Social capital to facilitate 'engineered' university-industry collaboration for technology transfer: a dynamic perspective

Omar Al-Tabbaa and Sumel Ankrah

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Abstract

Over the last decade, social capital concept has received considerable amount of research being regard as an important value creation mechanism. However, we still have limited understanding about the nature of interaction between the dimensions of this capital, and how it can be useful in mitigating the impediments evolve during government-sponsored (i.e., engineered) university-industry collaboration (UIC). In this paper, we address the previous gap by analyzing the dynamics of social capital dimensions during the preformation and postformation stages of UIC. The paper relies on a unique context that comprises five embedded case studies of UIC for technology transfer: the Faraday Partnership Initiative, a UK government-backed novel scheme for enhancing innovation. The analysis shows that the impact and interaction of the dimensions were not static but rather varying over-time. Further, we present a new value creation framework for social capital through mapping its power in reducing the intensity of difficulties emerged during the collaboration lifetime. We also identify two facilitating factors as critical in creating and maintaining social capital in engineered UIC. The present study thus contributes to a deeper understanding of the value of inter-organizational social capital.

Keywords: social capital dimensions, university-industry collaboration, inter-organizational relationship, technology transfer

1 INTRODUCTION

Social capital, generally refers to the collectively-owned asset which resides in and derived from durable relationships between actors and/or social units (Adler and Kwon, 2002, Nahapiet and Ghoshal, 1998), is reported to be a productive resource that boosts organization growth and innovation performance (Maurer et al., 2011, Tsai et al., 2013). Research has also pointed out that it entails beneficial outcomes including better group communication and knowledge sharing (Tsai et al., 2014), enhanced use of intellectual capital (Leana and Van Buren, 1999), and reduction of operations cost (Careya et al., 2011). Nahapiet and Ghoshal (1998) identified three dimensions to constitute social capital construct including structural, relational, and cognitive, whereby the value of social capital can be significantly moderated by the interaction between these dimensions (Tsai and Ghoshal, 1998). Accordingly, researchers sought to theorize and empirically examine the nature of this interaction (Carey et al., 2011, Zheng, 2010), describing social capital as a "dynamic and multifaceted theoretical" concept (Gedajlovic et al., 2013, p. 468).

Nonetheless, reviewing the literature in this area reveals two important issues. First, despite several studies have investigated the interplay between the dimensions, they have delivered inconsistent results. For example, whilst the structural dimension is found to be an antecedent for the relational one (e.g., Bstieler et al., 2015a, Tsai and Ghoshal, 1998), other research indicates that the combined effect of structural and cognitive dimensions determine the scale and intensity of the relational capital (Carey et al., 2011, e.g., Roden and Lawson, 2014). At the same time, a stream of literature has emerged that relatively underestimates the role of interaction between the dimensions, assuming that the value of social capital is derived directly from the sum of the three capitals which an organization has already possessed (e.g., Akhavan and Mahdi Hosseini, 2015, Maurer et al., 2011, Tsai et al., 2013). Second, there has been a substantial amount of research on studying the social capital in collaboration settings that have initial conditions designated as 'emergent' (e.g., Villena et al., 2011) or 'embedded' (e.g., Krause et al., 2007). The former concerns situations when organizations are merely motivated to collaborate due to environmental interdependences and perceived resources complementarity (Doz et al., 2000), whereas the latter describes collaborations that are based on the existence of strong social ties rather than conceived resources exchange or pre-planned targets (Ring et al., 2005). This indicates that we have limited understanding about the dynamics of social capital in 'engineered' collaborations, such as government-driven university-industry collaboration (UIC), whereby a triggering entity (e.g., the government) instigates and sponsors partnership formation and implementation processes aiming to achieve collective purposes (Dyer and Nobeoka, 2000). In this situation, the triggering entity is essential for partnership establishment because prospect collaborators do not experience strong stimuli to cooperate, and as such do not have apparent overlapping interest (Thune and Gulbrandsen, 2014). Specifically, in UIC setting, such condition is likely to complicate the partnership development as threats and opportunities might be perceived differently by the university and industry actors, given that they are inherently different organizations (Perkmann et al., 2013).

The current study seeks to address the above issues by investigating the impact, and interaction, of the three dimensions of social capital on the impediments of engineered UIC using a dynamic

perspective. In specific, we argue that one explanation for the inconsistency found in literature is to consider social capital as a dynamic concept (Gedajlovic et al., 2013); its components and interactions change over time. We explore this argument by studying the mitigating effect of social capital dimensions on obstacles emerged during the life of UIC which was initiated by a third party. To guide the research process we set our main question as: How do social capital dimensions and their modes of interaction influence the impediments evolve during the preformation and postformation stages of engineered UIC? To answer this question, our investigation puts forward a unique context that comprises five embedded case studies of UIC for technology transfer in a sponsored project: the Faraday Partnership Initiative, a UK government-backed novel scheme for enhancing innovation.

A better knowledge of how and why the interaction between the social capital dimensions can vary while facilitating conditioned UIC is essential to advance our understanding regarding the effectiveness of this concept. In particular, our study contributes to the literature in three main ways. First, this paper extends the existing literature by empirically demonstrating how the importance of social capital dimensions actually changes over time. For example, the findings show that one dimension (structural) appeared to be less important during the preformation stage, but it became more important in mitigating the obstacles unfolded during the postformation stage. This result can explain the divergence among researchers when testing the relationship between the dimensions, as it emphasizes the need to consider the time dimension when studying social capital (i.e., to specify the position of the study on the timeline of the relationship). Thus, we respond to the calls for advancing our understanding about the complex nature of social capital (Payne et al., 2011, Zheng, 2010). Second, we provide a new channel that can explain the power of social capital. The findings emphasize the role of diminishing of collaboration impediments as both a key benefit of social capital and an important driver of UIC effectiveness. In fact, the mediating effect of inter-organizational social capital between relationship formation and value creation has been studied through different explanatory frameworks including networking (Inkpen and Tsang, 2005), knowledge sharing and transfer (Filieri et al., 2014), innovation enablers (Camps and Marques, 2014), and entrepreneurial innovation systems (Yoon et al., 2015). Therefore, the current study is the first (up to our knowledge) to illustrate a novel value creation mechanism for social capital in terms of lowering the degree of challenges and difficulties dominating the UIC (Bruneel et al., 2010). Moreover, we suggest two distinct factors in the setting of engineered UIC as particularly essential in synthesizing the relationship between university and industry actors, when they are driven to collaboration by an external force. Therefore, the paper adds constructively to the literature that underscores the link between initial conditions and the developed pattern of inter-organizational relationship (Doz et al., 2000, Thune and Gulbrandsen, 2014). Third, given the central importance of UIC in innovation and technology development (Ankrah and Al-Tabbaa, 2015, Perkmann and Schildt, 2015), the current study provides an important policy-related implications by adding to the few research that explores obstacles hampering UIC (Bruneel et al., 2010, Hall et al., 2001). However, unlike the previous studies which limit their perspective by focusing on industry side at a specific period of time , our study incorporates data from multiple perspectives including universities, industry, intermediaries and other government-related

stakeholders at two different stages. This broad spread of data enhances depth, quality and rigour of the findings, as different informant types capture a variety of perceptions.

The reminder of the paper proceeds as follows. The theoretical background which informs this study is developed first. An overview of the research setting and methodology is then provided, followed by presentation of results. In the final section, the managerial and theoretical implications of the study are discussed.

2 THEORETICAL BACKGROUND

2.1 Social capital theory

Social capital origin can be traced back to the 1960s when Jacobs (1961) described it as relational resources within a community and family. Since then, social capital has received much interest, with scholars applying the concept to a broad range of phenomena including public life in contemporary societies (e.g., Doh, 2014), innovation (e.g., Pérez-Luño et al., 2011), transfer of knowledge between network members (e.g., Hau et al., 2013), and organizational learning (Expósito-Langa et al., 2015). Unlike traditional intangible resources (e.g., financial or human capital), social capital is distinctive in that it exists in the structure of relationships between actors, and therefore jointly owned (Coleman, 1988). However, the value of social capital is debated; it is argued that social capital is not a universally beneficial resource (Payne et al., 2011). In general, the 'dark-side' of social capital is argued to stem from "its capacity to fragment broader collectivities in the name of local, particularistic identities" (Kwon and Adler, 2014, p. 418). For example, in the case of buyer-supplier interaction, extreme social capital practice might hurt organizations performance by influencing the objectivity of the decision-making process (Villena et al., 2011). Moreover, whilst it may be useful for facilitating certain social actions, it could inhibit others (Coleman, 1988). For example, Perrow (1984) argue that the strong norms and mutual identification that may yield a powerful positive influence on group performance, could also limit openness to information as well as alternative ways of doing things, which could produce forms of collective blindness that sometimes have disastrous consequences. Also, Inkpen and Tsang (2005) suggest that in some cases shared norms may cause unnecessary expectations of obligatory behaviour which may result in problems of free riding and unwillingness to experiment beyond the network. Hence, it is argued that the mere existence of a tie does not automatically imply that the benefits of social capital will be realized (Payne et al., 2011).

2.1.1 The dimensions of social capital

Aiming to understanding the social capital concept, Nahapiet and Ghoshal (1998) clustered there types of social capital resources, labelled as social capital dimensions. The structural dimension encapsulates series of connections (as a matter of resources) that individuals or organizations have with others (Zheng, 2010). Thus, it focuses on the patterns and ties strength among the members of a collective which facilitate or curb the flow of information (Siegel et al., 2003). The relational dimension concerns those resources created through actors' interaction relationships. 'Trust', as one of these generated resources, facilitates exchange transactions in alliances (Koka and Prescott, 2002), and can induce joint efforts

(Bstieler et al., 2015a). 'Obligation' can be viewed as reciprocity on a mutual basis such as a readiness to return a favour with a favour (Pezzoni et al., 2012). The more frequent and the more profound and intense a tie is, the more are the obligations expected from the tie (Nahapiet and Ghoshal, 1998). 'Shared norms' have been linked to effective cooperation (Arregle et al., 2007) and the promotion of greater knowledge assimilation (Kreiner and Schultz, 1993). Yet, shared norms may cause unnecessary expectations of obligatory behaviour which may result in free-riding issues (Inkpen and Tsang, 2005). The cognitive dimension targets resources such as common interest or understanding the members of the network develop. These resources facilitate conditions of accessibility and recombination and give individuals the ability for exchange by providing a common basis for the transaction (Ansari et al., 2012).

2.1.2 The relationships among the dimensions

Studying the interaction between the three dimensions and their facets (or sub-dimensions) became an important theme within the social capital literature. Table 1 contains an analysis of representative studies in this regard. In conceptualizing the impact of social capital dimensions on combination and exchange of intellectual capital, Nahapiet and Ghoshal (1998) discuss the influence of each dimension independently of the other dimensions. However, they emphasized that the three dimensions are interrelated in important but intricate manner, whereby the three dimensions are not simply mutually reinforcing. Influenced by the previous theorization, several empirical and conceptual attempts have followed to uncover the nature of these complex relationships. For example, Tsai and Ghoshal (1998) argue that the structural dimension is an antecedent to both the relational and cognitive dimensions. Therefore, collaborators must have first shared experiences and interactions and then over time they develop trust, norms, and identity, as well as to believe in a common vision and purpose. Moreover, the authors contend that the cognitive dimension (including the shared purpose, vision, and language) is an antecedent to the relational dimension (i.e., a shared vision may lead to collective trust and norms to fulfil the common purpose of the relationship). Similarly, when studying buyer-supplier relationship, Roden and Lawson (2014) show that both structural and cognitive dimensions influence the development of relational capital. Yet, this influence is sensitive to buyer and supplier's ability to adapt. For instance, when buyers and suppliers adapt their processes and products for mutual benefit, this supercharges the perception of common goals (cognitive capital) and obligation (relational capital). However, Bstieler et al. (2015a)show an interdependency between a facet of the structural dimension (shared governance) and sub-dimension of relational capital (trust), but the cognitive capital (caused by the champion behaviour effect that creating common understanding and shared norms) was moderating this relationship.

Other studies have examined the effect of social capital on different outcome, but indicating that the interaction has less impact on the capitals stored in the dimensions themselves. This research comprises, for example, the individual impact of social capital dimensions on innovation types (Camps and Marques, 2014), and the indirect effect of social capital

dimensions on team innovation capability through intensifying the knowledge sharing practices (Akhavan and Mahdi Hosseini, 2015). Likewise, when Tsai et al. (2014) examined social capital development and impact on virtual team performance (used knowledge sharing as a proxy), the interplay between the three dimensions was marginalized (i.e., studied the dimensions as independent constructs). Instead, the role of group emotional stated (which is characterized by positive affective tone) emerged as more critical for augmenting the value of the three dimensions.

Based on a comprehensive literature review, Zheng (2010) find that the structural capital leads to intermediate outcomes that include diversity of information, power and influence (where these intermediate outcomes enhance innovation). However, the compiled empirical findings suggest that the structural and relational dimensions are not independent, but rather strengthening each other in a form of a feedback loop (Zheng, 2010). For instance, tie strength (as one structural facet) facilitates repeated interaction between actors thus increases the level of trust and norm between them - relational facets (Elfenbein and Zenger, 2014). In turn, as the level of trust and behavioural norms increases, the pattern of interaction become more intense (Karahanna and Preston, 2013). However, Zheng (2010) assert that the above dynamics was not be realized when considering the cognitive dimension (i.e., no support could be found to the direct link between the cognitive and structural dimensions), and claiming that the "literature does not provide a clear cutoff between the relational and cognitive" (p. 174). Thus he proposes that relational and cognitive dimensions are highly correlated.

The above review highlights the existing discrepancy in literature regarding the interaction between the three dimensions. In this paper, therefore, we seek to study this discrepancy using a dynamic perspective, arguing that one possible explanation to this incongruity is that the relationships between the dimensions actually change over time. We explore this argument through investigating the role of social capital in mitigating the challenges evolve within UIC for technology transfer at both preformation and postformation stages.

INSERT TABLE 1 ABOUT HERE

2.2 Barriers and challenges in UIC

Typically, establishing effective inter-organizational relationship is a daunting process (Al-Tabbaa et al., 2013, Ellegaard and Andersen, 2015). This becomes even more difficult when the two organizations belong to different sectors (e.g., private and public sectors), as policies and systems that control the interaction between actors of these organizations vary significantly in terms of flexibility, speed, and autonomous (Al-Tabbaa et al., 2015, Kindred and Petrescu, 2015). This applies to the case of partnership between university and industry (López-Martínez et al., 1994, Muscio and Vallanti, 2014). Nevertheless, it is noticeable that few studies have specifically examined this issue. Further, these studies have primarily focussed on the industry side. In principle, the potential conflicts in UIC conflicts can be due

to two causes. The first concerns the key differences between the two institutions (Bruneel et al., 2010). In this regard, each sector has its own values, norms, principles and believes, whereby the incompatibility between these institutional aspects can create disagreement among collaborators (Muscio and Vallanti, 2014). For example, the university system, which is typically perceived as inherently embedded in the Mertonian norms of science (Etzkowitz et al., 2000), adopts a relatively open approach to knowledge creation and dissemination (Perkmann et al., 2013). In contrast, the process of knowledge creation in the industry setting is characterized as being closed environment, whereby companies limit the access to their produced knowledge aiming to build competitive advantages and attain economic rents (Ankrah and Al-Tabbaa, 2015). The second aspect relates to disputes over the intellectual property (IP) rights of the collaboration outcome. Specifically, the collaboration between university and industry typically produces knowledge and technology that have a commercial dimension (Soh and Subramanian, 2014). However, increasing the level of commercialization can bring disputes to this relationship and distract the partners from their initial targets. For instance, an inverse relationship was found between the level of university patenting and the overall quality of these patents (Villena et al., 2011).

Accordingly, UIC are likely to be plagued with several difficulties (Hall et al., 2001) due to a weak attitudinal alignment between partners (Bruneel et al., 2010), as well as uncertainty over the economic rent of UIC and its long-term impact on university core aims (Shane and Somaya, 2007). Taking into consideration the nature of these hindrances (i.e., they occur within the social process of collaboration), we propose that the resources latent inside and derived from the social capital have the capacity to diminish their effect on UIC design and implementation process. For instance, norms, which is part of the relational capital, influences how people in organisations govern themselves and their interface with others (Nahapiet and Ghoshal, 1998). Shared norms have been linked to effective cooperation (Arregle et al., 2007) and the promotion of greater knowledge assimilation (De Carolis and Saparito, 2006), thus has the potential to reduce the friction of cultural and behavioural asymmetry between university and industry actors. Similarly, the pattern and strength of ties among the member (as part of the structural capital) influence the level of trust between them thus lessen the amount of time and investment required to assemble information (Bruneel et al., 2010). Furthermore, high level of trust reduces the fears of opportunistic act of partners (Bstieler et al., 2015a), leading to partners' resources and capabilities being fully recognized. Therefore, we build on the potential value of social capital to investigate how it can be useful in mitigating the intensity of UIC impediments as emerging over time. Figure 1 illustrates the conceptual framework of this study.

INSERT FIGURE 1 ABOUT HERE

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3 METHODOLOGY

3.1 Study context

The concept of the Faraday Partnership was first discussed in 1990 in response to the outcome of a meeting of a panel of industries and academics put together by the Prince of Wales to look at improving the interface between industry and universities. At the same time, the Faraday Partnerships were envisaged as UK's response to the success of the German Fraunhoffer organization. However, as the UK Government's budget was inadequate to duplicate the Fraunhoffera at the time, a cheaper and more relevant version for the UK was put forward by joining together essential institutions such as Research and Technology Organizations (RTOs), universities, professional institutions, Trade Associations, Firms, and in some cases the sector regulator (FPA, 2004, Airto, 2001).

The initiative activities were determined to encourage closer contact and exchange between universities and businesses. These included enhance active flows of people, technology and innovative business concepts between partners, promote core research that would underpin business opportunities, and stimulate business-relevant post-graduate training. Membership of the partnerships was open to all interested universities and companies, with no eligibility criteria. There were no formalized contract agreements between the members and a partnership per se; however, the members of any partnership established formal contracts to manage and organize the collaborative projects. The process of promoting interactions between the members was termed 'technology translation', and it required the skills and experience of technology translators employed by the core partners. These were individuals with years of experience at the academic/industry interface, and they acted as intermediaries to facilitate the technology translation process, by relating industry's needs to the knowledge base (i.e. universities). In 1997, the Department of Trade and Industry (DTI) and the Engineering and Physical Science Research Council (EPSRC) set the first call of the Faraday Partnership Initiatives, where the final number of established partnership in 2002 is 24. The Faraday Partnership Initiative (FPI) comprised four 'calls' –between 1997 and 2002- where groups were invited to submit proposals for partnerships to the department of trade and industry, who evaluated and selected ones to receive financial backing. In total, 24 partnerships were selected which focused on science-based technologies. In the fourth call, the total value of the FPI research portfolio was £160 million and 2477 companies were involved (FPA, 2004, Airto, 2001).

3.2 Case study method

The current study is part of a bigger research project that aims to investigate the inter-organizational relationship within the FPI and understand how technology transfer can take place in engineered (or sponsored) partnerships. Since our enquiry in this paper was about how social capital dimensions and their interaction affect the impediments evolve during the preformation and postformation stages of UIC, we focused on participants perceptions of their relationships with others. We adopted a qualitative in-depth case study as the

research approach (Yin, 2009). We selected a multiple case study method because of its robustness and its capability to augment external validity and guard against observer bias (Eisenhardt and Graebner, 2007). To generate insights to answer our research question, we drew on five of the 24 Faraday Partnerships. Due to confidential agreements, we have not offered the names of the five Partnerships nor their technology areas, as either of these would enable the partnerships to be identified since each partnership operated in a particular technology area. The five Partnerships were selected on the recommendations of the managing director of one of the oldest partnership, who was well acquainted with all 24 Partnerships. When approached, all managing directors of the targeted partnerships agreed to participate in the research. The managing directors of the five selected partnerships identified specific informants within their Partnerships.

Prior to the main data collection, we conducted two pilot studies to confirm the appropriateness of the key research issues and to help develop the interview questions in the research protocol. The first pilot study involved an interview with the operations director of partnership, and the second was an interview with a technology translator. For our primary data collection, we employed semi-structured interviews. Our informants for each partnership comprised at least two academics from different universities, two industrialists from different companies and two technology translators. The interviewees from universities and the companies headed their organization's involvement in the Partnerships, and the majority held senior positions within their organizations. The academic members were from various fields including engineering, chemistry, medicine, biomedical science, and physics. The industry members were from industries related to plastics, health products, oil and waste products, and instrumentation engineering. The total number of interviews was 37 with an average duration of 77 minutes. In total, the informants were from: university (9), industry (13), intermediary (11), and key stakeholder organizations (including department of trade & industry representative, Quo Tec Ltd. representative, and Engineering& Physical Science Research Council representative) (3).

A case study protocol was developed to guide the data collection and served both as a prompt for the interview and a checklist to make sure that all key topics have been covered. The interviewees were asked to reflect and describe any difficulties or obstacles they faced while planning and preparing to join the partnership, and also after establishing the partnership and moving to the execution stage. Guided by Nahapiet and Ghoshal's (1998) framework, the followed questions were about the experience of the informants with respect to the impact of the structural, relational and cognitive dimensions on the effectiveness of the relationships between actors within the Faraday Partnerships, and whether the development of these relationships was useful in mitigating the effect of impediments realized in the partnerships. On the structural dimension of social capital, the questions included, for example, the structure of the relationships (i.e., how the connections were made) between the university and industry actors and how various collaborators joined their partnerships. With regard to the relational dimension, the

questions were linked to the different components of trust and commitment (e.g., how trust was developing and if its impact has changed over time). For the cognitive dimension, the questions concerned the common interest or understanding that university and industry actors shared, and how they influenced the development of the relationship between the diverse members of the partnership. We also depended on data triangulation by using secondary data comprising archival data from the partnerships' websites. The archival data also include corporate brochures, organizational charts, and case descriptions about the partnerships.

For the analysis, we followed the three concurrent flows of activity (Miles and Huberman, 2008) comprising data reduction, data display, and drawing and verifying conclusions. We reduced the data via 'summarizing' each raw interview transcript by collating information in the transcript pertaining to the same issues and themes with the aid of NVIVO computer software. We anonymized the 'summarized' transcripts and conducted 'member checks' with our informants to gain confidence about the accuracy of the summary. Our data display was by means of a matrix format in Excel spreadsheet, representing examples can be found in the findings section. We populated the relevant cells of the matrix with information from the validated 'summarized' transcripts and also included in the matrix display information from the archival data and the Partnerships' websites. The matrix display facilitated thematic analysis to identify categories and themes common to UIC impediments before and after, and how social capital is produced through the relationships between the university and industry actors. The categories and themes were centre on the three social capital dimensions. For each theme, the relevant data was analyzed into overarching dimension (i.e. first order), the categories (i.e. second order) and the analytical themes (i.e., third order). However, in the presentation of our findings below, we focus mainly at the theme level, which is more informative, as it captures a better dynamic view of social capital.

3.3 Validity and reliability

Commonly stated criteria for judging the quality of research design include external validity, construct validity, and reliability (Miles and Huberman, 2008). Though we acknowledge the importance of internal validity, we did not address this validity criterion in our study as it is more relevant to explanatory case study, and not for exploratory studies (Yin, 2009). The methods used to meet these three criteria are presented in Table 2.

4 FINDINGS

We start by reporting UIC impediments explicating their underpinning challenges during the preformation stage, and then illustrate how the combined effect and interaction of social capital dimensions have influenced these impediments. We follow the same approach for the postformation stage.

4.1 UIC during preformation stage: impediments and social capital interaction

4.1.1 Impediments

In general, all informants perceived this stage, which involved initiating and formulating the partnership agreement, as complex and time consuming. The difficulty started at the beginning, where the selection procedure (i.e., to identify potential partnership which to be funded by the government) was referred to as competitive and included a two-steps bidding process (outline proposal followed by a full-scale project). Following the selection process, all parties with each partnership were bound together by a collaboration agreement, and one of the partners with legal status was entrusted with the responsibility of transacting business for the partnership on behave of all the partners.

To probe the impediments, the interviewees were asked to think and reflect upon their experience and concerns when began to consider and plan for joining the Faraday Partnership scheme. By analyzing the answers, three main themes (or impediments) emerged: lack of commonality in background, fear of priority conflict, and recruiting suitable partners, as illustrated in Table 3. The potential risk of each impediment is conceptualized as specific challenge(s) to partners at the preformation stage. Moreover, it is noticeable the identified obstacles have been raised by actors from both sectors, as indicated in the second column in Table 3.

INSERT TABLE 3 ABOUT HERE

4.1.2 Role of social capital

During the preformation stage, it was clear that all social capital dimensions were useful in mitigating the obstacles transpired at this stage. However, the structural dimension appeared to play a less important role when compared to the other two dimensions (i.e., relational and cognitive). In Table 4, we report the outcome of the analysis, including exemplary supporting evidence. The table explicates the role of social capital, and how the three dimensions and their sub-dimensions (or social capital facets), have evolved through interacting with each other.

INSERT TABLE 4 ABOUT HERE

Lack of commonality in background, the first impediment, resulted from the differences between the two institutions (i.e., university and industry) where actors from each side, for example, held different interpretations for the same terms, see Table 4. Such differences were likely to reduce the level of common understanding between prospect partners, thus complicating the negotiating process. In managing this obstacle, the data show two facilitating factors (role of intermediaries and predefine objectives) to effectively develop the cognitive capital between the actors. In this regard, technology translators were the most important intermediaries. They are individuals with years of experience at the

academic and/or industry interface, which they used when acting as intermediaries to facilitate the technology translation process; by a two-way process of relating industry's needs to the capabilities of the knowledge base held by universities and similar institutions. They provided as a bridging or brokering function by delivering specific meaning to the terms used in the negation and ensured that potential partners have similar understanding (i.e., create cognitive capital by having shared codes and narrative). At the same time, the predefined objectives (including principles and roles) of the Faraday partnership, which were set by the government through DTI and EPSRC, clarified the approach that actors need to follow. This clarity provided a collective platform to start working together in developing the partnership agreement on the basis of common understanding (i.e. a sub-dimension of the cognitive capital).

Considering the second obstacle, fear of priority conflict, both university and industry actors highlighted this obstacle, as it has the potential to lock the full engagement in the partnership. From university side, being more business-linked and business-like poses challenges to the main university mission (teaching and dissemination of knowledge) as it can detract from the university's commitment to 'open science'. On the other hand, commercial secrecy, which industry relies on, is often associated with a narrowly-framed and result-oriented enquiry, with profit as its main goal, and restricted disclosure of information. Despite this tension, the combined effect of both predefined objectives and intermediaries played a pivotal role in reducing this fear by developing mutual obligation (i.e. a relational facet) between partners regarding the partnership, see Table 4. In essence, this obligation was driven by the 'Faraday Principles' (emphasized by the technology translators) and the objectives set down by the DTI. These objectives became like a roadmap for the partnership, thus created shared values that motivated the university and industry actors to increase their commitment regarding the partnership and act in a favourable manner towards each other.

The final identified obstacle at the preformation stage is recruiting suitable partners. This issue was also relevant to both university and industry. The essence of this problem is uncertainty about the prospect partners in terms of trust and compatibility.

> *"I think we could have put something on paper that would have formed the partnership, but it would have been difficult to get a working relationship. The starting process would therefore have been slower because I think one of the key issues in partnership formation is trust in relationships. If you trust people and if you know you can work with them, then things progress" Management representative*

Here, the presence of pre-existent bonds (as a sub-dimension of the structural capital which reflects the network tie strength specified by Inkpen and Tsang (2005)) between some of university and industry actors increased the certainty about the commitment and capacity of their potential partners. They would know each other and have high level of mutual trust - or 'relational trust' (Santoro, 2000), as a sub-dimension of the relational capital, due to repeated interaction in the past that resulted in positive emotions, see Table 4. However,

some informants explained that although pre-existent bonds was important, they would still have formed or joined the partnerships without it, though in that case the process of partnership formation might have been difficult, which could in turn have negatively affected the success of the partnership. For instance:

> *"However, without this influence [pre-existent bonds], we would still have joined the partnership anyway, but perhaps, we would come at it from a different direction. I think we would definitely have needed more convincing through some initial marketing by the Partnership to convince us. But as it was a [government initiative], they did not have to do any marketing with us." University Academic*

This highlights an important difference between the 'engineered UIC' and other relationship motivated by perceived complementary between the partners. We draw on this issue in further details in the discussion section.

In addition to pre-existent bonds, the intermediaries had a key role in providing information and linking actors with similar interests, willingness, and capacities together, which would develop the sense of mutual obligations and expectations. Existing of obligation and mutual expectations (as an essential facet of the relational capital) fosters individuals' confidence about the identified actors of which to collaborate with.

Figure 2 provides a summary of the interaction discussed above between the social capital dimensions, sub-dimensions, the two facilitating factors, and their mitigating effect on the impediments of this stage.

INSERT FIGURE 2 ABOUT HERE

4.2 UIC during postformation stage: impediments and social capital interaction

4.2.1 Impediments

Similar to the previous stage, the informants elucidated several concerns and obstacles which emerged during the implementation of the partnership. However, it can be noticed that the number of impediments has increased comparing to the preformation stage. In specific, the analysis shows five distinct obstacles, namely: Cross-sector difference, opportunism behaviour, matching capabilities to create opportunity, ownership dispute over intellectual property, and government regulations/legislations imposed on the partnership, as presented in Table 5.

INSERT TABLE 5 ABOUT HERE

4.2.2 Role of social capital

Similar to the preformation stage, all the three dimensions were relevant in alleviating the challenges imposed by the obstacles unfolded during this stage. Yet, we realized that the importance of the structural dimension has remarkably increased in comparison to the

preformation stage. In Table 6, illustrate the analysis outcome including supporting evidence. The table explicates the role of social capital, and how the three dimensions and their sub-dimensions (or social capital facets), have evolved through interacting with each other.

INSERT TABLE 6 ABOUT HERE

Addressing the first impediment, cross-sector difference, while progressing in the partnership, university and industry actors were struggling in communication especially during problems identification. The approach of communication is largely rooted in the cultural system of each institution. Some industry actors perceived the university researchers as too theoretical and not very practical whereas the firm's focus is much more practical and centred on critical issues requiring immediate attention. This created a gap between the two sides. As informed by the analysis, the social interaction (a structural sub-dimension) was useful in creating shared codes and common understanding (cognitive sub-dimensions) between the diverse actors. Interestingly, we found that interaction through students training was prevalent than traditional interaction opportunities such as conferences and workshop. These include: 'Internships in the company for students', 'Student involvement in industrial projects', 'Joint supervision of Masters Degree dissertations and/or PhD Thesis by academic and industry personnel' and 'Personal Visits'. The previous four schemes were mainly the result of Collaborative Awards in Science and Engineering (CASE) studentships, which were very much used by the Faraday Partnerships. CASE studentship is a scheme funded by the UK Research Councils and industry under which a post-graduate works on research relevant to a company's needs while completing a PhD. The student gets industrial experience, the company benefits from academic resources and the sponsoring university gets direct interaction with industry. The following comment from an industry actor threw more light on this:

> *"We got a PhD which is financed from a CASE award, and that involves several times a year personally visiting the University, and this has been very beneficial to us, because although you are paying for a PhD, you get advice for your business from people you wouldn't normally get access to - they brainstorm with you and they offer new ways forward...such discussion are also useful to clarify any misunderstanding between us"*

At the same time, the Faraday principles and objectives provided essential guidance to bridge the differences between partners. In specific, the predefined objectives of each Partnership appeared to further bind the partners together in each Partnership. Therefore, together, the Faraday Principles and the Partnerships' own specific objectives served as underlying norms which provided directions to the actors, helped to create a reasonable degree of harmony between their goals and, by so doing, reduced the influence of cultural differences between the world of academia and of industry.

Opportunism behaviour is a unique impediment as it caused two distinct challenges: self-interest and competitiveness. For the former, social interaction was necessary to gradually build the trust between the actors. Specifically, the interactions from the networking promoted by the activities like conferences, workshops, seminars, symposia and forums, helped university academics and industry actors who did not have the benefit of prior relationships as trustworthy. Through social interaction, individuals get to know each other thus their self, as well as, collective objectives become clear and appreciated following their regular meetings. In principle, this type of trust is labelled as 'relational trust' (Santoro, 2000), which derives from information that become available to all individuals within the relationship through reparative cycles of interaction. The former challenges, competitiveness, was only evident by industry which perceived a risk of losing control of vital technologies and information leakages about the company research agenda, which could result in losing the innovation edge. In such scenario competitors can build on its innovation orientation to quickly develop similar products, leading to the potential of eroding a company's competitive advantage. In this regard, both intermediaries and frequent interaction were vital in mitigating this risk and increasing the trust between the two parties, see Table 6. Further, the developed trust appeared like 'calculative trust' (Santoro, 2000), whereby the trust is perceived as a result of a rationale choice of economic exchange or the belief in beneficial outcomes due to trustful behaviour. For example, an industry actor explained:

> *"Following our several meetings together, there was quite a high level of trust between us and everyone was actually remarkably frank with each other on how to design and develop products and bring products to markets. It is very refreshing actually, and the discussions are very open. There is confidentiality and whatever is said stays in the room."*

Concerning the third difficulty, matching capabilities to create opportunity, informants asserted that the full potential of partners' capacity was not utilized due to lack of information about their individual advantages, which was described by an industry actor as "wasted opportunities". However, not all participants shared the same view about this issue, as Intermediaries (mainly the technology translators) were proactive enough to bring the partners together frequently seeking to increase their interaction and exchange of knowledge aiming to identify potential opportunities. This continuous interaction allowed the embedded knowledge in the relationship between the university and industry actors to be fully exploited. A technology translator refers to this point as:

> *"I am involved in putting together the programme for our annual conferences in October, which is again liaising with academics, encouraging them to speak with industry, to put together a coherent story for the benefit of the delegates at the conference…such opportunities would be excellent to establish new useful links".*

For the last two impediments, the data did not provide significant evidence about the role of social capital and how the Faraday members were able to manage their challenges.

However, realizing the ownership dispute over intellectual property (i.e., the fourth impediment) as an issue in the data is a surprising finding. More specifically, we expected that partners were cleared about the IP ownership mechanism given the existence of governmental requirements and intermediaries (i.e., Faraday partnership is sponsored initiative whereby the IP ownership is predetermined by the funding body, or the government). Notwithstanding the sense of mutual reciprocity and expectations, formal contracts were executed by the university and industry actors within the Partnerships to specify their obligations (and rights) with the view of avoiding the possibility of legal disputes. In Faraday Partnerships, the general approach to managing intellectual property rights (IPRs) was that ownership usually went to the University. However, depending on the level of industry sponsorship, the intellectual property agreement granted certain rights by license to the industry sponsor, which ranged from non-exclusive royalty free rights to use the results for internal purposes, to exclusive royalty-bearing license rights for commercial exploitation. On the other hand, the approach for managing publication rights was usually through a clause in the collaboration agreement that allowed the industry sponsor to first review the publication prior to publishing. Where a patent or IPR was involved, the publication is placed on hold for a specified period of time (usually up to six months) to allow the patent or IPR to be first protected before publishing.

Figure 3 depicts how the interaction between the social capital dimensions can work in mitigating the impediments unfolded in the postformation stage in UIC.

INSERT FIGURE 3 ABOUT HERE

4.3 Effectiveness of Faraday Partnership initiative

In this section we shed some lights on the success of this initiative as realized in our data. However, given the length of the paper, which restricts the ability to report detailed account of this issue, we present a brief summary. Interestingly, not every partnership in this initiative was perceived as totally effective, but rather the results of the 24 partnerships can be envisioned as locating on a performance continuum which ranges from glowing success on one end to struggling on the other. Specifically, a management representative (who was aware of all partnerships) provided his reflection on the program as a whole, stating:

> *"I regard the Faraday Partnerships as falling into four different groupings. There are six, which are doing very well and have made an impact such that things have happened that would not otherwise have happened without their being a Faraday Partnership. Another six have done a good job. They have created an entity, which is generally known, and they have done things, which are useful, but they are not stars in their own areas. There are about six others which are giving grounds for concern in that there have been problems with them in one way or the other, either with the structure, which they have not got right or maybe they have not been interacting with the right people. And then there is the last six, which is the last tranche, which has only*

been in existence for barely two years or so, and therefore it is difficult to make a judgment on their long-term success"

This finding emphasizes the existence of various difficulties what complicate the planning and executing of UIC. Therefore, it brings support to the importance of research stream (like this study) that seeks to understand the causes and remedies for collaboration challenges that, if not addressed properly, might eliminate the potential value of such partnerships.

5 DISCUSSION AND CONCLUSION

5.1 Theoretical implications

In this research, we examine the social capital construct in the context of university-industry collaboration. We depart from the extant literature by exploring the dynamics of social capital in mitigating the impediments of UIC during two distinct stages: preformation and postformation. Our cases are derived from the Faraday Partnership, a government-sponsored scheme, which is a distinctive example of 'engineered' UIC. The study findings, therefore, have several important implications for research as explained next.

First, as noted previously, the three dominions of social capital are present and still evolving and perceived as an important source for creating organizational value (Yoon et al., 2015, Camps and Marques, 2014). However, in literature, no consensus can be found on how these dimensions interact. To a large extent, our unique perspective and setting can provide an explanatory account to this inconsistency. In particular, the findings, as summarized in Figure 2 and 3, add to the less prevalent view that the social capital embedded in the three dimensions and the pattern of their interaction actually change over time (Hughes and Perrons, 2011), and the argument that social capital process works differently across different networks (Inkpen and Tsang, 2005). The analysis revealed two groups of Faraday UIC impediments, where the social capital dimensions played an important, yet different, mitigating role during the two stages. By comparing the two stages together, it becomes evident that the social capital does not develop linearly as portrayed in prior investigations in this area, but through a continuous complex interaction among the three dimensions. Few studies (e.g., McFadyen and Jr, 2004, Villena et al., 2011) can provide support to this proposition. Molina-Morales and Martínez-Fernández (2009) argue that the intensity of social capital can change overtime, however, its impact on firm innovation performance is not always positive. For instance, trust (as one facet of the relational dimension) between members can develop over time to reach a point of which these members will be reluctant to monitor the relationship, leading to lower performance due to insufficient monitoring (Langfred, 2004). Therefore, organizations were recommended to identify an ideal level and keep adjusting their social dimensions accordingly (Hitt and Duane, 2002) to achieve optimal benefit (Molina-Morales and Martínez-Fernández, 2009).

Second, during the preformation stage, the structural capital (embodied in the pre-existent bonds facet) was found as less dominating in contrast to the relational and cognitive dimensions. This is an important finding given that the majority of research stresses the

importance of the structural dimension as the antecedent to the other two dimensions, in particular the relational one (e.g., Bstieler et al., 2015a, Roden and Lawson, 2014, Tsai and Ghoshal, 1998). One possible interpretation for this result could the fact that our cases are example of engineered relationship (i.e., being designed and initiated by third party and not the collaborating entities). Therefore, rather than having strong tie or former pattern of interaction (the structural dimension) which are important to establish organizational linkages (Zheng, 2010), the presence of champions or sponsor (i.e., the government body in our case) in engineered relationship can replace the role of pre-existence relationship and coalesce the heterogeneous organizations around the need to collaborate, thus enable potential partners to take advantage of an opportunity they failed to recognize (Dyer and Nobeoka, 2000). In the same vein, the study complements earlier research on the role of cognitive side of social capital, thus heeding the call for more investigation to clarify the nature and impact of this dimension (Bilhuber Galli and Müller-Stewens, 2012, Zheng, 2010). In principle, the findings illustrate how the two facets of cognitive capital (shared codes and narratives and common understanding), enhanced by the two facilitating factors and the structural dimension, were vital in overcoming interpretation and communication challenges by helping the partners to develop mutual perception on how to interact together, harmonize their interests, and facilitate building a shared vision for the partnership. More specifically, the sharing of narratives in terms of anecdotes and experiences by the various speakers at meetings such as conferences, workshops and training courses (as influenced by the structural dimension during the postformation stage) received prominence. These bridged the distance between the university and industry actors thus made it easier to discuss, generate and exchange knowledge. As Nahapiet and Ghoshal (1998) suggest, the sharing of narratives in a group is influential in creating, exchanging, and preserving rich sets of meanings in groups. Further, shared narratives within a group facilitate the combination of different forms of knowledge, including those largely tacit (Careya et al., 2011).

Third, as an extension to the previous point, the study identifies two facilitating factors as relevant to engineered UIC. Importantly, the factors played a vital role by exerting a positive effect on the relational and cognitive dimensions during the preformation stage, but the effect direction changed at the postformation stage (to influence the relational and the structural dimensions). At the beginning, clearly laid down objectives through the Faraday principles with the help of intermediaries' directions enhanced the cognitive capital by providing a fundamental understanding that helped to create a reasonable degree of harmony between partners. This understanding helped university and industry actors to realize the core objectives of the initiative, focus their attention, and provided clarity and guided them in how to proceed to the implementation stage. Later, the two factors enabled the collaborators to establish trust and obligation regarding the partnerships and increased commitment through mutual expectation developed between them. However, despite the impact of intermediaries on the relationship between university and industry has been discussed in literature (e.g., Lee, 2011, Tether and Tajar, 2008, Yusuf, 2008), our study

makes a novel contribution by uncovering the dynamic role of technology translators in developing the social capital dimensions during the two stages. As depicted in Figure 2 and 3, the role of the technology translators has evolved from developing mutual obligation and common understanding into building trust and creating new ties between the various actors in the partnership. Importantly, this change can be attributed to the idiosyncrasy of engineered UIC whereby intermediaries need to establish the commitment between the actors who typically lacks mutual trust and /or pre-existing relationships (i.e., being invited by the sponsoring body) first, then move to foster (i.e., improve trust) and expand (i.e., increase network tie) of the relationship while progressing.

Finally, in studying the impact (or value) of social capital, researchers predominantly have examined this construct as antecedent to knowledge development in terms of intellectual capital (e.g., Reed et al., 2006), knowledge transfer (Maurer et al., 2011), and innovation capacity (e.g., Subramaniam and Youndt, 2005), which are essential for improving organizational performance outcomes. However, in this study we provide a new mechanism for social capital to generate value: reducing the intensity of UIC impediments. In specific, we explicate how the various facets of social capital, as well as the facilitating factors, are effective in mitigating the challenges that emerged during the process of Faraday UIC. Furthermore, we uncovered how the nature of these impediments actually changes over time. This contribution is particularly important in terms of helping to set in place policies that will alleviate the problems before they undermine what might be rewarding sets of collaborations (Bruneel et al., 2010).

5.2 Practical implications

Beside these theoretical contributions, the study's findings provide some implications for practicing managers. First, our study suggests that university and industry institutions can utilize the concept of social capital to overcome several problems typically occur in cross-boundary relationships. The various roles of the three capitals in lowering the intensity of these difficulties were evident in the data. Importantly, the findings encourage frequent communication between the university and industry actors and also the use of many and different types of activities, especially those involving close personal interaction. Such activities are key in promoting identification, trust and shared meaning among the partners and therefore enhance the relationship. In addition, the use of intermediaries, helps to develop trust, enables partner identification and thereby enhances the collaboration's success. Therefore policies aimed at promoting activities at a close personal level and institutionalising intermediaries (including purposefully training technology translators), should significantly improve the relationships between university and industry partners (Luna and Velasco, 2003). In addition, consideration could be given to rewarding and motivating staff to maintain greater interest in these close personal level activities, in particular through a broader range of incentive or acknowledgement systems (Woolgar, 2007). For instance, greater use of equity arrangements, wider use of incentives for collaborative research or recognition of UIC in terms of staff appraisal and evaluation.

Furthermore, effective management of these links should also include measures to maintain reciprocity by pursuing mutually compatible specific ventures such as CASE studentships. Second, contractual mechanisms between universities and industry, especially IPRs, emerged in this study to be a source for conflict, suggesting the need for increased effort by both sets of actors to develop better mutual understanding of the issue. As universities appeared to be the most likely cause of difficulties with IPRs, we suggest that the university partner should maintain a flexible and negotiable position, within legal boundaries, on IP ownership and publication rights. In this respect, government (or other sponsors of these partnership) could provide an enabling environment to ensure a suitable framework for the creation and ownership of IP between universities and industry that encourages UIC.

5.3 Limitations and future research direction

The first limitation of the study concerns the generalizability of the results. This paper has presented the results of an exploratory qualitative in-depth case study research, which offers considerable benefits in terms of understanding how social capital influences the relationship between university and industry actors in UIC setting. However, extending our results by examining whether the same results regarding social capital dynamics can be found in 'emergent' or 'embedded' settings is a worthwhile avenue for future research. Second, the list of obstacles which we have identified is not exhaustive, and is based on the setting of engineered UIC. Thus other challenges could still be unnoticed. Therefore, a comparative study that explores the impediments in the three different scenarios of UIC (i.e., engineered, emergent, and embedded) would be necessary to comprehend our understanding in this area. Moreover, the findings demonstrate the role of social capital in reducing the intensity of collaboration obstacles. Nevertheless, more research is required to find out if other mitigating factors can be found. For instance, drawing on the alliance management capabilities literature (see, Wang and Rajagopalan, 2015), future research might address how university and industry can develop capabilities to systematically codify, store, and disseminate internally collaboration experience as resulted from their interaction. Such knowledge can be vital to avoid problems in ongoing as well as future organizational relationships (Niesten and Jolink, 2015). Finally, a further area for research is to investigate the ties strength between university and industry actors using network measures. The structural aspect of social capital refers to the connections among actors - with whom and with what frequency they share information. Although in this study we discussed the sub-dimension 'network tie', we did not examine the strength of the ties between the university and industry actors. Researchers, including Burt (2000), argue for the superiority of network measures in research on social capital. It would, therefore, be useful to investigate the suitability of this construct in UIC context.

In summary, this study has yielded several conclusions which can be useful for theory, and practice. We have argued that social capital construct has a dynamic nature when affecting UIC barriers. The empirical findings support this argument, as the impact of social capital dimensions and their interaction on these difficulties were changing during the life of the

relationship. An understanding of the nature of this change and its facilitating impact on relationship development may offer great potential for establishing effective UIC.

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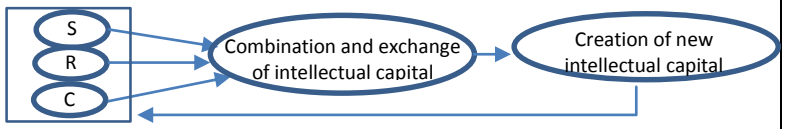
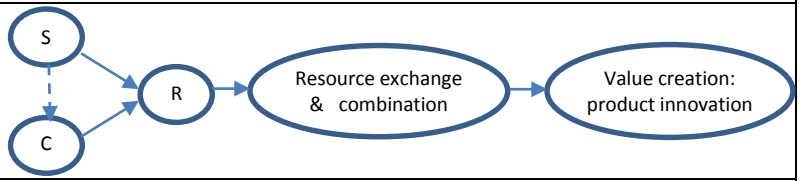
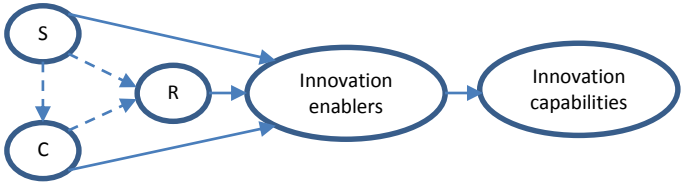
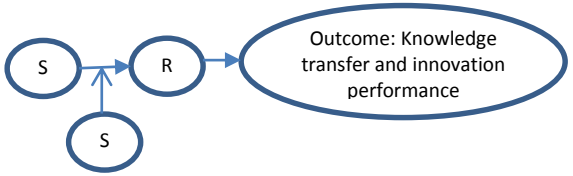
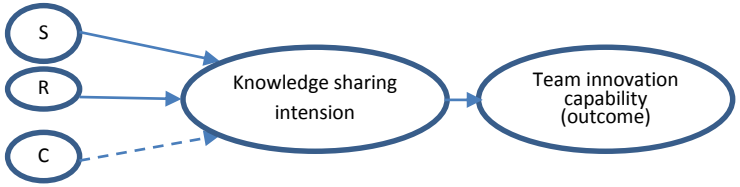
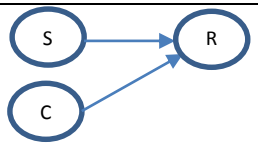
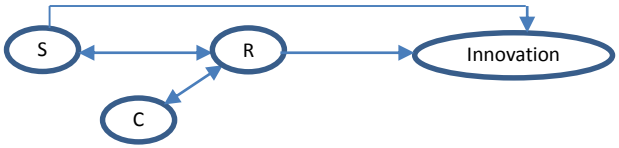
Table 1: Analysis of literature on the interaction between the three dimensions of social capital

Publication	Study focus	The interaction model and main findings
Nahapiet and Ghoshal (1998)	A theoretical study that posits a direct relationship between the three dimensions of social capital (SC) and intellectual capital (IC) development. In turn, new developed IC enhances the SC dimensions.	
Tsai and Ghoshal (1998)	A quantitative study examines the interplay between the dimensions using the following facets as proxies: Social interaction (structural), shared vision (cognitive), and trustworthiness (relational). The interaction enhances product innovation capability that is achieved indirectly through creating certain resource exchange pattern.	
Camps and Marques (2014)	The study proposes a specific interaction between the three dimensions, where this interaction, as well the capital stored in each dimension, creates innovation enablers that underpin firm's innovation capabilities. However, using qualitative data, empirical support could be found only to the direct impact of dimensions on establishing the enablers (and not the interaction).	
Bstieler et al. (2015)	A quantitative study that tests the certain facets of social capital on UIC outcome in terms of knowledge transfer and innovation performance. These facets include: shared governance (structural), trust (relational), and champion behaviour (cognitive). The structural dimension was found as influencing the relational one, however, the cognitive dimension moderates this relationship (i.e., the impact of shared governance on trust increases in the existence of high champion behaviour).	
Akhavan and Mahdi Hosseini (2015)	The study focuses on the individual impact of social capital dimensions on knowledge process. Several facets of social capital have been used as proxies for social capital including: social interaction ties (structural), trust, reciprocity, team identification (relational), and shared goal (cognitive). Despite empirical support is found for the structural and relational dimensions, the impact of cognitive impact emerged as insignificant.	
Roden and Lawson (2014)	Using the context of buyer-supplier relationship, the study investigates quantitatively the relationship between the structural (level of interaction) and cognitive (shared interest, shared values, and shared vision) dimensions on the relational dimension (trust, reciprocity, respect). The proposed relationships are found as significant.	
Zheng (2010)	By reviewing the literature, the study proposes a two-way relationship between the structural and relational dimensions, and the same type of link between the cognitive and the relational dimensions. However, no link in the literature could be found between the cognitive and the structural dimensions. This review adopts innovation as social capital final outcome.	

S: structural dimension, R: relational dimension, C: cognitive dimension

Indicates a significant relationship

Indicates a proposed theoretical relationship, however no empirical support could be found in the data

Table 2: Tactics for improving validity and reliability

Research quality criteria*	Tactic applied in this study
Construct validity: Focuses on the objectivity of the researcher, and that the drawn conclusions are derived from the data itself and not based on values or theoretical assumption of the researcher.	– We interviewed multiple respondents for each of the five partnerships to allow for the possibility of different viewpoints to be captured, establish comparability and enhance the reliability of the research data. – The data collection instrument included both open-ended and structured questions. – The majority of the interviewees checked the summarized transcripts of their interviews (feedback from the informants was in general satisfactory and five of them provided minor comments for enhancement). – Data triangulation by using multiple sources of evidence.
External validity: The extent to which the results obtained from the study can be generalized beyond the settings of the current case study.	– Using of multiple case studies allowed for achieving theoretical generalizability (the 'replication logic' can take place because the consistent results from each category provides support to the concluded theory)
Reliability: Emphasizes the replication of the study findings. Or the extent to which a study can be repeated (in same settings) and give similar findings.	– The case study protocol was followed in collecting the data. – A case database was established for the five cases. – All interviews were recorded to reduce observer bias.

*Adapted from Miles and Huberman (2008) and Yin (2009)

Table 3: UIC impediments and their underpinning challenges over the preformation stage

Preformation impediments	Underpinning challenges	Exemplary supporting evidence
– Lack of commonality in background	– Interpretation challenge: – Due to divergence in their backgrounds, potential partners from both sides hold inconsistent meaning of key partnership terminologies, and expected responsibilities of members. This led to confusion during activities planning, distribution of duties, and specifying jobs description. – Relevant to both Industry and university	As in these two quotes, it can be realized that university and industry actors had initially two different interpretations for technology translation process (a principle component of the Faraday Partnership scheme): *"When we started, we defined translation as the process of having somebody [i.e., technology translator] to interpret between academia and industry…but technology transfer is what they [i.e., the partners] do when they got it right. Therefore, translation leads to transfer". University academic* *"I would not regard transfer and translation as essentially different or the difference as particularly important. I think it is an issue of semantics…if I were to write a job description for a technology translator and a technology transferor, they will have the same job description from my perspective". Industry actor*
– Fear of priority conflict	– Digression from organization's core objectives challenge: – During preparation, both university and industry hold different (and in many cases contradicting) priorities that would influence the partnership agenda: whilst industry partners seek appropriating knowledge output, university focuses primarily on knowledge dissemination via publication – Relevant to Industry and university	*"I think industry still views academics as having specific agenda of only being interested in doing basic research or blue-sky research and therefore not living in the real words…such perception has complicated our initial negotiation". University academic* *"The conflict emerged early because of two contrasting viewpoints…they [university] look for the quality and novelty of science first and foremost, whereas we [industry] is looking for the commercial impact of science". Industry actor*
– Recruiting suitable partners	– Trust and compatibility challenge: – Formulating relationships was time and resources consuming. This process involved scrutinizing several prospect partners to find trusted and appropriated collaborators (e.g., with complementing capabilities) – Relevant to Industry and university	*"Actually trying to encourage SMEs, with limited scale and scope, to look at new technology through collaboration with university was not an easy task…finding a partner with adequate potentials is really a daunting task". University academic* *"In our initial meeting, there were a couple of people from big companies that argued that small companies and universities should not make products, but should rather develop technology to license to big companies [as they lack necessary capabilities]…a couple of other people including myself spoke in defence of small companies. There were some people from universities who were angry as well and the atmosphere was a bit polarized". Industry actor*

Table 4: The impact of social capital dimensions on UIC impediments during the preformation stage

Impediments	challenges	Role of social capital and other facilitating factors	Exemplary supporting evidence
– Lack of commonality in background	– Interpretation challenge	The intermediaries played a key role in developing the cognitive side of social capital embedded in the relationship (between university and industry actors) by providing specific definitions and terms to establish common understanding between them during negotiation. **intermediaries → Cognitive Capital (shared codes and narrative)**	The following definition was adopted by technology translators (as a key intermediary) and shared with all actors to specify the meaning of Technology Translation process: *"A proactive approach that involves a broad range of activities aimed at identifying the need of industry, communicating the needs of industry to the research community or knowledge source, identifying opportunities for innovation relevant to the need of industry from the knowledge source and exploiting these opportunities to realise them with the assistance of a technology translators who is needed to bridge the cultural gap between the knowledge source and recipient and also facilitate the process"*
		During the preformation stage, the Faraday principles and the specific objectives set by the sponsors, the Department of Trade and Industry (DTI) and Engineering & Physical Science Research Council (EPSRC), for each partnership created proactive shared meanings, connotation, and expectations across the stakeholders **Predefined objectives → Cognitive Capital (common understanding)**	*"Our experience with such schemes shows that establishing such principles and objectives right at the onset provides a fundamental understanding about what the scheme [e.g., the aim of the Faraday Partnership Initiative] is all about. That is very important and goes a long way to help concentrate their attention on what activities to pursue". Management representative* *"Like other relationships, there are bound to be issues between the academics and the people from industry especially because of the different cultures, but in my view our Partnership objectives have provided us with clarity and direction for the conduct of the relationship". University academic*
– Fear of priority conflict	– Digression from organization's core objective challenge	This challenge, which arose during the preformation stage, was mitigated by the reciprocal obligation held by partners from both sectors to maintain the balance in the relationship focus. The rational capital was created by the combined effect of intermediaries (mainly technology translator) and the existence of predefined objectives for the partnership. **Predefined objectives + intermediaries → Relational capital (obligation and expectation)**	*"I first identify the matching industry needs to academic capability and then I bring them [university and industry actors] together for a collaborative project...when I go to the preparation meeting I ask them to define their objectives and agenda, and here, it is important to ensure that there is enough written in the objectives to make sure there are obligations to commit them – one to the other. Then I monitor to ensure that there will be a working relationship". Technology translator* *"It is true to say that I did not know some of our industry partners when we actually started. But once we came together, we all had the responsibility for delivering the Faraday objectives, which in a way bound us together and kept us focused to meet our obligations". University academic*
– Recruiting suitable partners	– Trust and compatibility challenge	The pre-existent bonds were useful in expediting the selection of partners, where many university and industry actors already knew each other from previous relationships. These bonds have fostered an environment which helped to reduce ambiguity and increased confidence about potential partners because of the trust that already existed between the partners and the perceptions of mutual trustworthiness. **Structural capital (pre-existent bonds) → Relational Capital (trust)**	*"Without previous relationships, bringing them together [university and industry actors] would have been much slower because one of the key issues in Partnership formation is trust and relationships. If you trust people and know you can work with them, then things progress quickly". Management representative*
		The facilitating role of the management representatives and technology translators (i.e. the intermediaries) made it easier for individuals to identify potential actors holding similar expectations in terms of interests, commitment and capabilities required for effective implementation of the partnership. **intermediaries → Relational Capital (obligations and expectation)**	*"I had friendly people (i.e., the intermediaries) who helped us to find the appropriate companies to us. I did not have to do cold calling to find out people who were interested in the same things as I was doing in order to take my ideas forward in my own right". University academic*

Table 5: UIC impediments and their underpinning challenges over the postformation stage

UIC impediments	Underpinning challenge	Exemplary evidence
– Cross-sector difference: cultural variations between the world of academia and industry	– Communication challenge: – Delay collaboration progress as partners use incompatible discourse in communication that complicates cooperation (e.g. problems articulation) – Relevant to Industry and university	*"The output of research programs is a form of technology, but it is not in a form that is accessible to most of industry, thus needs more work before industry can adequately take it up…the language of research is not the language of industry. So we find companies that cannot talk to academic researchers because they just cannot talk the same language" Management representative". Technology translator* *"Industry has to have its own needs translated into itself. Industry may identify that something is not working very well, but they do not necessary know what might make it better. So the problem has to be precisely explained to academia during the course of the partnership". Management representative*
– Opportunism behaviour	– Self-interest challenge: – Conflict emerges as some partners started to push the partnership toward individual objectives while progressing in the partnership, which influence trust negatively – Relevant to Industry and university	*"During implementation, there is still quite a bit of tension between the aims of the partnership and the aims of the parent organizations. So it is not necessary a smooth relationship all the time. There is an impression with one or two partnerships that the parent organizations is not doing the right thing for the partnership all the time as it is much focussed on its own objectives. Sometimes that becomes apparent within a partnership, as some of the different partners appear to be losing out" Technology translator*
	– Competitiveness challenge: Fear of disclosing information about R&D agendas and/or technologies/data – Industry specific	*"Confidentiality remained a sensitive issue…we operate under confidentiality agreement. But of course it is a paper, and that is where it comes down to relationships. There is the possibility that some academics might want to tell everyone about research they are doing, particularly post-docs and PhDs, who may not have an understanding of the confidential agreement" Industry actor*
– Matching capabilities to create opportunity	– Utilization challenges: – Given that several collaborators were involved in each partnership, full utilization of partners' potential was limited due to incompleteness of shared information about each actor. – Relevant to Industry and university	*"I think the only thing one needs to be careful of is not to raise expectations and mislead people. So it is important to be realistic about what you can achieve with your partners and not lead people on the wrong track and cause them to waste time and money through their activities…each partner has specific advantages, but linking these advantages together in a meaningful way is a big challenge". Technology translator*
– Ownership dispute over intellectual property (IP)	– Return on investment challenge: – Decrease industry motivation for investment in the relationship due to inflexible university policies regarding intellectual property rights. Universities in many cases devalued the input of the industry – Industry-specific	*"Increasingly, the university is fairly strict about making sure that the agreements are not too one-sided with the industry. In old days, it was generally the rule that if industry paid the whole funding, they would get all the intellectual property rights, but that is not so common now since it does not appear that they are really paying for the whole funding. The university exists because the state funds it and there is a feeling that in actuality what industry pays is below the real cost, even if they appear to be paying the full cost of the research" University academic* *"Intellectual property is probably the most controversial issue…there is still a lot of lack of understanding about the realities, and in fact we have a lot of work to do in this area". Industry actor*
– Government Regulations/legislations imposed on the partnership	– Bureaucratic challenge: Consumes times and resources, thus delay progress to ensure compliance with all government requirements (the funding and regulating body). The impact of this challenge unfolded during implementation – Relevant to Industry and university	*"An important factor that hurts my work is regulations…Regulations, legislations, and policing and implementation are big issues….as I had stated legislation is very important for technology translators in this area [referring to his partnership's area of technology] to understand because it is the key and the driver, and because it is very mixed, it causes complication during execution". Technology Translator* *"Another barrier is regulatory issues with respect to how quickly you can actually develop or take a product from concept through animals and clinical trials to a patient, which was not really clear when we started". University academic*

Table 6: The impact of social capital dimensions on UIC impediments during the postformation stage

Impediments	Type of challenge	The role of social capital dimensions and other enabling factors	Exemplary evidence
– Cross-sector difference: cultural variations between the world of academia and industry	– Communication challenge	By maintaining a high level of individual interaction through different activities, the discrepancies between collaborators have been reduced by developing shared meaning embedded within these relationships **Structural capital (social interaction) → Cognitive capital (shared codes and common understanding)**	*"The exhibitions or trade shows were an important means to get them [industry actors] to see what we are doing, and also for us to exchange knowledge and ideas and to showcase advancements in my field…by discussing the concepts and issues and communicating among ourselves, we got rid of any misconceptions and improved upon our collective level of understanding". University academic* *"At the conferences I have attended, there is a lot of interest, and you learn a lot from just talking to the other people at the conferences. You learn a lot about what is happening within the academic world and where people have got the issues". Industry actor*
		The Faraday principles and objectives provided essential guidance to bridge the differences between partners by reconciling any variances through driving the actors to focus on achieving the partnership objectives. **Predefined objectives → Relational capital (norms)**	*"It is important that [university and industry actors] have a broad understanding of the two different cultures because industry functions very differently from academia. But it has not been that bad because I think that the Faraday objectives have guided them [i.e., university and industry actors] to keep their attention on really what the Partnership is about". Technology translator* *"Our specific Partnership objectives have acted as common values to encourage us to have fair dealings and collaboration with each other". Management representative*
– Opportunism behaviour	– Self-interest challenge	The interactions made available through the several activities such as conferences, workshops, seminars, symposia and forums, helped to build trust amongst university and industry actors who did not have the benefit of prior relationships (i.e., pre-existent bonds). Individuals get to know each other which clarified any concerns regarding the collective aim of the partnership. The interaction also provided evidence about experience and capacity (of these individuals) which contributed toward building trust between them. **Structural capital (social interaction) → Relational capital (relational trust)**	*"Initially there was a fair amount of district by potential stakeholders because they were a little unsure whether they were expected to contribute either financially or in kind to a partnership that was unlikely to give their particular group any advantages. But the distrust has since evaporated…most of our collaborative projects involved meetings and other activities which engendered relationship building and provided the ingredients of trust and commitment to keep the projects going...the continuous interaction between us made our individual and collective goals clear. This transparent atmosphere maintained the trust between us as any issue can be addressed directly". University academic* *"The networking activities including the face-to-face meetings are important to establish the trust and openness regarding the interest and goals of each of us that builds a more successful relationship". Industry actor*
	– Competitiveness challenge	The networking activities further enhanced trust among collaborators. Meeting with each other on frequent base was observed to reduce confidentiality issues as partners have become trustworthiness to each other. Moreover, the role of technology translators (the intermediaries) was essential to establish and ensure the confidence environment. **intermediaries + Structural capital (social interaction) → Relational capital (calculative trust)**	*"There was the issue of confidentiality when we first started, but I think people are becoming much more open now…regular meetings increased the level of confidence between us, I believe". Industry actor* *"The most important thing with regards to facilitating this kind of activity is being able to develop sufficient trust with people who have needs and gaps [industry] and others who have the capabilities [academia]. When you go to talk to a lot of companies, they will not give you information on what their future development is going to be because they think they are giving too much away. But if there is that trust and we are exposed to their plans, we can point them to where they could get that technology capability to move their business forward. So that trust is absolutely key to the technology translation process. But fortunately, most of them see us as honest brokers, and so we usually do not have any problems with trust". Technology translator*

Table 6: Continue

– Matching capabilities to create opportunity	– Utilization challenges	Intermediaries (the technology translators) were useful in connecting actors with similar interests and complementing capabilities during the course of the partnership. They helped both university and industry to identify and establish new collaborating opportunities to fully utilize their organizational advantages **Intermediaries → Structural capital (network ties)**	"What we do is that the technology translators hold a lot of information from having visited a lot of companies and universities. Therefore, say six months later when a situation arises, the connections start to form and one is able to bring together a small company that has developed a new technology, but has some problems with the technology, with an academic that is researching on a cutting edge technology in that particular area and also a large company that is interested in the technology". Technology translator "The good thing about the technology translators is that they bring us together in a way that makes us see ourselves as working towards a common goal, and considering our backgrounds in new ways, that really helps to go beyond the planned objectives and to discover new potentials". University academic
– Ownership dispute over intellectual property	– Return on investment challenge	No direct evidence could be extracted regarding the role of social capital (i.e., whether any of the social capital dimensions helped to minimize the risk of this challenge).	
– Government Regulations/legislations imposed on the partnership	– Bureaucratic challenge	No direct evidence could be extracted regarding the role of social capital (i.e., whether any of the social capital dimensions helped to minimize the risk of this challenge).	

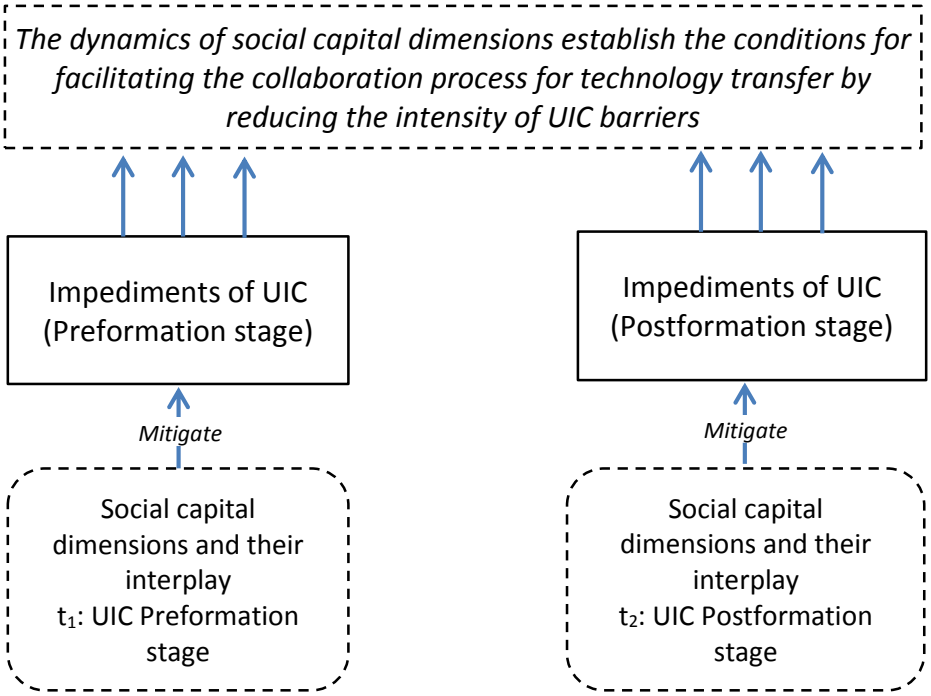


Figure 1: Study theoretical framework

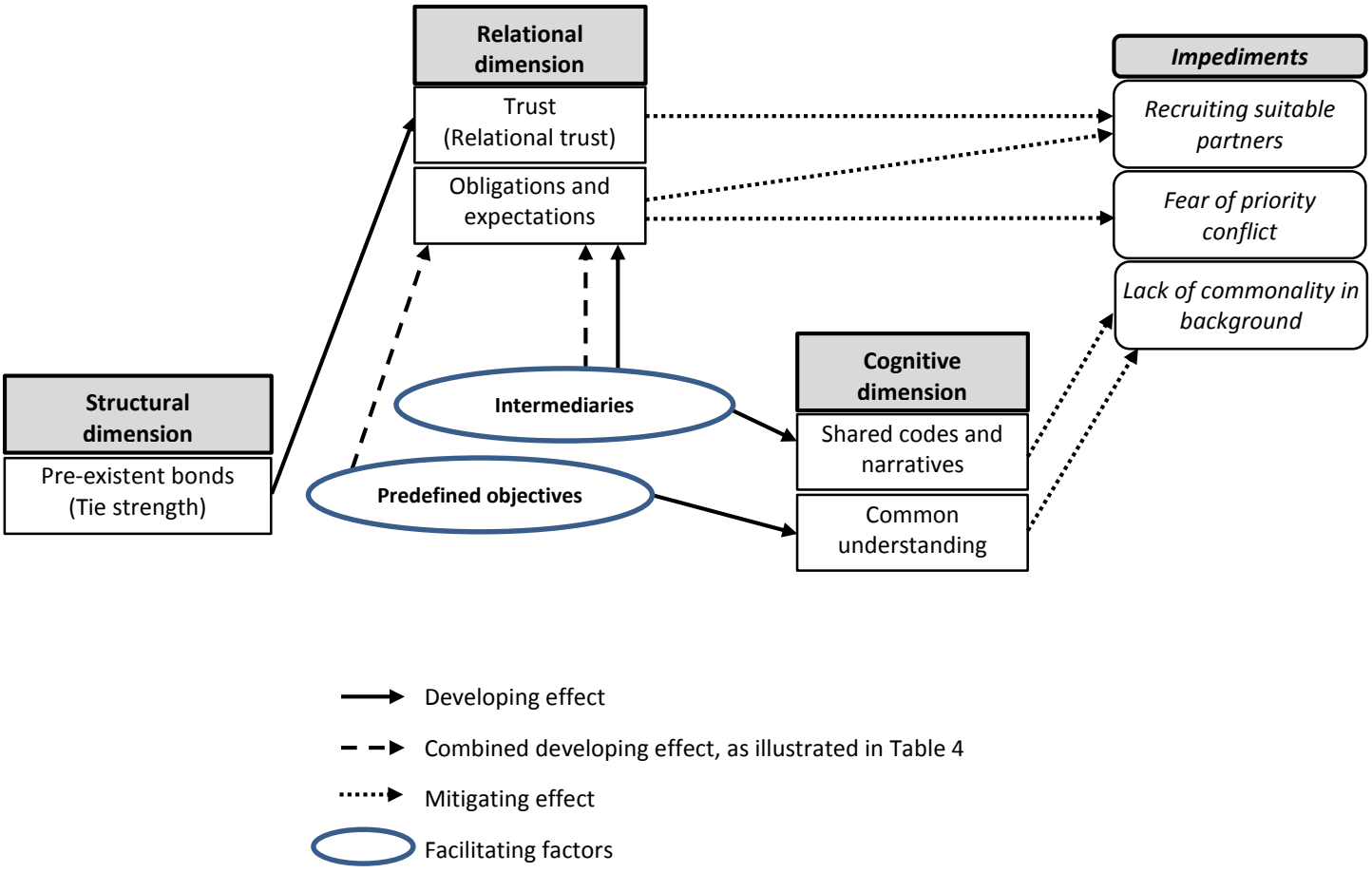


Figure 2: Dynamics of social capital dimensions in mitigating engineered UIC impediments during the preformation stage

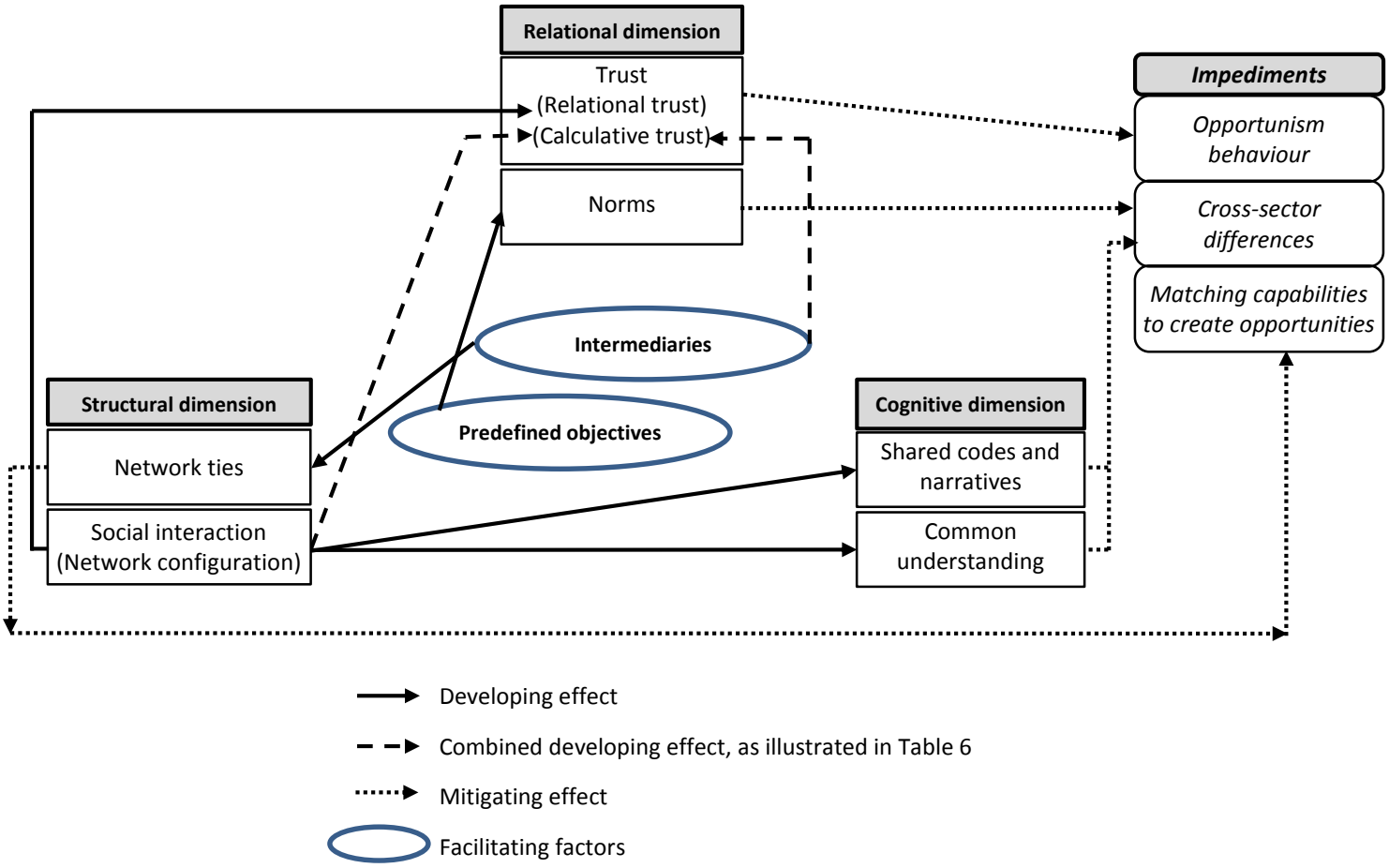


Figure 3: Dynamics of social capital dimensions in mitigating engineered UIC impediments during the postformation stage