Calamities in food supply chains; is senior management facing the future with confidence?

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Abstract

Calamities such as extreme droughts and infrastructure breakdowns potentially hamper the continuity of food companies, as well as the continuity of food supply at the level of Europe as a whole. Results from an expert elicitation in the Netherlands show that part of senior management is confident to be able to deal with such calamities. The overall picture however looks different as for instance only 30% has top-3 calamities incorporated in business continuity plans. Also, the majority sees some need for a Deltaplan, with a main role for the EU-government. Findings are useful in designing public-private partnerships for food supply resilience in Europe.

Keywords: Resilience; Risk perception; Risk management; Business Continuity Management

1. Introduction

Calamities such as extreme droughts, infrastructure breakdowns and pandemics potentially disrupt food companies' continuity, and, as a consequence, the continuity of food supply throughout Europe. Although food supply has shown to be rather robust during previous crises such as the 1986 Chernobyl disaster, various severe livestock epidemics, and 2003 droughts (Bindraban et al., 2008), there is increasing concern about food supply chains' resilience. For instance, Peck (2006) concluded that UK food companies are not well prepared for system-wide disruptions, such as loss of power and loss of water. Similarly, DEFRA (2009) stated that the UK food system has the potential to be significantly vulnerable to interruptions in energy supplies. Subuh et al. (2008) found that feed and food companies lack adequate strategies for responding to food terrorism. In addition, Aerts et al. (2008) presented scenarios of abrupt climate change, such as "a little ice age" and "a nuclear winter", potentially leading to food chain disruptions and famines. Also, in 2008, following the report from Bindraban et al. (2008), the Steering Committee Technology Assessment of the Ministry of Agriculture, Nature and Food Quality, The Netherlands, stated that EU food supply is rather robust, but that insufficient knowledge exists on food supply continuity if multiple disastrous scenarios occur in a short period of time or if scenarios occur that did not happen before in recent history.

Literature on the impact of calamities addresses either the continuity at the company level, or the continuity of food supply at the aggregate level of e.g. Europe as a whole. Moreover, company level studies generally focus on risk management and business continuity management, not on the perceived impact itself. At the aggregate level, impact analyses are qualitative, such as in Aerts et al. (2008), or carried out for the food system as a whole. An example of the latter is the report by Bindraban et al. (2008), who map the necessary changes of Europe's food system to respond to a complete stop of soy imports from America. In addition, none of these studies links

company level continuity with food supply continuity at the aggregate level. In this context, the objectives of this paper are (i) to analyse the perceived impact of various calamities on continuity at the company level as well as on food supply continuity in Europe as a whole; and (ii) to analyse the perceived relevance of risk management strategies to deal with such calamities. Results are obtained through expert elicitation. Experts are from feed and food companies operating in the Netherlands (and elsewhere) as well as from other organisations such as governments, research and sector organisations.

2. Calamities in food supply chains

Reviewing the literature on calamities in food supply chains yields a long-list of potential calamities and related risk management strategies. These are summarised in Table 1. Calamities range from food terrorism and infrastructure breakdowns to extreme weather events and economic crises. Also, the list of suggested risk management strategies is very diverse. Some risk management strategies are pro-active, such as stock holding, implementation of business continuity management (BCM) principles, focusing on local facilities and lifestyle, increasing energy efficiency and increasing global production in a sustainable way. Other strategies are more reactive, such as temporary waivers on regulations and culling of diseased livestock. Also, some risk management strategies are in the public domain while others are purely private. Examples of the latter can be found in BCM and information sharing practices. There is also a number of public-private partnership strategies, such as implementing surveillance systems, keeping larger stocks, effective crises management, and introduction of resilient crops and techniques.

[TABLE 1]

With regard to the perceived relevance and implementation of a number of the risk management strategies mentioned, company level expert studies by Peck (2006) and Subuh et al. (2008) revealed among others that crisis management is in practise more based on reactive actions than on proactive risk management. Also, BCM is found to be (partially) implemented, but is generally seen as a mechanism to protect the well-being of customers and shareholders, not as a tool for the public good or to maintain operations in times of national emergency. With regard to control actions in case of bio-terrorism, analyses showed that many control actions are undertaken but that the majority of food safety managers mistakenly interprets HACCP-based systems to be adequate for dealing with food terrorism. Also, food companies perceive their own security performance as better than that of their suppliers and the chain as whole. About stock holding, Peck concludes that "in a perfect world it is to be recommended that [..] redundant capacity and capability should be held by all organizations, just in case. In the present business climate however, this may not be a realistic proposition […]". These findings illustrate that analysing risk perception and risk management of calamities in food supply chains is not unambiguous, neither at the company level nor at the aggregate level.

3. Materials and methods

Survey design

The survey consists of two main blocks, the first dealing with the perceived impact of calamities and the second focusing on the perceived relevance of risk management strategies. The first part started by asking for the interpretation of "continuity". Two options were given, i.e. (i)

continuously providing a wide variety of products (business as usual), and (ii) continuously fulfilling consumers' minimum nutritional needs (possibly with less products on the shelf). Next, given a respondent's interpretation of continuity, the perceived threat of 11 calamities (see next paragraph) on food supply continuity in Europe was evaluated on Likert-scales from 1 (not threatened at all) to 5 (very much threatened). After that, respondents were asked to indicate their top-3 calamities threatening continuity at the food company level.

Calamities in the questionnaire are based on the long-list presented in Table 1, fine-tuned to potential Dutch circumstances. Some of the calamities are related to climate, such as "extreme drought in EU", "extreme drought in EU and high oil prices", "low stocks and extreme drought in EU", and "extreme cold in Western-EU". The other calamities focus on the availability of key inputs ("lengthy loss of key suppliers", "complete stop of soy imports from America"), labour ("pandemic affecting all employees"), electricity ("lengthy or structural unavailability of electricity") and transport facilities ("lengthy unavailability of river Rhine for inland shipping", "lengthy crisis of road transport in EU", and "lengthy unavailability of Rotterdam harbour"). Two of the climate-related calamities are situations in which multiple disastrous scenarios occur in a short period of time. All in all, none of the calamities exactly happened in the Netherlands in the recent past, although some are connected to potential threats that received a lot of media attention. For instance, loss of key suppliers and stop of soy imports relates to debates on non-allowed genetically modified substances and potential impacts for imports. A road transport crisis links to various road blockades in France in the past, which sometimes lasted 2 to 3 days. Problems with regard to electricity and oil link to 2008 problems with Russian gas transports and peaks in international oil prices. The pandemic scenario associates with global H5N1 ("bird flu") and Influenza H1N1 ("Mexican or swine flu") concerns in 2006 and 2009 respectively. Lastly, the stock issue connects to 2007 concerns about historically low stocks in the EU in combination with high prices on the world market. Three calamities, i.e. extreme cold, non-availability of the Rhine, and non-availability of the Rotterdam harbour, have no such linkages. Underlying causes are specified for some calamities, such as with regard to drought and cold, but not for all. For instance, the unavailability of Rotterdam harbour could be due to extreme weather but also due to terrorist bombing.

In the risk management part, respondents were first asked to indicate which of the top-3 calamities had already been incorporated in business continuity planning (not, not yet, partly, fully). Next, the perceived relevance of in total 16 risk management strategies for dealing with calamities at the company level (next paragraph) were scored on a scale from 1 (not relevant at all) to 5 (very relevant). Then the need for a so-called Deltaplan dealing with food supply continuity at the level of Europe as a whole was addressed, including the party(ies) responsible and the top-3 of potential risk management strategies in a Deltaplan.

Risk management strategies in the questionnaire are derived from risk management and BCM literature from among others Hardaker et al. (2004) and Peck (2006) respectively. Most measures are at company level, i.e. "larger raw materials stock", "larger final goods stock", "own fuel supplies", "company energy generation", "additional financial reserves", "scaling down", "scaling up", "spatial diversification", "redundant capacity", "process/product modification" and "flexibility of technology". Five strategies cover risk management tools that need to be taken up together with other stages of the supply chain, i.e. "broad sourcing/open chains", "closed chains", "horizontal alliances", "alliances with suppliers" and "local suppliers and customers".

Besides the predefined lists of calamities and risk management strategies, respondents were also able to indicate "other" calamities and strategies perceived to be relevant. In the third

block of the questionnaire companies were characterised with regard to stage (supplier, primary producer, processor, wholesaler), type of chain (meat, plant) and turnover. Also, we asked respondents' willingness to be involved in possible follow-up research. The questionnaire was pretested by 2 experts, one from university and one from an accredited certification institute dealing with the whole supply chain. Questionnaires were sent by email. Email was also used to follow-up on non-response.

Sample

In September 2009, the survey was sent to senior management and staff of 20 food companies and 20 other organisations, including government, research and sector organisations[1]. Companies were chosen in such a way that ideally all stages of meat and plant chains would be covered. After 3 months 30 surveys were returned, mostly by email, some by mail or fax, implying a response rate of 75%. As illustrated in Table 2, 16 respondents were from food companies and 14 from other organisations. They turned out to be indeed from senior management and high-level staff.

[TABLE 2]

Within the category of food companies, there are 3 animal feed companies, 1 large-scale primary producer, 3 processors, 4 wholesalers and 5 companies covering multiple stages of the chain. The primary producer, animal feed companies and processors are regarded as production companies. Also, 2 of the 5 companies covering multiple stages of the chain are regarded as production companies as they do not have any wholesale activities. Food companies' turnover is between Euro 1 million and Euro 1 billion (n=4), Euro 1-10 billion (n=7) and above Euro 10 billion (n=1).

Respondents showed high commitment for participating in follow-up research as all but one answered positively to this question. Also, a relatively large number of respondents, i.e. one-third (6 food companies, 4 other organisations), took the opportunity to indicate other calamities and risk management strategies than the predefined ones, as summarised in Appendix 1. Reasons for non-response are not certain and may range from time constraints to potential (shareholder) sensitivity of the topic under consideration.

Follow-up interviews

To gain deeper insights into the answers provided, we did 3 follow-up interviews: 2 with food companies and 1 with a research organisation. These were selected based on their different views expressed, i.e. a relatively low perceived impact of calamities, a relatively high perceived impact of calamities, and a full incorporation of top-3 calamities in business continuity planning.

4. Results

Interpretation of food supply continuity

About half of the food companies considers food supply continuity as "business as usual" (53%); the other 47% of the food companies views it as "fulfilling minimum nutritional needs, possibly

[1] Surveys sent to other organisations differed somewhat from the version described, i.e. (i) top-3 calamities were framed more generally towards "threatening the continuity of food companies operating in the Netherlands", (ii) we did not ask to what degree top-3 calamities are covered in business continuity planning, and (iii) also the relevance of risk management strategies was framed more generally towards food companies in the Netherlands. Both versions of the questionnaire are available on request.

with less products on the shelf". Other organisations all regard food supply continuity as fulfilling minimum needs. In answering the question, many respondents made links with sustainability. For instance, business as usual in the future was stated to still behold ample choice and availability of products, but with a different package of more sustainable products. Similarly, in the future less products on the shelf may mean not only literally less products, but also very different, i.e. more sustainable, products. Interestingly, the 47% of food companies adhering this view apparently trust that they themselves are still able to stay in business.

Perceived impact of calamities

From the various predefined calamities the unavailability of electricity, a lengthy road crisis and low stocks in combination with a drought are perceived to be the most threatening for food supply continuity in Europe (Table 3). Also, other risks (open question) scored relatively high (ranked 2nd), especially for food companies. These other risks, as listed in Appendix 1, are mostly in the field of production risks such as unavailability of drinking water, food and water contamination from terrorism, extreme droughts on multiple continents and dependence on fossil fuels including related power of the Middle-East. Also policy issues were mentioned quit frequently, such as with regard to distorting legislation in the field of bio-energy, and (as mentioned during one of the follow-up interviews) governments adhering to status quo situations in a forced way. Also monopolistic behaviour and the risk of much higher prices, potentially leading to food wars, were mentioned as potential calamities threatening food supply continuity in Europe.

[TABLE 3]

Calamities perceived on average to be not very threatening for continuity in Europe relate to the unavailability of the river Rhine (ranked lowest), extreme cold in the West of Europe, extreme droughts throughout Europe, and a complete stop of soy imports from America. This is quit similar for food companies and other organisations, although food companies perceived the unavailability of the river Rhine as even less threatening than other organisations did. The relatively low perceived importance of a complete stop of soy imports from America is in line with findings from Bindraban et al. (2008), who concluded that a sudden stop of soy imports into the EU would not threaten the fulfilment of EU consumers' minimum dietary needs. The relatively low ranking of pandemics seems to be in line with a comment made during one of the follow-up interviews in which it was indicated that recent attention for Mexican flu and "bird flu", including government incentives to design business continuity plans in case of such pandemics, has already triggered food companies to manage this risk. The relatively low perceived threat from a lengthy unavailability of the Rotterdam harbour likely relates to the presumption that other harbours, such as Antwerp and Le Havre, stay accessible. This presumption was mentioned a few times. Detailed scores (not in Table 3) show that respondents generally were not very pronounced with regard to their perceptions, i.e. relatively few scored "1" (not threatening at all) and "5" (very much threatening).

For company level continuity, Table 4 shows that calamities perceived to be important are different from those at the aggregate level. For food companies, besides unavailability of electricity and a lengthy crisis of road transport, important calamities now also include a lengthy loss of key suppliers and a complete stop of soy imports from America. Other organisations now also perceive a lengthy unavailability of the Rotterdam harbour as an important risk. Apparently, these "new calamities" are regarded as threatening for the continuity at company level, but without substantial distorting effects for food supply at the aggregate level.

Within the group of food companies, different perceptions were found for among others companies with fresh produce which are heavily depending on import and export versus companies with processed food who are operating on global markets. The first, as shown in follow-up interviews, perceive calamities as much more risky than the second, who heavily trust that sustainable goods and sustainable relationships also "keep the door open" in case of calamities. Differences were also found between production companies and wholesalers; production companies seem to worry more about the risk of calamities than wholesalers. For instance, at the aggregate level production companies perceive extreme droughts in combination with high oil prices, and a lengthy loss of key suppliers as significantly more threatening than wholesalers ($P \leq 0.05$). Also, production companies mentioned other risks than the predefined ones, while wholesalers did not. In addition, in the top-3 assessment of calamities threatening company level continuity, production companies put more attention to the drought calamities than wholesalers did. In addition, differences were found for food companies perceiving continuity as "business as usual" versus those having the "minimum view". Business as usual is apparently more at risk in case of "other risks" and calamities such as low stocks and droughts ($P \leq 0.05$). All in all, however, correlations between calamities perceived to be relatively most threatening, such as low stocks and droughts, a road transport crisis and non-availability of electricity, were significantly positive ($P \leq 0.05$), suggesting that food companies in general agree on the level of threat of these type of calamities.

[TABLE 4]

Perceived relevance of risk management strategies

Before going into the longlist of risk management strategies, we first look to the business continuity planning activities with regard to the top-3 calamities threatening continuity at the company level, i.e. unavailability of electricity, loss of key suppliers, stop of soy imports and a crisis of road transport (Table 4). Table 4 shows that less than half of the food companies has fully incorporated these risks in business continuity planning. For instance, the risk of a lengthy road transport crisis in the EU is stated to be fully incorporated in BCM by 20%, while 40% has not incorporated it at all. Moreover, for 2 calamities perceived to be threatening at the aggregate level, i.e. "other calamities" and low stocks in combination with an extreme drought in the EU, even none of the food companies indicated to have these fully incorporated in business continuity planning. In addition, 2 food companies, after having indicated the top-3, did not answer the BCM question at all. As revealed during the follow-up interview, the reason for one of these companies being that alternative solutions are hardly available or only at very high costs. This was actually reinforced by the other food company interview, in which it was stated that risk analyses and related business continuity planning are only undertaken for known hazards for which feasible solutions are available. Moreover, during these interviews it was expressed that BCM is mainly undertaken for economic reasons, not for reasons of social responsibility. Even when triggered by governments, aspects such as level playing field are perceived to be very important.

Specific risk management strategies perceived to be relevant to enhance company level continuity are mainly in the area of solving risks together with other stages of the supply chain, such as in broad sourcing and alliances with suppliers (Table 5). The latter is especially true for food companies. Also, company level energy generation is perceived to be relevant. In fact, highest importance was given to "other strategies" (Appendix 1). While predefined strategies addressed actions at company level, open answers focused on public and public-private risk

management strategies. Suggested strategies in the public domain are among others an increased role of FAO and WHO in crisis management, meetings comparable to top meetings in the financial world (e.g. between the European Bank and the US Federal Bank), and a check on whether current global food organisations are adequate for dealing with potential future calamities. At the public-private partnership level, there is mainly a call for increasing sustainability, among others by reducing spoilage and by triggering dietary changes. Also, attention is paid to assure transport and electricity facilities and to prevent livestock epidemics. At the private level, suggested strategies include improved issue management, logistical solutions, chain flexibility and valorisation of by-products.

[TABLE 5]

Withy regard to strategies perceived not to be relevant, Table 5 shows that these can be found in the area of costly measures such as larger final goods stocks, own fuel supplies, scaling down production and investing in redundant capacity. Interestingly, the latter is listed twice in Appendix 1 as being a useful risk management strategy, i.e. once as "provision of latent capacity at farm and processing level" and once as "emergency plan to allow farming everywhere possible setting aside nature plans and environmental requirements". All in all, continuity of food companies in case of calamities is perceived to benefit more from alliances, open chains, flexibility, alternative sourcing and spatial diversification as compared to scaling down, focusing on local suppliers and setting up closed chains. With regard to flexibility, this is even more true for production companies than for wholesalers (Table 5). Also, the high perceived relevance of alliances with suppliers is especially true for food companies who perceive continuity as business as usual ($P \leq 0.05$, not in Table 5). The relatively high variation of the perceived relevance of risk management strategies, as illustrated by relatively high stand deviations in Table 5, likely relates to the diversity of calamities included, each requiring a different type of risk management solution. For instance, a significant positive correlation was found for food companies' perceptions on the importance of a lengthy loss of key suppliers and the relevance of additional financial reserves, scaling up and spatial diversification ($P \leq 0.05$). Part of the variation may however also reflect opposing views, such as with regard to the relevance of redundant capacity, as mentioned above.

Perceived need for a Deltaplan

To adequately manage calamities, one-third sees a need for a Deltaplan (Table 6), one-third sees a potential need for such a plan, and about one-third sees no need for it at all. Still, from the latter group, 4 respondents shared ideas on parties responsible (but, apparently, without entitling their involvement as a Deltaplan). Food companies are mostly in the first group, i.e. seeing a need for a Deltaplan, while other organisations are mostly in the "possibly group". Also, the first group entails more companies regarding continuity as business as usual, while those with the "minimum view" are more in the second. From the group completely disliking the idea of Deltaplan including the idea of any other party being responsible for food supply continuity except the food companies themselves (n=5), 4 are food companies. These companies all scored relatively low on the perceived threat of calamities.

[TABLE 6]

The party considered to be most responsible for a Deltaplan is the EU-government, mentioned by 53% of respondents. Still, the majority (i.e. 13 out of 25 respondents, see footnote 1 under Table 6) regards a Deltaplan as a multiple-party responsibility. The relatively large role for governments coincides with the suggested public and public-private risk management

strategies discussed before (Appendix 1). Strategies perceived to be important in a Deltaplan are larger raw materials stock, additional financial reserves, broad sourcing and horizontal alliances. They clearly differ from the strategies perceived to be important at the company level. Differentiating strategies to parties perceived to be responsible, shows that in case NL-governments are perceived to be responsible, scaling up is relatively important, while for EU-governments this is larger raw materials stock. For food companies it is suggested to focus on alliances with suppliers.

5. Conclusions, discussion and further research

In this study we analysed the perception of food companies and other organisations with regard to the threat of calamities for the continuity of food companies, as well as for the continuity of food supply at the aggregate level of Europe as a whole. High response rates and large commitment for follow-up studies illustrate senior management's interest into this topic. The following conclusions can be drawn:

(1) Calamities perceived to be relatively threatening for food supply continuity in Europe are unavailability of electricity, a lengthy crisis of road transport, and low stocks in combination with a drought. Continuity of individual companies is, next to unavailability of electricity and a lengthy crisis of road transport, perceived to be threatened most by a lengthy loss of key suppliers, unavailability of the Rotterdam harbour and a complete stop of soy imports from America. Most differences in perceptions are found within the group of food companies, i.e. production companies seem to worry more about calamities than wholesalers. Also, companies with fresh produce perceive calamities to be relatively more threatening than companies with processed food.

(2) From the calamities perceived to be threatening continuity at company level, on average 30% is fully covered in companies' business continuity planning. For calamities threatening food supply continuity in Europe this percentage is lower. With regard to risk management strategies perceived to be relevant for safeguarding continuity of companies strategies such as alliances, open chains, flexibility, alternative sourcing and spatial diversification score much higher than strategies in the field of scaling down, focusing on local suppliers and setting up closed chains. Besides, also public strategies such as improving international governance comparable to financial sectors are perceived as relevant. Also, the majority sees some need for a Deltaplan in which multiple stakeholders are involved but with a main responsibility for EU-government. Such a Deltaplan would involve strategies such as larger raw materials stock and additional financial reserves.

(3) Overall, the study shows that part of senior management is confident to be able to deal with calamities such as described in this research. They thereby heavily trust on resilience of sustainable production systems, embedded in a policy environment consistently supporting sustainability. The average picture from the analyses however shows less confidence because of the relatively limited business continuity planning for major calamities. In addition, because even this seems to be an overestimation as business continuity planning and underlying risk analyses seem to focus on the known hazards for which economically feasible solutions exist.

Discussion and further research

- *System boundaries*. Given a globalising world and the fact that Europe is a relatively rich part, does complicate the definition of the boundaries of "food supply in Europe". For most calamities, borders are not fully closing down; it might "just" become more difficult or costly to transport goods to Europe. In this context, one could argue that "no matter what calamity will happen, food supply in Europe always goes on, as commodities and products can be bought elsewhere". Although this might be true for some cases, it may not be ethical or feasible in other cases. Answers from respondents however show they generally rely on sustained flexibility and open trade. Further research would have to reveal to what extent these presumptions are realistic.
- *Interpretation of food supply continuity*. Overall, 70% interprets "continuity" as fulfilling consumers' minimum nutritional needs; only half of the food companies regards it as "business as usual". In one of the follow-up interviews it was indicated that in botch cases however consumer demand is central. In this perspective, further research on consumers' perceptions would be highly relevant, i.e. what is consumers' (minimum) demand in terms of choice, availability, price and products at the time of a calamity. In addition, contingent valuation studies can reveal consumers' willingness to pay for safeguarding food supply continuity.
- *Belief in disaster relief*. Food supply continuity appears to be mostly perceived as a public-private partnership issue. However, the high preferred participation of governments entails the potential risk of food companies relying too much on "disaster relief" in case of calamities. Further research should address the efficiency of potential risk management strategies including the role of governments. Governments should be involved in such a way that food companies still get proper incentives for adequate self risk management. Lessons learned from recent financial crises can be helpful in this respect.
- *Linking company and aggregate levels*. Some of the calamities perceived to be among the most threatening for continuity at company level are identical to those at the aggregate level, i.e. the unavailability of electricity, and a lengthy crisis of road transport. Others are perceived to be threatening for the company level, but not for the aggregate level, or the other way around. But why is this so? Are knock-on effects from companies to the aggregate level non-existing? Dynamic chain models which are able to simulate the impact of calamities on continuity of chain stages, and ultimately, chains' outputs would enhance the insight into company and chain level resilience. Combining various of such models, covering strategically important supply chains, enhances insight into the resilience of food supply at the level of Europe as a whole. In fact, in such models, all previous research steps are integrated, i.e. company's flexibility, the chain's ability to fulfil consumer demands, and the impact of public-private risk management strategies respectively.
- *Food supply governance*. Findings from this study are largely in line with literature, i.e. food companies attempt to safeguard business continuity, but mostly from an economic perspective (not from a social responsibility point of view), keeping abundant capacity is not efficient, and, overall, BCM is only partially implemented. In addition, food companies and related organisations are not very pronounced with regard to the perceived potential impact of calamities, possibly reflecting uncertainty. Also, given the high attention for sustainability issues, there may be some misinterpretation between food security on the longer term versus food supply continuity in the short run. Furthermore, some of the open answers reveal a focus on company level issues, not on large-scale calamities. Further research should address to what extent the suggestions given in the field of international governance, crisis

management and crisis training can improve awareness and risk management of calamities, without doom-mongering.

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Table 1: Potential calamities affecting food supply in Europe, potential impacts and proposed risk management strategies.

Source	Calamities	Impact	Risk management
Manning et al. (2005)	Food terrorism with foreign animal disease	Economic disruption, consequential losses, loss of consumer confidence, possible impacts for human health	Public-private strategies; Adequate resources; Preparedness plans and routine exercises; Surveillance systems
Peck (2006)	Large-scale disruptions, i.e. fuel shortages, loss of power, loss of water, and disruptions from sickness and infectious disease	-	Temporary waivers on regulations; Implementation of business continuity management; Adjusted distribution strategies and stock holdings/locations in advance of foreseeable disruptions; Protocols on range reduction between suppliers and customers
Boin and McConnell (2007)	Critical infrastructure breakdowns	-	Contingency planning; Promoting societal resilience[1]
Bindraban et al. (2008)	Various, but with focus on collapse of trade affecting EU soybean (meal) imports	Decrease of meat availability in Europe, but no threat for food security. Serious effects for feed and meat industry	Raising stock levels of soybean in Europe; Cultivating more protein-rich feed crops within Europe; Exploration of dual-purpose crops
Aerts et al. (2008)	Abrupt climate change[2]	Many, including food chain disruptions, famines, and infrastructure damage	Some prevention possible; Migration south; Adjustments[3]
Subuh et al. (2008)	Food terrorism[4]	-	Control actions; Information sharing practices; Actions enhancing robustness[5]
DEFRA (2009)	Energy supply disruptions, pandemic flu, extreme weather events and transport disruptions, disruptions to the domestic food chain, economic risks to the food industry	-	Increasing global production in a sustainable way; Improving trading and market conditions; Managing crises effectively; Working together
Meuwissen et al. (2009)	Livestock epidemics	Direct costs, consequential losses	Risk prevention; Protective vaccination; Culling

[1]Among others: preparing first responders, business continuity planning, working with communities, and joint preparation and training.
[2]Including "little ice age", "nuclear Winter" and "volcanic Aerosol".
[3]Among others: focus on local facilities and lifestyle, port de-icing or relocation, increased energy efficiency, increased renewable energy, reliance on food trade with south, stockpiling of freshwater, introduction of resilient crops and techniques, alliance with neighbours for trade and security, and capability to adjust with wealth and health.
[4]Not only from terrorists, but possibly also from supply chain partners with conflicting interests and dissatisfied employees.
[5]More specifically "control actions" include aspects of process strategy, management and technology, infrastructure management, and security metrics. "Information sharing" relates to communication management, management technology, and relationship and public interface management. "Robustness" includes emergency plans and emergency budgets.

Table 2: Description of sample (n=30).

	Number	Turnover (euro)[1]			
		<1 million	> 1 mill. – < 1 billion	> 1 billion – < 10 billion	> 10 billion
Food companies	Total = 16				
- Feed companies	3	-	1	2	-
- Primary producers	1	-	1	-	-
- Processors (plant and animal)	3	-	1	2	-
- Companies covering multiple stages of the chain	5	-	1	3	-
- Wholesale	4[2]	-	-	-	1
Other organisations	Total = 14				
- Government	4				
- Research	3				
- Sector	3				
- Other	4				

[1]Not all food companies disclosed turnover.
[2]Including 2 respondents from 1 company.

Table 3: Perceptions of impact of calamities on food supply continuity in Europe, overall and for various groups (mean scores)[1,2].

	Overall (n=30)			Role in food supply		Stage of chain[3]	
	Mean	SD	Rank	Food comp. (n=16)	Other org. (n=14)	Prod. (n=10)	Whole -sale (n=3)
Extreme drought in EU	2.8	0.81	9/10	2.8	2.8	2.7	2.3
Extreme drought in EU and high oil prices	3.3	0.71	5	3.4	3.3	3.4**	3.0**
Low stocks and extreme drought in EU	3.4	1.00	4	3.6	3.1	3.6	3.3
Extreme cold in Western-EU[4]	2.7	0.77	11	2.6	2.8	2.5	3.3
Lengthy unavail. of Rhine for inland shipping	2.0	0.93	12	1.8*	2.3*	2.0	1.7
Complete stop of soy imports from America	2.8	1.29	9/10	3.1	2.6	3.2	3.3
Lengthy crisis of road transport in EU	3.5	1.17	3	3.4	3.5	3.4	3.3
Lengthy or structural non-avail. of electricity	4.2	0.79	1	4.2	4.3	4.3	4.0
Pandemic affecting all employees	3.1	1.03	7	3.3	2.9	3.6	3.3
Lengthy unavailability of Rotterdam harbour	2.9	1.01	8	2.9	3.0	3.1	1.7
Lengthy loss of key suppliers due to crisis	3.2	1.19	6	3.2	3.2	3.3*	2.3*
Other[5]	4.1	0.64	2	4.5*	3.8*	4.5	-

[1]Measured on a scale from 1 (not threatened at all) to 5 (very much threatened).
[2]Asterisks indicate significant differences at P≤0.05 (**) and P≤0.10 (*).
[3]Food companies are grouped according to stage of chain: production companies (primary producers, feed companies and processors) and wholesalers. Companies covering multiple stages including wholesale are excluded (n=3).
[4]Due to changing gulf stream.
[5]Open question, see Appendix 1.

Table 4: Top-3 calamities perceived to threaten continuity of food companies and % in Business Continuity Management (BCM) plans.

	% in top 3		% in BCM of food companies (n=13)			
	Food companies (n=15)	Other organisations (n=14)	No	Not yet	Partly	Yes
Extreme drought in EU	-	-	-	-	-	-
Extreme drought in EU and high oil prices	7	5	0	0	100	0
Low stocks and extreme drought in EU	5	5	0	0	100	0
Extreme cold in Western-EU[1]	2	5	0	100	0	0
Lengthy unavail. of Rhine for inland shipping	-	2	-	-	-	-
Complete stop of soy imports from America	12	5	0	25	50	25
Lengthy crisis of road transport in EU	12	24	40	0	40	20
Lengthy or structural non-avail. of electricity	27	31	10	10	50	30
Pandemic affecting all employees	10	5	25	0	0	75
Lengthy unavailability of Rotterdam harbour	2	10	0	0	0	100
Lengthy loss of key suppliers due to crisis	15	7	20	20	20	40
Other[2]	7	2	0	0	100	0
Total	100	100				
Overall			14	11	46	30

[1]Due to changing gulf stream.
[2]Open question, see Appendix 1.

Table 5: Perceived relevance of risk management strategies for business continuity, overall and for various groups (mean scores)[1,2].

	Overall			Role in food supply		Stage of chain	
	Mean	SD	Rank	Food comp. (n=16)	Other org. (n=14)	Prod. (n=10)	Whole-sale[3] (n=3)
Larger raw materials stock	3.4	1.30	5/6	3.3	3.6	3.7	3.7
Larger final goods stock	2.6	1.18	14/15	2.6	2.6	2.7	4.0
Own fuel supplies	2.6	1.24	14/15	2.4	2.8	2.2	2.5
Company energy generation	3.5	1.15	2/3/4	3.3	3.6	2.9	3.5
Additional financial reserves	3.2	1.33	9/10	3.6	2.9	3.7	2.5
Broad sourcing / open chains	3.5	1.30	2/3/4	3.6	3.4	3.1	4.5
Closed chains	2.7	1.20	13	2.7	2.6	2.9	2.0
Horizontal alliances	3.2	1.23	9/10	3.2	3.1	3.1	3.5
Alliances with suppliers	3.5	1.17	2/3/4	3.9*	3.1*	3.7	3.7
Local suppliers and customers	2.8	1.18	11/12	2.9	2.7	2.7	2.5
Scaling down	2.0	0.94	17	1.9	2.1	1.7	3.5
Scaling up	2.8	1.28	11/12	3.3*	2.4*	3.1	3.0
Spatial diversification	3.3	1.10	7/8	3.6	2.9	3.6	2.5
Redundant capacity	2.3	0.86	16	2.5	2.2	2.4	2.5
Process/product modification	3.3	1.23	7/8	3.4	3.3	3.3	3.5
Flexibility of technology	3.4	1.15	5/6	3.2	3.6	3.4**	2.0**
Other[4]	4.4	0.55	1	4.3	4.5	4.3	-

[1]Measured on a scale from 1 (not relevant at all) to 5 (very relevant).
[2]Asterisks indicate significant differences at P≤0.05 (**) and P≤0.10 (*).
[3]Food companies are grouped according to stage of chain: production companies (primary producers, feed companies and processors) and wholesalers. Companies covering multiple stages including wholesale are excluded (n=3).
[4]Open question, see Appendix 1.

Table 6: Perceived need for Deltaplan, party(ies) responsible and top-3 strategies for Deltaplan.

	Total (n=30)	Responsible party(ies) (n=25)[1]			
		NL-government	EU-government	Sector organisations	Food companies
Yes	10 (33%)	3 (30%)	9 (90%)	2 (20%)	3 (30%)
Possibly	11 (37%)	4 (36%)	8 (73%)	1 (9%)	3 (27%)
No	9[2] (30%)	1 (11%)	3 (33%)	0	1 (11%)
Overall (%)		8 (21%)	20 (53%)	3 (8%)	7 (18%)

[1]Number of respondents indicating 0, 1, 2, 3 or 4 party(ies) were 5, 12, 9, 3 and 1 respectively.
[2]From whom 5 give no further indications on responsible party(ies).

Appendix 1: Categorisation of answers to open questions

	Answers[1]
Risks (n=10)	
Price risks	- Much higher prices (leading to food wars)
Production risks	- Food and water contamination (due to diseases, pests, disasters, terrorism)
	- ICT problems
	- Livestock epidemics
	- Unavailability of drinking water [2x]
	- Extreme droughts on multiple continents
	- Crisis at plant level
	- Dependence on fossil fuels and power of Middle-East
Institutional risks	- Political issues
	- Redundant legislation
	- Distorting policy, e.g. with respect to bio-energy
Other	- Economic environment
	- Environmental issues
	- Monopolistic and patent behaviour in food production
Risk management (n=10)	
Private	- Active issue management
	- Research and development
	- Invest in logistical solutions
	- Provision of latent production capacity at farm and processing level
	- Sourcing of alternative raw materials; Increasing chain flexibility
	- Increased valorisation of by-products
Public	- Improved international governance
	- Increased role of e.g. FAO and WHO in crisis management (comparable to top meetings in banking sector between European Bank and FED) [2x]
	- Need for a global Deltaplan including a check on whether current global organizations are adequate [2x]
	- Risk and crisis training at policy level
	- Emergency plan allowing to farm everywhere possible (setting aside nature plans and environmental requirements)
Public-private	- In the field of assuring sustainability: - Consistent implementation of sustainability at policy and business level - Less spoilage and more environmental friendly production - Link with sustainability and dietary changes, i.e. less and possibly other products on the shelf
	- Assuring transport and electricity facilities
	- Prevention of livestock epidemics
	- A Deltaplan in which all parties are involved, i.e. NL and EU-governments as well as sector organisations

[1]Answers in questionnaire topics (ii), i.e. degree to which calamities threaten food supply continuity in Europe ("Risks"); and (iv), i.e. relevance of risk management strategies for assuring the company's business continuity ("Risk management").