere.

Technical characteristics	Targets or limit values
Modern and flexible design	-
Car parking	Minimum 150 spaces
Transport links	4 bus routes / dedicated transport
Waiting time and queuing system	For appointments, 90% within 10 min waiting window
Extended opening hours	3 days a week open until 9 pm
Service integration / appropriate service design	No unproductive conflict between partners
Communication culture and processes	Communication SOP
Aesthetic interior decor	-
IT system and DIY technology	50% of customers using online appointments, check-in
Top quality healthcare service	13 points on the Performance Framework
Multi-lingual support / council services	-
Disabled access inside/outside	Over comply with regulations
Different types of consultancy rooms	-
Good signage and clear layout	Reduce number of direction queries
Single point of access (pharmacy, physio, hot desk specialist services)	Less than 20% of customers to be referred elsewhere

*Table 5.14: Identification of the target values*

While these targets are very challenging, the decision-makers wanted to set the bar high at the design phase so as to be innovative. It was also mentioned that this will be agreed with the different partners to see what is realistic and achievable and reviewed once the infrastructure is up and running.

#### **5.4.4.9. Set Initial Service Requirement Specification – Absolute and Relative Scores**

The last step of the QFD process is to quantify the requirements, based on the aggregation of the different types of information input into the HoQ model. It is important to quantify the requirements in order to focus on the attributes which have the most impact and return, as Table 5.15 shows.

It can be noted that, from the first iteration of the QFD process, ‘service integration / appropriate service design’ was the technical characteristic with the highest weighting (14.2), followed by ‘extended opening hours’ (11.0), then ‘modern and flexible design’ (10.8), and then ‘single point of access’ (8.8). At the bottom, ‘multi-lingual support’ (2.2), ‘different types of consultancy rooms’ (2.3) and ‘aesthetic interior decor’ (3.4) can be found.

<b>Technical Characteristics</b>	<b>Normalised Relative Weight</b>
Modern and flexible design	10.8
Car parking	4.7
Transport links	4.7
Waiting time and queuing system	7.8
Extended opening hours	11.0
Service integration / appropriate service design	14.2
Communication culture and processes	7.0
Aesthetic interior décor	3.4
IT system and DIY technology	5.8
Top quality healthcare service	7.3
Multi-lingual support / council services	2.2
Disabled access inside/outside	6.0
Different types of consultancy rooms	2.3
Good signage and clear layout	4.1
Single point of access (pharmacy, physio, hot desk services)	8.8

*Table 5.15: Normalised relative weight*

#### 5.4.4.10. Representation of the QFD Model – 1<sup>st</sup> Iteration

Figure 5.23 below shows the entire HoQ model after the first iteration. In this section, the QFD process was detailed and the HoQ application to the design of the new infrastructure development was explained. However, the QFD process is iterative; it starts at a high level, as was illustrated here, and drills down further by using the technical characteristics as the requirements, which initiates its second iteration. This enables the decision-makers to go a step further and supports the rationale behind each set of design decisions. The results of the second iteration are presented below.

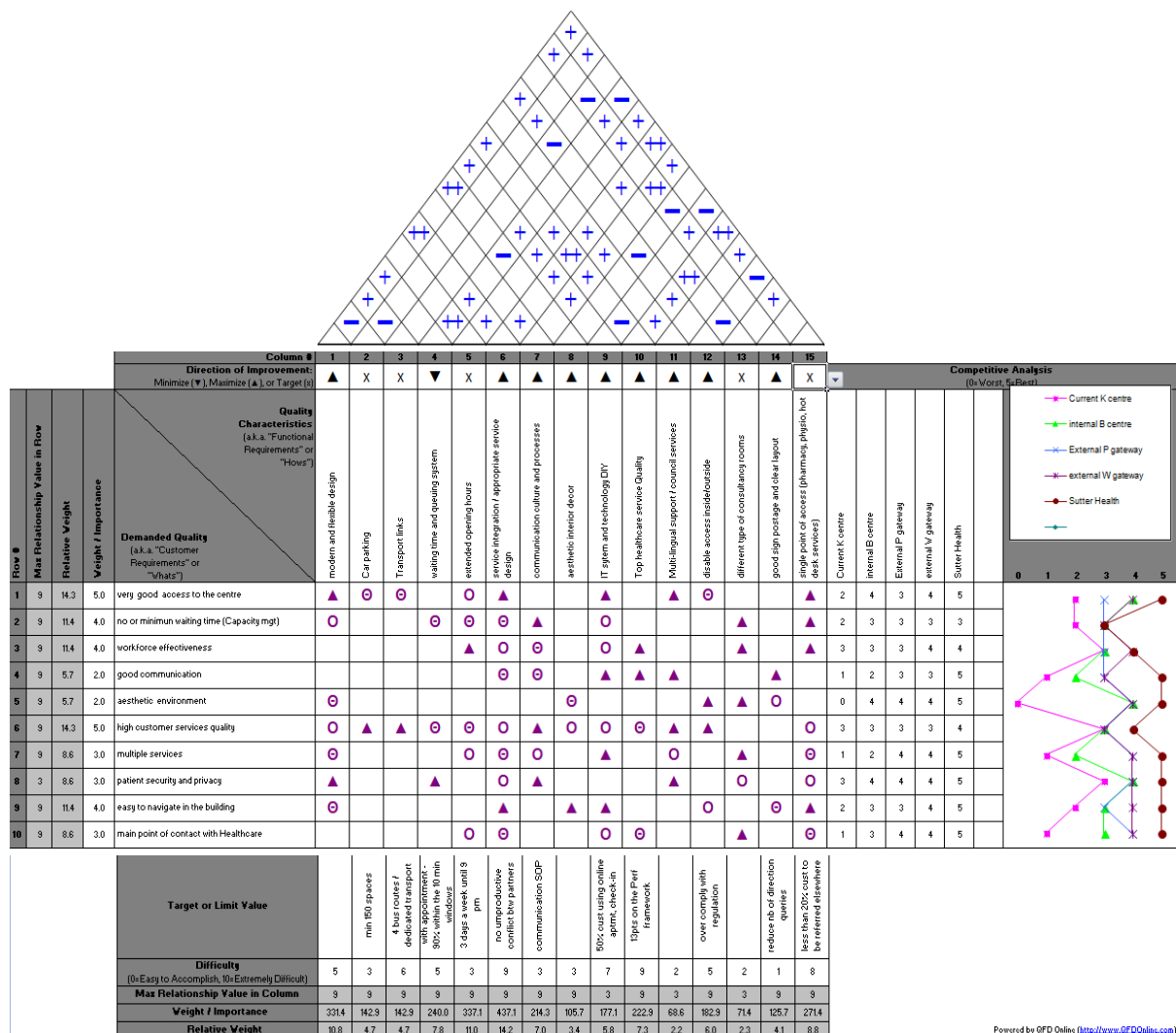


Figure 5.23: The entire HoQ

### **5.4.5. QFD Case of K - 2nd Iteration**

In this section, the process of the second iteration is described and the results provided. It will be further explained how the second iteration adds value to the design process.

#### **5.4.5.1. From Characteristics to Requirements**

The first step of the process was to collect the ‘voice of the stakeholders’ and compile their requirements in the HoQ, which takes place during the first iteration. In the subsequent, or second, iteration, all that is needed is to transfer the previous characteristics into the requirements. Therefore, without interpretation, this second iteration comprises the 15 requirements, modified through the process of the first iteration: i) a modern and flexible design; ii) suitable car parking; iii) specific transport links; iv) an effective and transparent waiting time and queuing system; v) the provision of extended opening hours; vi) a successful service integration; vii) deployment of an efficient communication culture and processes; viii) an aesthetic interior decor; ix) an integrated IT system and the provision of DIY technology; x) the achievement of top quality healthcare service; xi) the provision of multi-lingual support; xii) over-compliance with disabled access regulations for both the inside and the outside; xiii) the provision of different types of consulting rooms; xiv) the provision of good signage and a clear layout; and, xv) becoming a single point of access, complete with a pharmacy, physio and hot desk clinical specialist services.

#### **5.4.5.2. Rating their Importance**

During the first iteration, the importance needed to be identified by the stakeholders. However for the second iteration, the weightings had already been calculated. The relative weightings are used here (*c.f.*: Table 5.15).

#### **5.4.5.3. Establishing the Service and Infrastructure Characteristics**

To respond to and achieve the requirements, 15 technical characteristics were identified and agreed upon, based on a consensus between the decision-makers. These were: i) ‘modular design based on patient flow’; ii) ‘multi-functional rooms’; iii) ‘IT system based on unique platform’; iv) ‘online, live booking system and capacity system (including the car park)’; v) ‘shift working pattern for medical and admin staff’; vi) ‘diagnostic equipment (x-ray, scan)’; vii) ‘innovative healthcare equipment (telecare)’; viii) ‘glass

building, natural light and use of technology screen for information'; ix) 'co-location of high quality services'; x) 'well-being classes'; xi) 'interpreter team'; xii) 'own transport for disabled and older patients'; xiii) 'extra services (cafe, library, internet access)'; xiv) 'centre managers, clear leadership'; xv) 'walk-in, minor surgery, pharmacy, physio, hot desk clinical services with specialist rota'.

#### 5.4.5.4. Analysing their Relationships

As in the first iteration, the relationships between the requirements and the characteristics were analysed, using the pre-defined scale: 1 or Δ = weak relationship; 3 or O = moderate relationship; 9 or Θ = strong relationship. Figure 5.24 below shows the results.

<div> <div>Quality Characteristics (a.k.a. "Hows")</div> <div>Demanded Quality (a.k.a. "Whats")</div> </div>	modular design based on patient flow	multi-functional rooms	IT system based on unique platform	online live booking system and capacity system (incl. car park)	shift working pattern for medical and admin staff	diagnostic equipment (x-ray, scan)	innovative healthcare equipment (telecare)	glass building, natural light and use of technology screen for information	co-location of high quality services	well-being classes	interpreter team	own transport for disabled and older patients	extra services (cafe, library, internet access)	centre managers, clear leadership	walk-in, minor surgery, pharmacy, physio, hot desk clinical services
modern and flexible design	Θ	Θ	▲	▲	▲	▲	▲								▲
Car parking				O											
Transport links												O			
waiting time and queuing system				Θ				Θ					O		
extended opening hours		O		▲	Θ		▲			▲			▲		▲
service integration / appropriate service design	Θ	O	Θ		O	O	O		Θ					O	Θ
communication culture and processes			Θ	▲	▲				▲					Θ	
aesthetic interior decor								Θ					▲		
IT system and technology DfY			▲	Θ				O							O
Top healthcare service Quality	▲					Θ	Θ		Θ	O					O
Multi-lingual support / council services		▲									Θ		▲		
disable access inside/outside							▲					Θ		▲	
different type of consultancy rooms	▲	▲					▲								
good sign postage and clear layout	▲							O						Θ	
single point of access (pharmacy, physio, hot desk specialist services)	▲					▲	▲		▲						Θ

Figure 5.24: Relationships analysis

As previously seen, the most important requirements identified from the first iteration quantification process were 'service integration / appropriate service design' (14.2), 'extended opening hours' (11.0) and 'modern and flexible design' (10.8). These three requirements will be discussed briefly in relation to the characteristics.

### ***Service Integration / Appropriate Service Design***

It can be seen in Figure 5.24, which represents the relationship matrix, that the decision-makers agreed that ‘service integration / appropriate service design’ had a moderate relationship with ‘multi-functional rooms’, ‘shift working pattern for medical and admin staff’, ‘diagnostic equipment (x-ray, scan)’, ‘innovative healthcare equipment (telecare)’, and ‘centre manager, clear leadership’. If the service integration is achieved, then the procedures in place, which relate to the characteristics, will need to be clear right from the start. Moreover, strong relationships were identified between ‘modular design based on patient flow’, ‘IT system based on unique platform’, ‘co-location of high quality services’, and ‘walk-in, minor surgery, pharmacy, physio and hot desk clinical and specialist services’.

### ***Extended Opening Hours***

It was established that ‘extended opening hours’ had a weak relationship with the ‘online, live booking system and capacity system (including car park)’, ‘innovative healthcare equipment (telecare)’, ‘well-being classes’, ‘extra services (cafe, library, internet access)’, and ‘walk-in, minor surgery, pharmacy, physio, hot desk clinical and specialist services’. However, it had a moderate relationship with ‘multi-functional rooms’, and a strong relationship with ‘shift working pattern for medical and admin staff’.

### ***Modern and Flexible Design***

‘Modern and flexible design’ had a weak relationship with ‘IT system based on unique platform’, ‘online, live booking system and capacity system (incl. car park)’, ‘shift working pattern for medical and admin staff’, ‘diagnostic equipment (x-ray, scan)’, ‘innovative healthcare equipment (telecare)’, and ‘walk-in, minor surgery, pharmacy, physio, hot desk clinical and specialist services’. However, it had a strong relationship with ‘modular design based on patient flow’, and ‘multi-functional rooms’.

#### **5.4.5.5. Modifying the Requirements as Necessary**

This stage is designed to review what has been input into the model so far. It is used to build a consensus and get agreement from all the decision-makers involved. As mentioned previously, only minor, insignificant tweaks were made.



#### 5.4.5.6. Analysing Characteristics' Correlations and Trade-offs

The decision-makers needed to identify the correlations between the characteristics, so as to consider the trade-offs and balance the resources at the design phase, as Figure 5.25 illustrates. To evaluate the correlations, there is a standard notation: ‘++’ means that there is a strong, positive correlation between the characteristics, ‘+’ means that there is a positive correlation, ‘-’ means that there is a negative correlation, and, finally, ‘- -’ means that there is a strong, negative correlation.

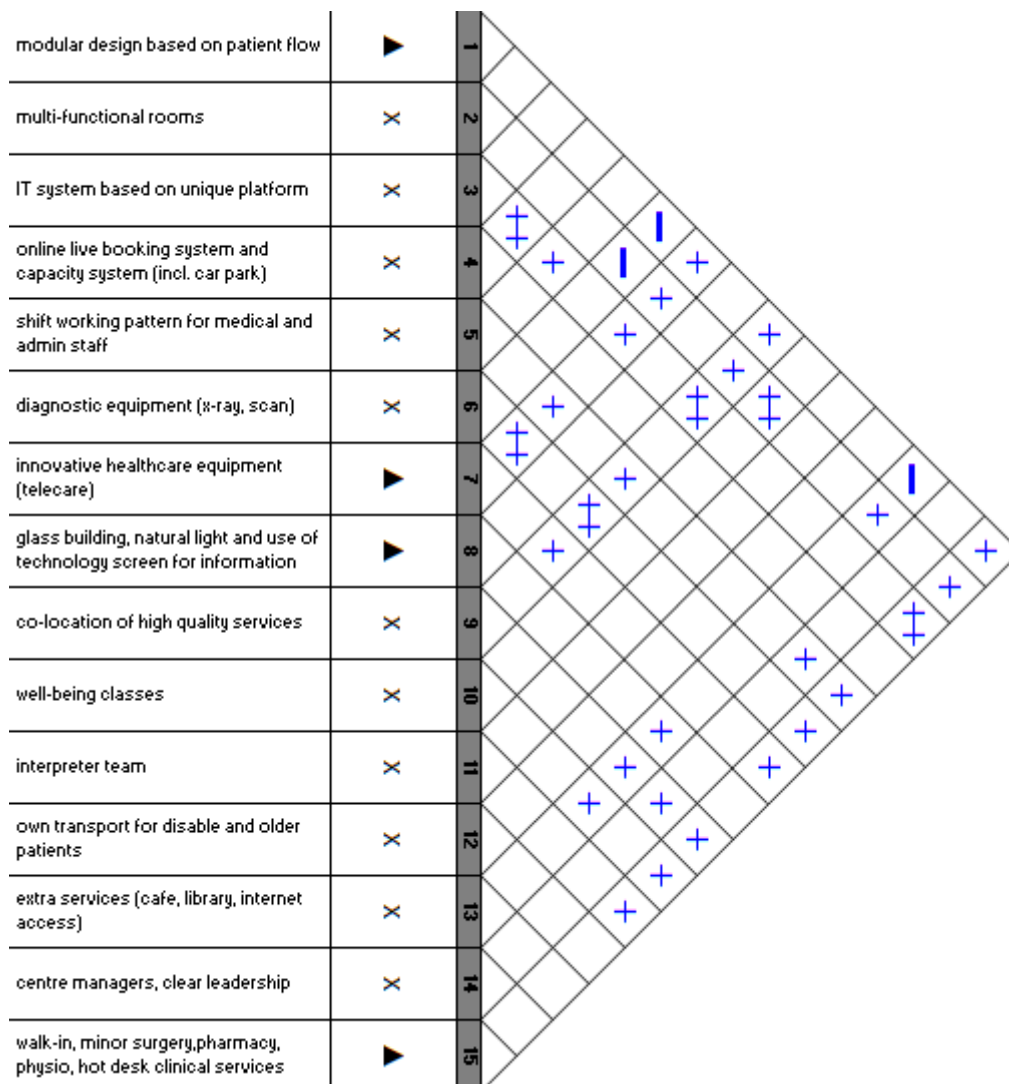


Figure 5.25: Trade-off analysis – 2nd iteration

It is relevant to note that, out of the 105 possible correlations, only 3 were marked with a negative coefficient and 29 marked with a positive or strongly positive coefficient. As previously explained it is important to focus on the negative correlations, as they require

the consideration of appropriate trade-offs in terms of design decisions. It can be seen that ‘modular design based on patient flow’ has a negative correlation with the bulky and static ‘diagnostic equipment (x-ray, scan)’. For the same obvious reasons, ‘multi-functional rooms’ has a negative correlation with ‘diagnostic equipment (x-ray, scan)’. It was established that ‘modular design based on patient flow’ also had a negative correlation with ‘extra services (cafe, library, and internet access)’ as these will consume space and prevent the ability for more flexibility to be built into the design.

#### **5.4.5.7. Technical Comparison and Competitive Assessment**

In the subsequent iteration, there were no technical comparisons or competitive assessments made as these were only undertaken at the highest level of the iteration process, and will be reviewed at completion stage of the project.

#### **5.4.5.8. Identifying the Target Values**

As aforementioned, this step is aimed at setting up the objectives for each of the 15 technical characteristic, as Table 5.16 illustrates. The decision-makers agreed to identify 15 targets and limit values. It was agreed that 50% of the building’s area would be devoted to modular design. This means that the infrastructure will be designed and built in a variety of ways, in order to meet complex user needs. In relation to this, it was also agreed that, in all the clinical rooms, a minimum of three different types of activities should be performed. This is to ensure that a flexible infrastructure is built and that the utilisation ratio is kept above 60%. To enable good communication, the IT network will be critical and it was decided to ensure that the different partner organisations, located within the infrastructure, use just one, sole platform. To provide good information to the users, a reliable, online system is expected to be put in place, so that users will be able to book appointments online, use self-check-in and visualise the capacity for car parking. To allow for the extended opening hours, two shift patterns will have to be designed for both the medical and admin staff. As part of the strategy to be a ‘one stop shop’ infrastructure, so as to reduce hospital referral and admission to hospital, x-ray and scan machines will be installed. Moreover, to be innovative, the aim is to develop a telecare system. A realistic target of 5% of the consultations will take place via telecare, and this will free up some capacity within the building. 50% of the users will take advantage of the online, DIY equipment. The ability to ask staff to take on different roles and responsibilities within the

infrastructure is important, as this will release the admin staff from many non-added value activities. As part of the strategy, at the design phase it was decided that, within two years of running, the infrastructure will potentially be able to apply for an award, recognising the co-location and its service integration excellence and innovation, through the fact that a walk-in centre, minor surgery facility, pharmacy, physiotherapy, and a hot desk facility for clinicians, consultants and specialists are all integrated together, under one roof. Furthermore, it was suggested that the planning be started for five well-being classes a week. To cope with the accessibility issues identified, it was decided that the acquisition of three vans was necessary, to support disabled and older people. Finally, from the Benchmarking exercises, it was decided that the new infrastructure will have two centre managers, who will be the leaders of the infrastructure, responsible for both the facility and its operations and services.

Technical Characteristics	Targets or limit values
Modular design based on patient flow	50% of area is of modular design
Multi-functional rooms	Minimum 3 different activities per room
IT system based on unique platform	1 IT platform
Online, live booking system and capacity system (incl. car park)	Online system available 24/7
Shift working pattern for medical and admin staff	2 shifts
Diagnostic equipment (x-ray, scan)	1 x-ray, 1 scan machine
Innovative healthcare equipment (telecare)	5% of consultations to use telecare
Glass building, natural light and use of technology screen for information	50% of patients to use DIY equipment
Co-location of high quality services	Award application for integration
Well-being classes	5 well-being classes/week
Interpreter team	1 team, 10 languages
Own transport for disabled and older patients	3 dedicated vehicles
Extra services (cafe, library, internet access)	Cafe, library, wifi, and internet
Centre managers, clear leadership	2 centre managers in rota
Walk-in, minor surgery, pharmacy, physio, hot desk clinical and specialist services	Co-location of these services

*Table 5.16: Identification of the target values – 2<sup>nd</sup> iteration*

#### 5.4.5.9. Set Initial Service Requirement Specification – Absolute and Relative Scores

As in the first iteration, the last step is the quantification process, based on the aggregation of the information. The results are shown in Table 5.17 below. It can be noted that ‘walk-in, minor surgery, pharmacy, physio, hot desk clinical and specialist services’, within the target of ‘co-location’, was the most weighted criterion (12.5), which emphasised both the importance and potential synergies which can be generated by this single point of access. This was followed, in weighting, by ‘modular design based on the patient flow’ (11.5), ‘IT system based on unique platform’ (9.7) and ‘co-location of high quality services’ (9.7).

Technical Characteristics	Normalised Relative Weight
Modular design based on patient flow	11.5
Multi-functional rooms	8.5
IT system based on unique platform	9.7
Online, live booking system and capacity system (incl. car park)	7.7
Shift working pattern for medical and admin staff	7.4
Diagnostic equipment (x-ray, scan)	5.9
Innovative healthcare equipment (telecare)	6.8
Glass building, natural light and use of technology screen for information	6.1
Co-location of high quality services	9.7
Well-being classes	1.5
Interpreter team	0.9
Own transport for disabled and older patients	3.1
Extra services (cafe, library, internet access)	1.9
Centre managers, clear leadership	6.9
Walk-in, minor surgery, pharmacy, physio, hot desk clinical and specialist services	12.5

*Table 5.17: Normalised, relative weightings for the 2<sup>nd</sup> iteration*

#### 5.4.5.10. Representation of the QFD Model – 2<sup>nd</sup> iteration

Figure 5.26 below shows the entire HoQ model after the second iteration. In this section, the HoQ application to the design of new infrastructure development was detailed for the second iteration, in which the characteristics of the first iteration were used as the

requirements of the second. This enabled the decision-makers to drill down a level to conceptualise the design even further, thus increasing their strategy alignment and developing a common vision. This also led the decision-makers to establish targets, which will need to be achieved in line with their future perfect vision.

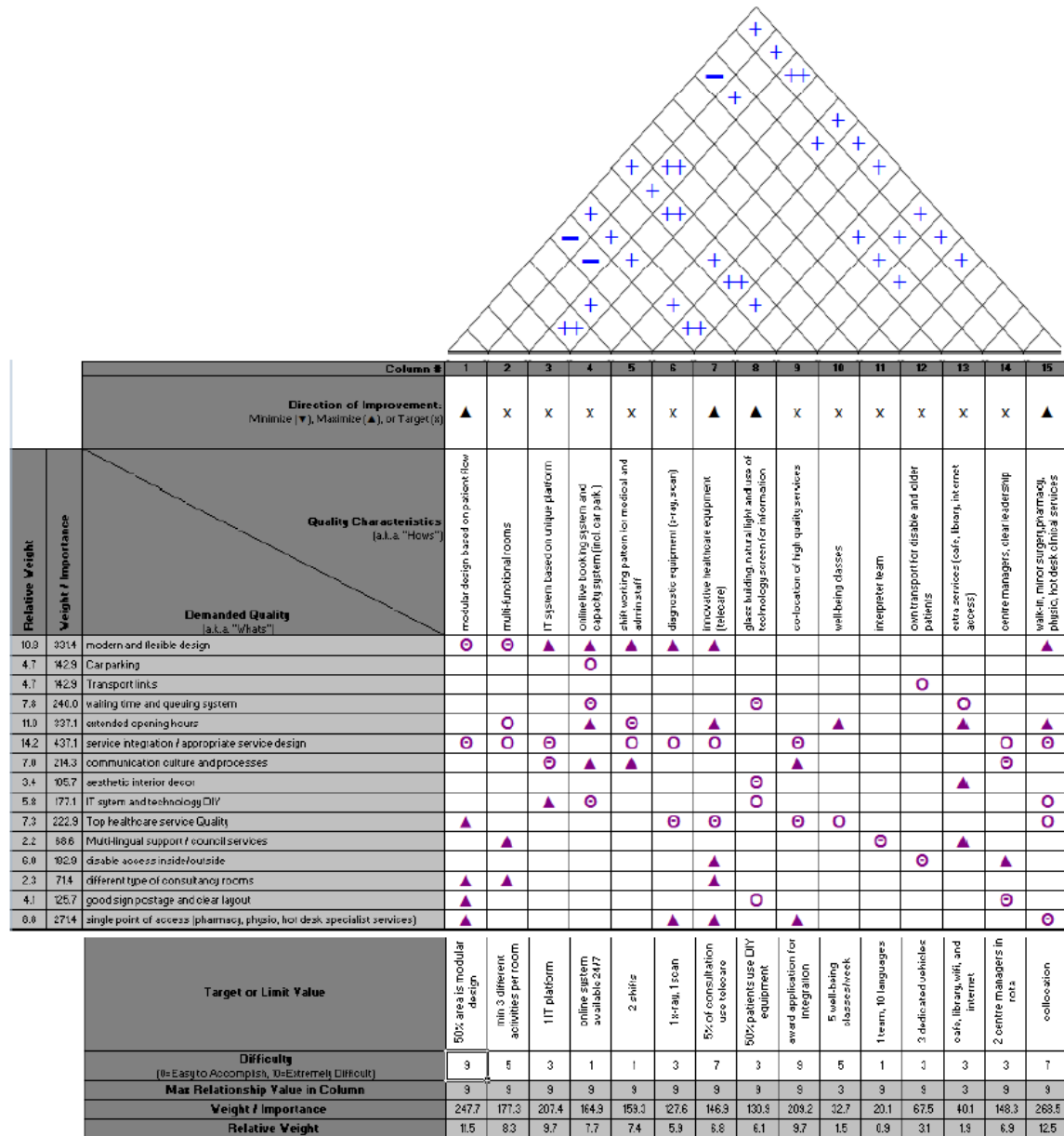


Figure 5.26: The entire HoQ for the second iteration

Having presented the results for the QFD process, based on two iterations, the researcher has demonstrated how QFD, based on its standard framework, HoQ, was used by the decision-makers to support the design decisions, in a very transparent and rational way. The design was an extremely difficult activity, often lagging behind the overall phase, and

the responsibilities were passed on to the external planners and architects, leading to long delays and wrong decisions.

#### **5.4.6. Summing up QFD**

In this third part of the experimental findings chapter, QFD was implemented into the K project to: i) capture the ‘voice of the stakeholders, customers and patients’, translating them into the design of both the infrastructure and the service operations; ii) further increase the different departmental strategies to be aligned, and; iii) support the decision-making process at the design phase. This was achieved through an iterative process, facilitated by HoQ, which enabled the cross functional teams to drill down to the service design, by analysing the service/product characteristics and setting up target values, based on the desired requirements.

## 5.5. Conclusion

This chapter has described and analysed the findings from the embedded-experiment variant design study. It was explained how, through the use of ER and AHP, MCDA and Benchmarking, along with the bespoke performance measurement framework and QFD, addressed some of the evidence based issues and supported the decision-making processes. Figure 5.27 below illustrates the conceptual model, summarising the findings from this experimental findings chapter. Chapter Six will answer the sub-research questions and discuss the findings further.

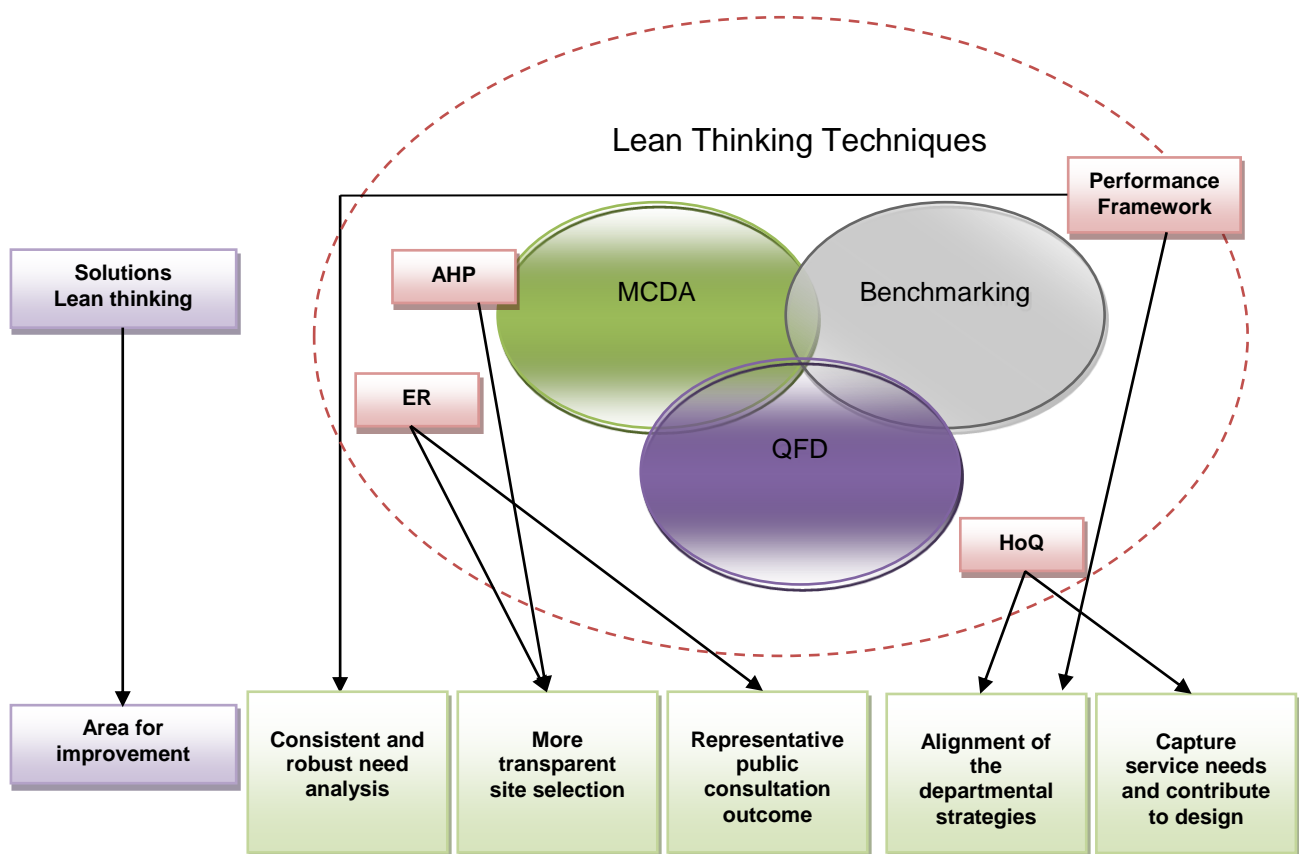


Figure 5.27: The experimental findings' conceptual models

## **6. Chapter Six – Discussion**

Through the presentation of the research findings, Chapter Four identified and brought to light evidence of the problems related to new infrastructure development. Throughout Chapter Five, the experimental findings were presented, through which techniques, inspired by Lean thinking theories, were implemented, in order to overcome the root-cause problems and enhance decision-making processes. It was demonstrated that MCDA was improving the transparency of the decision-making relating to site selection, and enhancing the representativeness of the public consultation outcome, by engaging with all the stakeholders in the models' criteria and weightings identification process. Moreover, Benchmarking and the bespoke performance framework enabled the decision-makers to further align the departmental strategies, engaging with a continuous improvement process, as well as enhancing the consistency and robustness of the need analysis, by having in place a structured framework. Finally, QFD supported the alignment of the departmental strategies, as well as capturing the services' needs and contributing to the design decisions. Hence, based on the literature chapter and the two findings chapters, the discussion was formed and will be presented here, in Chapter Six, through which the five sub-research questions will be answered. However, in the first section, the major, conceptual models will be re-visited and summarised, in order to provide a holistic perspective on the research and its findings. The last section of this chapter provides the discussion regarding the overall process of new infrastructure development (NID), structured around the planning, design, construction and management phases. This section establishes the concrete links between the Lean tools and techniques and their overall utilisation.

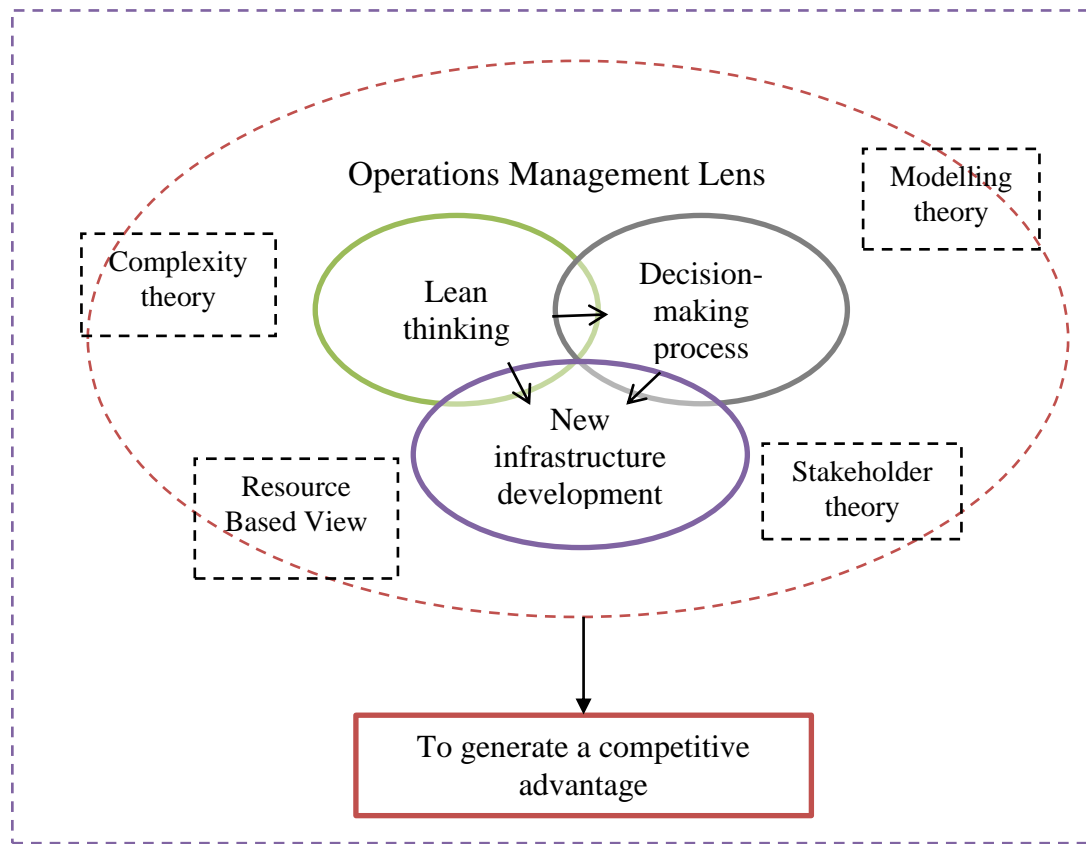


## **6.1. Summary and Conceptual Models**

In this first section of Chapter Six, it seems relevant to build upon the conceptual models developed in Chapters One, Two, Four and Five, in order to summarise the research so far, and visualise how the different elements fit together.

### **6.1.1. Summary from the Literature around the Conceptual Model**

As presented in Chapter One and Chapter Two, this research relies on three bodies of knowledge: i) Lean thinking; ii) Decision theories; and, iii) built environment. Each of them was individually reviewed in the literature chapter, in great length. Due to the multiple perspectives and their backgrounds, the researcher studied their inter-connections through an Operations Management (OM) lens, as Figure 6.1 below suggests. The OM lens has helped to create and formalise the links between the bodies of knowledge underpinning and the Resource Based View (RBV) theory (Peteraf, 1993; Barney, 1991; Barney, 2001; Cousins, 2005). However, other theoretical concepts have been introduced in this thesis, so as to fully capture the holistic perspective of new healthcare infrastructure development, and make a contribution to knowledge and to practice. For instance, modelling theory was used to justify the rationality concept, Cynefin was applied to define the complexity theory (French, 2013; Snowden, 2002; Snowden & Boone, 2007), and the stakeholder theory was utilised to justify the consensus concepts. All of these theoretical concepts have been applied to this research and gravitate around the three bodies of knowledge, as Figure 6.1 illustrates.



*Figure 6.1: The theoretical conceptual model of the bodies of knowledge*

To recapitulate, the argumentation was that every firm and organisation needs to develop and sustain a competitive edge, no matter the sector in which they operate (private or public) or industry (manufacturing, construction or healthcare). Hence, RBV was a useful theory to apply when studying this phenomenon, as it provided a robust framework (Too & Too, 2010). As Cousins (2005) summarised, RBV argues that organisations are a bundle of productive resources and capabilities, which are under the control of managers and decision-makers. Resources that are managed more efficiently and effectively will produce and deliver products and services at both a lower cost and a better quality level, which will satisfy the customers; hence, allowing firms to gain the competitive advantage. Therefore, RBV contributes to this research by identifying these superior resources and by supporting the organisation in sustaining them over the long term, as these resources are often environmentally dependent and temporary, due to their imperfect imitability, imperfect substitutability and imperfect mobility (Barney, 1991; Peteraf, 1993; Barney, 2001).

Although RBV is a well-established theory in the private sector, it is less so in the public sector; the healthcare being a good example of this. However, nowadays, as healthcare organisations aim to become world class (DoH, 2010), and, increasingly, patients are able to choose between their healthcare providers (DoH, 2010), the market has become less regulated and healthcare organisations are evolving more and more to meet the challenges of a competitive environment. This given context leads public sector organisations and markets into behaving similarly to private sector industries, and analogies can be made, both easily and relevantly. This justifies the rationale behind looking at the new healthcare infrastructure development from an RBV perspective, assuming that infrastructures are one of the firms' key, productive resources (Penrose, 1959; Too & Too, 2010) and that their fitness for purpose is critical for medium term success, especially within the healthcare sector (Kagioglou & Tzortzopoulos, 2010). The infrastructure is the interface between the service provision from healthcare professionals, and the service delivery received by the patient. Nonetheless, there is a lack of fitness for purpose within this new healthcare infrastructure, which was theoretically identified and empirically demonstrated, and which impacts the organisations' performances, quality and user satisfaction (*c.f.*: Chapter Four). Thus, it hinders healthcare organisations in becoming world class.

From an RBV perspective, the organisation needs to identify how the development and management of these complex, superior resources (*i.e.*: infrastructure) can be enhanced and improved. The final section of this thesis, in the form of Chapters Six and Seven, brings together the elements of the answer, using the conceptual models developed and the PBLCF (Partial & Bespoke Lean Construction Framework).

The theory suggests that Lean thinking and Operational Excellence are amongst the resources and knowledge that can support a firm in improving both their key production processes and their decision-making processes, enabling them to satisfy the customer requirements, reduce wastes in the system, control cost and enhance productivity, which are all of the ingredients required to develop a competitive edge (Christopher, 2005; Porter, 1980; Womack & Jones, 1994; Womack & Jones, 1996). Hence, Lean thinking was applied and adapted to the specific context of new healthcare infrastructure development. Alves *et al.*, (2012), Bamford *et al.*, (2014), Koskela (2004) and Radnor *et al.*, (2012) demonstrated that Lean thinking principles and techniques can be applied to any industry (*i.e.*: manufacturing, healthcare, construction). However, these are extremely

sensitive to the environment, their success being dependent upon culture, root-cause problems, local market and business conditions, level of knowledge, and incentive structures.

Therefore, in this research, the specific context was related to the decision-making processes; and the prime focus came from a system thinking perspective to adapt Lean tools and techniques so as to improve the speed, quality and rationality of the planning and design decisions. It is explained that decision-makers are bounded rational individuals (Simon, 1947), which is materialised through both the lack of information and the complexity of the systems. Rationality is referred to the quality of thinking behind the decision-making process and outcome. It is relevant to note that rationality has been associated with a type of decision-making, which follows various characteristics: thoroughness, logic, and systematic thinking. Moreover, the decision theories suggest that procedures, frameworks, logical methods and models, all help to structure both the decision-making and the shared cognition, in order to support the decision-makers' quality of thinking as well as the appropriateness of choice in this complex business world (Pidd 2003; Rosenhead & Mingers, 2001; Salaman, 2008). Hence, in this thesis, it is argued and demonstrated that adapted Lean thinking tools and techniques, such as: MCDA, Benchmarking and QFD, can support the move towards a rational and satisfactory state by reducing or dealing with: i) the non-deliberative decision; ii) the missing, lack and asymmetry of information, the stakeholders ignorance, as well as the subjectivity; and, iii) mental errors, such as anchoring, status quo and the sunk costs (Cohen; 2013; Pomerol, 2012; Salaman, 2008).

As the business world is dynamic, as opposed to linear and deterministic, there are many sources of risk and uncertainties associated with these complex systems. Moreover, complexity was identified as a recurrent source of the issues. Thus, the theoretical concept of complexity was developed and framed using the Cynefin framework (French, 2013; Snowden, 2002; Snowden & Boone, 2007). Therefore, due to the complexity of the decision-making, a range of Lean methods and frameworks have been developed.

Finally, the literature chapter has helped to justify the five sub-research questions in context, demonstrating the way in which their development was theoretically driven. These will be further answered in this chapter. The sub-research questions were associated

with the two overarching research questions: *RQ 1: What are the root-cause problems associated with new healthcare infrastructure development?* And *RQ 2: How should Lean thinking concepts be implemented to support the decision-making processes for new healthcare infrastructure development?* While these overarching questions will be addressed in Chapter Seven, in the following sections of Chapter Six, each of the sub-research questions will be answered. Having briefly summarised the main concepts and ideas developed within the literature chapter, the next part of this chapter will sum up the findings' chapters.

### **6.1.2. Summary of the Findings around the Conceptual Model**

To answer both the research questions and the sub-research questions, a multiphase mixed-methodology, around an empirical action research study, was designed from a pragmatism paradigm, as is defined extensively in Chapter Three (Creswell & Plano Clark, 2011; Plano Clark & Creswell, 2008). The data was collected and analysed, using process data (from 2000 onwards), interviews (N=25), surveys (N=85), observations and workshops (N=25), and the experimental solutions were developed and implemented around the planning and design of new healthcare infrastructure, within a local NHS organisation responsible for managing these critical and complex infrastructure development processes.

As Figure 6.2 shows, through the interviews, process data and the survey findings, the root-cause problems for the weak performances and slow development of the planning and design of new infrastructure were established and confirmed. The decision-making processes were at the centre of these problems. More specifically, according to the analysis, the decision-making within the planning and design phases were the bottleneck of this overall and complex process. Furthermore, the issues were broken down into five categories: methods, complexity, communication, organisational and environment.

The survey was designed to further understand this phenomenon and establish the relationships between the different variables. It was recognised that, while the different groups of stakeholders had a similar perception of the problems and performances; out of the three factors identified (effective planning, adequate structure process and consistent actions), only the effective planning had a significant impact on the output (the high quality and performance of the new infrastructure). In other words, throughout the survey

analysis, it was established and confirmed that, in order to increase the quality and performance of these new infrastructures, the organisation had to: i) improve the consistency and robustness of the need analysis, which would support the decision-makers in planning and designing the processes adequately; ii) develop some mechanisms to increase the transparency and rationality of the site selection, which would speed up the planning phase; iii) increase the representativeness of the public consultation outcome, which would satisfy the local population and meet the national and local strategic guideline; iv) deploy mechanisms to ensure the alignment of the departmental strategies in terms of the development of new healthcare infrastructure, which would reduce the lack of fitness for purpose associated with this new infrastructure; and, finally, v) create mechanisms to capture the service needs and contribute towards the design decision-making process, both to speed up the processes and improve the fitness for purpose element.

As was extensively discussed in Chapter Five and summarised in Figure 6.2 below, to overcome these issues and tackle these areas for improvement, three Lean thinking inspired techniques were developed and deployed: MCDA through two modelling processes, ER and AHP; Benchmarking with its bespoke performance framework; and QFD, using the HoQ model.

MCDA was used to overcome two major issues, which were identified in Chapter Four: i) the site selection was not sufficiently transparent for the local population; and, ii) the public consultation outcomes were not representative of the local population's opinions. Benchmarking and the bespoke performance framework were used to: i) overcome the evident lack of alignment between the different departments, which was hindering the performance of the new infrastructure; and, ii) fulfil the need for more consistent and robust need analysis, in order to improve the decision-making processes. QFD was used as a Lean thinking technique, enabling: i) the decision-makers (DM) to explore the relationships between the stakeholders' vision and integrate it with the requirements from the local population, at the end of the planning phase and during the design phase; as well as, ii) to capture the service needs to support the design decisions.

The rationale for selecting these Lean techniques was explained in Chapter Five. Moreover, it is useful to note that, although these techniques are considered non-

prescriptive, full integration with the more prescriptive guidance from the DoH proved possible, thus improving the infrastructure development processes.

Moreover, the conceptual model, as detailed in Figure 6.2 below, links the sub-research questions with the findings. In the first instance, the sub-research questions were theoretically driven, from the literature review, and then empirically tested, so as to address them, as Figure 6.2 shows. Having summarised both the literature and the findings, presented through the conceptual models and the research questions, the following section will focus on answering the sub-research questions.

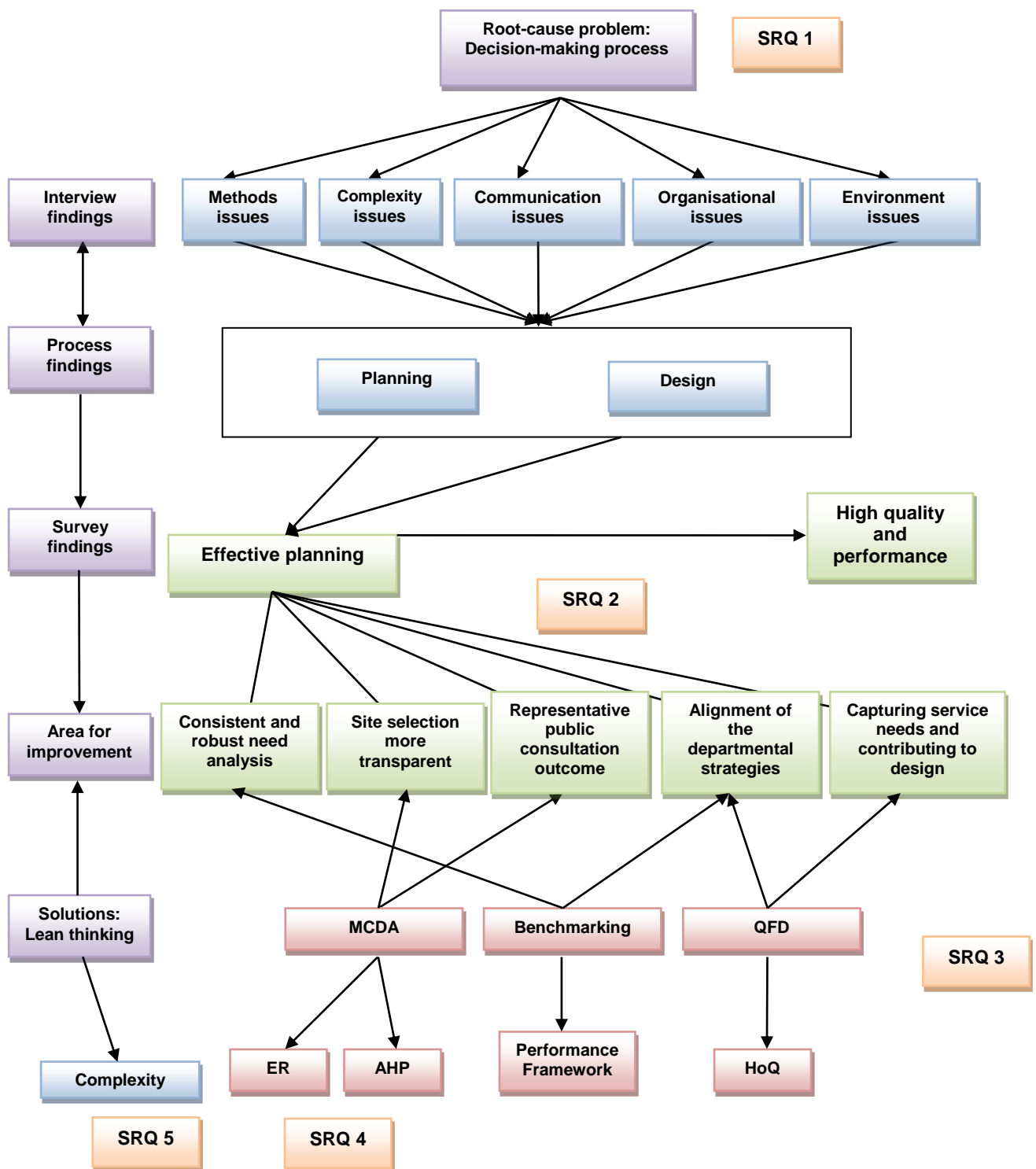


Figure 6.2: The conceptual model of the multiphase research



## 6.2. Sub-Research Questions

To structure the discussion chapter of this thesis, each sub-research question will be addressed. As explained in Chapter One, the two overarching research questions are: *RQ 1: What are the root-cause problems associated with new healthcare infrastructure development?* *RQ 2: How should Lean thinking concepts be implemented to support the decision-making processes for new healthcare infrastructure development?* These were sub-divided into five, theoretically driven, sub-research questions, as shown in Figure 6.3 below. In the following sections, each individual sub-research question will be answered. The research questions will then be addressed in the Conclusion – Chapter Seven.

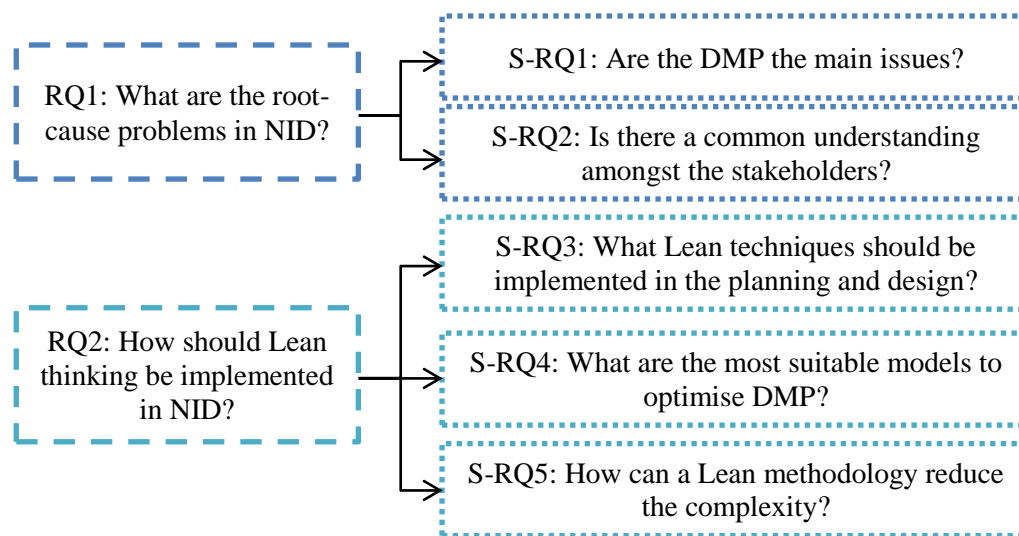


Figure 6.3: Structure of the research questions

### 6.2.1. S-RQ1: Are the Decision-Making Processes the Main Issues within the New Infrastructure Development?

As explained theoretically and confirmed empirically, during the planning and design phases, the organisation's leaders and senior managers face several sets of decisions, such as: site location, project selection, type of procurement route, size and layout, operations and services design and integration, and the service quality level. The optimisation of these decisions is critical for the success of any project (Pellicer *et al.*, 2014). Considering their complexity, strategic aspect and long lasting consequences, these decisions affect the overall quality of the infrastructure, and the stakeholders' perceptions. Moreover, decision-makers have to take the process behind the decisions into consideration, by

looking at the transparency and rationality aspects. Not only does the decision need to be optimal and satisfactory, it has to be perceived as transparent and rationale by the different groups of stakeholders.

From the analysis of the findings, it was established that decision-making is the major bottleneck activities during the overall planning and design processes. An Estates Manager described it this way: *“the decision-making as too bureaucratic [...] which has been one of the major frustrations in the development and construction of new infrastructure”* (FEJW03). Another Estates Manager pointed out: *“we need to make sure we have got all the decision-makers around the table right from the start, and that we get full buy-in from them regarding a specific project. They need to understand the implications on the development process for not making sound decisions.”* He went on to explain that: *“if the stakeholders have six decisions to make and one of them is on the critical path, (i.e.: site selection), we don’t want to be wasting time doing the others things when we have got to make that decision”* (MNMD08). These frustrations and inefficiencies were due to multiple, organisational, silo structures, and complex process implications, leading to a lack of transparency for the stakeholders and the public. The lack of process ownership, perceived by the cross-functional team members, and the lack of evidence based processes in place to reach rational choices, were issues that emerged from the analysis. With the input (dataset, information, knowledge and expertise) available to the infrastructure programme teams, the decision-making processes were not seamless and the operations’ delivery was lagging behind and stalling the whole development process. This went some way towards explaining the long development cycle times – up to 15 years – and the large amounts of variation (*c.f.*: Chapter Four). For instance, it was demonstrated that selection of the site could take as long as two years to complete. These operations are high value added activities, as they engage with the local population and have long term consequences; thus, they need to be optimised.

Furthermore, having categorised the 16 emerging issues associated with their primary themes: method, complexity, communication, organisational and environmental, as Table 4.2 illustrated (*c.f.*: Chapter Four), it became clear that the relationships between an issue and a theme were not straight forward, but multi-dimensional. For instance, an issue could be connected with and/or impacting another issue from a different theme. Hence, Table 6.1 below shows both the primary and secondary relationships identified between the

issues and the themes, as well as the impacts or consequences, which an issue can have on another issue. These composite relationships were best represented in a matrix, as Table 6.1 illustrates.

For example, through the analysis, it was understood that the lack of innovative thinking, despite being primarily related to a method issue, is, to a certain extent, also connected to issues associated with the communication, organisational or environmental domains. Moreover, although the lack of synchronisation from the different groups of stakeholders primarily emerged as a communication issue, it was clear that it was also related to some method issues, as well as impacting on the complexity issues. Therefore, as Table 6.1 presents, nine of the issues were found to be directly impacting the complexity issues – these are marked in Table 6.1 with the ‘#’ symbol.

By analysing all the sets of data, it became apparent that the complexity of the decision-making processes was the underling element forming these relationships. Decision-making processes are the common denominator between the five domains. Therefore, this analysis demonstrates and confirms that the root-cause problem is associated with the complexity of the decision-making. Decision-making activities are the underlying issues across the five domains. The lack of methods and procedures create barriers to running the decision-making processes effectively. The complexity, risks and the uncertainty prevent the decision-makers from making critical decisions. The lack of an effective communication system also hinders the decision-making processes. Finally, both the organisation design and the environment pressurise the decision-making processes also.

Issues	Method issues	Complexity issues	Communication issues	Organisational issues	Environmental issues
Activity based perspective	√	#			
Activities in series	√				
Lack of innovative thinking	√	*	*	*	*
High variety and variations	√	#			
Lack of ability to use information	√	#			
Uncertainty and risks within the public sector	*	√	*		
Meetings, mechanisms to make decisions		√	#	*	
The public consultation and transparency	*	√	#		
Lack of synchronisation within the different groups of stakeholders	*	#	√		
Lack of a cross functional understanding of the process	*	#	√	*	
Lack of a project management approach	*	#		√	
A silo organisation		#	*	√	
Lack of definition of roles and responsibilities		#	*	√	
Political issues					√
Lack of cash available	*	#			√
Lack of stability		*	*		√

√ = Categorisation of the problems identified from the thematic analysis

\* = Secondary relations

# = Impact / consequences

*Table 6.1: Primary and secondary relationships between the issues and the themes, and the impact matrix*

Hence, it is argued that the development of bespoke decision-making models improves the method issues by setting the right procedures in place, which reduce complexity issues, support effective communication, and, finally, structure the new infrastructure development processes around these sets of decisions, which enhances the visibility and strategic focus.

According to the Lean thinking philosophy and the theory of constraints, root-cause problems and bottleneck activities should be resolved and optimised. For instance, deciding upon scheme development priorities, identifying the best location for sites, defining optimum size, and selecting the most appropriate service portfolio all have to be

optimised as a priority, in order to improve the new infrastructure development (NID) process performances. These are multifaceted decisions, and the process of making them needs to be improved so as to gain efficiency and effectiveness in the overall development process.

This research is suggesting and demonstrating how Lean thinking models can be implemented to enable the improvement of the development process, through waste reduction and customer focus, starting with streamlining and optimising the decision-making (Thomas *et al.*, 2002; Womack and Jones, 1997; Yang *et al.*, 2011).

If this seems to be merely a matter of common sense, it is important to re-enforce the fact that the research showed and evidence based that it was not obvious to the decision-makers, or to the main stakeholders of the organisation. As it was pointed out *“it is difficult to highlight the reasons for the [NID] weak performances; otherwise, we would have sorted this issue a long time ago”* (FEJW03). This can be explained by the tacit nature of the decision-making, which was defined as a process, involving a sequence of tasks, which start with the recognition of a problem and ends with a recommendation (Sharifi *et al.*, 2006). It is a tacit or formal process, taking place in the minds of decision-makers to identify the right, best or most satisfactory decision (Hollnagel, 2007). Associated problems with the decision-making are related to the lack of information, the asymmetries of data and the bounded rationality, as explained in the literature chapter. These problems have been addressed by the use of MCDA, with ER and AHP, and QFD, as will be detailed later, in the section on S-RQ-3.

To sum up, considering the complexity, the strategic aspect and the long lasting consequences of each decision, associated with the transparency, inclusivity and rationality objectives of the organisation, decision-makings were emerging as being the bottleneck and the root-cause problems of the new infrastructure development processes. This analysis explained and confirmed the nature of the problems, which allowed the organisation to define a set of solutions and implement the changes. However, it was critical to test whether the different groups of stakeholders involved had the same perception and understanding of the NID process and performances.

### **6.2.2. S-RQ2: Is there a Common Understanding of the Process Issues and Performances amongst the Different Groups of Stakeholders?**

Having described the context, measured the baseline performances and confirmed the root-cause problems, it seems relevant to summarise some of the key findings so far. The high complexity involved within the planning and design of new healthcare infrastructure explains some of the inefficiencies: *“the planning and design of healthcare infrastructure needs to consider the human, political, environmental, legal, financial constraints, and meet the strategic objectives set locally and nationally, which is extremely complex”* (GHCT04). However, the main issues are associated with the decision-making processes. These contextual constraints and problems are causing long cycle times and high variations in these cycle times, of between three and 15 years, as the process data showed (*c.f.*: Chapter Four).

The bespoke characteristics of the new healthcare infrastructure development – both the process and the output are unique – as well as the low volumes of delivery, represent barriers to improvement. Furthermore, the need to satisfy the requirements of the large stakeholder base lead to substantial performance problems, especially for government owned infrastructures, such as this type of healthcare infrastructure (Too & Too, 2010). Therefore, it was legitimate to test whether there were different perceptions amongst the four, defined groups of stakeholders: decision-makers, providers, suppliers and contractors, and members of the public, as defined and categorised in Chapters Two and Four (*c.f.*: Figure 4.6). It was assumed that, if there was an agreement and a common understanding, then it would be possible to develop, test and implement solutions.

Results from the ANOVA analysis indicated no differences between the decision-makers, providers and contractors, and suppliers for the 14 variables. The only differences were found between the views of the decision-makers and the public. These differences only occurred on two items, and can be explained by the fact that these two groups have opposite perspectives (worldview) and understandings. Specifically, decision-makers believe that GIS (Geographic Information System) could be used in a more systematic manner, so as to improve the decision-making; perhaps they feel that they might fully understand and appreciate its utilisation in terms of optimisation. However, members of the public may see its utilisation as a gimmick or a constraint, and certainly not as an adding-value activity within the site selection decision-making process. The other

significant differences were seen within the perception of the fitness for purpose of the latest new infrastructure development (NID). Whilst the decision-makers felt that the latest NID were fit for purpose (3.59), to a certain extent, members of the public disagreed (2.63). This could be explained by the fact that the decision-makers recognised the improvement made through the work achieved; whereas, the patients and members of the public were still focusing on the areas for improvement.

However, this study mainly highlights that there is an agreement between the stakeholder groups, regarding the nature of the major issues. The common agreements and consensuses, within this survey, are evidence based, which enables recommendations to be made, in order to specifically identify the ways in which the organisation can improve its new infrastructure development (NID). Therefore, it is considered that there is a consistent, common understanding and perception of the issues and the performances across the different stakeholder groups, especially if the significance at  $p < 0.10$  is not considered, following the traditional statistical theories (Hair *et al.*, 2010). These are extremely important findings when challenging some of the pre-conceived ideas on new infrastructure development, as suggested in the literature (Too & Too, 2010).

Thus, there is a general consensus that the public consultation should be undertaken in a more systematic manner, during the planning process (3.94). By law, this public consultation exercise must have a minimum length of three months, during which time the organisation goes out and consults its local population on the different decisions to be made (*i.e.*: the site selection location, service portfolio and design). As mentioned by Groome (2010), the public consultation is seen as the critical activity within the planning phase – it is the mechanism by which to collect the ‘voice of the patient’, ‘voice of the customer’ (VoC) and that of the local communities. The organisation hoped to justify and rationalise some of its decision-making output based on this public consultation. Therefore, it is recognised that a more consistent model for consultation could be appropriate and should be developed (*c.f.*: MCDA and QFD).

As theoretically suggested previously, and emphasised by Fernandez-Solis (2008), Kagioglou and Tzortzopoulos (2010), and Liyanage and Egbu (2004), the new infrastructure development (NID) is complex. An element that contributes to this complexity is the different procurement routes and models available. This organisation

uses two major procurement routes: LIFT and Third Party Development (3PD). The different routes have completely different ownership and processes, which impact the decision-making. Although it might not be entirely possible, it was relevant to note that respondents felt strongly about having just one process to accommodate the different routes (3.80). This is in line with the standardisation principle mentioned earlier. The researcher is aware of the implications, but recognises the possibility for moving towards a single procurement route, so as to optimise the decision-making processes, even if the mechanisms and external validation processes are different.

Besides, the respondents agreed with the principle that more work undertaken early in the process positively impacts the productivity of the overall process. The traditional way of working is to draft a very basic outline business case (OBC), in order to get the necessary approval, before developing the full business case (FBC). However, it is now suggested that more work should be done on the outline business case in the first instance, in order to gain agreement on the key decisions earlier in the process, avoiding costly rework. This would help to get the buy-in of stakeholders and would commit more resources to the project earlier on. It is believed that shifting some of the decision-making to earlier in the process would support the speeding up of the overall project, and reduce the uncertainty. Additionally, this would provide more transparency for the local population, and could be undertaken in parallel with the public consultation; an idea that was developed earlier. Consequently, members of the public would have access to more concrete and reliable planning information, leading to a more productive and fruitful consultation.

On the other hand, the respondents recognised that the public consultation outcomes were not entirely representative of the local community's vision (2.84). This is important as the organisation has the ambition to build its decisions on transparency. Therefore, the current activity of engaging with the local population can be challenged, and some alternatives suggested (*c.f.*: MCDA and QFD). This was demonstrated perfectly earlier, as the respondents disagreed with the fact that the site selection was sufficiently transparent for the local population (2.80).

Another issue exposed was that the different departmental strategies (Estates, Primary Care, Finance, and Public Health) were not sufficiently aligned; thus impacting the levels of effectiveness and efficiency within the new infrastructure development process (2.48).



This confirms what Boyer *et al.*, (2005) explained, and what Miller (2012) illustrated through the Shingo Model in the third dimension. This was amongst the lowest rated items, proving that the misalignment was felt very strongly, especially by the providers. This means that, if the strategies of the internal partners are not aligned, it is extremely difficult to optimise the decision-making processes. This is the reason why the bespoke, performance framework and Benchmarking needed to be developed, so as to address this misalignment issue (Boyer *et al.*, 2005; Kaplan, 2001; Kaplan & Norton, 2001a,b,c).

Finally, a more fundamental and technical issue raised, which the survey denoted, was the problem of transforming data into reliable information for planning and designing the infrastructure and the services, which would make the future infrastructure fit for purpose. The public consultations should capture the service needs' data and contribute to the service design decisions. These issues will be addressed using an aspect of the Lean thinking modelling – QFD.

To sum up, according to the results, the stakeholders agreed that: i) more consistent and robust need analysis could be performed to improve decision-making (Groome, 2010); ii) generally, the site selection decision was not sufficiently transparent for the local population (Vahidnia *et al.*, 2009); iii) the public consultation outcomes were not representative of the local population; iv) the different departmental strategies were not sufficiently aligned to support optimum decision-making processes (Schraven *et al.*, 2011; Francis & Glanville, 2002); and, finally, v) the public consultations did not entirely capture the service needs and contribute towards the service design decisions (Codinhoto *et al.*, 2010).

According to the Factor Analysis and Multiple Regression Analysis, performed in Chapter Four, these factors can be resolved with more effective planning processes in place, which will be materialised through utilisation of a set of Lean inspired, decision-making models (Alexander, 1994; Koskela & Ballard, 2006; Meredith & Mantel, 2006; Slack *et al.*, 2010). However, the question is: what are the Lean tools and techniques that should be implemented, in order to address these agreed issues?

### **6.2.3. S-RQ3: What Lean Tools and Techniques should be Implemented within the Planning and Design Phases?**

As discussed in Chapter Two, Porter (1980) and Cockburn *et al.*, (2000) explained that very few firms have the resources to pursue every single action that might improve their performances, in order to gain, or sustain, a competitive advantage. Therefore, root-cause issues and bottlenecks have to be prioritised, and an Operations Strategy (OS) should indicate the way the firm might best achieve its objectives, to a certain extent (Bamford & Forrester, 2010).

The findings and analysis demonstrated that decision-making processes were the root-cause problems, responsible for the poor and weak process performances of the planning and design of new healthcare infrastructure. Moreover, it was demonstrated that the different groups of stakeholders had both the same understanding and perception regarding the nature of the problems. Hence, the effectiveness and efficiency of the decision-making, behind the planning and design activities, could be enhanced by developing bespoke and non-prescriptive, Lean thinking inspired models.

MCDA has been implemented to improve the rationality and transparency of the decision-making process for site selection and scheme prioritisation. Benchmarking and a bespoke, performance framework have been designed and implemented, in order to improve the strategy alignment between the different groups of stakeholders, learn from practice and generate a mechanism for continuous improvement and innovation. Finally, Quality Function Deployment (QFD) was implemented to support the design decisions, as well as to enhance the strategic alignment, by synchronising the infrastructure design with the service design.

Through the analysis completed, it can be seen that these Lean thinking techniques have enabled: i) improvements, in terms of speed, transparency and rationality of the decisions, through the consensus and utilisation of evidence based frameworks and methodologies; ii) the enhancement of the strategic alignment between the different groups of stakeholders' strategies, through a more consistent and robust performance assessment; and, finally, iii) the reduction in the level of rework and defects, associated with the design decisions.

Furthermore, these models translate the Lean philosophical concepts and principles, as defined by Hines and Rich (1997), Womack and Jones (1994), and Womack and Jones (1997), by: i) reducing the non-added value activities; ii) being user and patient orientated, involving them within the decision-making process; and, finally, iii) setting a continuous improvement roadmap. In the following sections, each technique will be analysed further, on an individual basis, building upon the discussion in Chapter Five.

### **6.2.3.1. MCDA**

As demonstrated in Chapter Five, MCDA was the first of the Lean inspired techniques used to overcome two major issues, as identified in Chapter Four: i) the site selection was not sufficiently transparent for the local population; and, ii) the public consultation outcomes were not representative of the local population.

By developing and solving the models through several iterations, it emerged that MCDA, using ER and AHP, allowed: i) the reduction of the information asymmetry; ii) a consensus to be developed; iii) a rational understanding of the results to be achieved, by managing the uncertainty and risks associated with the site selection; and, finally, iv) the structuring of the public consultation, by reversing the process, i.e.: identifying the criteria before the alternatives.

As in Ertuğrul and Karakaşoğlu (2008), Ram *et al.*, (2011), and Tavana and Sodenkamp (2010), MCDA has enhanced the rigour and robustness of decision-making processes, such as: site selection and portfolio rationalisation within the planning of new infrastructure development. It has given the decision-makers confidence in their decisions and developed the public consultation effectively and efficiently. OPJB90 stated that: *“using MCDA adds rigour and robustness to the process of making decisions and doing the planning. It speeds the process up by only having to do it once. We do the consultation with a view to collecting the information we need to populate the model, and put the information through it. Then, we analyse the results, which we can confidently communicate to the stakeholders. So, it is a relatively simple and effective process.”* Thus, it has meant that the organisation did not need to re-open the public consultation, as it used to happen previously, and the decision-makers could justify the process and its outcome, rapidly and transparently.

Using MCDA was very powerful in achieving a consensus and reaching a rational outcome, through developing the models within the groups before collecting the required data. *“One of the advantages of using the ER and AHP models is, during the first couple of iterations, when we are perfecting the model, we are making sure that the criteria are correct and the weightings are relevant. Once we have done that, we don’t have to do it again, so it will speed the process up”* (OPJB90). Moreover, it was analysed by GHCT40, who summed it up this way: *“MCDA was very good - it was really important to develop the model with the group of decision-makers, but also with a group of patients as part of the public consultation. From memory, we all came up with actually quite a similar outcome. [...] I found that very transparent, robust and objective.”*

Furthermore, thanks to the ER assessment process, the uncertainty and risks were managed and the bias reduced, as Taroun and Yang (2013) demonstrated. *“We realised that we didn’t come up with the solution we were all necessarily expecting, even though, I think, we all went into the room with a fairly skewed vision of what we thought was the right location. When we used the ER approach, the answer we came up with was coherent and in line with what the patients had identified”* (GHCT40).

ER relies on a voting system, scoring and the degree of belief to build up the consensus and reduce the information asymmetry. Using techniques, like ER and AHP, helped in developing the consensus with the stakeholders, in that they were able to consider every voice within the weighting of the criteria. It is a democratic and transparent process, as per the vision of the organisation (Saaty & Vargas, 2001).

In Chapter Two, the bounded rationality was defined, according to Simon’s (1947; 1955) publications and the concepts of decision-makers being logical, completely informed and entirely sensitive were explained, based on the works of Salaman (2008) and Pomerol (2012). Using MDCA, with ER or AHP, enabled the decision-makers to focus, structure their thinking and maintain a certain consistency, by diminishing the bias and reducing the influence of individuals’ emotions. OPJB90 pointed out that: *“ER allows taking the emotion out of the assessment process. It is not about moving services away, it is about identifying what the criteria are that we should be considering the most to optimise the decision. So, it is not only about the site selection, it is about what we should be thinking when we build the model for site selection, which is a subtle difference.”*

Furthermore, using MCDA enabled the decision-makers to be objective and well informed, even when they had an incomplete knowledge about the choices and what the potential consequences of selecting an alternative were (Hollnagel, 2007; Pomerol, 2012). Mechanisms were used, such as the sensitivity analysis, to overcome these issues, as extensively described in Chapter Five. The financial attributes (*i.e.*: ‘total cost’ criteria) were analysed further, so as to reduce uncertainty and deal with the incomplete information available. Finally, ER allowed measurable and quantitative outputs to be obtained, for which the values of the various outcomes were generated, measured and compared (Biswas, 1997; Pidd, 2003).

Thus, this successful, Lean inspired experiment led to another question – between ER and AHP, which modelling technique was the most suitable in this environment? This is addressed in the S-RQ 4.

#### **6.2.3.2. Benchmarking and the Performance Framework**

As reviewed in Chapter Two, there is evidence of a lack of overall performance measurement and management within the built environment sector, especially within the development of new healthcare infrastructure, as detailed in Hinks and McNay (1999), Lawlor-Wright and Kagioglou (2010) and Williams (2000). On the other hand, Warnock (2000) and Grant (2010) confirmed how important performance measurement and management is in transforming the Operations Strategy into a set of meaningful actions and decisions, leading to the achievement of the operational strategic objectives. Measuring and assessing the performance enables the organisation to set quantitative targets, and then to control any deviations away from the plans. It was assumed and verified that it is very difficult to manage a process, effectively and efficiently, if no measurement systems are in place (Deming, 1986; Kaplan & Norton, 2001a, b, c). Moreover, by setting up a bespoke performance measurement system, it supports the adoption of a holistic value chain perspective, and translates the new infrastructure development so that it can be viewed from a process perspective (Shohet & Lavy, 2010). As no relevant and appropriate performance measurement and management system was available, a bespoke framework was developed, as presented in Chapter Five. This allowed the aggregation of qualitative and quantitative data, so as to establish key performance indicators (KPIs) for the measurement and management of the healthcare infrastructure (Hinks & McNay, 1999; Shohet & Lavy, 2010). The framework is

composed of four themes and 39 criteria, or KPIs, and the outcomes of three Benchmarking projects were reported, illustrating the impact on the innovation level and continuous improvement. Benchmarking was defined as: i) the search of best and good practices; and, ii) their adaptation to a specific process, leading to performance improvement (Adebanjo *et al.*, 2010; Breyfolge, 2003; Freytag & Hollensen, 2001; Marwa & Zairi, 2008).

It was relevant to note that the performance measurement framework monitors two aspects of the performance: i) the infrastructure as the product; and, ii) the process of developing the infrastructure. The literature demonstrates little evidence of process performance measurement; hence, this was addressed by the last theme, named ‘processes’, and composed of nine KPIs (Rytter *et al.*, 2007; Martín-Peña & Díaz-Garrido, 2008).

Thus, the development and deployment of this inspired Lean thinking technique allowed the different functional strategies to be aligned further, by agreeing on the key criteria to measure and by evaluating their importance. The decision-makers were able to establish a performance gap, both internally and externally, thanks to this bespoke, performance framework, designed and presented in Chapter Five. This bespoke performance framework, comprising 39 KPIs, has been extremely useful as a starting point for challenging the current practices and helping the decision-makers to explore different models for planning, designing and managing healthcare infrastructure.

It has led to the need analysis being performed in a more consistent and robust manner, around the identified KPIs. Moreover, by focusing on the framework, the decision-makers were able to communicate transparently about what data was required to make the decisions. From the experimental findings, the team of experts appreciated working within this framework. In Chapter Five, two types of Benchmarking results were presented: external, with the P and W projects; and best practice, with Sutter Health. Moreover, going forward, the organisation planned to use the framework, in a systematic manner, for internal Benchmarking. It is relevant to note that both primary and secondary data were used to populate the model and to develop a deep understanding of the process, which is in line with Marwa and Zairi (2008), and Adebanjo *et al.*, (2010). The bespoke, standard framework developed enabled the collection of the relevant information and made a uniform collection method possible, to reduce the bias.

Moreover, it was noted that Benchmarking enabled the increase of the innovation level by enabling good practices from the partners to be learnt, and challenging the status-quo in such ways as: considering the co-location with a library; defining the role of the infrastructure manager; and even using the Choosing by Advantage (CBA) technique to optimise the decision-making. Internally, Benchmarking is helping to introduce a more consistent approach to infrastructure management, enabling the comparing and contrasting of the performances of the main infrastructures against each other, and generating focus regarding continuous improvement activities. However, to be used optimally, it was felt that both Benchmarking and the performance framework should be integrated within the planning and design decisions. Therefore, it was important to link it with QFD.

#### **6.2.3.3. QFD**

In Chapter Five, the results presented two iterations at the infrastructure level, in which the Operations Strategy and the ‘voice of the decision-makers’ were the starting points. The aims were: i) to capture the voices of the stakeholders, customer, user and patient, and then translate them into the design of both the infrastructure and the service operations; ii) to further increase the alignment of the different departmental strategies; and, iii) to support the decision-making process at the design phase.

To achieve a successful QFD implementation, a multi-disciplinary team, of eight to 10 experts, was set up. Furthermore, the appropriate amount of resource, time and training needed to be allocated. This was critical in order to best collect the ‘voice of the customer’ (VoC), and carry out the relevant activities that allowed the team to generate the House of Quality (HoQ), and make the relevant design decisions, as demonstrated in Chapter Five. QFD was used to achieve higher performances in the design decisions and to ensure fitness for purpose within the design of the new infrastructure, which will lead to user satisfaction, and, theoretically, contribute to sustaining a competitive edge, in accordance with Cauchick Miguel (2005), Rahman and Qureshi (2008), and Sher (2006).

The QFD process was well received by the team and they recognised its benefits. A decision-maker stated that *“QFD adds value and supports the clarity of communication between the different stakeholder groups. It enabled synchronisation with the planners and architects. The more detailed information we can provide the architects, the designers, the planners, and the more accurate the tenant requirement documents are, the*

*more chance we have got of getting the infrastructure fit for purpose” (OPJB90). It was explained that QFD enabled the organisation to “cut down on some of the waste. Because we are more tightly specifying what we want, there is less waste, as we have more chance of getting what we want by identifying the requirements and communicating them precisely, as opposed to providing vague instructions as we used to do” (OPJB90).*

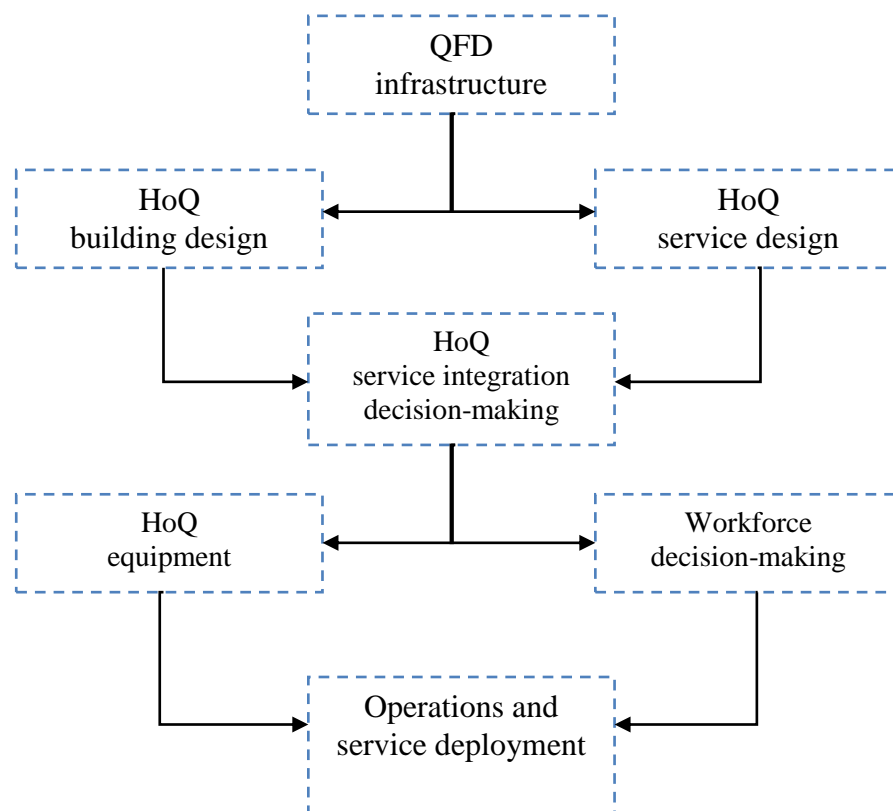
It was found that timing was crucial when collecting unbiased information. It was observed that, during the public consultations, the respondents sometimes struggled to generate positive, constructive feedback, as the members of the public were focused on the location rather than the service design. However, with the structured, QFD framework in place, the respondents were more willing to share their ‘ambitious’ ideas, so that they could be taken into account. The synchronisation of agenda and strategy enabled the design process to be streamlined. Furthermore, it allowed materialising and visualising the decision-making processes, making the outcomes more objective and transparent for the stakeholders.

QFD was used as a robust, user oriented methodology, so as to speed up the design decision process and help in achieving a consensus regarding service design, patient pathways, service integration and the building design, which came to pass through the discussions generated during the iterations of the HoQ. As with MCDA, it added transparency, rigour and robustness to the decision-making process, and was extremely effective when associated with the mapping of the service pathways and integrations. This was the first experiment used to structure the design phase along with QFD. It can be supposed that, each time QFD is applied the organisation will grow in maturity and start the next application of QFD by populating it with more accurate factors than the previous one, which will further impact the effectiveness and efficiency of the design decisions. QFD also enables the focus to be on communication and creates appropriate synergies between the different functions – it enables silo structures to be challenged; a problem identified in Chapter Four. QFD facilitated the planning and the communication, as well as supporting the co-ordination of skills, competencies and information needed to complete the design stage and optimise future construction and management of the infrastructure (Hauser & Clausing, 1988).



QFD was the planning and development technique deployed to provide the decision-makers, providers and suppliers, and contractors with a framework in which to collate and share structured information, in order to ensure that fitness for purpose was built into the design element of the infrastructure, as well as to take into account customer requirements. Ultimately, this leads the organisation to achieve a competitive edge by satisfying customers, reducing costs, and, to a certain extent, by enhancing innovation at infrastructure level (Andronikidis, Georgiou, Gotzamani & Kamvysi, 2009; Griffin, 1992).

However, it is suggested that QFD could be used at different levels, with further iterations, until saturation is reached, as Kutucuoglu, Hamali, Irani, and Sharp (2001) suggested. This would then lead to re-organise even further the design stage around the QFD process, as illustrated in Figure 6.4 below.



*Figure 6.4: QFD cascaded down*

This piece of research suggests that the QFD process should be started during the planning phase, as demonstrated using the K project. The HoQ framework is used to collect and integrate data from the different sources, using the information gathered from the public

consultation. The decision-makers and other key stakeholders can then develop the design decisions with their shared vision in mind, as was presented in Chapter Five. In this specific experiment, two iterations were shown. However, the decision-makers could decide to go through third and fourth iterations, in order to refine the design features and support the decision-making processes still further. Once saturation is reached and agreed upon by the stakeholders, and the vision and strategies have been shared, communicated and are aligned, at this stage, the decision-makers will know the type of resources needed and will be aware of the potential trade-offs. This is a very useful and informed position to be in. Ultimately, the decision-makers are able to build the full business case, providing accurate information to any external parties, such as architects, planners and builders.

However, the decision-makers could go even further. As suggested in Figure 6.4 above, the results generated by QFD, at infrastructure level, have generated design characteristics that could be split, either into building design, or services' design. For instance: 'modern and flexible design'; 'car parking'; 'aesthetic interior decor'; 'disabled access inside/outside'; 'different types of consultancy rooms'; 'good signage and clear layout'; 'modular design based on patient flow'; 'multi-functional rooms'; 'diagnostic equipment (x-ray, scan)'; 'glass building, natural light and use of technology screen for information'; 'walk-in, minor surgery, pharmacy, physio, hot desk clinical and specialist services' are all characteristics generated by and linked to the building structure, to a certain extent.

Conversely, 'transport links'; 'waiting time and queuing system'; 'extended opening hours'; 'service integration / appropriate service design'; 'communication culture and processes'; 'IT system and DIY technology'; 'top quality healthcare service'; 'multi-lingual support / council services'; 'IT system based on unique platform'; 'online, live booking system and capacity system (incl. car park)'; 'shift working pattern for medical and admin staff'; 'innovative healthcare equipment (telecare)'; 'co-location of high quality services'; 'well-being classes'; 'interpreter team'; 'own transport for disabled and older patients'; 'extra services (cafe, library, internet access)'; 'centre managers, clear leadership' are all characteristics generated by and linked to the structure of the services.

Hence, it could be suggested that HoQ models simulate each specific focus, increasing and optimising the decision-making processes still further, during the design phase, by bringing downstream stakeholders into upstream decision-making processes, and by

increasing transparency and rationality. This helps to define and design the service integration, by overlaying the two structures – the building and the services. Ultimately, the decision-makers will be in position to reduce uncertainty and define the equipment and the workforce needs, with precision, by the end of the design phase.

QFD helped to speed up the design process; hence, reducing the overall cycle time, as well as bringing stability into the quality assurance planning, along with increased possibility for innovation (Griffin, 1992; Xie *et al.*, 2003). Furthermore, it is predicted to contribute towards cost reductions in the new infrastructure, by reducing the rework and design changes and reducing the risks of failure (Bouchereau & Rowlands, 2000; Gonzalez *et al.*, 2004). Additionally, QFD allows the enhancement of cross-functional team communication, as mentioned by Chan and Wu (2002), and Waterworth and Eldridge (2010). Finally, it will have improved the organisation's overall, operational performances, by meeting or exceeding customer demands and requirements, thus increasing their overall satisfaction (Andronikidi *et al.*, 2009; Bouchereau & Rowlands, 2000; Chan & Wu, 2002; Gonzalez *et al.*, 2004; Han *et al.*, 2001).

The researcher strongly believes that QFD can be the Lean thinking solution to support the entire design phase. It has many similarities with Evidence Based Design (EBD), as Codinhoto *et al.*, (2010) suggested. As defined in Chapter Two, EBD is a tool used to share a vast amount of information, so as to optimise design decisions made between the architects, engineers and healthcare planners. Like EBD, QFD and HoQ assisted the decision-makers in optimising decisions, regarding size and design of the room and the equipment needed, based on the available knowledge and information (Malkin, 2008).

Thus, by utilising QFD from the planning stage, the structure of the information required from the consultation phase was structured. It was particularly useful and relevant when considering and balancing the trade-offs between the variables, and speeding up the design decision-making processes. Throughout a series of interviews, questionnaires, focus groups, market surveys, patient feedback and complaints, substantial data was fed into the framework. In this instance, the process was organic, but it could be made to be more structured. For example, by using a standard set of questions, the 'voice of the users' can be systematically collected and analysed. As suggested by Dale *et al.*, (2007), the questions used could be along the lines of: what services do you use; why do you use these

services; who else uses these services; when do you use these services; where do you go to use these services; how do you use these services? The analysis supports the decision-makers in establishing the infrastructure needs and service requirements. It can be suggested that the results are aggregated into a database and then shared between the decision-makers. However, it is important for the QFD framework to be integrated with MCDA and Benchmarking, as it will be demonstrated in the conclusion and conceptualised by the Partial & Bespoke Lean Construction Framework (PBLCF).

**6.2.4. S-RQ4: What are the Most Suitable Models (ER v AHP) in Optimising the Decision-Making Processes in this Research Environment?**

A recurrent concept, which emerged in Chapter Two and was materialised in Chapter Five, was that: “*all models are wrong but some are more useful than others*” (Box and Draper, 1987). Hence, as highlighted above in the MCDA section, the question is: what is the most suitable model, between ER and AHP, in optimising the site selection? The researcher was interested to build upon the results’ comparison between ER and AHP, as presented in Chapter Five, so as to identify which model could provide the most precise and accurate, hence satisfactory, outputs for the site selection.

A framework developed from the literature was assembled to assess both MCDA models and discuss their implications from a practical and managerial perspective. The rationality element was not considered as a criterion on its own, but rather as an aspect linked to each of the five criteria, transversal to both the process and results, as detailed in Chapter Two and summarised in Figure 6.5 (Breyfogle, 2003).

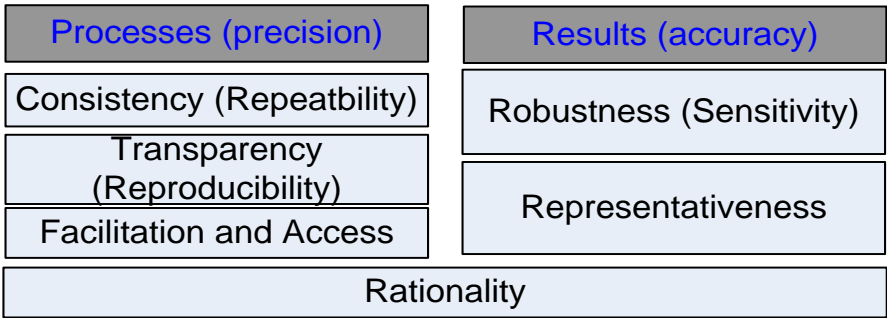


Figure 6.5: Models comparison framework

### ***ER and AHP Processes and Their Precisions***

The processes for weighting and assessing the criteria had to be consistent, repeatable and transparent, because they were used by the group of decision-makers at different times. To test this, parts of the process were selected and tested by asking the stakeholders to re-weight and re-assess criteria and alternatives, in order to establish to what extent the same weightings and assessments could be reproduced, and to test the capabilities of the measurement models (Breyfogle, 2003). This goes some way towards addressing the concerns regarding the myths of MCDA, which state that it does not always provide a right answer, as Belton and Stewart (2002) suggested. Moreover, different groups of stakeholders were asked to weight and assess the same criteria and alternatives, based on the same given information, to establish whether the differences were significant or not. This relates to view MCDA as being highly useful for exchanging knowledge (Tavana & Sodenkamp, 2010).

By using ER, the weighting and assessment processes generated good consistency. Over time, participants were able to repeat their assessments, quite confidently, by using the Likert scale methodology. However, by using AHP and the pair-wise comparison, the process was found to be less consistent, especially as the model became bigger anomalies and contradictions were created. This could partly be explained by the decision-makers not being familiar with pair-wise comparison methods. Therefore, it can be suggested that ER was more likely to be a consistent method for assessing alternatives, but could lead to some inconsistency within the weighting process, as participants and decision-makers were reluctant to use the whole scale and the range of most of the weightings were only between 6 and 9 on the entire, 1 to 10 scale, which could affect the final results, as seen in Chapter Five. Therefore, in terms of consistency, it was recommended that the pair-wise comparison is used at the criteria level, and the degree of belief technique is used in the assessment, so as to reach an optimum process consistency.

Transparency was the primary criteria for justifying the MCDA route, as discussed earlier in this chapter. The objectives were to embed inclusive processes and make them easy to understand for the large range of stakeholders involved. In this case, ER seemed easier for the majority of the participants involved, reinforcing the findings from the literature, which states that ER is a 'simple' process, and that there are many different ways to compile and aggregate the results, as Xu and Yang (2001), and Xu (2011) explained.

On the other hand, the pair-wise comparison had to be established by a consensus, and some of the stakeholders and decision-makers found it slightly confusing and rather redundant, which reduced the transparency factor. Hence, it was confirmed that, for the large range of stakeholders, ER was more a transparent process than the pair-wise comparison. It was easier to track, as the individual inputs could be highlighted, as part of the process is to average the different scores given by all the participants, and the process allows the average scores to be reproduced on different occasions. By using AHP, it was necessary to identify the pair-wise weight, or assessment, based on the general consensus given at the specific time. However, it was found that it did not keep track of what happened during the process, which could, arguably, make it less transparent than ER.

Both models can be facilitated using a large number of stakeholders. However, it was felt that AHP was easier and faster, as it interacts with a higher level of the structure. Moreover, AHP uses one mechanism for both weighting and assessing (i.e.: pair-wise comparison); whereas, ER uses the Likert scale for the weighting, then the degree of belief for the assessment of the alternatives. More time needed to be allowed for facilitating ER as opposed to AHP. Although both use pieces of software – IDS for ER and MiR for AHP – AHP was also easily facilitated by an excel spread sheet, which proved convenient for the decision-makers. Having said that, from the feedback received, participants were more comfortable using the Likert scale and degree of belief system than pair-wise comparison, despite the training provided beforehand. It was felt that AHP was more accessible, as it remained at the aggregate level of the hierarchy model – very useful for unstructured problem solving – whereas, ER goes down to the smallest level of the model; in this case, the sub-criteria (Saaty, 1980; Wang, Yang & Xu, 2006).

### ***ER and AHP Results and their Accuracy***

The robustness of the results was hampered by the possibility of introducing bias; the stability of the models and the sensibility aspect of the results were other factors considered. Ideally, the model needed to be bias proof and sensible enough to adequately translate the results. It was suggested that, potentially, AHP was the more sensible option, as the spread of the results shown in the K example (a larger difference); however, it was more likely to introduce bias into the results, by finding consensus based on the strongest personality in the room, while weighting and assessing criteria and the alternatives. Moreover, the AHP method could possibly introduce unsteady elements by not following

a logical and consistent pair-wise assessment, and there is a danger that contradictions might be input into the model. Both techniques provide sensitivity analysis. This translates the robustness of the results, as one can further understand what the ranking means, plus what influence changing a weighting, or unit of assessment would have on the results. Therefore, it was analysed that ER was less subject to bias and was slightly more stable than AHP, perhaps because it works at the lower level of the model. It was also important to evaluate whether the model distorted reality by appreciating the level of subjectivity. The mechanism, for establishing whether or not this was the case, was to compare the results of the model against other measurements. In this case, the measurement available was the extensive survey of N=3055, undertaken by the organisation during the public consultation, from which 92% of the participants were in favour of Location A. The AHP model shows a wider range between A and B, with 23.2 points of difference (*c.f.*: Figure 5.14); whereas, the ER model only established a difference of 2 points, in both cases normalised (56-54) and non-normalised (51-49), as illustrated in Chapter Five (*c.f.*: Figure 5.13).

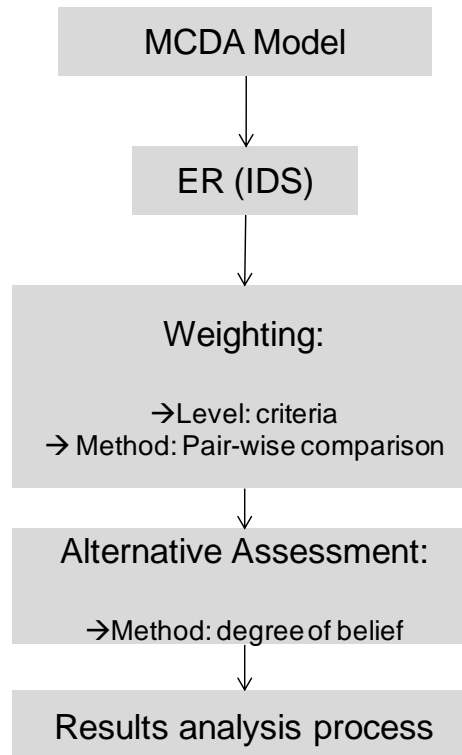
The rationality aspect was defined by asking the stakeholders which process they perceived to be the most rational. ER came out in front. However, from our example, the AHP results seem to be more in line with reality – traditionally, the questionnaire was the tool used to make the final decision for the site locations. In this case, the reality (as a contextual field of information) was translated better through the AHP model than the ER model. As mentioned previously, this was due to the tendency of using only part of the scale (6 to 9), with ER, especially at the weighting stage. This was clear in the experiment, as presented in Chapter Five, which, through the smaller range for the criteria, confirmed weightings varying from 8.90 to 22.22 (once normalised); whereas, with AHP, the weightings fluctuated from 3.53 to 38.89 (*c.f.*: Table 5.7). This has had a substantial impact on the results. It was analysed that the AHP model better translated the reality, as perceived by the local population, thanks to its criteria pair-wise, comparison element.

Therefore, significant differences between the processes and the outcomes of the two models were found. According to the model selected, the results were statistically and significantly different; thus, this could have impacted the final decision. The process selected also impacts the practical and managerial implications and behaviours for both the participants and decision-makers. ER uses different methods for weighting and

assessing and works at the lower level of the model, which supports the transparency and robustness elements; whereas, the decision-makers found AHP to be more flexible, very efficient and extremely relevant in a smaller strategic committee, in which the level of transparency for the local population was not necessarily the prime issue. Moreover, the pair-wise comparison seemed more appropriate for grasping the real, or subjective, differences. This section reinforces the quote, stated at the beginning, that: “*essentially, all models are wrong, but some are more useful than others*” (Box & Draper, 1987). From the findings, it was felt that this is greatly dependent upon the environment.

Therefore, the most reliable and appropriate modelling technique to use in the specific context of site selection for future healthcare infrastructure, when seeking a rational, inclusive and transparent solution, would be a hybrid version of both ER and AHP. It was agreed that both models were reliable techniques with different characteristics. Thus, to optimise both the process transparency and consistency, within the robustness of the results and the level of representativeness, the researcher suggests the use of ER, merged with the AHP pair-wise comparison at the criteria weighting process. It is believed that, by implementing this hybrid version, the rationality of the decision can be optimised still further, by developing an informed, sensitive and transparent decision for the site selection. Consequently, it is recommended to work at the lower level of the model, as ER suggests, in order minimising the information asymmetry; but that the weightings of the criteria are established, through the pair-wise comparison, as AHP implies, and as is illustrated in Figure 6.6 below.





*Figure 6.6: Merging the ER process with the pair-wise comparison*

The use of these models directly influenced the organisation's board of directors when making an informed decision on the location of the £15 million health centre. As several attributes were conflicting, these techniques were useful in order to aggregate the different stakeholders' perspectives, and to reach agreement on the selection of the key factors needed for identifying the optimum healthcare infrastructure location. By going through this process, the healthcare organisation became more informed and sensitive towards appreciating the differences between the alternatives, which, ultimately, enabled a more rational ranking of alternative by preferences. This process also proved beneficial to the users and local communities, who were able to both follow and take part in the evidence based, decision-making process.

Having reviewed the three Lean techniques – MCDA, Benchmarking and QFD – in depth, in the previous sub-research question, and having established, using the site selection as an example, which MCDA model, out of ER and AHP, was the most satisfactory; the last sub-research question will be reviewed, so as to analyse how these Lean inspired models and techniques both reduce and help to manage the level of complexity underlying within the planning and design of new healthcare infrastructure development.

### **6.2.5. S-RQ5: How Can a Lean Methodology Reduce and Help to Manage the Level of Complexity?**

Finally, in order to answer this last sub-research question, the researcher will analyse the role of Lean methodology in relation to the complexity issues. To frame this section, the Cynefin model will be applied, as presented in Chapter Two (Snowden & Boone, 2007). It has been demonstrated that complexity was a recurring theme throughout the research, and inherent to the healthcare built environment. Hence, as pointed out in Chapter Two, the Cynefin framework is an analytical, decision model, used for decision theory, knowledge management, IT infrastructure design, and project management. Cynefin recognises the causal differences that exist between different types of systems and provides decision-makers with an effective way to analyse a context, so that they can use the appropriate methods and approaches for the relevant domain (Snowden, 2013). Once the domain is identified, the decision-makers will behave differently and use a diverse range of tools, techniques and strategies, according to the context and environment, as Figure 6.7 illustrates.

In the specific context of this research, the stakeholders started by evolving in the complex domain to manage the process behind the new healthcare infrastructure development. It has been assumed and verified that, when planning and designing new healthcare infrastructure, the decision-makers' natural behaviour was to probe, act and then respond, which contributed towards the inefficiencies and ineffectiveness established during this research. Examples of their previous behaviour were found in the management of the public consultation; the way in which they selected the site location; and, their use of a high number of unproductive meetings as the mechanism by which to make decisions. All of these examples perfectly illustrate the lack of analysis behind past decision-making processes.

Furthermore, due to the requirements for collegial and transparent decision-making, based on consensus, robust processes had to be put in place to avoid biased and irrational outcomes, as Baker and Mahmood (2012), and Valentin (1994) pointed out. This proved to be some of the impetus underpinning the implementation of the soft OR techniques, the system thinking approach and the Lean tools, such as MCDA, Benchmarking, the performance framework and QFD.

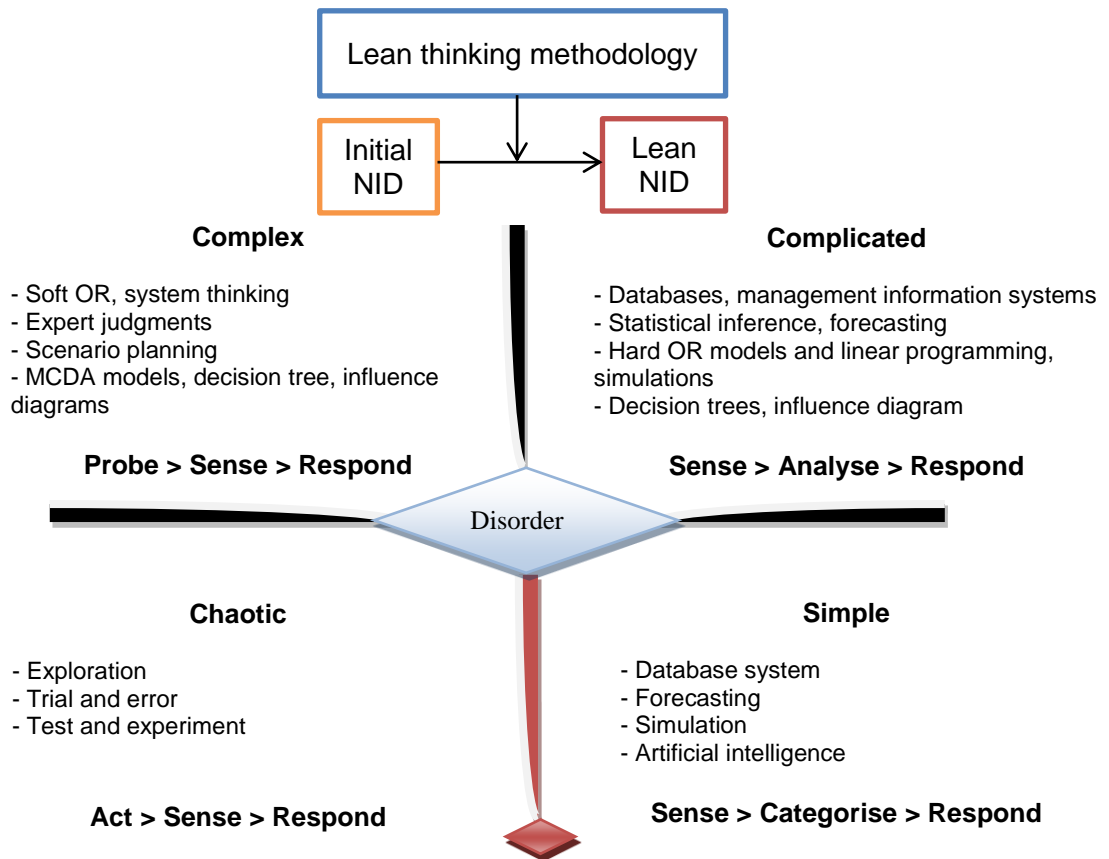


Figure 6.7: Cynefin framework (adapted from Snowden & Boone, 2007; French, 2013)

As demonstrated in the S-RQ3, this Lean methodology enabled the decision-makers to structure the overall process around: MCDA, the bespoke performance framework, Benchmarking and QFD, in order to optimise the planning and design decisions. MCDA and QFD supported the management of the complexity of the decision-making surrounding the planning and design. Benchmarking and the performance framework helped to manage the complexity of the strategy synchronisation. Hence, by re-visiting the planning and design processes and implementing these Lean techniques, the decision-makers were able to take a pro-active approach towards new infrastructure development. Thus, the stakeholders have been able to sense, analyse and then respond, which is the behaviour adopted when evolving within the complicated domain. Consequently, the implementation of the Lean methodology helped to manage the uncertainty, arguably creating a less complex environment. As suggested in Figure 6.7 the implementation of the Lean methodology can act as a mechanism to transfer the new infrastructure development (NID) from evolving in a complex system to a complicated system. This is

achieved by: i) reducing various forms of uncertainty; ii) structuring statistical thinking about decision analysis; and, iii) appreciating the self-knowledge of the decision-makers' values and reducing the information asymmetry (French, 2013).

In the complicated domain, the cause and effect are more meaningful than in the complex domain; there is potential to forecast the performances and to develop good management practices. This can be achieved by using subjective probability, as in MCDA, the performance measurement and QFD. Having said that, these Lean tools assume that the probabilities are subjective to the decision-makers' belief and knowledge about the particular event, and that the probabilities may change based on the information available, as Pidd (2003) explained. This is also in line with the ontology borrowed – reality as a contextual field of information. Thus, to a certain extent, decision-makers are able to move away from working purely under uncertainty and start working under risk, by exploring the different scenarios, running sensitivity analysis, establishing the trade-offs in the planning and design decisions, and reducing the information asymmetry. The uncertainty is reduced by clear strategies, upon which consensus has been reached, translated by the performance framework and Benchmarking.

By going through several iterations of this Lean methodology and by gaining in maturity, the organisation will be able to develop a coherent and comprehensive dataset, analysis of which will allow the forecasting and prediction of the relationships between the events. Data will be captured, aggregated and transformed into information, which will be taken into account during the next new infrastructure development and production, leading to further optimisation of the decision-making processes, and, ultimately, to developing a complete edge.

This partial Lean methodology supports to structure the overall process of new infrastructure development, as it will be demonstrated in the following section. Thus, the researcher argues that these bespoke tools and techniques deployed lead to the management of the complexity underlying within the new infrastructure development (NID), and enabling the decision-makers to behave as in a complicated domain. As illustrated in Figure 6.7, the Lean methodology led to the reduction of the uncertainty; thus, the complexity in the system. The Lean methodology acts as a system transitional mechanism, which leads to further optimisations. However, this phenomenon may take

some time to function fully, and would always be correlated to the degree of leanness and maturity of the organisation, as explained in Bamford *et al.*, (2014). As discussed in the literature, the degree of leanness increases throughout several iterations (Green & May, 2005).

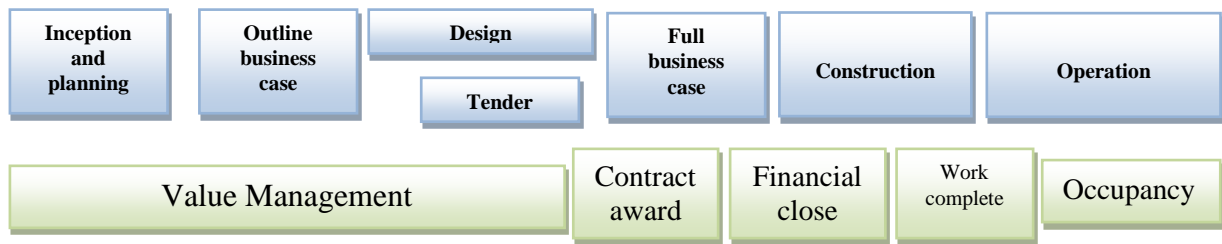
The following section will take a process perspective and explain how the tools and techniques fit together. Therefore, the overall NID process and life cycle, taking into consideration the planning, design, construction and management, will be analysed and presented.

### **6.3. The Overall Process, Life Cycle and Value Management**

Having addressed the five sub-research questions, it seemed beneficial to provide a holistic perspective of the NID process. This section will present and discuss the four phases of new infrastructure projects, using an overarching framework (*c.f.*: Figure 6.9), and overlap them with the built environment life cycle (*c.f.*: Figure 6.8), as described in the literature review (Myers, 2008; Pellicer *et al.*, 2014). The rationale for this section is to strengthen the practitioner contribution.

As shown in Figure 6.9, the overarching framework looks at projects from a macro angle and describes the four main phases, along with the associated milestones that are common to all new developments: i) the planning phase, during which the Operations Strategies must be aligned and key decisions must be made, in order to shape the network and the future development; ii) the design phase, when the design processes of both the infrastructure and the services are developed, and when both designs must be synchronised so as to maximise the fitness for purposes and levels of innovation; iii) the construction phase, from the financial close to the handover processes; and, iv) the management phase, when the continuous improvement activities and culture are embedded and fed back into the future NID processes.

In the sub-chapter of Chapter Two which discussed the literature surrounding the built environment, the life cycle of new healthcare infrastructure (NID) was described and the following model presented, suggesting that the value management or the most adding value activities were undertaken within the planning and design phases.



*Figure 6.8: Project life cycle (adapted from Myers, 2008)*

The following Figure 6.9 depicts the developed framework by overlapping the new infrastructure development process with the theoretical life cycle of the built environment. In the longer term, this developed framework will support and promote: i) the processes standardisation; ii) the reduction of variations; and, iii) focus on a process perspective, as opposed to an activity based one (*c.f.*: Chapter Four). It is also a relevant communication and monitoring tool. The rationale is that each project can be controlled against this framework and each milestone allows the comparison and more effective management of resources. It is strongly suggested to associate the financial processes with the overarching framework. This enables to create a baseline model to build the continuous improvement process. It is important to have this overarching framework, which depicts the major steps of any new infrastructure development, and to appreciate how it fits in with the life cycle. This fully addresses some of the specific issues and problems identified in Chapter Four. The researcher recognises that the construction phase is different, as it is undertaken outside of the organisation's boundaries and expertise, and that the management phase is a more continuous activity, rather than simply a 'one-off'. However, in order to be optimised, it is strongly believed that projects must be viewed in their entirety, from a holistic perspective. It is noteworthy to mention that, as part of this overarching framework, there are indications of where and when MCDA, the performance framework, Benchmarking and QFD are applied within the overall process.

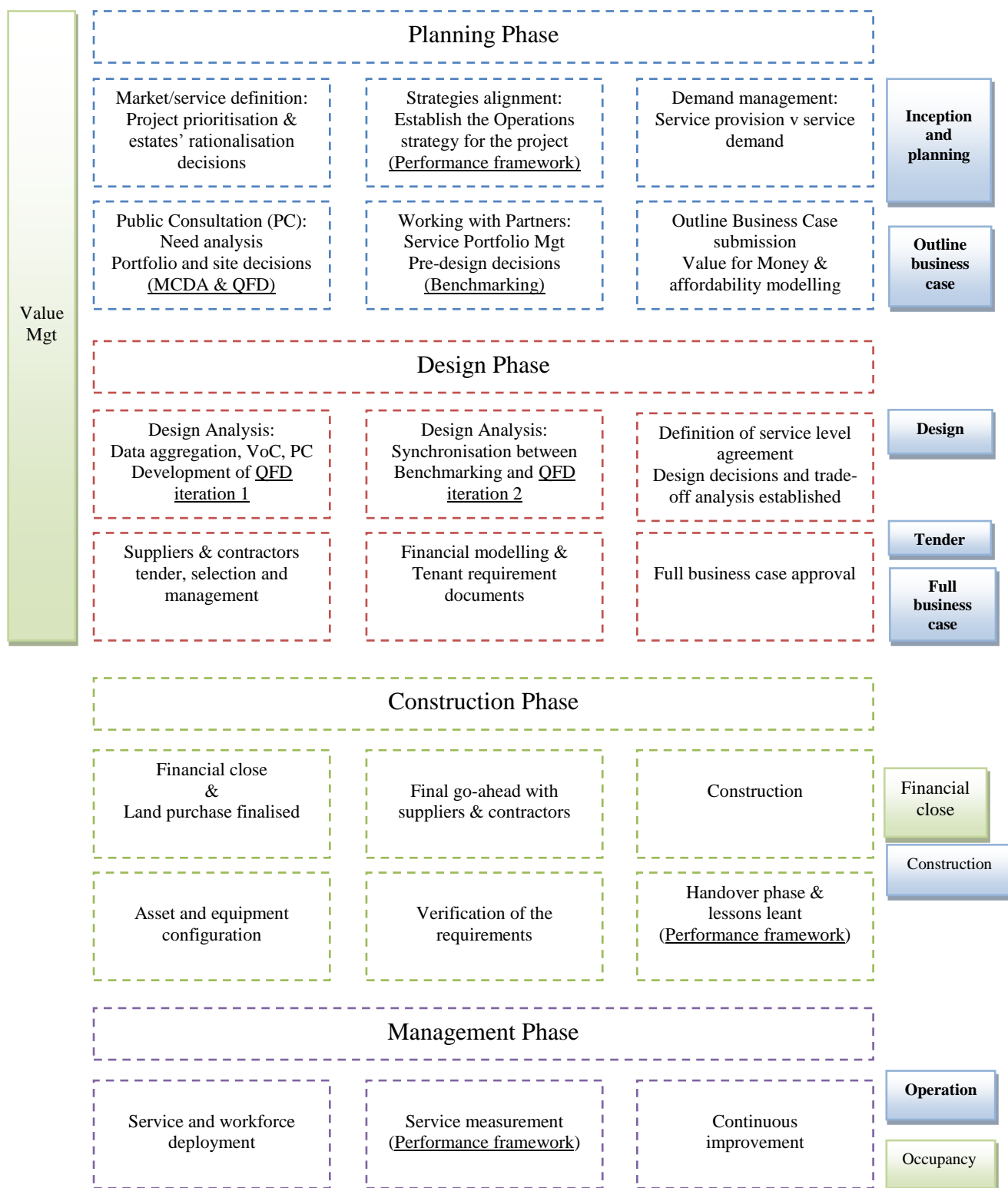


Figure 6.9: The overarching framework for new healthcare infrastructure development

### **6.3.1. Planning Process**

The planning process is the start of any projects, when key decisions must be made and optimised. This phase must be in line with the Operations Strategies, as explained previously. In the planning phase, major key decisions are being made on such aspects as: infrastructure rationalisation, scheme development prioritisation and site selection. Stakeholders' roles and responsibilities must be clearly linked with these decisions to avoid confusion and inefficiencies. These are complex strategic decisions and it is strongly recommended to use models and processes to rationalise these decisions and improve their robustness, transparency and speed (*c.f.*: MCDA, ER and AHP). Moreover, as detailed in Chapters Four and Five, within the planning stage, the site selection appears to be the process bottleneck. Thus, to improve the planning process, developing MCDA models to optimise the site selection, seemed the relevant and appropriate Lean approach.

Within the planning phase, it is also crucial to engage with the local population. The main objectives are to collect the 'voice of the customer' (VoC), then manage the public expectations and engage, in a transparent manner, with the large range of stakeholders, regarding the services' requirements and the future site location. Thorough processes developed around MCDA and QFD have been implemented to reach the objective of transparency and consensus.

It has been demonstrated that the organisation can potentially speed up its NID process and reduce the planning cost by optimising the public consultation. Moreover, at this stage, the use of the performance framework, Benchmarking and QFD can further support the outline business case development, which: i) summarises the affordability; ii) demonstrates the potential for value for money; and, iii) meets the strategic objectives of the organisation, before moving onto the design stage.

### **6.3.2. Design Process**

The planning and design phases need to be smoothly linked – it was observed that a loss of momentum and time was occurring between these two phases. It has been established that using Quality Function Deployment (QFD), as the design process, could allow generating effectiveness and efficiency into the design phase (*c.f.*: Chapter Five). Through analysing the data collected during the planning phase, using QFD, it becomes possible to



build quality into the design of the operations and infrastructure, especially when the integration of the services is being sought, as demonstrated earlier in this chapter.

During the design phase, it is important to create an information exchange structure between all the stakeholders involved: GPs, clinical staff, the architects, the contractors, the sub-contractors, and the experts: Estates, Finance, Service Development and Primary Care, which becomes possible through the use of the QFD processes. By having a robust process in place to organise the design phase, the tenant requirements and the full business case, along with the financial modelling, can be integrated and synchronised. By doing this, decision-making processes, within the design phase, are optimised.

### **6.3.3. Construction Process**

The construction phase was the least problematic phase of the whole development process, with a shorter cycle time (*c.f.*: Chapter Four). However, the organisation needs to work closely with the partners, contractors and sub-contractors, in order to optimise this phase. It was established that, when the planning and design phases have been rationalised and optimised, the construction phase is often effectively undertaken, even when outsourced.

The main objective is to learn from the Lean construction body of knowledge in order to develop good working partnership practices with the contractors and sub-contractors in order to optimise the processes, using the following concepts: standardisation of processes and components (Alves, Milberg & Walsh; 2012); pre-fabrication methods; and, Just-In-Time delivery, with LPS and BIM (Azhar *et al.*, 2008; Ballard, 2000; Dossick & Neff, 2010; Kiviniemi, 2012). These core Lean components allow for: i) waste reduction, via the JIT and pre-fabrication implementation; ii) process focus in production planning and control, with The Last Planner System; iii) end customer focus: the suppliers, contractors and designers must understand the final customer requirements, for instance early involvement of contractors in the design phase throughout QFD has been a key aspect; iv) continuous improvement aiming to reduce waste and improving productivity over time; v) cooperative relationships, involving a partnership approach with the supply chain of the construction project; and, vi) system perspective, to avoid sub-optimisation (Eriksson, 2010). Furthermore, Building Information Modelling (BIM) will become standard practice for all public sector projects, above £3m, from 2016 (Arensman & Ozbek, 2012; Dossick

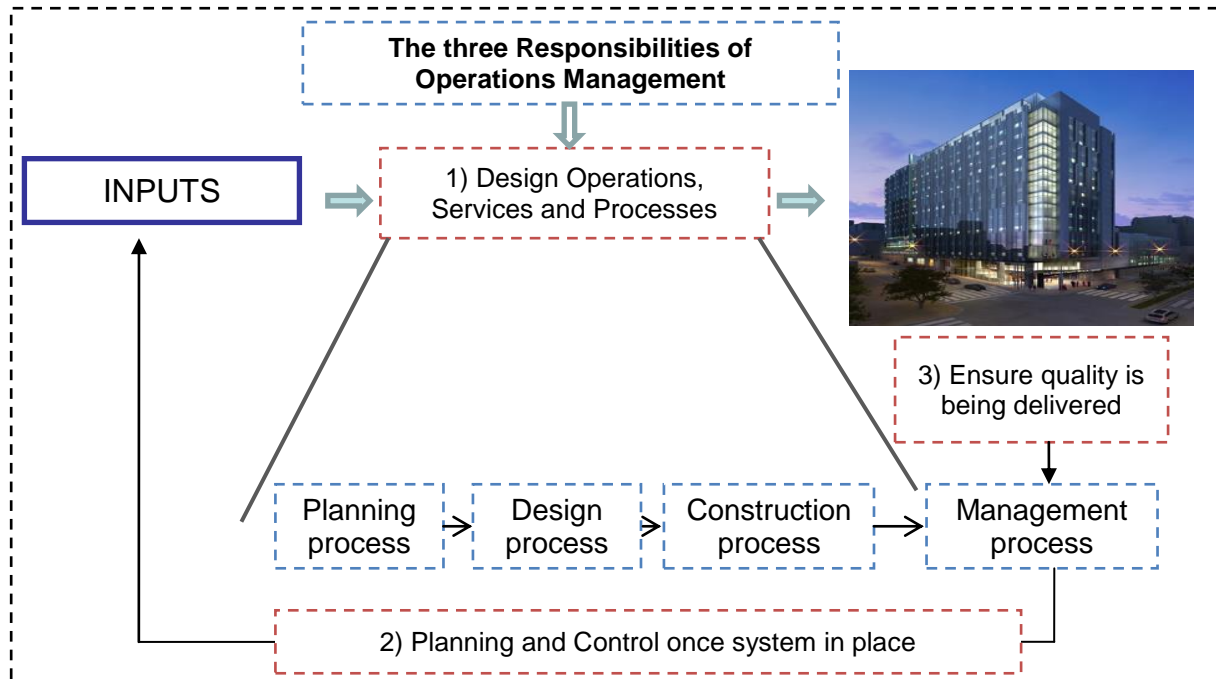
& Neff, 2010). It is believed to be an excellent complementary system to QFD, in supporting the planning and design of complex projects still further.

#### **6.3.4. Management Process**

The first year of the management of new infrastructure is critical and can be associated with the soft facility management roles and responsibilities. These complex facilities must be carefully run in order to be optimised. A continuous improvement model and culture can be put in place, notably by launching internal audits, Benchmarking activities and monitoring performances within the standard measurement framework, especially designed for the organisation (*c.f.*: the performance framework). The Lean principles applied for the management of the operations and services of the infrastructures are: i) to focus on creating value for the customer, ii) to eliminate wastes; and, iii) to set up for incremental improvements. It is suggested that the above practices could become part of the building managers' roles and responsibilities – they could implement the strategy throughout the infrastructure network and closely link the infrastructure performances with the estates teams. Many good practices could be learnt from Benchmarking activities.

#### **6.3.5. Input – Transformation - Output Process**

Therefore, from an Operations Management perspective, the built environment process can be modelled as an input, transformation and output operation. The following model, Figure 6.10, presents the transformation process for developing new healthcare infrastructure. This model enables a process perspective to be taken. The aim is to design the processes and operations necessary to satisfy the milestones, as described in the overarching framework, as detailed in Figure 6.9 above. Moreover, there are the two further responsibilities, as suggested in the transformation process in Figure 6.10: i) to control the running system; and, ii) to ensure that the new infrastructures are delivering the quality required. In the long term, this will be critical in order to satisfy the main Operations Management functions, composed of designing, planning and controlling, and improving the NID processes. It is believed that the Partial & Bespoke Lean Construction Framework (PBLCF), presented in the conclusion chapter, will support the optimisation of this transformation process.



*Figure 6.10: NID transformation process*

This section comprised the holistic reporting of the research findings and bridged the gap between the literature and the practice. In the following part of this thesis, Chapter Seven, the research questions will be addressed and the final conceptual model, PBLCF, will be presented.

## 6.4. Conclusion

In this chapter, the researcher has built upon the literature and the findings to form the discussion. This discussion chapter was structured into 3 sections. Firstly, a summary depicting the major conceptual models developed was provided; then, the five sub-research questions were addressed; and, finally, an overarching framework was presented, to link the theory and the practice together. This chapter has created all the connectivity necessary to conclude this thesis, present the final conceptual model – the Partial & Bespoke Lean Construction Framework (PBLCF) – and make claim to the three types of contribution, all of which will be detailed in the final chapter.

## **7. Chapter Seven – Conclusion**

In this final chapter, the conclusions of this piece of research will be drawn together. The Partial & Bespoke Lean Construction Framework (PBLCF) will be discussed and presented as the final conceptual model of this thesis and the results emphasised. The two main overarching questions will be addressed succinctly, so as to summarise some of the key findings and discussions engaged in throughout this monograph. Furthermore, after reviewing the aims and objectives, the claimed contributions, towards practice, knowledge and methodology, will be argued. This chapter will end by detailing the recommendations, as well as the limitations, associated with this research, before revealing potential, future research.

### **7.1. The Partial & Bespoke Lean Construction Framework (PBLCF)**

This final conceptual model, presented in Figure 7.1 below, was generated from this empirical mixed-methodology research. The Partial & Bespoke Lean Construction Framework (PBLCF) is based on the development and implementation of Lean thinking models and techniques, and is designed to optimise the decision-making processes and enhance the effectiveness and efficiency of new healthcare infrastructure development. This was achieved by reviewing Lean thinking theory and the best practices developed in the manufacturing setting, and by adapting and transferring the knowledge and good practices into the context of the healthcare built environment, as advocated by many researchers (Green & May, 2005; Jorgensen & Emmitt, 2008; Kagioglou & Tzortzopoulos, 2010).

As thoroughly detailed, this research was structured into two phases: i) an exploratory sequential design to identify, test and verify the issues preventing new healthcare infrastructure from being both fit for purpose and developed within a reasonable timeframe (currently, new healthcare infrastructure has a development cycle time of up to 15 years); and, ii) an embedded-experiment variant, used to develop and implement appropriate Lean solutions, tackling root-cause problems and bottlenecks within the processes by the utilisation of MCDA, Benchmarking and QFD methods.

The data analysis revealed and proved that the decision-making processes were the main issues preventing enhancement of the performances of new infrastructure development. Thus, as a key emphasis, the inspired Lean models developed had to improve these decision-making processes, by making them: i) inclusive and transparent for all the stakeholders; and, ii) rational and satisfactory. These improvements were mainly experienced within the decision-making during the planning and design stages of the new healthcare infrastructure, impacting the decisions on such items as: site selection, estates' prioritisation, service portfolio, service design and infrastructure design. Thus, Multiple Criteria Decision Analysis (MCDA), with the use of two models – Evidential Reasoning (ER) and Analytical Hierarchy Process (AHP) – were implemented to optimise the site selection. Quality Function Deployment (QFD) was used to rationalise the design decisions, and Benchmarking, alongside a bespoke performance measurement framework, were used to collect relevant data, feeding it into the other models, measuring the

processes performances and progress. All these models and techniques were tailored to the specific environment of new healthcare infrastructure development. However, it was essential to synchronise and link these techniques together so as to enhance the benefits generated, which led the researcher to develop this PBLCF conceptual model, presented in Figure 7.1 below.

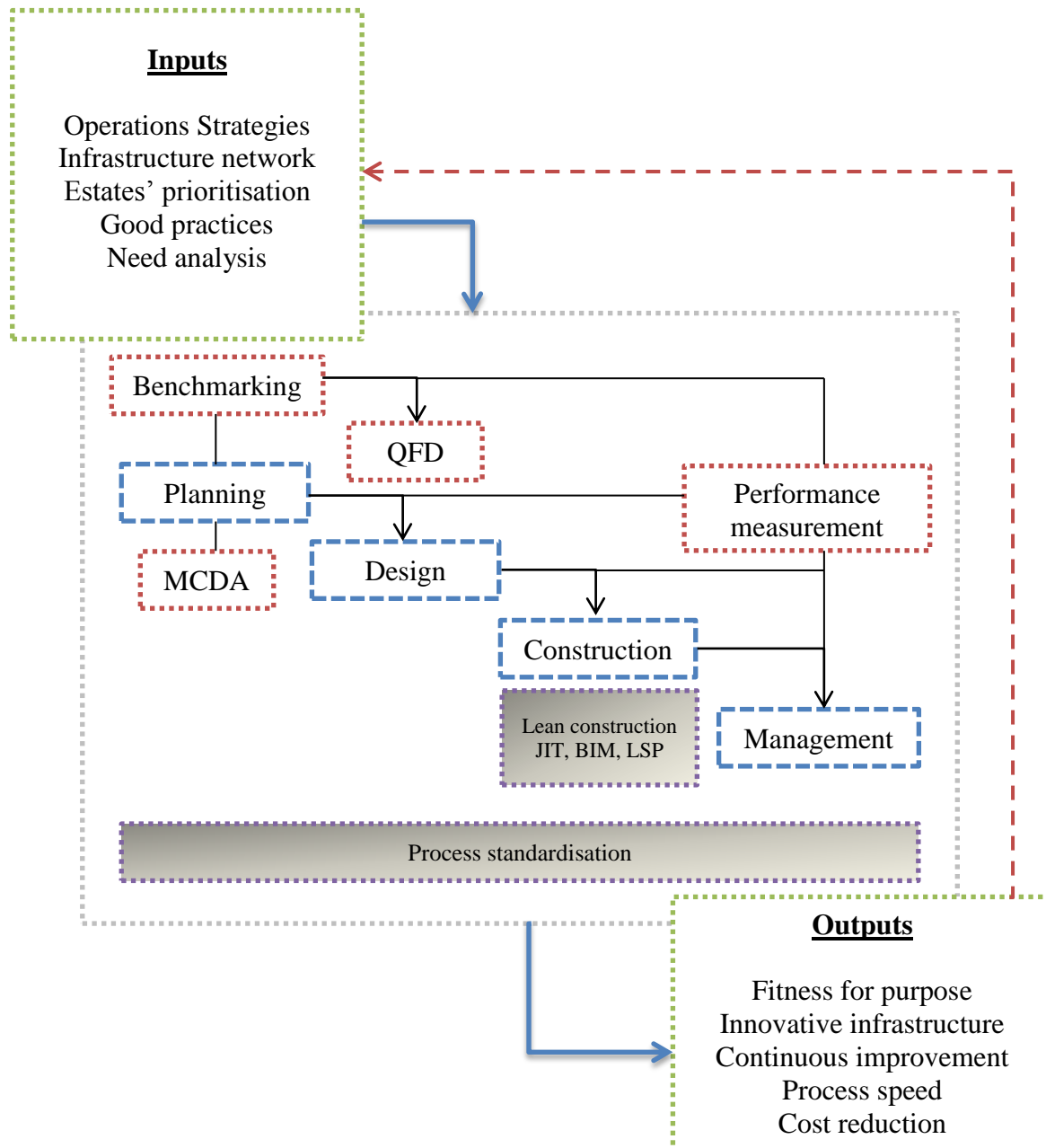
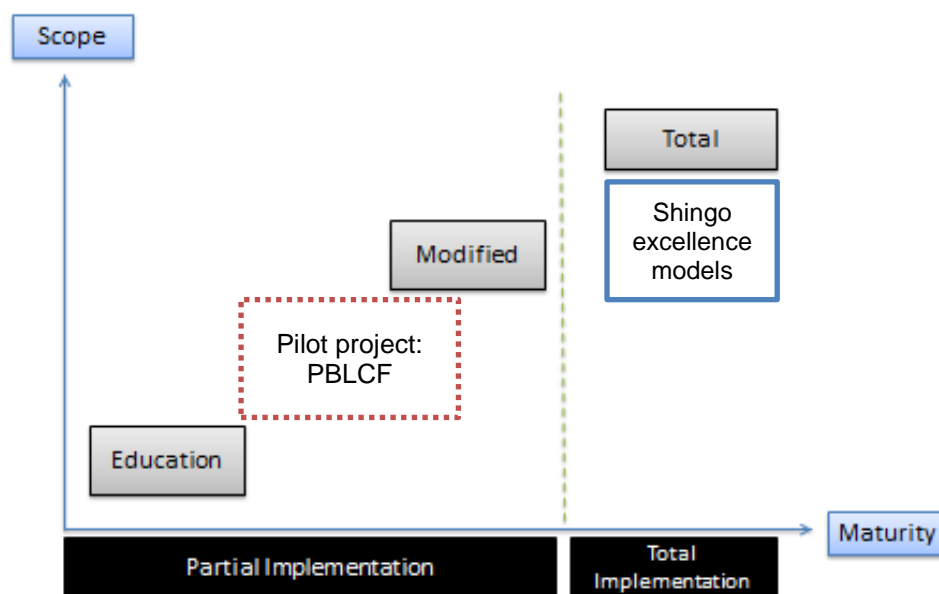


Figure 7.1: The PBLCF conceptual model

As discussed within the literature review, there are several levels of leanness depending on the scope of the implementation and the maturity of the organisation (Bamford *et al.*,

2014; Dale *et al.*, 2007; Green & May, 2005; Safayeni *et al.*, 1991). This level of leanness can be modelled as a continuum, separated into two sections – the partial and total (or full) implementation. The PBLCF is suitable for deploying a partial, as opposed to a total Lean implementation, as the Shingo model supports and promotes. As the PBLCF is exclusively focusing on the new infrastructure development process, according to the partial Lean implementation model, it can be categorised as a ‘pilot project’ level framework, as illustrated in Figure 7.2 below.



*Figure 7.2: Partial Lean implementation model (adapted from Safayeni et al., 1991 and Bamford et al., 2014)*

However, the PBLCF potentially depicts a ‘modified level’, from which the organisation would work around the standardisation of the processes throughout the life cycle of the project, and from which specific techniques associated to Lean construction, such as JIT, BIM and LPS, would become current practice within the organisation. This is illustrated by the shaded boxes in the PBLCF model, in Figure 7.1 above.

Moreover, the PBLCF illustrates a bespoke and non-prescriptive model: i) bespoke, as the framework can be applied to any new healthcare infrastructure development, by linking

the diverse systems and procedures, already potentially in place, with the governmental good practices and still fitting in with the specific context and environment; and, ii) non-prescriptive, as the models are adaptable and must be tailor made for fuller optimisation of the decision-making processes. For instance, the MCDA models can be reviewed and other techniques (*e.g.*: TOPSIS, VIKOR or UTASTAR) can be used to solve it, even though this research has shown that a hybrid version of ER and AHP could be the optimum model for this specific environment (*c.f.*: S-RQ 4). Likewise, Benchmarking and the performance framework have been designed to evolve over time – the researcher expects the decision-makers to claim ownership of the performance system and make it fit with the Operations Strategy. Additionally, although the research findings suggest how the utilisation of QFD could be optimised, through several iterations (*c.f.*: S-RQ3), in order to reach a saturation point, it is accepted that other processes could be developed by the decision-makers to best fit the type of project, culture and stakeholders' preferences. Besides, potentially, the QFD process could be associated with EBD (Evidence Based Design) and BIM (Building Information Modelling).

Having said that, this research demonstrates and provides evidence for an integral solution to improve decision-making; hence, the performances, fitness for purpose and innovation level. The PBLCF will generate substantial benefits by developing tacit and formal knowledge about the management of the new infrastructure development (NID) processes. The PBLFC is the starting point from which organisations can structure their NID processes. However, it will be expected that organisations will make sense of this model, claim ownership of it and modify it, as opposed to other prescriptive, conformance frameworks.

Additionally, the PBLCF formalises the interactions between the models (MCDA, Benchmarking and QFD) and the infrastructure development life cycle (planning, design, construction and management). The system thinking behind the framework is a powerful mechanism, designed to take a holistic perspective of the process (*c.f.*: Basden & Wood-Harper, 2006; Bennetts, Wood-Harper & Mills, 2000) and allow the main issues and problems to be tackled (*c.f.*: S-RQ1). It enables the planning and design phases to be linked in order to minimise waste; it allows collecting and analysing the voice of the customer in a systematic manner, communicate and make decisions based on data, rather than feelings; thus, rationalising the decision-making processes, as demonstrated in



Chapters Five and Six. Finally, it allows the vision of the process to be structured, enabling the decision-makers to move away from an ad-hoc perspective when managing the NID processes, as well as allowing for feedback and the creation of close-loop mechanisms.

Furthermore, this conceptual model puts into perspective the critical input variables, the process transformation activities and the output variables, which need to be controlled and sustained throughout any project. The critical inputs identified are data from several sources: Operations Strategy, stakeholder requirements, and knowledge and expertise regarding the prioritisation and need analysis. With PBLCF, these sets of data are shared, transformed and used within the models to optimise the decision-making processes.

The transformation process is linked with the planning, design, construction and management phases, necessary to achieve fast, fit for purpose and innovative new infrastructures. To optimise this transformation process, the integration of Benchmarking and MCDA (at the planning phase), feeding into the QFD during the design phase, enables substantive benefits to be reaped, which will be estimated and detailed later on in this chapter. The critical aspect is the utilisation of the performance measurement framework, in order to consistently monitor the performances of the processes, as well as the outcome variables – the fitness for purpose, the speed and the innovation achieved. These are the feedback loops, necessary in any system, to set up and drive continuous improvement.

Therefore, this methodology follows the Lean principles, through: i) eliminating waste – by getting things right first time throughout eliminating the re-works associated with ad-hoc methods; ii) focusing on value for the customer – by engaging further, in a consistent way, with local communities, clinicians and other user groups, then robust and transparent decisions are made, (MCDA, QFD); and, iii) setting up processes for continuous improvement – by monitoring the performances, at both the process and output levels, the lessons learnt are captured and fed back into the process, following a systematic and formal procedure.

Consequently, the PBLCF allows the organisation to: i) articulate a vision of how the business' processes contribute to the overall strategy; ii) translate the customer requirements into clear processes and define the performance objective levels, in terms of quality, cost, speed, dependability and flexibility; iii) make decisions to shape the

operations' capabilities, allowing long term development; and, finally, iv) reconcile the requirements, operations' policy and capabilities. Hence, according to the RVB theory, the PBLCF has a role to play in developing the organisation's competitive edge, by effectively and efficiently enabling the development of its superior resources (Barney, 2001; Cousins, 2005; Too & Too, 2010). The PBLCF can be adopted by an organisation committed to Operational Excellence and operating in an uncertain environment, as a framework to blend together the formal and informal interactive management control system, in order to effectively manage its NID processes (Eldridge *et al.*, 2014).

## **7.2. Results Expected and Estimated**

This research claims that, by consistently deploying PBLCF, the organisation will be expected to achieve some beneficial results. Firstly, enhancement of its new infrastructure's fitness for purpose aspects will be achieved, through the optimisation of the decision-making processes. Improvement to levels of innovation can be expected, as it engages with a continuous improvement roadmap; thus, defects, rework, over and under construction, and the unnecessary processing of data and information will be minimised and waste eliminated. Also, a reduction in the cycle time and an increase in the process speed, by an estimated value of between 18% and 24% overall, about 22% on average, will be gained. This will be achieved by a reduction in the planning cycle time, from 4.17 years down to 3 (a reduction of 28%); a reduction in the design cycle time, from 2.23 years down to 1.80 (a reduction of 19%); and, a reduction in the construction cycle time, from 1.24 years down to 1 (a reduction of 19%) (*c.f.*: Chapter Four, Table 4.1) – these estimations were based on the data collected and the improvements made during the period of two years during which this research was carried out. Finally, the reduction in the total cost, associated with the new infrastructure development, of an estimated 7% circa, will be achieved, by optimising the public consultation activities, the development of the business cases, and the 'opportunity cost' generated by the overall improvements of the NID, as well as by shifting the key decision-making to earlier in the process, altering the dynamism and behaviour of the cost and resource commitments of a project, as it will be detailed further and illustrated in Figure 7.3, at the end of this chapter.

### **7.3. Research Questions**

In this section, the overarching research questions will be briefly and succinctly addressed, in order to recapitulate on the main findings and discussions.

#### **7.3.1. RQ1: What are the Root-Cause Problems Associated with New Healthcare Infrastructure Development?**

It was discovered that the root-cause problems, associated with inefficiencies and ineffectiveness, were caused by a lack of operational decision-making within the planning and design processes. It was demonstrated that the ad-hoc methods used did not favour appropriate communication and data exchange between the different groups of stakeholders, required to solve complex decisions regarding the planning, design and construction of a new infrastructure, and that models were required (Baker & Mahmood, 2012). Furthermore, these issues were heightened by the misalignment between the infrastructure's objectives, the organisation's plans and the strategies of the stakeholder groups. The lack of partnership, between those involved within the process and between the different groups of stakeholders, was leading to information asymmetry, preventing transparency and optimisation within the decision-making processes; hence, directly and negatively impacting the cycle time performances (Egan, 1998; Latham, 1994; Myers, 2008).

Besides, there were no formal means by which the organisation could be made aware of or collect what is recognised to be the best of current practices within the industry (Myers, 2008). This is, to a certain extent, associated with a lack of mechanisms in place by which to learn from previous projects and good practices, both at organisation level and also from an industry perspective, as well as a lack of performance measurement processes in place (Kagioglou & Tzortzopoulos, 2010). All these factors were inhibiting the decision-making, by preventing a holistic value chain perspective from being taken, and a full understanding of the NID processes, as a whole, from being gained (Lawlor-Wright & Kagioglou, 2010; Shohet & Lavy, 2010 Williams, 2000).

### **7.3.2. RQ2: How Should Lean Thinking Concepts be Implemented to Support the Decision-Making Processes for New Healthcare Infrastructure Development?**

To overcome the identified problems, Lean thinking inspired models were implemented, enabling the improvement of the decision-making processes surrounding planning and design. MCDA was implemented and tested in order to optimise the site selection problem, using ER and AHP as opposed to a total cost (*c.f.*: Bhutta & Huq, 2002). Benchmarking and the bespoke performance measurement were developed to support the alignment of the strategies, to set up continuous improvement mechanisms and to inspire innovative thinking. QFD was implemented to optimise the design decisions with an end customer focus. However, this set of Lean techniques was designed around the holistic processes – planning, design, construction and management – both to generate synergies and tackle direct and indirect issues. This is represented by and through the PBLCF, in Figure 7.1. It enables the organisation to reduce process waste, take a system perspective, understand the final consumer requirements, develop continuous improvement activities and strengthen the cooperative relationships within the supply chain of the construction project (Eriksson, 2010).

Furthermore, it is worth noting that, through the PBLCF, the enterprise alignment (creating constancy of purpose and thinking systemically), the continuous improvement (focusing on process, embracing scientific thinking, focusing on flow and pulling value, assuring quality at the source, and seeking perfection) and the results (focusing on creating value for the customer) are all taken into account. These are three of the four dimensions covered in the Shingo model. The cultural enabler dimension is more tacit and belongs outside the scope of a partial Lean implementation. Rather, this dimension is associated with a total Lean implementation, as suggested in Figure 7.2.

Thus, the PBLCF serves as a guide and scaffolding, providing examples of the required systems that drive behaviours and approaches that support a Lean thinking implementation within the healthcare built environment. Consequently, and as demonstrated in S-RQ5, the PBLCF assists with the management of the inherent complexity within this system.

#### **7.4. Review of the Aims and Objectives**

As described in Chapter One, the researcher aimed to: i) identify and appreciate the main issues associated with the lengthy and complex processes that healthcare infrastructure development has been facing; and, ii) develop and deploy bespoke techniques and models to enhance the transparency, inclusivity and optimisation of the decision-making, enabling faster development of fit for purpose infrastructure. This research established how and to what extent the Partial & Bespoke Lean Construction Framework (PBLCF) has been designed and implemented to improve new healthcare infrastructure development, as well as to assist in the management of the system's complexity.

To achieve these aims, a set of objectives was identified and met, throughout the research: i) a comprehensive review of the relevant literature on Operations Strategy and Management, Lean thinking, Lean construction and the built environment was established, which enabled a theoretical justification of the five sub-research questions and identified the gaps; ii) the performance of the NID process was measured to evidence based the baseline capabilities and establish some of the main problems; iii) Lean inspired techniques and models – MCDA, Benchmarking and QFD – were developed, in order to improve the transparency and rationality of the decision-making process during the planning and design phases; and, iv) the PBLCF conceptual model, designed to optimise the performances of the new infrastructure development process in terms of speed (cycle time), quality (fitness for purpose), visibility (transparency of the decision-making) and cost (total capital cost), was generated.

#### **7.5. Review of the Contribution**

As presented in the introduction to this monograph, the researcher had three types of motivations underpinning this research: i) empirical or practical motivations; ii) theoretical motivations; and, iii) methodological motivations. These are now connected to the claimed contributions of this research. These three types of contributions were established, because the researcher assumes and believes that, within research in the Business and Management field, but, more specifically, within Lean thinking and Lean construction, by basing a rationale solely on theory, or solely on practice, researchers can run the risk of misinterpreting, or misconstruing, a particular impact, or result,, especially when these phenomena are still at the pre-paradigm stage of their evolution (Kuhn, 1970).

Hence, researchers need to study the two together in order to make a contribution to knowledge (Snowden, 2013), which is in line with the pragmatism epistemology borrowed.

#### **7.5.1. Contribution to Practice**

The research has evidence based and corroborated Glanville (2002) and Kagioglou and Tzortzopoulos' (2010) findings by suggesting four generic strategic directions to follow, in order to improve new healthcare infrastructure development: i) development of less rigid and less prescriptive forms of procurement, based on partnering and long-term relationships within the whole construction supply chain; ii) development and agreement upon the mechanisms by which to achieve greater optimisation, within the planning, design and construction decision-making; iii) development and agreement on how to both manage and measure levels of performance and to drive continuous improvement; and, iv) development of information frameworks and systems to support the strategic planning and design programmes for the healthcare environment, as well as mechanisms by which to effectively capture and share the lessons learnt and good practices.

This research has also confirmed that, by developing a bespoke Lean model, materialised in the form of the PBLCF, to support the improvement of its superior resources (Too & Too, 2010), a healthcare organisation can start moving towards its goal of gaining world class status, by: i) improving its operational efficiency; ii) providing a framework in which to implement transformation; and, iii) eventually, shaping a potential competitive advantage (Bamford *et al.*, 2014).

#### **7.5.2. Contribution to Knowledge**

At a different level within the context of the built environment, the outputs from this partial Lean implementation are a response to the call, made by many scholars, for more empirical research in this domain, in order to add to the recent Lean construction body of knowledge (Alves *et al.*, 2012; Eriksson, 2010; Green & May, 2005; Jorgensen & Emmitt, 2008; Koskela & Ballard, 2012). It is hoped that this empirical action research has contributed to refining the plethora of Lean thinking meanings within the built environment, and brought about some elements which will support both the development and further understanding of Lean thinking and decision-making, throughout empirical applications.

Furthermore, this research addressed a critical issue for academics and practitioners: *“the central problem is not how to organise to produce efficiently, although this will always remain an important consideration; but how to organise to make decisions and to process information”* (Koskela & Ballard, 2012), which was the rationale behind linking Lean thinking and decision-making within the PBLCF. It is strongly believed that, by implementing the PBLCF, the firm organises itself to process, share and communicate information, in order to make more satisfactory decisions.

### **7.5.3. Methodological Contribution**

Finally, the researcher claims a methodological contribution, by demonstrating how mixed-methodologies are compatible, yet incommensurable, when using pragmatism as the main paradigm. The iterations of induction, deduction and induction cycles were the foundation of this multi-phase design, in which both qualitative and quantitative data was analysed, contributing equally towards the findings.

### **7.6. Recommendations**

The researcher has recommended that the organisation keeps working with and adjusting the framework. The PBLCF should be used as a ‘bamboo scaffolding’, in order to guide and optimise the decision-making processes within new infrastructure development. By going through several iterations, the organisation will gather a systematic project experience, which will enable the development of project competences, leading to the shaping and then the sustenance of a competitive edge, through formal knowledge and documentation of effective problem solving mechanisms (Ibrahim, Price & Dainty, 2010; Perez-Araos, Barber, Munive-Hernandez & Eldridge, 2006).

### **7.7. Research Limitations and Future Research**

However, there are a number of limitations associated with this research. These are recognised but also create opportunities for building future research.

Firstly, the findings have been developed based on the process data available at the time of the research, from 2000 onwards. It is recognised that, due to the long process cycle time and its complexity, it was challenging to access a larger sample of new infrastructure development process data, from conception to completion. Moreover, the NHS does not necessarily collect this type of information. Therefore, estimations had to be developed

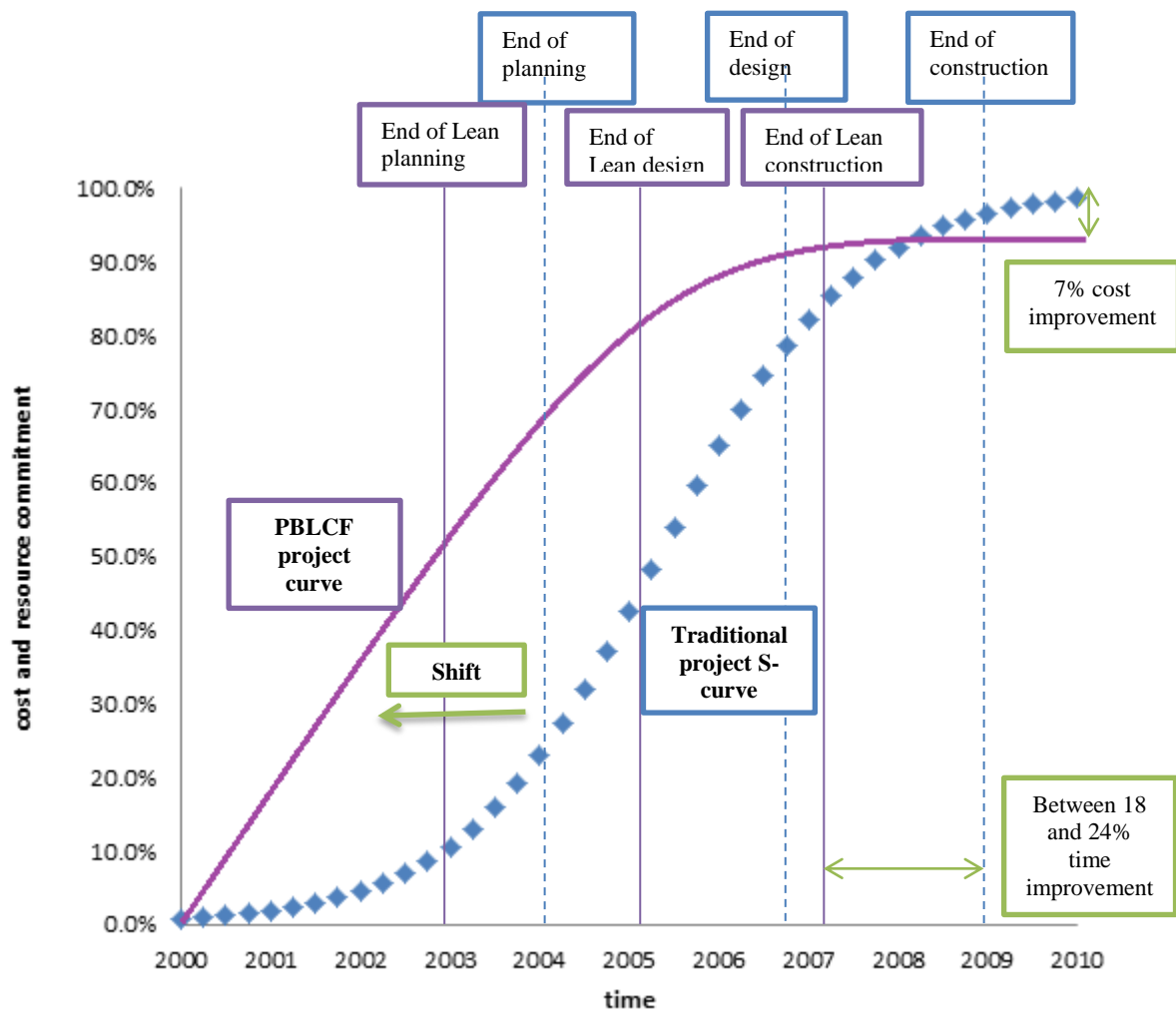
from different sources and then aggregated, with the support of recollection from the experts and historical information. Furthermore, if secondary performance data was available across the UK, statistical analysis would have enabled additional triangulations to be made. The results would have assisted in testing whether or not there were differences between the process' performances and capabilities of this specific organisation, compared to the national baseline, which would have enabled the generalisations of the findings to be strengthened. However, this limitation was overcome, to a certain extent, by the extensive literature review.

Secondly, this research has been developing and deploying Lean models within a single organisation, based on the root-cause problem analysis. Even though the researcher is confident in the validity and reliability of these findings, the research would have proved more powerful had there been the opportunity for the researcher to work simultaneously with two or three other organisations, so as to corroborate the findings even further; thus, enhancing their generalisations. This was not possible due to limited access and resource constraints. However, the external Benchmarking was a reliable mechanism by which to collect data outside the boundaries of this research, and to contain some of this limitation's impact. Moreover, limited boundaries are often a necessary decision, in an inductive logic, to get an in-depth understanding of the phenomenon and contribute to the body of knowledge in the first instance. The generalisation process can be undertaken as part of future research, during which this conceptual framework and the different models will be tested and validated, with the aim of generalising the results for use by other healthcare organisations in the UK.

Thirdly, the cost improvements claimed were also projected, due to a lack of financial data available. The researcher recognises that detailed, financial data would have been extremely relevant in support of this research's impact and contribution to practice. From the research, it was emerging that, by implementing Lean thinking to optimise the decision-making, the commitment of project cost and resources behaviour will evolve from the traditional S-shape curve to a logarithmic-alike shape, as Figure 7.3 illustrates. As explained in the results' section above, the cost and time gained are represented and are respectively estimated to be around 7%, and between 18 and 24% on average. However, this research was unable to demonstrate these results based on concrete project data, as other research has been able to do, and validated in by the Sutter Health programmes in



the US (c.f.: Feng & Tommelein 2009; Tommelein, 2011). However, this was not the primary objective of this research, but would be an excellent direction for building future research – accurately measuring the impact of the PBLCF and evaluating to what extent the behaviour of the cost and resources committed has shifted, as suggested in Figure 7.3 below.



*Figure 7.3: A comparison of the cost and resource commitment and behaviour during the life cycle of a project*

Figure 7.3 shows the type of cumulative cost and resource commitment evolution during the life cycle of the project. Two curves of cycle times are represented. The S-curve illustrates an example of a hypothetical, but realistic, project, with a total cycle time of 9 years – planning = 4 years, design = 2.8 years and construction = 2.2 years – whereas, the logarithmic-alike curve illustrates the behaviour of the cost and resources of the same

hypothetical, Lean project, with a total cycle time of 7.2 years – planning = 3 years, design = 2.2 years and construction = 2 years.

This represents a 20% reduction in the total time, with a 25% reduction in the planning cycle time. Throughout the implementation of the PBLCF, the organisation will speed up and optimise its decision-making processes, which will lead the decisions-makers to commit 50% of the total cost and resources to the project within the planning and design phases, instead of 20%, as in traditional projects. Within the design phase, a 21% reduction in the cycle time will be achieved; yet, only 5% more cost and resources, than in traditional projects, will have been committed in order to produce this beneficial result. Finally, within the construction phase, a 9% reduction in the cycle time can be attained, whilst having committed, or spent, less money and resources, from an overall, cumulative perspective. It is predicted and simulated that the organisation can achieve a 7% total cost reduction by enabling elimination of waste, rework and by optimising the planning and design decision-making.

Although this has been simulated and predicted from a theoretical perspective, the researcher would be interested to test and verify these findings in future research. This will also become an opportunity to look at Lean implementation in the built environment from another theory set, the Total Cost Economics (TCE), which, often, is perceived as the main alternative to Resource Based View (RBV).

Finally, this research was set exclusively within a healthcare context. However, the researcher aspires to develop a stream of research, based on Lean application, to the construction of sport mega-event infrastructures. Construction of stadiums, designed for the Olympic Games, the Paralympics and other World Cup events, has a major role to play within the future economy of hosting countries and in their sustainability strategies, which is impetus to the exploration of the role of Lean thinking in optimising the planning, design and construction processes of these sporting infrastructures.

## **7.8. Final Reflective Commentary**

This PhD thesis has allowed the researcher to combine his academic interests – Operational Excellence, decision-making and the built environment – in order to start establishing an expertise in the recent field of Lean construction. Throughout this journey,

the researcher has gained a substantial amount of theoretical and practical knowledge about Lean thinking – its history, decision-making processes and some specific techniques, including MCDA, Benchmarking and QFD. Additionally, this research has provided the opportunity to learn about research philosophy, plus different paradigms and their histories, which are fascinating subjects. Hence, this research has inspired the researcher to explore these areas further, by strengthening the research in the area of Lean implementation within new infrastructure development, then publishing and disseminating the findings.

From a more personal perspective, this research process has structured some fundamental questions about knowledge and reality, and has provided strong foundations upon which to continue a journey in academia, in terms of researching and teaching.

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## **Appendices**

### **Appendix 1: Structured Interview Questions**

Thank you for agreeing to be interviewed as part of my PhD research.

The aim of my research is to explore the decision-making processes and mechanisms within the planning and design of healthcare infrastructure, through an empirical study. Therefore, I would like to collect your views on how your organisation works, so as to develop its infrastructure.

This study is strictly confidential; names and information, which could identify individual interviewees, will not be included in the thesis. Although extracts from the interviews may be included as part of the final thesis, your name will be excluded and any identifying characteristics will be removed.

The interviews will last approximately 60 to 90 minutes. I would like your permission to record your interview, please. Copies of the recording, or any notes that I may take during the interview, will remain entirely confidential. Moreover, the final version of the thesis will be available to you if you wish to see it.

A consent form can be signed on the day of interview. This form will not be used to identify you. It will be filed separately from all the other information.

Thank you for agreeing to help me with this study.

### **Written Consent Agreement and Signature Sheet**

#### **Study Participation**

I confirm that:

- The purpose of this research has been explained to me
- I have voluntarily agreed to take part in this research
- I give my consent for the interview to be recorded on the understanding that the recorded material will remain confidential.

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**Signature**

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**Date**

## **Structured interview - wave 1:**

### **Part 1: Detail of the current decisions-making process within the NHS and within the planning and design of healthcare infrastructure.**

Question 1.1: Briefly and generally speaking, how would you describe the decision-making processes and mechanisms within the NHS?

Question 1.2: How would you describe the new infrastructure development process? What do you think about its general performance both at national and at organisation level?

Question 1.3: Within the infrastructure development processes, how would you describe the decision-making, and what are the associated roles and responsibilities of the different stakeholders?

Question 1.4: Within the planning and design phases, where do you feel the key adding value activities are and where the key problems are?

Question 1.5: From my observations, it seems that the decision-making are problematic. How can you explain this phenomenon?

### **Part 2: Focus on the bottlenecks within the new infrastructure development.**

Question 2.1: In your opinion, do you think decision-making are lagging the overall process, why do you think that is?

Question 2.2: For example, could you please describe the site selection decision process? Is it optimised during the public consultation?

Question 2.3: Do you think that the internal and external structure of the organisation is set up in favour to develop effectively complex projects?

Question 2.4: Do you believe that the stakeholders' roles and responsibilities are well defined to allow effective project developments? (LIFT, Estates, Primary care, Services Planner, Architects).

Question 2.5: Do you think that project management techniques (developing structure project planning, standards milestones, Gantt chart) could support the effectiveness of the development?

Question 2.6: What are the costs and reworks associated with the planning and design of infrastructures?

Question 2.7: Do you think the organisation capture the lessons learnt? Is the knowledge reused to enable continuous improvements?

Question 2.8: According to your experience, what would be the 2 or 3 improvements that the organisation should first focus on in order to improve the overall new infrastructure development?

### **Part 3: Now that we have set the scene, what would be the ideal scenario?**

Question 3.1: How long do you think the process take in average – and how long should the entire process ideally take (from planning to completion)?

Planning time:

Design Time:

Construction Time:

Question 3.2: How innovative should the new development be in term of design and services?

Question 3.3: In an ideal scenario, would a standardisation of the processes be relevant considering the bespoke nature of the product?

Question 3.4: Is Lean thinking based on the following principles adequate and appropriate for planning and designing healthcare infrastructures?

Elimination of wastes:

Focus on creating value for the customers:

Continuous improvement:

How close or how far do you think the organisation is from implementing these objectives?

Question 3.5: Do you think that more in-house work done would be relevant to optimise the development of new infrastructure? Or do you think that the PFI and the LIFT models are close to the best solutions; even if the organisation may have a lack of control during the design and construction phase under these procurement models?



## **Structured interview - wave 2:**

### **Part 1: Improvement with Lean thinking (MCDA, QFD, and Performance Measurement and Benchmarking)**

Question 1.1: Do you think that these models and frameworks support the improvement of the planning and design of healthcare infrastructure, by speeding up the process and improving the innovation level?

Question 1.2: What type of models and frameworks would you consider to improve the transparency and the robustness of decision-making?

Question 1.3: What type of models and processes would you implement to create an information exchange structure to support the new infrastructure development focusing on the value for the customer and set up for continuous improvement?

### **Part 2: The implementation of the Lean thinking**

Question 2.1: What are the barriers to implement further Lean techniques, is a partial implementation useful?

Question 2.3: Do you believe that the finance processes are in line with optimising the infrastructure development? Can it be changed?

Question 2.2: There is the opportunity to change the behaviour of the project costs and resources commitment from the traditional S curve towards a logarithmic shape (as this graph illustrates) - what do you think?

## Appendix 2: Survey instrument

### Survey: New Infrastructure Development

Please read the following statements and mark the appropriate boxes according your views on the new infrastructure development (NID). If necessary, please use the comments boxes to elaborate your answers. The data collection will be analysed anonymously. It will enable to evaluate the current state of this process and identify the room for improvement.

Could you please complete the questionnaire before Friday 24<sup>th</sup> of June 2010? Thank you very much for your time and cooperation, it is appreciated.

#### Profile:

- 1 Gender: ☐ Male ☐ Female
- 2 What is your role in the organisation?
- ☐ Decision-maker ☐ Provider
- ☐ Contractor and Supplier ☐ Member of the public

#### Likert scale:

Please rate the following statements using the provided scale 1 to 5.

1= strongly disagree, 2= disagree, 3=neither agree nor disagree, 4= agree, and 5= strongly agree.

Business strategy is defined as the pattern of decisions taken over the long-term to achieve the organisation strategic goals defined by the board.

Strategic decision-making processes and mechanisms		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
		1	2	3	4	5
3	The different departmental strategies are sufficiently aligned to allow effective planning and efficient NID decision-making.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4	Consistent and robust need analysis is performed to assess the local healthcare requirements and these requirements are translated into the design.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5	GIS (Geographic Information System) could be used in a more systematic manner to make a contribution to the strategic planning decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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The public consultation is the process run by the organisation to collect the voice of the local community. Legally it needs to be carried out for at least during 3 months. As part of this consultation process, questionnaires are sent out, leaflets are distributed and public meetings are organised.

Public consultation (PC) processes		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
		1	2	3	4	5
6	The choice of the location for a new site is sufficiently transparent for the local population.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7	The public consultation could be carried on earlier in the process and in a more systematic.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8	The outcomes of the public consultations are representative of the local population needs.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9	The outcomes of public consultations allow capturing the service needs to positively contribute to the service design process.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Currently the organisation requires two business cases, which both seek the approval of different boards. The first is the outline business case identifying the current situation and the proposal for the new infrastructure. The second is the full business case, which is more detailed with the final financial modelling and a thorough planning of the new infrastructure.

<b>Business cases processes</b>	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	1	2	3	4	5
<b>10</b> The outline business case can be developed further and the full business case minimised.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>11</b> Potentially one process could be designed to accommodate the different procurement routes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>12</b> Ideally the purchase of the land should be postponed until the feasibility study, utilising a Risk vs Cost analysis, is complete.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

The implementation phase takes place when the infrastructure has been completed and the services start to be provided to the local population.

<b>Implementation and results perceived</b>	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	1	2	3	4	5
<b>13</b> The latest new infrastructure developments are fit for purpose.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>14</b> The latest NID are well managed.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>15</b> In the latest NID the service design and integration are successfully implemented.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>16</b> In the latest NID there is a systematic continuous improvement process in place.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Appendix 3: Location A & B information summary

Sub-Criteria	Location A	Location B
<b>Vandal Proof</b>	No data suggesting that this is a high risk area for vandalism. This can be factored in when designing the building and regardless of the site location.	
<b>Open Location</b>	Slightly more open	More industrial
<b>Parking Space</b>	Site can allow up to 150 car parking spaces.	Site can provide over 150 car parking spaces.
<b>Expansion Capacity</b>	2.5 acre site able to accommodate 4000m <sup>2</sup> building 2 storey high with small room for expansion.	5 acre site able to accommodate 5000m <sup>2</sup> building with ample room for expansion without building upwards.
<b>Construction Cost</b>	Tight site and therefore construction restricted making it more costly. Need to find alternative accommodation for social care staff during construction.	Would be able to keep people on current site whilst work going on.
<b>Rates (Taxes)</b>	Felt that both sites should be scored the same as not able to separate on rateable value.	
<b>Roads / Traffic – easy access</b>	Both thought to be the same, it just depends on which road you would be travelling in from.	
<b>Public transport links</b>	Both considered the same.	
<b>External pedestrians / Disabled access</b>	Main road not as busy for patients crossing, but may need to put a pelican crossing in.	Maybe advantageous with regard to access, however busier and wider main road to cross.
<b>Affordability for the local community to commute</b>	Would depend on where people live and how they commute. No change for people as current site.	It is within walking distance for most people in the deprived surrounding areas. However it would cost other disadvantaged communities more as 2 buses could be required to commute.
<b>Presence of Pharmacy required</b>	Good for the pharmacy there at the moment.	Maybe longer to get a pharmacy due to technical rules regarding pharmacy licenses.
<b>Fit with surrounding area</b>	Both the same. There are various buildings with different designs around, so shouldn't be restricted with the design of the building.	
<b>Flexible Design</b>	Limited space on site.	Larger site.

<b>Land Risk</b>	Low risk	More risky as previous industrial use.
<b>Construction Risk</b>	Restricted site meaning logistical challenges including limited car parking during construction period. Noise in surrounding residential area.	Large site and self-contained so no phased construction required and no issues with car parking, site cabins.
<b>Local Service Provision</b>	There are already several primary care providers within locality.	There is limited primary care provision within the locality (North Street Branch).
<b>Timeframe and delivery speed</b>	Slightly longer to build but land is already in PCT/council possession.	Land is privately owned and negotiations would need to be had with the owner and their agents.

## Appendix 4: Sutter Health Benchmarking Assessment

ESTATES & PREMISES							NHS
Ref	KPI	Description	Data	Weighting	Scoring	Comments	
A1	Design	There are clear ideas behind the design reflecting the strategy	Using Lean design tec.	5	9	SmithGroup is delivering Cathedral Hill hospital using the techniques of Lean Design, which has never been achieved before on a healthcare project of this scale	
A2	Size	The premises has an appropriate scale and feels welcoming	100,000 m2 with carpark	3	5	This huge hospital will replace the current California Pacific Medical Centre and will accommodate service from St Luke both in San Francisco	
A3	Capacity	The capacity of the premises suit the catchments area demand	555 beds	4	7	With substantial efforts put into the design and layout it is expected to improve the traditional capacity management	
A4	Resources Utilisation	The resources are effectively used	Shared	4	7	The larger units organization are set up for allowing greater sharing of resources and support	
A5	Space Utilisation	The space is effectively used	15 stories	4	9	Lean efforts led to a re-examination of current models of care, targeted toward achieving space efficiencies and productivity without compromising patient care.	
A6	Equipment Utilisation	The specific equipment is well used	Excellent	4	7	Effective planning and communication mechanisms in place to optimize the equipment utilization, flexible and shared approach	
A7	Estates Running Costs	The total yearly premises cost	?	4	5	Confidential	
A8	Eco-Friendliness	The total yearly energy consumed	Excellent	3	9	Cathedral Hill aspires to improve the energy effectiveness of an inherently inefficient building type.	
A9	Building Layout	The interior is logical, aesthetically pleasing and appropriately signposted	Excellent	4	9	Organized around comprehensive centers of care rather than traditional departments, enhancing the delivery of patient care while improving space efficiencies, and workflow	
A10	Building Facilities	The building offers good facilities to the staff and the consumers	Excellent	4	9	The facilities offers to the staff and the visitors are excellent, modern	
A11	Quality	General and durable finish	Excellent	5	7	The use of standardized spaces allows for maximum service line adaptability and acuity flexibility in the future	
BACK				TOTAL	15.18182	NEXT	

### Appendix 4.1: Estates and Premises Analysis of Sutter Health

SERVICES

NHS

Ref	KPI	Description	Data	Weighting	Scoring	Comments
B1	Services Provision	The right services are suitably provided to the consumers	Good practice	3	5	With the construction of Cathedral Hill, the services provided are being re-assessed
B2	Level of Integration	Intra and Inter organisational integration is successfully deployed	High	5	9	By implementing the Lean approach - adding value for the customers - the integration level needs to be high eg: manifesto, relationship contracts,
B3	Service Culture	There is a clear service culture where the consumer is at the centre	Yes	4	9	The design the service based on the cellular model, where the layout and design are planned around the patient flows
B4	Implementation	The cultural change has happen effectively	Effective	4	7	The Lean implementation has started in 2005, but it has been effective
B5	Service Planning	The co-location of services have been achieved through effective planning	Yes	4	7	Also there is not this pure notion of service integration, the planning and design of pathways are established with the patient flow at the centre
B6	Business Results	The number of hospital admission has dropped, and the inequalities reduced	?	3	5	With Cathedral Hill hospital the CPMC will be closed, and St Luke's services transferred (St Luke from 230 beds to 80 beds)
B7	Impact on the Community	The services and the building have a positive impact on the community	Positive	3	7	Improved service quality is expected
B8	Financial Mechanism	The financial mechanisms have been clearly defined and are respected	Clear	4	7	The financial mechanism are clearly defined, also pool of incentives schemes
			BACK	TOTAL	13.5	NEXT

## Appendix 4.2: Services Analysis of Sutter Health



OPERATIONS MANAGEMENT							NHS
Ref	KPI	Description	Data	Weighting	Scoring	Comments	
C1	Opening hours	The premises offers a flexible range of opening time	Hospital	4	7	Hospital services	
C2	Consumer Pathways	There are clear designed pathways	Innovative	5	7	Before the designing, clinical workflows based on the patient movement were studied with the notion of optimizing these flows.	
C3	Staff Interaction & Mgt	Clear and effective staff activities and responsibilities allocation	Good	4	7	The 'cellular concept' is configured with the required staff to complete key steps in the care delivery process thereby minimizing hand-offs, discreet steps and cycle time	
C4	Leadership	There is an effective and non ambiguous senior management	Sutter Health	5	9	There is a strong leadership dictating the strategy without any ambiguity to all partners	
C5	Staff Satisfaction	The staff satisfaction is assessed and corrective actions are taken	?	4	5	Certainly during the construction process, the staff is involved, and feedback is collected all along the process	
C6	Consumer Satisfaction	The consumer satisfaction is assessed and corrective actions are taken	?	4	5	Objectives: consolidating resources and offering better care at less cost	
C7	User Involment	Improvements are based on the Voice of the User / Consumer	Yes	4	7	The voice of the consumer is carefully assessed on a regular basis	
C8	Conflict Resolution	Conflicts are effectively resolved by senior managers	Collaborative Agreement	4	9	The conflict resolution are based on consensus, this has been established with collaborative integrated Lean agreement	
C9	Engineering Systems	The engineering systems are well design and efficient in use	Efficient	3	7	Thanks to the collaborative approach the engineering system has been improve even more than expected	
C10	Accessibility	Public transport, road, parking, pedestrian access	Excellent	4	7	Cathedral Hill is right in the middle of San Francisco, access is very convenient by car, public transport or by foot but parking will be an issue	
C11	Health & Safety	Waste management, fire planning strategy	Very important	3	7	Health and Safety is being taken very seriously and at a strategical level, with visual display and appropriate communication	
			BACK	TOTAL	14.0909	NEXT	

Appendix 4.3: Operations Management Analysis of Sutter Health

PROCESSES							NHS
Ref	KPI	Description	Data	Weighting	Scoring	Comments	
D1	Strategies Alignment	The different partners strategies are logically aligned	Excellent since Lean prog	5	9	Sutter and California Pacific Med Ctr (CPMC) are using a progressive project delivery approach called Integrated Project Delivery (IPD) enabling excellent alignment. With a development of a manifesto signed by the stakeholders	
D2	Need Assessment	The need assessment outcomes has helped to design the services	?	5	5		
D3	Development Cycle Time	The planning and the construction cycle time have been under control	Only since Lean	5	7	In 2005 they stopped and re-grouped the project using Lean because it was over budget - since it has been meeting the planning	
D4	Site Selection	The site location has been transparently and optimally selected	?	4	7		
D5	Decision Making Process	The decision making process is robust and transparent for all stakeholders	Choosing by Advantage	5	9	A modeling techniques called Choosing by Advantage has been implemented at all level of the planning and design phase to optimize the decision making process	
D6	Public Consultation	The local community enthusiastically participated to the public consultation	Extensive	3	5	Extensive consultation were undertaken	
D7	Project Delivery	The methods used to deliver the programme	Excellent	5	9	A system has been design to address each level of the project delivery, physics of work, organizational structure and commercial relationship. Use of new form of contracts Integrated Form of Agreement	
D8	Transition Phase Mgt	The services relocation were run smoothly	?	4	7	At this stage this has not been achieved but lot of thoughts are being put into the transition phase to minimize the disruption	
D9	Construction Process	The construction has took advantage of standardisation and pre-fabrication	Lean construction	4	9	Smith Group is the main contractor with an extensive experience in Lean construction - Work in collaboration with Berkeley University expert on Lean construction serve as learning laboratory	
			BACK	TOTAL	16.7778	NEXT	

Appendix 4.4: Processes Analysis of Sutter Health