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Coping with unpredictable supply: the role of flexibility and adaptation

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Abstract

Purpose – This paper aims to address how firms cope when input due to primary uncertainty is unpredictable, and thus timely and adequate supply to customers are impossible to guarantee.

Design/methodology/approach – Two sets of data are applied to capture uncertainties, flexibilities and adaptation strategies amongst suppliers and producers respectively.

Findings – The findings show that flexibility is a prerequisite to cope when faced with unpredictable supply. Flexibility comes in many forms. They are partly firm-specific and can be conceived as a valuable resource.

Research limitations/implications – The present study is limited to one industry only.

Practical implications – Unpredictability imposes the need for adaptations, which requires flexibility. However, adjustment to the new landscape is a prerequisite to succeed.

Originality/value – This paper offers insight on how firms cope when needed input to operate is unpredictable, i.e. an almost neglected topic in the marketing literature, where adequate supply in most cases is seen as unproblematic.

Keywords Primary uncertainty, Unpredictable supply, Adaptation and flexibility, Uncertainty management, Supply

Paper type Research paper

Introduction

It is almost a truism that adequate and timely supply is a pre-requisite for customers' and producers' value creation, making it possible for customers to reach their consumption goals, whatever they may be, and allowing the producer to stay in business, survive, and prosper (Vargo and Lusch, 2004). In much of the marketing literature supply is considered important, but unproblematic. In many industries supply is "secure" due to storage and/or predictable supply. In such industries marketing tends to focus on surveillance of and interaction with customers and adjustments of products/service offerings in order to keep them loyal and satisfied. However, this is not always the case. In some industries, e.g. the seafood industry, which will be addressed here, supply of raw material is almost unpredictable (cf. Ottesen and Grønhaug, 2003; Prochaska, 1984). How is it possible to cope in markets where the customers hold well-established preferences, i.e. they demand fresh, high



quality products, but where uncertainty regarding the volume, quality and timing of the catch is high, making it almost impossible to guarantee a timely and adequate supply of the products demanded? This paper addresses how industry actors cope in such situations to survive and prosper. Due to unpredictability adjustments must continuously be made. For example, firms may be forced to adjust the products and volumes offered. However, such adjustments presume various forms of flexibility. Thus, the key focus in this paper is to improve our understanding of the linkage between unpredictable supply of critical input factors (supply uncertainty), adaptations and flexibilities and the firms' serving of customers to stay in business and prosper.

The remaining part of this paper is organised in the following way: The next section addresses adaptation and flexibility. We have chosen to do so because adaptation is a pre-requisite to staying in business in hostile ever-changing environments. Moreover, adaptation signifies change, and in order to change flexibility is a pre-requisite. The forms of adaptation are many, and so are the forms of flexibility. Adaptation, to be relevant, must, however, be adjusted to the context and actual changes encountered. The environments in which the firms are embedded, and where the changes are taking place, are associated with uncertainty. The subsequent section discusses some consequences of supply uncertainty for central interdependent actors in the value system: the supplier, the producer, and the customer. In this paper the analysis is kept at the industry level. However, an industry is comprised of the aggregate of its individual actors. Focusing on the aggregate of actors and their behaviours thus allows us to capture the full range of adaptation and flexibility in this industry, which is also of key importance for marketing.

After this, we introduce our tentative perspective to guide and direct, but not dictate, our empirical investigation, followed by a presentation of our research methodology, encompassing two studies, each based on multiple data sources, and our findings. Finally, the findings are summarised and discussed, and the implications of the findings and need for future research is addressed.

Adaptation and flexibility

Firms are embedded in ever-changing, partly unpredictable environments. In order to survive and prosper they do their best to exhibit purposeful, i.e. goal-directed, behaviours. In addition, firms need to adjust or adapt to changes in the business environment. The concept of "adaptation" signifies a change or an adjustment. For example, a firm may get a request from one of its most important customers to modify its product, or a supplier may be told that the expected quantity it needs to deliver is far higher than its current expected capacity. If firms respond positively to such signals they exhibit adaptive behaviours.

Why do firms adapt? A firm can be conceived as an "open system" (Katz and Kahn, 1978), implying that it is dependent on input from others, on transforming the input, and on exchanging its output at prices that at least cover its costs (at least in the long-run) in order to survive and prosper (Pfeffer and Salancik, 1978), and a system where excess profit is conceived to be advantageous.

Adaptation requires effort, resources and knowledge, i.e. knowledge about what to do, for example how to handle a sudden threat or exploit an emerging opportunity, as well as the capability or flexibility to handle necessary changes imposed by adaptation.

Firms exhibit adaptive behaviours in their self-interest. Firms and their managers choose to adapt because they conceive it to be the best way to take care of their self-interest. They do so within the limits of their restricted resources and constraints of their prior investments. Firms and their managers (as other human beings) are also constrained by their limited cognitive capacity, or as termed by Simon (1957), their “bounded rationality”. This does not, however, imply that they behave “irrationally”. Rather, they try to exhibit goal-directed, rational behaviours within the limits of their cognitive constraints.

Multiple forms of adaptation and uncertainty

Adaptation, and thus flexibility, comes in many forms. For example, Håkanson (1982) distinguishes between adaptation of product specifications, product design, manufacturing process, planning, delivering procedures, stockholding, administrative, and financial procedures. Brennan *et al.* (2003) classify adaptation as productive planning and scheduling, stocking, holding, production process, finance or contractual terms and conditions, organisations structure, and others.

Similarly, multiple forms of flexibility have been identified:

- labour;
- product;
- operation;
- expansion; and
- production flexibility.

Sethi and Sethi (1990), for example, found more than 50 characteristics related to flexibility limited to the literature on process and production only. (For a detailed review of the literature, see Dreyer, 1998.)

If the purpose was to make a classification (suitable for capturing any type of adaptation in every context), the classification would either have to be very comprehensive, or the category used so general, that any type of adaptation could be subsumed in any of the categories included. Similarly, relevant flexibilities for the necessary adaptation are context and situation specific. Contexts and situations are numerous. Accordingly, relevant adaptations and flexibilities need to be identified for the actual, individual firms in their respective contexts.

Uncertainty

In the research literature several types of uncertainty have been recognised (see Sutcliffe and Zaher, 1998 and Miller and Schamsie, 1999 for reviews). Sutcliffe and Zaher (1998, p. 6), for example, distinguish between primary uncertainty, competitive uncertainty, and supplier uncertainty. They conclude that primary uncertainty “arise from profound lack of knowledge of the state of nature” and include the uncertain outcomes of a range of exogenous changes in the broader environment. Supplier uncertainty relates to exchange patterns. For example, suppliers may act opportunistic (Williamson, 1975). Competitive uncertainty relates to competitors’ actions (Porter, 1980). For example, what competitors will do next may be unknown. Here, primary uncertainty is seen as the main challenge.

Supply uncertainty and central actors

As noted above, a timely supply of the products/services demanded is almost considered to be a pre-requisite for the firms to be able to survive and prosper in much of the marketing literature. According to the authors, this can be seen as an artefact caused by a focus on industries and marketing situations where a buffering of supply (Thompson, 1967) is seemingly rather unproblematic. However, in industries such as the fish processing industries, as addressed here, there is a close connection between supply and performance, complicated by the fact that the supply situation is uncertain.

In the literature addressing dynamic capabilities and flexibility the attention is also directed towards other forms of uncertainty than changes in volume and products in the market place, such as for example supply uncertainty. Admitting that several forms of uncertainty exist also leads to a wider set of appropriate strategic actions at hand in order to respond and prosper. In industries where firms have limited resources and information available in their efforts to respond properly to changes, flexibility is acknowledged as an important source of competitive advantage, in particular in turbulent settings.

According to the open-system perspective indicated above, firms usually need various types of input in order to produce an output that can match the competition in the market place, indicating that supply is important. This issue has been addressed in the vast literature on purchasing and logistics. For example, White and Hanmer-Lloyd (1999) argue that a firm's competitiveness in the output market is increasingly dependent on its ability to differentiate itself in the input market, and claim that the firm must "... vigorously utilise the opportunities that the input market represents" in order to obtain exclusive access to externally sourced competencies (White and Hanmer-Lloyd, 1999, p. 3).

In the industry being analysed here, supply is based on catches of wild fish. Both quantity and composition of the catch are partly uncontrollable and unpredictable. Also, the industry has long-standing traditions, and customers hold well-established preferences. Thus, the uncertainty does not relate to customers' (buyers') preferences and willingness to buy, but rather to secure sufficient supply. Further, the producer (marketer) does not operate in a vacuum. As reflected in the open-system metaphor the producer is dependent on suppliers (who usually are dependent on their suppliers). Stated another way, the suppliers, producers, and customers are all interlinked parties in a value system (Porter, 1980). Both the supplier and the producer have self-interests, and they want to stay in business, prosper, and survive. The customer has self-interests as well. How do they cope when supply is uncertain, as illustrated by this particular industry?

A tentative perspective

To cope with and try to enlighten the above question, we have developed a tentative perspective (see Figure 1). The tentative perspective can be viewed as our "glasses"; a way of seeing and capturing the actual problem. A perspective, either stated explicitly or implicitly, has implications for the collection of data and subsequent interpretations, and thus also for suggested arguments and explanations. In our view, an explicit perspective makes it easier for readers to evaluate the actual research approach, choices, and interpretations of findings. Thus, the purpose is not to dictate, but to guide and direct, our investigation, as well as making it easier for readers to assess our findings and conclusions.

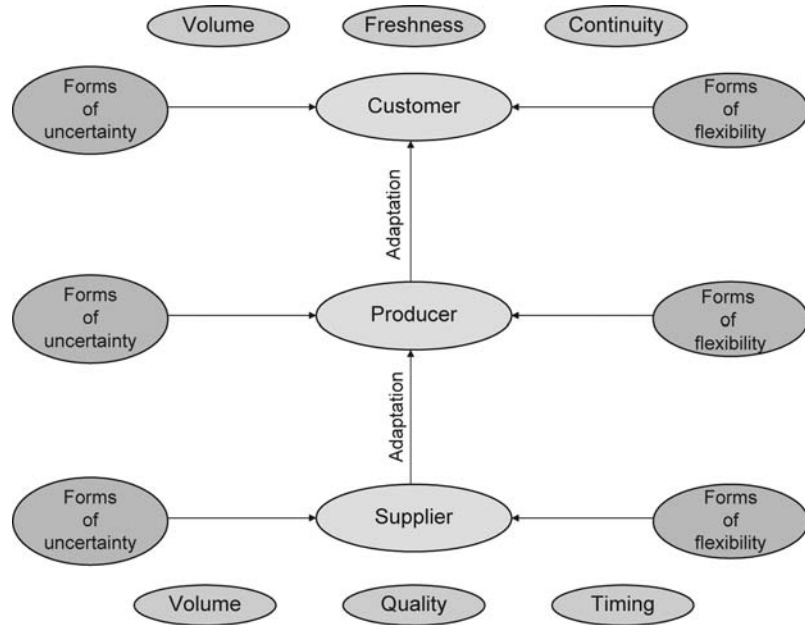


Figure 1.
Actors and challenges

Figure 1 is to be read as follows: Starting at the bottom line we see that the suppliers face uncertainty both with regards to volume, quality, and timing of the catch. Of key importance is what form of flexibility the supplier acquires/develops, and how they adapt to serve the producers in order to stay in business, and to maintain a competitive edge. Next, the producers face the uncertain supply situation; which forms of flexibility do they develop/acquire and how do they adapt in order to keep their customers? Finally, the customers face the uncertain supply when preferences dictate a certain level of continuity and freshness. How do they adapt in order to best satisfy their needs? Thus, this rather general perspective, influenced by the idea of a value system and the open-system metaphor, indicates a link between uncertainty, adaptation and the forms of flexibility developed.

Research methodology

In this section we present the research methodology that serves as the basis of our investigation to identify forms of uncertainty and flexibility of relevance for the actors involved as well as their strategies of adaptation concerning the unpredictable supply situation.

The selected industry, i.e. the Norwegian seafood industry, is a long-standing, traditional industry organised in a value system encompassing a harvesting part (i.e. fishing vessels) that supplies the fish processing plants along the coast with fish. The industry, which largely consists of small and medium-sized firms, produces a wide range of products that are primarily sold on the international food market. The industry is heterogeneous in terms of firm size, products offered and firm performance.

Returning to Figure 1 it is established that the research challenges here are to identify different forms of uncertainty for the three groups of actors involved,

i.e. suppliers, producers, and customers, as well as the forms of flexibility, or coping strategies, necessary in order for these groups of actors to adapt properly. Moreover, a central challenge is to bring forth valid insights. Here, this signifies the identification of “real” and important forms of uncertainty and flexibility, and the application of adaptation strategies suited to produce a proper response.

In the study two sets of data sources were applied. One data set relates to uncertainties, flexibilities, and adaptation strategies among suppliers. The other data set relates to capturing the same information for producers. It should also be noted that forms of uncertainty and flexibility identified at one level have implications for the subsequent level in the value system. Uncertainties and forms of flexibility, as well as adaptation strategies, for customers were inferred. The methodological approach chosen was inspired by empirical economic research with emphasis on longitudinal data and quantitative techniques.

The first set of data to identify forms of uncertainty, flexibility, and adaptation strategies among suppliers includes available statistics concerning catches of cod, price statistics, and firm structure for the years 2000-2006. Available statistics have been applied to capture prices, seasonal variations, vessels involved in the harvesting, and development and variation of quotas, as well as estimations by use of an econometric model to capture the net sales value of different applications of cod caught and kept alive (see Appendix 1 for further details on uncertainty assessments).

In order to identify uncertainty, flexibility, and adaptation strategies among producers we applied a database containing data of, among other elements, survival, profitability, costs, and investments among a population of processing firms. The data are very detailed, updated yearly, and covers a period of more than 20 years.

Uncertainty relates to variations. In order to identify forms of uncertainty, those factors showing the greatest variation were identified. Relevant flexibilities were identified by comparing 35 low-performing firms and 35 high-performing firms to see how they coped with the various forms of uncertainty. Flexibility is thus reflected through the ability to handle unpredictable changes. The identification of forms of flexibility was guided by a thorough review of how various types of flexibility have been defined and captured in previous research (Dreyer, 1998; Dreyer and Grønhaug, 2004).

Based on the identified sources of uncertainty (see Appendix 1), and relevant theories from the literature, the following flexibility measures were constructed (see Appendix 2).

Volume flexibility, measured as fluctuations in annual quantity of fish processed by each firm over the period studied. Two measures are developed; one is based on the standard deviation (VOL1), and the other accounts for the differences between maximum and minimum volume (VOL2). Both variables relate the fluctuation to average annual volume (for further details related to measures of flexibility, see Appendix 2).

Product flexibility was captured by four measures of changes in firms' product-mix during the chosen period. Two of the variables (PROD1 and PROD2) are based on the fluctuation in volume produced of the firms' main product. Another two are based on how much production volumes fluctuate on average in the four main product categories processed by the industry (ANVTOT1 and ANVTOT2). In order to examine to what extent this form of flexibility is given priority, the fraction of the total investments spent on modernising the production equipment during the chosen period is also measured (INV1).

Fluctuations in annual labour costs (ARB1 and ARB2) capture labour flexibility. Financial flexibility is measured by the firms' cash position (Net liquidity balance). (RISK) is measured by the relationship between financial result and investment level.

Productivity (EFF) is an annual index that measures the relative productivity position of one individual firm compared to the rest of the firms in the industry studied.

Findings

In this section we present the findings from our investigation. In turn, we present findings related to suppliers, producers, and finally customers.

Suppliers

In order to maintain sustainable fisheries, an annual quota to be caught is established based on continuous measurements on the development in the most commercially interesting stocks of fish. The annual quotas fluctuate due to both historical catches and biological variations. Figure 2 shows the annual Norwegian quotas for cod, which is the key species in the value system studied here.

Inspection of Figure 2 reveals great fluctuations. The fluctuations cause an urgent need for flexibility to utilise the capacity of the vessels involved. Further complicating the matter is the fact that the catch does not only fluctuate across years, but also during the year. Approximately 80 per cent of the annual catch is caught during the months of January through May. The fluctuations are caused by fish migration patterns and weather conditions. This traditional catch also results in quality variations.

A variety of possible solutions to moderate supply fluctuations have been developed and tried over the years. These encompass solutions such as building robust vessels allowing for fishing during adverse weather conditions; freezing the catch on board, and giving onshore processing plants access to ownership of vessels, i.e. upstream vertical integration. These solutions have, however, not been very successful. For example, more robust vessels are costly, and they do not alter the fish migration patterns. Freezing fish on board the vessels helps conserving the catch, but frozen fish is considered to be of lower quality than fresh fish, it is less appreciated by customers, and thus attracts lower prices. Also, in order to fully exploit vessel capacity, vessel

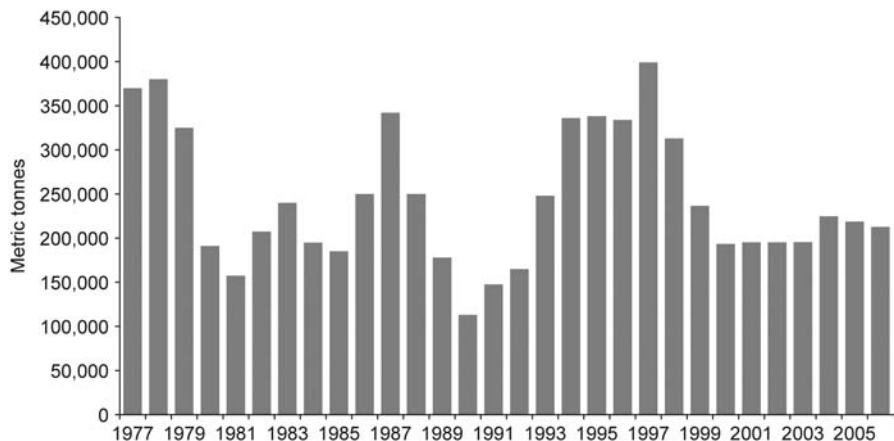


Figure 2.
Fluctuations in annual
quotas of cod

owners try to expand their portfolios of quotas. However, present legislation only allows actors to buy a limited number of quotas. Most vessels have access to quotas for other species. This gives them input flexibility by switching from catching one species to another, according to how prices and quotas fluctuate to exploit the vessel capacity.

Volume flexibility is also important for coping with fluctuations in the catch (see Figure 2). One important way of achieving this type of flexibility is by having sufficient catch capacity in periods when the quotas are high. This is achieved by variations in the length of time at sea to catch the allotted quotas and by motivating the staff to stay extra time onboard by paying the crew a fixed portion of the sales revenue. However, this capacity position and pay system causes slack in catch capacity and decreases income for the crew in periods with low quotas.

The fluctuations – both across years and months – pose serious challenges for producers in their efforts to serve their customers on a regular basis, according to their preferences. A new solution has emerged more recently, i.e. so-called catch-based aquaculture. The underlying idea is to catch the cod in periods when the fish is close to shore and easy to catch, keep it alive, and feed it to better serve the market demand for fresh cod on a regular basis. This strategy has some obvious advantages. Because prices fluctuate inversely with the volume caught, decreased fluctuations in catches allow for higher prices and thus higher profitability. In addition, reduced fluctuations will allow for the same volume to be caught with less total capacity, which in turn may result in improved capacity utilisation.

In a study of the implementation of this strategy, however, several barriers were also detected (Nøstvold *et al.*, 2007). Suppliers applied new technology in order to develop their flexibility, both in terms of handling volume fluctuations, and changing their product selections. When inspecting live-caught volumes and comparing them to the development of cod quotas, we revealed a pattern indicating that during periods when quotas were low, the volumes of cod caught alive increased. Conversely, in periods when quotas were high, the volumes of cod caught alive decreased. This pattern indicates increased flexibility among suppliers due to this new technology. Many vessels chose to catch cod alive, but the volumes were rather small and this strategy was only applied for shorter periods in some years. This approach indicates that they have the flexibility needed to change their harvesting strategy, but that they still prefer to catch fish the traditional way, even though prices for cod caught alive is 30-40 per cent higher. Why so is a puzzle. Probably a part of the explanation is established habits and ways of doing things. Another is that keeping fish alive is more time-consuming and less efficient.

Producers

As shown in Table I and in Appendix 1, producers are challenged by great variations in input volume. Product-mix, use of labour, and profitability fluctuate enormously. Also, these variations are more or less unpredictable, primarily caused by variations in input. The supply of fish can be used to produce a variety of products. The technological barriers to changing the products and product mix are modest. Changes in product mix create fluctuations in product margins. Accordingly, shifts in margins should serve as motivation for shifts in product mix for firms in order to secure its competitive position in the raw materials markets. Thus, to perform in the best possible way producers must produce the mix of products with the best margins in order to secure input of cod. Moreover, firms vary in their ability to utilise this form of product flexibility.

	Failures		Survivors		<i>t</i> -value
	Mean	SD	Mean	SD	
<i>Volume flexibility</i>					
VOL1	0.209	0.128	0.354	0.210	3.42**
VOL2	0.421	0.297	0.845	0.490	4.32**
INV1	0.517	0.279	0.613	0.265	1.48
<i>Product flexibility</i>					
PROD1	0.189	0.130	0.296	0.187	2.80*
PROD2	0.380	0.256	0.701	0.455	3.63**
ANVTOT1	0.641	0.198	0.722	0.237	1.52
ANVTOT2	1.319	0.456	1.682	0.588	2.85*
<i>Labour flexibility</i>					
ARB1	0.218	0.134	0.283	0.263	1.30
ARB2	0.467	0.309	0.674	0.617	1.75
<i>Financial flexibility</i>					
Net liquidity balance	-0.243	0.301	0.125	0.271	5.47**
RISK	-0.160	0.135	0.004	0.135	5.18**
<i>Productivity</i>					
EFF	0.695	0.213	0.756	0.132	1.47

Note: *Significant at < 0.01; **significant at < 0.001

Table I.
Flexibility among low-
and high-performing
firms

It was also hypothesised that the best performing firms possessed a higher degree of the forms of flexibility needed than firms whose performance was not as good. Table I shows the mean scores (and standard deviations) for the various forms of flexibility in the two groups studied.

A closer examination of the mean scores for the two groups reveals that the scores for all the flexibility measures are higher among the high compared to the low performing group of firms. Also, most of these differences are statistically significant. In assuming (somewhat unrealistically) that the various flexibility measures are unrelated, the probability for such a result by chance is $P(B = 12) = 0.002$; $p = 0.5$, $n = 12$.

The various flexibility measures do, however, correlate to some degree. Through a multivariable analysis, i.e. logistic regression analysis (see Table II), of firms that survived and firms that went bankrupt, it was established that financial flexibility (RISK and Net liquidity balance) is the most important form of flexibility, followed by volume and product flexibility. However, most important is the combination of these forms of flexibility. Further inspection of Table II also reveals that the combination of these forms of flexibility is important in explaining variations in competitive advantages and financial performance among processors in this value system. From Table II we also see that almost 90 per cent of the firms were correctly classified into the two groups.

The identified forms of flexibility are no doubt of importance for the survival and profitability of firms. The extent to which firms possess these forms of flexibility can, in our opinion, also be conceived as firm specific competencies or resources. The identified forms of flexibility do not, however, decrease fluctuations in supply of the product offering demanded by consumers, i.e. fresh cod, and thus they cannot guarantee a timely supply of the same product offering.

Customers

This article stated that customers in this industry hold well-established preferences, and that they, in principle, want stability in supply. Despite efforts by actors at preceding stages in the value system to cope with unpredictable supply, the customers are still exposed to variations in supply of the preferred product.

The customers stay loyal and they are satisfied. Can this be explained? Customers are not “blind”. They learn realities. They learn that seasonal variations exist, for example, as in former days, that strawberries are available and taste best during late summer, but also that variation in supply may depend on geographical location and weather conditions. Learned realities relate to learned expectations. As long as supply in an industry stands up to learned expectations, customers remain satisfied (Oliver, 1997).

How do customers cope with variations in supply? They learn about other alternatives and they seek variety. They also learn to switch in a conditional way. For example, a customer is looking for a product “X”. When this product is unavailable, it elicits the search for an alternative product “Y”. In the value system studied here, the customers have to adapt to a situation where supplies fluctuate. One way of adapting is to adjust consumption to the available supply, i.e. to adjust to a seasonal consumption pattern. Accordingly, consumption of fresh food often fluctuates according to harvesting strategies that more or less balance consumer preferences and biological production. In only some parts of the year the quality and access match customer preferences. During these parts of the year the consumption reaches a peak. When preferences and access are more difficult to match, consumption is at its lowest.

The consumption of fresh fish used to be limited to an area close to the area where the raw materials were caught or grown. As technology and logistics have developed, alternative adaptation strategies have emerged. In order to meet consumer demands during those parts of the year when supplies are insufficient, technologies have been developed to extend the period from production to consumption without quality loss. Another way of adapting is to search for alternative suppliers both in other regions and in other value systems. For example, switching from supplies from wild catches to supplies from aquaculture. As time and costs in transporting raw materials and products decrease, food markets in general, and fresh food markets in particular, are, to an increasing extent, supplied with products grown and caught in other parts of the globe. This, however, is also an indication that suppliers and producers in the value system, described here, are challenged by global competitors and competition.

Logistic model	B	Wald	Sig.
VOL2	4.83	4.91	0.026
PROD2	4.84	4.07	0.043
ANVTOT2	2.66	4.04	0.045
ARB2	-1.57	0.56	0.459
Net liquidity balance	3.53	1.73	0.189
RISK	28.81	7.38	0.006
Constant	4.69	4.41	0.036

Notes: Class result: $n = 65$; Number of misclassifications = 7 (10.7%); Number of correct classifications = 58 (89.3%). Fit: Chi-square: 57.66; Sig = 0.0000

Table II.
Logistic regression
analysis of the impact of
six types of flexibility on
performance

Discussion

The above discussion and reported findings show that being able to adapt to hostile and turbulent environments is almost a prerequisite to being able to survive and prosper as a firm. Adaptation implies change, which in turn presupposes flexibility. Flexibility and adaptation come in many forms. Relevant flexibilities are contextual and situational. Our findings clearly reflect that flexibility is of central importance for the survival and profitability of firms, and that many adaptations and forms of flexibility relate to marketing, such as changes in product mix and tailoring demand to supply. The extent to which firms possess specific flexibilities can be considered a firm specific competence or resource acquired through learning, prior investments, competitive position, and so on.

In some situations, such as in the present case, changes and variations are caused by primary uncertainty outside the control of firms and their managers (Ottesen and Grønhaug, 2003). Even though firms try to master the imposed variations in supply, customers are still exposed to a situation far from allowing for a “timely and adequate supply”.

The unpredictability and imposed changes noted above also impact the way stakeholders in this value system adapt. For example: Consumers may respond by changing their seasonal consumption patterns towards species that are consistently accessible throughout the year. Suppliers may change to aquaculture to be able serve markets with high quality fresh cod on a regular basis. This illustrates the need for adaptations, and thus the need for flexibility. Our findings also reveal that unpredictable changes may have uncertain consequences.

The link between flexibility and marketing is important. As illustrated, flexibility and markets are not only driven by uncertainty related to changes in consumer preferences, but also by changes in supply markets and emerging technological solutions. These changes create new forms of uncertainties among key actors that can make new forms of flexibility relevant and valuable and old ones obsolete.

Many adaptations, and thus flexibility requirements, relate to and/or have implications for marketing. For example, the explosive development within modern information and communication technologies, has, in part, changed marketing practices. The new technologies represent new opportunities, and new solutions demand new ways of thinking and performing tasks, and thus “force” adaptation and flexibility. The successful ones are those who have been able to adequately adjust to the new “landscape”, and thus have developed and acquired the necessary flexibility to do so (Anand and Ward, 2004; Volberda, 1998; Ahmed *et al.*, 1996).

The present study is limited to one industry only. Adaptations occur in all industries. Adaptations and flexibility requirements may, however, vary across industries, and to some extent also across firms embedded in the same industries.

One swallow does not make a summer, nor does one study reveal the whole truth about flexibility. No doubt, more research is called for. First, this research should be replicated in other contexts to examine whether the reported findings hold true for other industries as well. As noted above, adaptation and flexibility come in many forms. Many of these relate to marketing. More studies are needed about adaptation, including what market actors try to do, whether adaptations are “forced” or imagined, which types of flexibility are needed, and to what extent firms possess these flexibilities in various industries. An interesting question is also whether possession of flexibility initiates change and thus also adaptation?

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Appendix 1. Assessment of uncertainty

In order to capture uncertainty factors, we looked at fluctuations in the factors studied, using an index, the volatility index (s), developed for describing stock market fluctuations (Hull, 1993). The volatility index (s) is defined as:

$$s = \sqrt{\frac{1}{n} \sum_{i=1}^n (v_i - \bar{v})^2}; \text{ where } s \text{ is the standard deviation of } v_i = \ln\left(\frac{X_t}{X_{t-1}}\right)$$

This index measures the relative change (v_i) from one period ($t-1$) to the other (t) for the actual factor (X). In order to compare these fluctuations with other factors, the index (s) is the standard deviation of the relative changes for the entire period studied. If there are large fluctuations from one period to the other, the volatility index (s) will be high, and if there are small fluctuations, s will be low. By comparing the value of the index for different factors, it is possible to rank the fluctuations.

An important dimension of uncertainty, the predictability of the fluctuation, is not captured by the volatility index. In order to account for this, we have used a “random-walk” model. The random-walk model is defined as:

$$X_t = A_0 + A_1 X_{t-1}$$

The random-walk model shows how well the level of a factor (X) in period t is predicted by the level of the factor in the preceding period ($t-1$). The predictability of this simple model can be measured by the regression coefficient of determination, R^2 . If R^2 is 1, then the model wholly explains the variation, and if it is 0, then the model explains none of the variation.

By calculating both the volatility index (s) and regression coefficient of determination (R^2), we can rank both the levels of fluctuation and the predictability in different factors of uncertainty. The factors of uncertainty and the variables used in the calculations are shown in Table AI

Total catches, both by month and by year, are included to map fluctuations in supplies of raw materials. As can be seen from Table AI, we have chosen to map both total catches and catches of the main species; cod. We have included the fluctuations in off-vessel prices for these catches to study price fluctuations, and we have used data on the total amount of raw material used for different potential products to study fluctuations in the product mix processed by the industry. Data on gross margins are used to analyse fluctuations in profitability at the product level. We have also used the return on total assets at the industry level in order to capture the fluctuation in profitability. As can be seen at the bottom of Table AI, we have chosen to split the industry into two groups, one group consisting of plants that mainly process frozen products, and the other consisting mainly of plants which process conventional products.

From the s and R^2 columns in Table AI, we can draw the following conclusions:

- The correlation coefficient between the two indexes is 0.66 ($p < 0.01$), indicating that the two measures rank the factors almost identically.
- The fluctuations in off-vessel prices are small and quite predictable, as R^2 is almost 1. The volatility index (s) also confirms modest fluctuations in this factor.
- Both the s and R^2 levels indicate that profitability fluctuates enormously, and is thus unpredictable.
- Volume and product mix factors seem to have the same level of uncertainty.

Uncertainty factor	Variable (X)	Total period	Period (t)	Fish	Products	N	s	R ²
Volume	Volume of raw fish	1980-1996	Year	Cod	All	17	0.27	0.44
		1973-1995	Year	Ground fish	All	22	0.14	0.57
		January 1988-December 1995	Month	Cod	All	96	0.53	0.50
Price	Off-vessel price of raw fish	January 1991-December 1995	Month	Cod	All	59	0.05	0.86
Product mix	Volume of raw fish	1973-1995	Year	Ground fish	Fresh	22	0.24	0.73
					Frozen	22	0.15	0.65
					Salted	22	0.40	0.54
		January 1991-December 1995	Month	Cod	Dried	22	0.27	0.39
					Fresh	59	0.51	0.32
					Frozen	59	0.35	0.46
Profitability	Gross margins	September 1991-December 1995	Month	Cod	Salted	59	0.54	0.49
					Dried	59	2.37	0.11
					Fresh	51	1.18	0.21
Return on total assets	Return on total assets	1977-1995	Year	Ground fish	Frozen	51	0.26	0.34
					Salted	51	0.30	0.10
					Dried	51	0.41	0.12
					Conventional	18	1.54	0.08

Table A1.
Uncertainty factors by
industry level, period
studied, and levels of
uncertainty (s and R²)

Appendix 2

Factor	Variable	Definition
Volume flexibility	VOL1	(Standard deviation of annual volume of raw fish)/(Average annual volume of raw fish)
	VOL2	(Maximum annual volume of raw fish – Minimum annual volume of raw fish)/ (Average annual volume of raw fish)
	INV1	(Accumulated investments in production equipment)/(Accumulated total investments)
Product flexibility	PROD1	(Standard deviation of volume of annual raw fish used in the main product)/(Average annual volume of raw fish used in the main product)
	PROD2	(Maximum – Minimum volume of raw fish used in the main product)/(Average annual volume of raw fish used in the main product)
	ANVTOT1	$ANV1_i = \frac{Std(X_i)}{\bar{X}_i}; i = 1, \dots, 4$ <p>X = Annual volume of raw fish used in different products i = Product. Four main products are included in the study; fresh, frozen, salted and dried imax = Maximum annual volume of raw fish used in product i Imin = Minimum annual volume of raw fish used in product i</p> $ANVTOT1 = \left(\sum_{i=1}^n ANV1_i \right) \frac{1}{n};$
	ANVTOT2	$ANV2_i = \frac{\bar{X}_i \max - \bar{X}_i \min}{\bar{X}_i}; i = 1, \dots, 4$ <p>n ∈ {1, 2, 3, 4} X = Annual volume of raw fish used in different products i = Product. Four main products are included in the study; fresh, frozen, salted and dried imax = Maximum annual volume of raw fish used in product i Imin = Minimum annual volume of raw fish used in product i</p> $ANVTOT2 = \left(\sum_{i=1}^n ANV2_i \right) \frac{1}{n};$
Labour flexibility	ARB1	n ∈ {1, 2, 3, 4} (Standard deviation of annual labour costs/average annual labour costs)
	ARB2	(Maximum annual labour costs – minimum annual labour costs)/ (Average annual labour costs)
Financial flexibility	Net liquidity balance	Cash//total assets
Productivity	RISK	(Accumulated profit/accumulated investments)
	EFF	Production value of fish products (output)/number of employees, total assets, volume of raw materials (input)

Table AII.
Definitions of variables in Table I

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