Daftar Isi

Product Characteristic Uncertainty in Supply Chains: Cases from the Food Industry

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Abstract

The food industry is a complex supply chain, where the path of a specific food product may vary and the supply chains within the food industry may have different structures from each other. Another important characteristic of the food industry is the high frequency of new product introductions; this increases choice for consumers and initiates uncertainty related to product issues such as high product failure rates, short product life cycles and high inventory holding costs. Consequently, it is important to understand product characteristic as a source of supply chain uncertainty, how they can be managed and the resulting impact on performance. This research presents a review of the available literature on supply chain uncertainty and related fields, highlights that although product characteristic has been identified as a source of uncertainty, insufficient empirical evidence has been presented. Multi-case study research, using semi-structured interviews, has been conducted across a group of inter-related companies in the food industry in Indonesia to investigate the role of product characteristic in creating uncertainty. The result of analysis helps to refine the concept and provides a basis for detecting and managing product characteristic uncertainty, critical in the current competitive context.

Keywords: supply chain, uncertainty, uncertainty management, food Industry, indonesia .

Abstrak

Industri makanan adalah industri dengan rantai suplai yang kompleks. Produk makanan tertentu bisa saja memiliki struktur rantai suplai yang berbeda dengan produk makanan lainnya. Selain itu, industri makanan juga berciri seringnya muncul produk-produk baru, yang manjadikan pilihan konsumen bertambah banyak dan berakibat timbulnya ketidakpastian produk, misalnya dalam hal resiko produk

gagal, daur hidup produk yang pendek, dan tingginya biaya persediaan. Karena itu, memahami karakteristik produk sebagai sumber ketidakpastian adalah penting, bagaimana ketidakpastian ini dikelola, dan apa dampaknya pada kinerja perusahaan. Penelitian ini memaparkan tinjauan pustaka tentang ketidakpastian pada rantai suplai dan menemukan bahwa meskipun karakteristik produk sudah diidentifikasi sebagai sumber ketidakpastian, bukti-bukti empiris masihlah belum mencukupi. Metode multi kasus, dengan instrumen interview semi struktur telah diaplikasikan dalam penelitian ini. Responden berasal dari perusahaan dalam rantai suplai industri makanan di Indonesia. Investigasi data empiris telah dilakukan untuk mengetahui peranan dari karakteristik produk dalam menciptakan ketidakpastian dan hasil analisa membantu memperjelas konsep dan memberikan dasar untuk mendeteksi dan mengelola ketidakpastian, yang penting dalam konteks persaingan bisnis masa kini.
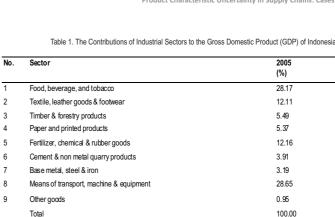
Kata kunci: rantai suplai, ketidakpastian, manajemen ketidakpastian, industri makanan, indonesia

1. Introduction

Uncertainty is generally defined as a decision maker's perceived inability to predict something accurately (Duncan, 1972; Milliken, 1987). An organisation has to manage this uncertainty or perceived uncertainty" because its impacts on decision making and planning in organisations (Matthews & Scott, 1995). Uncertainty is increased as an organisation becomes more global and rely more on external supply chain partners. This issue is prevalent, for example, in a market which is characterised by innovative products, a short product lifecycle, and a wide variety of products (Fisher, 1997). This issue is referred in this article as product characteristic uncertainty. Product characteristic uncertainty is inherent in the Food Industry. Webster (2001) explains that the food supply chain generally consists of primary producers (e.g. farmers), food manufacturers (e.g. dairy, ice cream, and bakery manufacturers), distributors, retailers, and end-customers.

A food supply chain also includes other participating partners such as packaging companies, third party logistics providers, or shipping companies. Maloni & Brown (2006) find that the food industry is an extremely complex supply chain, where the path of a specific food product may vary. Reiner & Trcka (2004) also find that supply chains within the food industry have different structures from each other, which required detailed analysis in evaluating the possible improvements of the supply chain. Another important characteristic of the food industry is the high frequency of new product introductions (Fisher et al., 1994; Beer, 2001; Maloni & Brown, 2006); this increases choice for consumers and initiates uncertainty related to product issues such as high product failure rates, short product life cycles and high inventory holding costs.

Therefore, the food industry is an appropriate choice for the investigation of product characteristic uncertainty. Several reasons can be highlighted: a large number of suppliers and the importance of optimizing the process, product innovation and short product life cycles, mass production with new trends toward mass customization, and globalisation effects that raise food safety concerns. Another important consideration of selecting food industry is because its important contribution to the economy of Indonesia, estimated to represent 27.55% of the total Gross Domestic Product (GDP) of the country (Data Consult, 2006). Given the importance of the food industry to the Indonesian economy (see Table 1), finding ways to improve food supply chain would bring positive benefits to the economy of Indonesia.

Table 1. The Contributions of Industrial Sectors to the Gross Domestic Product (GDP) of Indonesia

No.	Sector	2005 (%)	2006 (%)
1	Food, beverage, and tobacco	28.17	27.55
2	Textile, leather goods & footwear	12.11	11.59
3	Timber & forestry products	5.49	5.76
4	Paper and printed products	5.37	5.25
5	Fertilizer, chemical & rubber goods	12.16	12.66
6	Cement & non metal quarry products	3.91	3.81
7	Base metal, steel & iron	3.19	3.08
8	Means of transport, machine & equipment	28.65	29.32
9	Other goods	0.95	0.98
	Total	100.00	100.00

Source: (Data Consult, 2006)

2. Research Methodology

This study consists of two phases. Firstly, a comprehensive literature review to investigate studies on product characteristic as a source uncertainty and how it is managed. Secondly, an empirical study by employing case study research (see for e.g., Eisenhardt & Graebner, 2007) to rationalize this finding, to enable a better understanding and to extend the knowledge further.

Twelve case companies (see Table 2), which have supply chain links, had been surveyed from early March 2008 until end of June 2008. These companies consist of four suppliers, four food manufacturers, and four retailers. This interrelated links across the case companies are particularly helpful to enable extensive data triangulation, thus increase the validity and reliability of research outcomes (Yin, 2009; Onwuegbuzie & Leech, 2007). Thirty two interviews were conducted with functional managers from the respected case companies and some of them were video recorded. A content analysis approach (see for e.g., Arksey & Knight, 1999) is selected where *Atlas.ti*, a software tool for qualitative data analysis, had been used to analyse data..

Table 2. Overview of case companies

Type	Case	Description
Supplier	S1	Chocolate supplier
	S2	Plastic packaging supplier
	S3	Carton packaging supplier
	S4	Flour supplier
Manu-facturer	M1	Ice-cream manufacturer
	M2	Drinks manufacturer
	M3	Dairy products manufacturer
	M4	Bakery
Retailer	Re1	Major supermarket
	Re2	Major wholesaler
	Re3	Mini-market
	Re4	Traditional (market) store

The data collection is largely based on the perceptions of interviewees, which is potentially a problem. However, everything possible has been done to reduce this potential problem, for example, by collecting extra information, e.g., company reports, company brochures, company websites, etc, to enable the cross-checking of information with interview data (data triangulation) and to increase data validity. *Atlas.ti* has also been used extensively to compare interview data across interviewees; for example, when *Atlas.ti* detects that several interviewees have expressed the same, or a similar perception, for a particular question, then the perception is considered likely to be a correct response. The case study protocol was also tested in a pilot of two case companies: a food manufacturer and a food retailer. The objective of the pilot was to test and improve the case study protocol, develop the skills required from the researcher, and to provide a good insight into the phenomena and sufficient data for analysis.

3. Literature Review

The knowledge about key product characteristics is important in today businesses because it allows a company to innovate, redesign, or repositioning its product. However, studies on product characteristics follow different perspectives (see e.g., Kaul & Rao, 1995; Alegre et al., 2006; Horn & Salvendy, 2006; Salavou & Avlonitis, 2008; Huertas-García & Consolación-Segura, 2009). These different perspectives, for the purpose of this study are called product dimensions. Kaul & Rao (1995) describe product dimensions by its physical specification and attribute. The physical specification dimension refers to the measurable aspects of a product. The product attribute dimension is the factors that complement the product specification e.g. product life cycle, variety etc., and is usually influenced by the customer.

Another study by Horn & Salvendy (2006) suggest that the product attribute is influenced by affect and preference; affect refers to the impact of the product emotionally on the consumer, for example, arousal and pleasure while preference dimension refer to the justification of preference by customers, for example, how customer values creativity and how important is creativity to the customer. Product dimensions may also be explained by its newness to the customer – reflected in the customer perception of innovativeness by using or consuming it – , its newness to the firm – reflected in the level of innovativeness and radicalness to the firm that produce it – , and new product uniqueness as compared to similar products (Salavou & Avlonitis, 2008).

A change in product characteristic may also initiate uncertainty as it influences process, methods and standards on manufacturing it (Charu & Sameer, 2001). Analysing the literature in the supply chain field, this study has identified four product dimensions which initiates product characteristics uncertainty. These four dimensions, explained below, become a major problem for supply chain management as they affect business performance; understating and controlling these dimensions is becoming the key issue for supply chain management. The first dimension is *product specification*, suggested in the study by van Donk & van der Vaart (2005). An uncertainty will be initiated when each customer order has a different product specification.

Here, the set of products to be manufactured is unclear and hence causes difficulty of developing the product. This is an important issue to address because it influences an organisation's ability to plan resources and manage capacity, either to be used or held in reserve. Fagade et al. (1998) added that the issue of product specification uncertainty will also increase complexity; this may give rise to the

manufacturing cost or a delay of product delivery as more time and resources is needed for process design modifications. For example, when one-off or new products are introduced, product specifications may initially be vaguer than is the case for established repeat products. Product specification leads to uncertainty when a product is new and the specification is not yet fully clarified (Donk & Vaart, 2005). Often switching suppliers are needed in response to change in product specification and this also may incur additional cost. Increasing uncertainty in product specification requires greater attention to the supplier relationship as a good supplier relationship may enable the supplier to accommodate specification changes (Olsen & Ellram, 1997; Fynes et al., 2004).

For example, the car industry tends to create an efficient supply chain characterised by standard, mass production output. However, customer preferences of car specification is increasing such as engine, colour, options, and trim level, even for the same model (Turner & Williams, 2005). Product specification uncertainty is also strongly related with quality performance (Ward et al., 1995; Hallgren, 2007). The second dimension is product attributes in terms of *product life cycle*, as discussed in the study by e.g., Fisher (1997), Miller (1992), and Gerwin (1993). They argued that when a product has a shorter life cycle, the unpredictability or uncertainty increases. This is because, when a company continuously launches new products due to short product life cycles, the problems – such as engineering and quality issues – increase. These engineering and quality issues may then result in production outputs, which are at variance with planned production targets. A shorter product life cycles leads to uncertain output volumes, leading to more frequent quality and engineering problems (Sawhney, 2006).

D'Aveni (1995) also discusses how short product life cycle may initiate hypercompetition where business environment is characterised with higher levels of uncertainty, dynamism, and hostility. An empirical study by Davis (1993) – the Hewlett Packard case – finds that with a shorter product life cycle, performance to predict future orders are decreased and variability in the supply chain occurs more frequently. Shorter product life cycle may make quantity commitments more unpredictable (Vaart et al., 1996). However, it is interesting to note that companies may intentionally follow the routes strategy of compressing product life cycle by increasing flexibility to increase its product positioning competitiveness in the market. Decreasing product life cycles means companies pursue to bring new products to market as quickly as possible; this brings competitive advantages such as innovation leadership, quality image perception, market share and profitability (Sanchez & Perez, 2005).

Sullivan (2008) confirms that product life cycle is important in supply chain alignment. Wong & Arlbjorn (2008) and Lockamy-III et al. (2008) explain that demand uncertainty is also caused by short product lifecycle because previous knowledge is irrelevant. Product life cycle also an important factor in determining partnership and long term collaboration with a particular supplier to increase flexibility. A short product life cycle may give rise to implication to companies for production processes, for the way companies are organised and for the way their supply-chains operate (Storey et al., 2005).

Vorst & Beulens (2002) proposed the third dimension – the *perishability of a product* – which creates problems in the supply chain process. Perishability uncertainty may be caused by short shelf life and easy to be damaged (Vorst et al., 1998). For example, fruit and vegetables have a shelf life of a few days only. Seasonal variations or weather may also increase uncertainty for a highly perishable product such as failures to provide adequate air-conditioned transportation or inability to quickly process a perishable product that has limited storage time may cause process stoppages (Vorst & Beulens, 2002).

In addition, some products may be bruised or damaged during the transportation process, and the extent of this is uncertain as it may depend on driving and/or weather conditions. Products perishability often leads to uncertainty in output volumes (Vorst & Beulens, 2002). Here, it is important to create a supply chain system that enables fresher products, less obsolescence and fewer returns from customers. The challenge, however, is to manage trade off between fresher products through frequent delivery and small quantity and the savings through economies of scale in transportation and warehousing activities (Holweg et al., 2005).

The fourth dimension is proposed by Fisher (1997) who suggested that a *high variety of products* will also increase uncertainty because of increasing issues of product mismanagement, for example increasing difficulties in controlling the accuracy of stock level status and product movement. Hence, there is a greater risk of obsolete stocks. In contrast, a company that only produces one type of product has no decisions to make about the product mix or what to stock for any given period. The level of variety offered is a strategic choice, and the higher the level of product variety offered, the greater the uncertainty about demand for the alternative products on offer. The effect of product variety on uncertainty will be reduced if demand volume for each alternative product is relatively stable.

Therefore, four dimensions of product characteristics are identified in the literature as a source that may give rise to uncertainty. For *product perishability*, rigorous empirical evidence in the food industry has already been presented in the literature (Vorst & Beulens, 2002). The authors believe that these issues emerged from their study of case company data in the food industry in the Netherlands. Convincing empirical evidence has also been presented for the *product life cycle* by Sawhney (2006), though this is in the electronics industry, and therefore evidence is needed to establish whether this also exists in the food supply chain.

For the remaining two dimensions, there is no empirical evidence using the definitions of the dimensions as given above. The *product specification* has been discussed in the literature by van Donk & van der Vaart (2005), but only as part of broader uncertainty issues that occur from the demand side of a company. Wong & Arlbjorn (2008) did a literature review and find out that interaction among supply chain, uncertainty, and strategy implementation is rarely been investigated; and also how they these have been employed practically.

4. Empirical Data Analysis of the Four Dimensions of Product Characteristic

The first step of empirical data analysis involves converting all data (e.g., interview notes, recorded audio, other written materials) into a case study database in electronic format which is then organized in *Atlas.ti*. The case study database is important to enable systematic management and subsequent data retrieval. The second step involves creating indices based on categories which are derived from the literature review and research objectives. Indexing data requires a significant amount of time and the functionality of *Atlas.ti* which supports indexing has helped to speed up the indexing process.

It is to be noted that the analysis process is not fully automated and the researcher still plays a critical role. The third step of empirical analysis is data retrieval, where the researcher searches for particular information under specific topics or categories. Here, *Atlas.ti* provides sophisticated tools to speed up the retrieval process.

Using specific parameters like Boolean operators ('and', 'or', and 'not'), the researcher is able to investigate the relationships between extracts from the texts. Information, as an output from this process, is then used in the fourth step of analysis - interpreting data and reporting. By combining interview quotes, advanced information can be generated relating to product characteristics and its dimensions. Data patterns can be identified and explored further and the result of analysis can be transferred into plausible writing and strengthen the picture that the researcher has drawn from the literature review. Figure 1 below presents the steps used to conduct empirical data analysis.

Figure 1. The Process of Empirical Data Analysis

In general, the findings have provided evidence of all four dimensions of product characteristics uncertainty previously identified in the literature. However, each dimension arguably has a different impact on the case companies. For example, the dimension of product specification is the source of uncertainty with the highest perceived uncertainty levels and is of major concern to nine case study companies. The other dimensions are more varied with levels of uncertainty varying among supplier, manufacturer and retailers, hence be argued to be of less importance to the food industry as a whole. below summarizes the empirical findings in terms of evidence of the four dimensions of product characteristics uncertainty. The subsequent sections discuss each dimension of product characteristics uncertainty across the case companies in detail. The dimensions that were found in the empirical data are also cross-checked with the existing literature. The cross-case analysis not only supports the existing literature, it may also bring more depth to the explanations, thereby enabling a better understanding of the concepts previously discussed in the literature.

Table 3. Case Study Evidence

Type	Case	Dimensions of Product Characteristics Uncertainty			
		Specification	Life-cycle	Perishability	Variety
Supplier	S1	X	X		
	S2	X			X
	S3	X			
	S4	X	X		
Manufacturer	M1	X	X		
	M2	X	X		
	M3	X	X		X
	M4		X	X	
Retailer	Re1	X		X	X
	Re2			X	X
	Re3	X		X	
	Re4				X

4.1. The Product Specification Dimension

This dimension was identified in nine case companies (see Table 3). For the suppliers, it is argued that this is at least partially explained by their supply chain position. Because the suppliers are towards the upstream end of the supply chain, it takes longer for information regarding the expectations of customers and the specifications of the products they desire to reach them. When there is a long chain of information, it becomes difficult for a supplier to have a good understanding of end-customer tastes and preferences. In particular, if almost the entire product is customized to the customer order, the uncertainty is high because each product has a different specification.

For example, the purchasing manager of the chocolate supplier (S1) stated that *each customer has their own requirement of product specification and has caused excessive stocks.* The purchasing manager explained that this specific requirement of product specifications had caused difficulties in planning what type of raw material to order, when, and in what quantity. The manufacturers reported that product specification issues were related to their marketing strategy. For example, to maintain their position as one of the major ice cream producers, the ice cream manufacturer (M1) has to continually produce competitive products that match the other competitors' offerings, especially the market leader; this, in turn, leads to product specification uncertainty.

However, it is not an easy task to develop each new specification and whilst it is being developed, there are many uncertainties in the process, such as the raw materials to order and the manufacturing process times. The interviewees from the bakery manufacturer (M4) did not explicitly mention product specification issues in their organisation. This is because they considered other issues to be more important, such as the *product lifecycle* and *product perishability,* as explained below. It is deduced that product specification is not so problematic in the bakery manufacturer (M4) as it is well managed given the close relationships with their suppliers, e.g. the chocolate supplier (S1).

The supermarket (Re1) and the mini market (Re3) also reported this *product specification* issue, for example in fresh foods. Fresh foods represent a significant portion of the mini market (Re3) sales; sales of many fresh food products, e.g., nasi goreng (fried rice), mie goreng (fried noodles), and bakwan (vegetable fritters), depend on the fit between the taste and consumer preference. Here, it is crucial to find suitable foods (i.e., suitable product specifications) that can be sold out in one day. The interviewees from the wholesaler (Re2) also mentioned the importance of new products being offered in their stores, and their policy to review their product portfolio against customer preferences twice a year. However, they did not indicate that this is a problematic issue and therefore it is concluded that it is well managed within this company.

The traditional store (Re4) also sells fresh foods, e.g., from the bakery, but not with the same impact as the mini market (Re3) as they can return unsold products to the supplier. Hence, they do not face the same product specification issues as the mini market (Re3). Although the issue of product specification uncertainty had been raised before in the literature by van Donk & van der Vaart (2005), the case study evidence above adds clarity to this previous literature by giving empirical evidence of the presence and effect of this source of uncertainty. For example, van Donk & van der Vaart (2005) discuss the automotive sector in which volumes are relatively stable, but there is a need for flexibility in the mix of products made.

Similarly, in their empirical evidence from a pigment producer, they indicate that uncertainty about the mix is pertinent. Hence, most of their discussion refers to mix and specification together rather than looking at product specifications separately, implying that the main issue is in terms of uncertainty about which products are to be made rather than the specification itself. From the case study evidence presented in this article, it is concluded that uncertainty in the specification itself can be problematic in the food industry as it can be particularly difficult to determine the right recipe for each new product. This leads to uncertainty, for example in terms of raw materials to purchase, as well as in output volumes until processing times are clarified. This can affect all members of the food supply chain, as major supermarkets also take part in determining the right recipe for the products they sell.

4.2. The Product Life Cycle Dimension

The second dimension – *product life cycle* – was identified in six case companies (see Table 3), especially when the life cycle of the product is short. For example, the marketing manager of the chocolate supplier (S1) stated that they *do not know how the market will respond to a new product and whether a customer order will be repeated in the future.* Here, there were many cases of short product life cycles as customers may unexpectedly withdraw orders that they had already placed with S1 without any prior notice. The analysis of case study data suggests various reasons why a customer may withdraw its planned order. For example, a customer may claim that they lack sufficient financial resources, the product is being redesigned, or sales promotions have failed to increase demand sufficiently.

A short product life cycle or even a one-off order can disrupt the chocolate supplier's (S1) operations with knock-on effects in the supply chain because the company has to change its production plan and cancel orders from its suppliers. The plastic packaging supplier (S2) and the carton packaging supplier (S3) also reported unpredictable product life cycles, but not with the same impact as the chocolate supplier (S1) or the flour supplier (S4). The logistics manager of S2 stated that their product, *e.g. a plastic bottle ordered by a customer, can be used for two to three years, and only the label is changed.* The logistic manager explained that it was less problematic to redesign the label; this means that the *product life cycle* issue is well managed in this company.

The carton packaging supplier (S3) obtains the product from its sister companies that have manufacturing facilities; this also means that this is a less problematic issue because the impact of the problem is also tackled by the sister companies. As with the chocolate supplier (S1) and the flour supplier (S4), the four manufacturers (M1, M2, M3, M4) are relatively quick to renovate or to update their products in the market besides the launching of new products; they reported many cases of short product life cycles. For example, the purchasing manager of the dairy manufacturer (M3) stated that p*owdered milk product, which is a product for the medium to upper level income market, has the highest frequency of product review and may change four to five times per year.*

This is because of the importance of continually analysing sales performance for each product, and being ready at any time to update or launch new products into the market and replace current offerings in order to maintain competitiveness. Therefore, the company has to stop production of any uncompetitive product, even though it may mean that the life cycle of the product is shorter than expected. This case study evidence strengthens arguments by Miller (1992) and Fisher (1997), who stated that the short life cycles of products could be a source of uncertainty due to the need to introduce new products; short life

cycle products may also cause knock-on effects, for example, in terms of more frequent engineering and quality problems that are associated with new products.

4.3.   The Perishability of a Product Dimension

The third dimension of the product characteristic, i.e. *the perishability of a product*, was identified in four case companies (M4, Re1, Re2, Re3), see details in Table 3 . The other eight case companies did not raise this issue because they do not sell perishable products. The baked goods of the bakery manufacturer (M4) have a short shelf life and obsolescence; this is a major issue for the company. The marketing manager of M4 stated that they *have had cases of products expiring in traditional stores because of wrong product placement on the shelf as the retailer did not sell on a FIFO basis.* The marketing manager explained that unsold products could be returned to the manufacturer. Hence, the bakery manufacturer (M4) holds the risk. The retailers (Re1, Re2, Re3) that sell fresh foods, e.g., vegetables, fruits, meats, etc reported perishability as being of particular concern because fresh foods have short product shelf lives and make up a considerable part of their product portfolios.

 The purchasing manager of the wholesaler (Re2) stated that fresh foods is a problem *because of their short shelf life and many cases of rotten food because of overstocking.* It is important to determine the optimal stock of fresh foods to minimize losses, because the wholesaler (Re2) pays in cash to source the fresh foods from the farmers. Hence, the retailer bears any unsold product costs. However, a retailer (Re1-Supermarket) has been identified as using a pricing strategy to encourage consumers to buy the product before they pass their best date, hence this reduce wastage. The traditional store (Re4) sells bakery products that have a short shelf life. However, as mentioned before, they can return unsold products to the supplier. Therefore, the empirical evidence presented here confirms the importance of this issue for the food supply chain, as discussed by van der Vorst & Beulens (Vorst & Beulens, 2002), but only where fresh foods are involved with a short shelf life and only where the risk is borne by the company concerned.

4.4.   The Product Variety Offered by the Firm Dimension

The fourth dimension, i.e. *the product variety offered by the firm*, was identified in five case companies (see Table 3). The purchasing manager of the supermarket (Re1) stated that p*roduct dynamics, for example introducing new varieties, is unavoidable as this is their key competitive advantage*. This becames an issue because any mismanagement of the products may cause a great deal of obsolete stock; this may also include obsolete raw materials, as in the cases of the plastic packaging supplier (S2) and the dairy manufacturer (M3). Fisher (1997) explained that a greater variety of products will increase the difficulties of controlling the accuracy of stock levels and product movements; thus there is a higher chance of obsolete stocks.

The case study data supports Fisher's argument, as in the case of the plastic packaging supplier (S2), where a high level of product variety increased difficulties in planning optimal purchasing quantities for raw materials and production quantities of finished products. The product variety in the traditional store (Re4) is small compared with the other larger case companies mentioned above. However, as the interviewee stated, the product variety is comparatively high for their small scale business, and that this is because the traditional store tries to provide as many different products as possible.

They believe the completeness of their product portfolio gives them a competitive edge, enabling them to win customers from other traditional stores in that area.   This high variety of products, however, creates losses such as unsold products and damaged products caused by obsolescence and mishandling.   The other case companies did not raise *product variety* as being of particular concern because they have a limited product variety. For example, the carton packaging supplier (S3) has standard product shapes; the customisation is in the printing, labelling and sizing.

Only the carton packaging supplier (S3) has low uncertainty across all dimensions of product characteristics. This is because the company does not have a manufacturing facility, but instead submits the orders to the sister company abroad. Here, the problems are shifted to the sister company as they have to understand and translate orders into real products that satisfy their customers. S3 may still play an important role, especially at the beginning of the process to understand customer requirements and customer service after product delivery. Thus, it faces some uncertainty too but considers this to be at a low level.
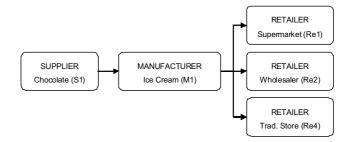

Figure 2. Ice Cream (M1) Supply Chain

It is to be noted that the discussion above is focused on firm-level issues. However, further analysis of case study data suggests potential issues at the supply chain level. For example, the ice cream manufacturer (M1) faces a product specification issue (see Figure 2 above). Here, the production manager of M1 explained that to achieve a unique formulation that brings new and better taste to the end-customer, they have to select competent suppliers and develop partnerships with them. Product specification becomes a supply chain issue if suppliers have problems, such as, a longer time required to produce the raw material, or raw material scarcity; these are experienced by the chocolate supplier (S1).

The issue became more problematic when the ice cream manufacturer (M1) relied totally on the chocolate supplier (S1) to supply its chocolate raw material because they had suffered negative experiences with other chocolate suppliers. This dependency increases supply chain vulnerability if product specification issues materialise; this issue also has knock-on effects for the retailers, for example in terms of delayed deliveries and products being out of stock.

5.   Conclusion

Taken together, the results of the analysis of firm-level cases have enhanced understanding of product characteristics uncertainty by providing empirical evidence to support previous studies and clarification to previous studies which proposed the dimensions but lacked explanation or empirical evidence. The product specification, such as colour, length, size, packaging, can lead to uncertainty in processing times, e.g., when a product is new and the specification is not yet fully clarified.

It is not an easy task to develop each new specification and whilst it is being developed, there are many uncertainties in the process, such as the raw materials to order and the manufacturing process times. The product lifecycle may lead to uncertain output volumes, as there are more frequent new product introductions, leading to more frequent quality and engineering problems. A short product life cycle potentially disrupts the operations of a company with knock-on effects in the supply chain; the company has to change its current production plan and notify its suppliers that they too must cancel orders. The perishability of products also leads to uncertainty, such as in term of output volumes.

For example, it is difficult to determine the optimal stock of fresh foods to minimize losses caused by any unsold product. The product variety offered may lead to uncertainties such as the quantities of product to stock. A large number of product varieties would increase difficulties to plan optimal quantity of order for raw material and production for finished product, and increasing case of stock out or stock obsolescence.The product characteristics uncertainty is inherent in the food industry. The finding suggests that product characteristic is a source of uncertainty which is challenging but important problems.

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