CONFIGURING NEXT GENERATION FOOD SUPPLY CHAINS: A RISK PERSPECTIVE

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ABSTRACT
An often overlooked aspect of today's business environment in general and supply chains in particular is uncertainty. The scenarios of loss of supplier, transport strikes, IT services failing, stock outs etc are becoming all too common. Looking at the future of supply chains, uncertainty and risk appear to be increasing and will play a crucial part in the configuration of next generation supply chain. This paper presents an alternative approach to supply chain configuration using supply chain risk as the minimising variable. Perishable nature of the product and high risk impact in the Food supply chain offers perfect conditions to situate the study. Also, current trends in food supply chains namely globalisation, consolidation and commoditization indicate greater need for inherent risk minimisation while configuring future supply chains (Roth.A.V 2008). Using data from secondary sources and semi-structured interviews with respondents in a food supply chain, this exploratory study identifies the factors which need to be considered while configuring such a supply chain. The relationship between these factors is developed into a research framework.

SUPPLY CHAIN CONFIGURATION
Configuration is defined as "an arrangement of parts or elements that gives the whole its inherent form" (Webster 2008). Chandra et al. (2007) describe the problem of supply chain configuration as one which relates to determining which units (e.g. suppliers, plants), their size, location etc to include in the supply chain. It also looks at establishing and maintaining the linkages between these units. Whilst configuring and even reconfiguring a supply chain has been a topic of significant interest amongst researchers the basis of the configuration is often limited. Beamon (1998) reviews the available literature pertaining to the design and optimization of supply chains and identifies several performance measures for supply chain modelling. These can be broadly classified either on the basis of cost reduction (minimize cost, maximise profit), inventory reduction (lean, agile) or customer satisfaction (target service level). The configuration of supply chains have typically been studied at two levels. Firstly, the macro level which looks at the system as a whole and aims to find solutions for strategic decision making. Secondly, the micro level looks at individual entities and aims at resolving specific problems with the aim of minimising a particular variable. A link between the interactions of the previous two levels may be formulated through coordination (Chandra, Grabis 2007). Srai(2008) lists the key elements of supply network configuration as the supply structure, the flow of material and information between the network, the roles, inter-relationships and governance between the network partners and the "value structure" of the product.

Although there are several studies especially in the field of modelling which look at supply chain configuration (Geoffrion, Powers 1995, Vidal, Goetschalckx 1997) they often assume the operational parameters to be deterministic. Supply chain modelling within uncertainty is gaining popularity with researchers (Cheung, Powell 1996, Van Landeghem, Vanmaele 2002) but they tend to look at individual characteristics rather than the chain in its entirety. In recent paper by Ritchie (2007) identifies that the aggregate Supply chain risk is a function of supply chain configuration therefore it stands to reason that minimising risks in the overall supply chain could be a valid basis for its configuration.

CURRENT TRENDS IN THE FOOD SUPPLY CHAIN

The food supply chain technically spans the entire 'farmer to fork' process. The exact supply chain path for a particular food product depends on the product characteristics, size and market power of the supply chain members (Maloni, Brown 2006). The peculiarities of the food supply chain stem predominantly from the nature of perishability of the products and the high levels of risk associated with food. Within the food supply chains there are some trends noted by researchers which have a bearing on risk. Roth et al. (2008) identified three trends namely those of **commoditisation**, **consolidation** and **globalisation**. **Globalisation** refers not only to global sourcing of raw material, but also food processing, packaging and transportation. **Consolidation** refers to the trend amongst food supply chain members to combine as many food categories as well as levels of the supply chain in pursuit of higher margins. There has been an increase in both vertical and horizontal integration within food chains. Young (2002) looks at the reasons behind vertical integration and identifies *changes in customer preferences, IT environmental pressures* and *reductions in global trade barriers* as some of the main reasons. **Commoditisation** refers to the distinction between food products as either value added or commodities. Commodities are traded as undifferentiated goods competing mostly on price for example grains for which traceability back to the farmer becomes particularly difficult. Another sub category of commoditisation is the batch mixing chains like those of milk powder where different batches of milk powder are aggregated across different suppliers.

Despite extensive food safety legislation, increasing customer concerns and its consequential costs imposed on society as a result of frequent food safety and security scares has lead to an increase in the focus on the causes, effects and prevention of hazards(Fearne, Hornibrook et al. 2001). Helen Peck (2006) in her report on business reliance in the food sector identified a big gap in the preparedness for business continuity management (BCM) as very few companies had adopted a proactive or preventative stance to crisis management and operated mostly in the reactive mode. One of the conclusions of her report was that the drive for efficiency and the just-in-time philosophy used by the food industry has progressively reduced stock levels throughout the supply chain - with the resulting damage to its resilience when an emergency occurs. The consolidation of distribution networks by food manufacturers and the trend towards using 3PL (Third Party Logistics) providers, and reducing distribution sites means that the loss of a site due to events such as a fire or flood could also cause a disruption in the supply chain. Statistically such events are predictable but as shown by Peck (2006), many managers pointed out that the trend toward fewer and larger production and distribution sites meant that the potential impact was increasing.

FUTURE TRENDS IN NEXT GENERATION FOOD SUPPLY CHAINS

Through an extensive literature search the following further trends have been identified as being critical to future food supply chains:

1) Increased dependence on Technology: The prominence of technology within food supply chains seems to be positioned to grow. However, currently the usage is directed more towards improving efficiencies rather than for supply chain management (Hill, Scudder 2002)). Another aspect of technology is the detection of contamination within food supply chains. The technology to measure contagions is ever increasing which brings more issues to light.Also Fritz et al.(2009) identify that vertical coordination between agri-food supply chains necessitates the use of advance IT systems for larger enterprises.

2) Increased interdependence: Due to closer vertical coordination the contracts tend to become longer and can span 5-10 years which are very different from traditional contracts (Young, Hobbs 2002). This entails a change in the relationship as well as

interdependence between the entities. The producer is often supported by the chain in terms of technology and in turn is expected to respect the quantity, quality and timing of delivery. The production methods, documentation and on-farm audits form an integral part of such a relationship.

3) United approach to standards (HACCP, ISO, BRC, IFS): Reducing food contamination and recall is a major challenge for food supply chains. Given the risk impact of food products, food standards have become embedded in supply chains and often govern the way in which the entire supply chains operate. On the other hand Henson (2005) identifies the growing prominence of private standards as against public standards within food supply chains. He argues that this is happening primarily because of the growth of large retails as leaders in the industry, who in an attempt to achieve product differentiation find public standards either absent or inadequate. The introduction of Sanitary and phytosanitary measures (SPS) by the World Trade organisation attempts to deal with the two issues of providing "safe" food at the same time ensuring that the Food standards are not an excuse for protecting domestic producers. It allows countries to set their own standards but states that regulations must be based on science (http://www.wto.org/english/tratop_e/sps_e/sps_e.htm).

4) Traceability: Given the risk of product recall due to food contamination, the traceability within food supply chains is particularly important and has been the focus of several researchers (Kelepouris, Pramatari et al. 2007, Agarwal 2001, Wilson, Henry et al. 2008, Davies 2004, Dupuy, Botta-Genoulaz et al. 2005). Kelepouris et al.(2007) state that traceability will become a prerequisite for successful food enterprise in the years to come. Advances in technology have given rise to several traceability mechanisms like RFID tagging but these have not been taken up by many organisations. Davies(2004) suggests that this might be because the potential benefits of traceability offers are not comparable to the cost of work involved particularly for the small to medium enterprises(SME).

5) Training: Training is another trend which is particularly important in the food supply chains given their nature as operator error can lead to damage to the entire organisation and perhaps even to the sector. The case of peanut butter contamination at Peanut Corporation of America (PCA) (FDA, 2009) highlights the interconnectedness of the food sector as more than 2000 products had to be recalled.

6) Credence Attributes: Credence attributes within the food supply chain are defined as the characteristics like country of origin, food miles, ethical sourcing, organic food, carbon footprint etc (Roth, Tsay et al.2008,Henson 2005)which are changing the dynamics of supply chains and are positioned to grow. Glennie et al. (1996) suggests that the 1990s were characterised by the 'creation of myriad sub-groups of consumers in place of earlier and larger class centred constellations'. These 'new consumers' give more emphasis to aspects of quality and convenience than to price and quantity. The retail market growth of organic food rose a staggering 1508 percent from 1994 to 2005 (The Soil Association 2006).

7) Changing consumer habits: There is extensive evidence of changing food habits for example an interesting statistic out of UN FAO report states that the per capita intake of meat in China has grown from 20 Kg in 1980 to 50 Kg in 2007 (FAO 2008). This in turn can create huge pressures on the supply chain entities. Ready meals and processed food are sectors which have witnessed unprecedented growth in the past decade with imports highly processed goods showing a 27.6 percent growth between 1996 to 2005 (DEFRA 2007).

8) Greener Logistics: Green logistics is a more generic trend which isn't specific to the food sector but needs a mention given its importance in supply chain configuration for the future.

RESEARCH METHODOLOGY

The research stems from three research questions:

1. What are the trends affecting next generation food supply chains?
2. What are the risks affecting next generation food supply chains?
3. Can next generation food supply chains be configured with an aim to minimise risks?

The research approach is qualitative and conducted in two stages. The first stage includes secondary data analysis and second stage consists of semi-structured interviews with supply chain professionals within a UK confectionary supply chain. Secondary data in the form of extensive literature review and industry reports from within the field of supply chain design/configuration as well as supply chain risk management is used for content analysis. The data from these secondary sources and interviews was analysed using 'document summary sheets' and 'contact summary sheets' as suggested by Miles and Huberman (1984). Relevant units of meaning were extracted from each source. These units were in the form of quotes, words, and critical incidents (as a complete unit). Based on the risks affecting next generation food supply chains, a framework is developed which provides an insight into configuring food supply chains with the intention of minimising risks and eventually minimising the impact of the risks.

FOOD SUPPLY CHAIN RISKS

Broadly, Supply chain risks have been classified by Kliendorfer and Saad (2005) in two broad categories. First, risk arising from the problems of coordinating supply and demand and second are risks arising from disruptions to normal activities. Christopher and Peck (2003) on the other hand categorise risks into five categories. Firstly those that are Internal to the firm namely Process and control risks. Secondly those risks which are external to the firm but internal to the Supply network, these include demand and Supply. Lastly they categorise risks which are external to the network i.e. environmental.

Although a comprehensive list of risks in the food supply chain is absent a selection of major risks was identified through literature (Peck 2006), Agiwal and Mohtadi (Agiwal, Mohtadi 2008), Roth, et.al.(2008), BBC (2005), CNN (2006), Coghlan (2008), Fairclough (2008), Carey, 2007, Chan, *et al.,* 2008, Gale and Hu (2009), etc. are shown in the table below:

Risk	
Product contamination	Loss of IT
Product recall other than contamination	Unexpected economic forces
Pandemic	Unavailability of Raw material
Loss of Power/Water	Increased labour cost
Loss of premises	New food safety regulations
Loss/Disruption in logistics	Asset price collapse
Terrorism	Fuel price rise
Natural disaster	Loss of supplier
Strike action	

Table 1: Types of food supply chain risks

However what can clearly be seen is that these risks are not mutually exclusive and often materialisation of one risk leads to another for example natural disaster might lead to disruption in logistics or loss of premises. Another example could be that loss of IT might lead to faulty product leading to product recall. This meant that it would make more

sense to analyse the risks with respect to their final impact if not managed correctly (Figure 1). Doing this analysis showed that the impact could lead to either recall of product or loss of revenue or a mix of both, finally resulting in a greater impact of 'Loss of reputation' and in some extreme cases 'Loss of business' (as in the case of the Peanut Corporation of America). In a survey conducted within the UK food supply chain (Dani, Deep, 2009), it was inferred that Loss of reputation (due to food contamination), Loss of power (electrical, oil, etc.), Loss of IT were the risks considered as high by the entities in the food supply chain.

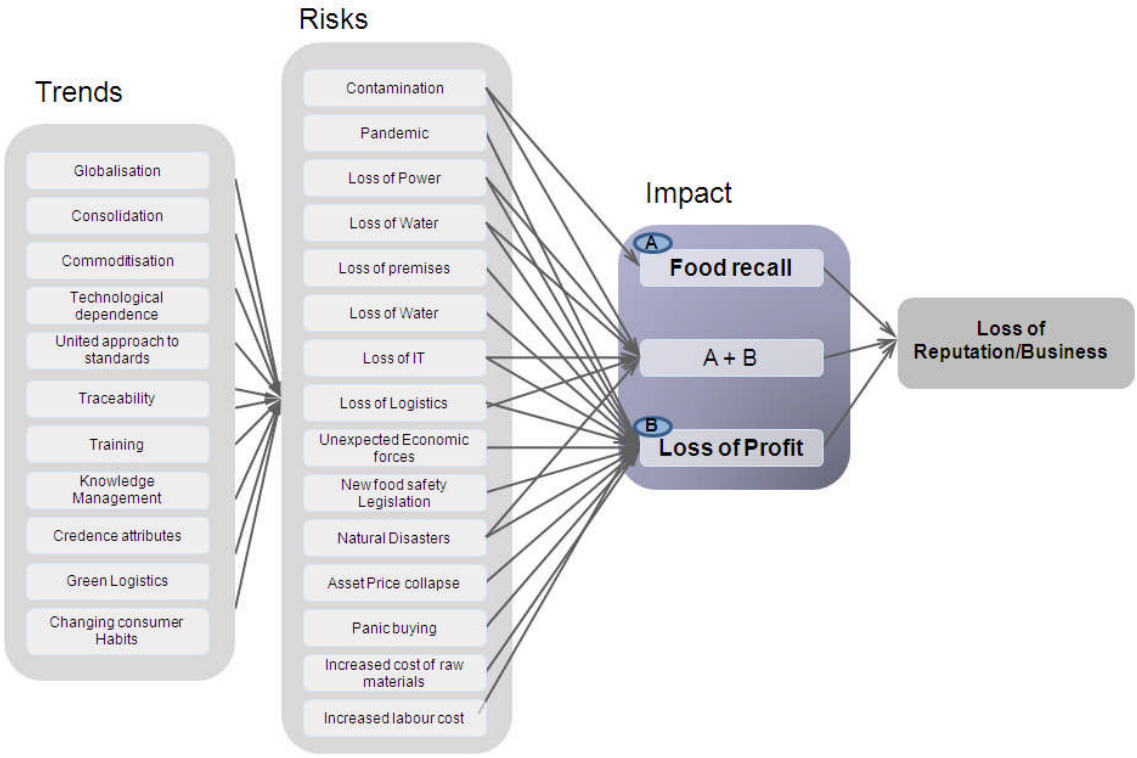

Figure 1: Impact of risks on the food supply chain

CONCEPTUAL MODEL (STITCH)

When configuring supply chains, a number of factors are considered to achieve optimum performance. Some supply chains may be configured around high quality norms, whereas some around low costs (Lean) and other may be configured around customer requirements (Agile, mass customised, Leagile, etc.). Currently, supply chains are rarely configured around minimising risks and /or minimising 'Loss of reputation'. By analysing the data available through secondary sources, semi-structured interviews and considering the future trends affecting food supply chains, a few factors are identified which will be essential for both minimising risks and eventually minimising the larger consequences (impacts) of the risks.

A framework (STITCH) has been proposed which brings these factors together which will provide a useful insight into configuring next generation food supply chains. The standard measures of Quality, Cost and Customer requirements are still valid and the new factors will work towards minimising the impact of risk along with supporting the standard measures. The factors are:

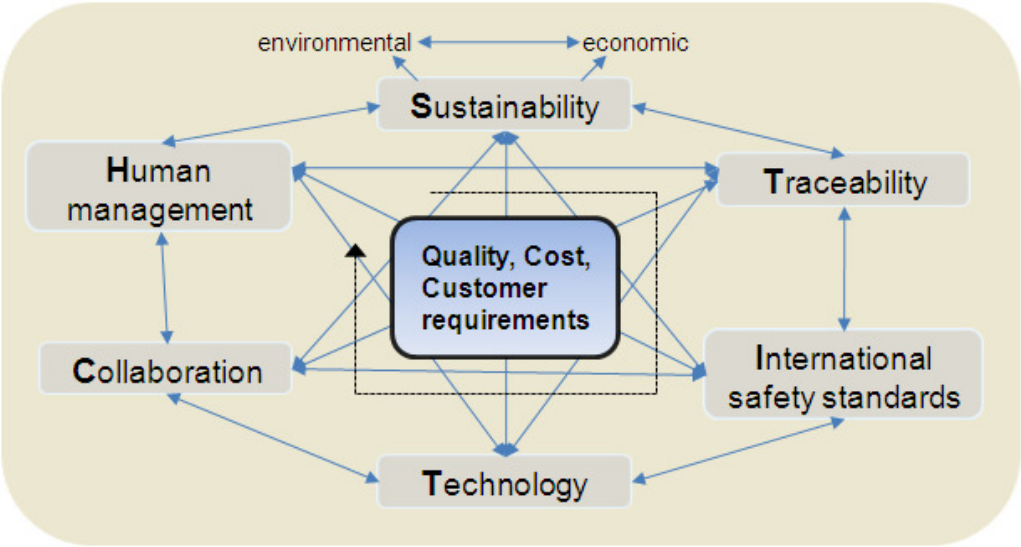

Figure 2: The STITCH model of configuring next generation Supply Chains

Sustainability: Limited supply of raw materials and increasing importance given to credence attributes makes sustainability especially important within the food sector. Sustainability will look at achieving both, economic sustainability (sourcing ethically, at appropriate costs, in appropriate quantities) and environmental sustainability (meeting green legislation, reducing wastage, reducing the carbon footprint, etc.)

Traceability: Traceability emerges as one of the key factors needed to configure the future food supply chains supply chains. Although traceability is linked to technology (RFID), collaboration and International safety standards it stands on its own right as a variable to minimise risks in the supply chain. Traceability is important as processes and systems need to be in place for information to permeate along the complete chain.

International safety standards: Although compliance to standards is common place within the food sector there is evidence of a next higher level of international standards mostly in the form of private standards which are more detailed and are a key to product differentiation. It was observed that the growth of these private standards is increasing and crosses local and economic boundaries. These international safety standards are therefore a key to risk minimisation for future supply chains. Also, as environmental, ethical and safety legislations gets tougher across international boundaries, configuring supply chains in compliance with these standards and also developing the capability of re-configuring based on changes to standards will be essential.

Technology: Technology is playing an increasing role in the supply chains however the use of technology for risk minimisation is an area which has a lot of further potential. It has two aspects: **risk detection** for example detection of contagions and **risk management** through using technology to monitor supply chain coordination and development of early warning systems. Technology also provides the platform for traceability in the supply chain.

Collaboration: Organisations are typically not keen on sharing their weaknesses and risk management practices. However, since food supply chains transcend international boundaries, it is essential for collaboration to develop for compliance with legislation, for food safety and in general reducing wastage in the system. Knowledge sharing and collaboration can be crucial in minimising as well as mitigating risks.

Human management: Human management in terms of both training of personnel and knowledge management appear to be a crucial risk minimisation variable. Human beings in the food supply chain are essential to keep up the compliance, use technology in the correct way, and use the appropriate sourcing guidelines. They are also a key to maintaining collaboration.

All the factors are essential in their own way and the supply chain can be configured keeping in mind only one factor. However, food supply chains are dynamic in nature and the final consequence of food contamination (which is also tied in with loss of life) makes it even more necessary to consider these factors together (as a STITCH) to configure the supply chain. Each factor has a bearing on each other. For e.g. for better traceability, there needs to be better technology, better collaboration and the motivation for the human beings to use the systems in place to make it happen. For achieving sustainability again human involvement (in the form of innovation and compliance) and better technology and improved collaboration are essential.

CONCLUSION

The paper has presented insights from a qualitative study conducted to study the trends and risks affecting next generation food supply chains, and suggest ways to configure the food supply chains to minimise risks. A conceptual model (STITCH) has been developed which considers the important factors relevant for minimising risks and suggestions are provided on how the factors work with each other for the configuration. Although, the model seems to be simplistic, the relationship between the factors as depicted through the links is complex and dynamic. The links between the factors are not tested and correlations may be sought between the various factors to realise the exact effect each has on the other factors. This will help individual supply chains to consider the relevance of the factors for their own scenarios and configure the supply chains based upon the weights applied to the factors. The next phase of the research will endeavour to operationalise the links and empirically test out the factors for their strength in alleviating food supply chain risks.

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