Consumer health hazards in international food trade

Thom Achterbosch

I

The Agricultural Economics Research Institute (LEI) is active in a wide array of research which can be classified into various domains. This report reflects research within the following domain:

- ☐ Statutory and service tasks
- ☐ Business development and competitive position
- ☐ Natural resources and the environment
- ☐ Land and economics
- ☐ Chains
- ☑ Policy
- ☐ Institutions, people and perceptions
- ☐ Models and data

II

Emerging risks have been defined as potential food-borne, feed-borne, or diet-related hazards that may become a risk for human health in the future. This study disentangles how emerging risks relate to international trade. It develops a basic framework for the economic analysis of emerging risks, and describes a case study on residues of antibiotics in farmed shrimp to explore the use of trade analysis methodologies for the purposes of signalling and warning. The main conclusion is that an understanding of risk creating and risk reducing behaviour is pivotal for the identification of emerging risks.

IV

Contents

Preface

Recent years have shown several food related incidents that were unforeseen at the time. The increasing complexity of food supply, technological innovations and ongoing globalisation appears to drive new hazards into existence, or to reduce our capacity to manage the hazards that are known. Such new, unforeseen problems have been dubbed emerging risks. Government intervention in relation to food risks has often been reactive, whereas food safety incidents tend to build up rapidly. A more pro-active approach to risk prevention could prevent or make harmless the potential hazards before they have developed into problematic risks.

This study is part of a four-year research programme 'Emerging risk in the food chain', which aims to develop methods for pro-active signalling of food-related hazards. As a basic step, this paper examines the relation of international trade to the emergence of food risks. Related publications explore the perceptions of stakeholders of emerging risks, the lessons from incidents to food safety and animal health in the last decade, and current perspectives on emerging risks from food science.

The research has been commissioned by the Netherlands Ministry of Agriculture, Nature and Food Quality (LNV) in cooperation with the Food and Consumer Product Safety Authority (VWA). The guidance and kind support provided by Rob Theelen (LNV), Wim Ooms (VWA), Hub Nooteboom (VWA) and Geert Houben (TNO) is gratefully acknowledged.

Dr J.C. Blom
Director general LEI

8

Summary

Consumer health hazards in international food trade

Emerging risks have been defined as a potential food-borne, feed-borne, or diet-related hazard that may become a risk for human health in the (near) future. The detection of emerging risks would provide increased scope for pro-active intervention measures that aim to prevent a potential hazard from becoming a risk.

This study examines the implications of international trade for the emergence of food risks. In responding to this stock-taking question, the research covers a range of aspects, including the general aspects of trade, international food supply chains, food quality and safety management, and more detailed aspects regarding particular food products. The methods applied in this research are literature review and data analysis.

Based on available literature, a basic framework for the economic analysis of emerging risks is laid out. There are at least four risk-related dimensions to international trade, and valuable information on emerging risk identification can be obtained on each of these:
- the shipments of goods and services;
- the transfer of hazards from origin to destination;
- information exchange between buyers and sellers on food safety and quality, and processes and production methods;
- the contractual relation between the two parties (e.g. on quality standards, liability). It is argued that an indicator of vertical integration is a potentially relevant indicator in emerging risks identification: firms that are well-embedded in integrated supply chains are more likely to be trusted on their private interests in preventing consumer health hazards.

The second part of the paper describes a case study on residues of antibiotics in farmed shrimp to illustrate how international policies and markets affect risk, and to explore the use of trade analysis methodologies for emerging risk identification. Data available for this purpose include time series of detailed trade data, and reports from border inspections on risk.

With regard to the use of trade data, intuitively there is a positive correlation between the growth of trade and risk levels. Upon deeper examination, however, one needs to account for three relations: To what extent does trade growth imply the intensification of production?; To what extent does demand expansion affect requirements on the quality of the product?; How do producers adjust to the presence of food safety risk when the contractual relations with buyers alter in response to market demands?

As far as the scope for constructing signals from risk data is concerned, there is a need to assess how statistical information *on currently known hazards* can assist to get signals on emerging risk. There appears to be scope to inform emerging risk identification

with data on known hazards in output. Economic theory predicts where risk is more likely to emerge; if firms operate rationally, they will pursue prevention of food risk up to the point where the expected benefit of reducing risk in food supply (bigger sales revenues over time) equals the cost of preventive measures. A strong statistical likelihood of contamination should, then, raise questions on the cost/benefit ratio of preventive measures, and on the economic environment. The extent of cooperation of firms in supply chains or producer organisations is a potential determinant of the cost/benefit ratio, or an indicator of risk.

The main conclusion is that economic theory can provide instrumental perspectives to further advance existing thought on how to arrive at pro-active signalling of emerging risk. Understanding risk creating and risk reducing behaviour is pivotal for the identification of emerging risks. Basically, economics can assist in assessing and ranking conspicuous findings inside and outside the food chain. Several economic developments, including (international) trade, are useful as possible indicators but they require careful scrutiny.

It is suggested that the following topics receive further scrutiny as preparatory work for purpose of pro-active signalling of emerging risk:

- under what conditions can we expect that producers and consumers decisions will align with public objectives (i.e. with due care and diligence on prevention and signalling potential food related risk)? Under what conditions do their private interests deviate 'to a worrying extent' from public objectives?
- the role of information, trust and perceptions. More cooperation in the food production and supply chains will, in theory, result in bigger drive for prevention and transparency. How does this affect consumer trust in the food industry and authorities, and can that reduce the vulnerability of the food system for widespread scares?
- some form of decision support system is a requirement for an operational structure of emerging risk identification.

The above issues require a more thorough analysis of the behaviour of producers and consumers in order to effectively interpret and rank the signals in emerging risk identification. Various fields of economics provide useful methods and insights for that purpose. A particularly promising tool for the analysis of strategic interactions between producers, consumers and food authorities is game theory. For the analyses of choice under limited information - a fundamental problem in the presence of uncertainty or risk - behavioural economics usefully integrates psychology and economics.

10

1. Introduction

Economists often distinguish risk from uncertainty. Risk relates to situations where probabilities are knowable; uncertainty proper applies to situations where probabilities cannot even be defined (Johansson, 1991:135). Traditionally, economic theory and empirics have been at better ease with the former, especially in relation to consumption decisions (how certain are tomorrow's earnings), the management of financial portfolios (spreading risk), macroeconomics (managing exchange rate volatility) and environmental economics (current policies affect future choices and vice versa). Gollier (2001) provides an account.

The four-year research programme 'Emerging risk in the food chain', promoted by the Dutch food authorities, aims to enhance the effectiveness of hazard identification relating to food and consumer health in the EU. The current structures for hazard identification in the EU, e.g. rapid alert systems, have proven useful but many times incapable to flag hazards as they emerge. Complementary activities are deemed necessary, therefore, for *emerging risk identification*, or, a 'system or procedure aimed at proactively identifying and preventing potential hazard from becoming a risk.' (VWA, 2005:12). The reader will notice the risk analysis terminology. For economists, the programme purpose lies at the core of the distinction described above: the aim is to convert uncertainty into risk.

1.1 Background and objectives

The programme 'Emerging risk in the food chain' aims to develop methods for pro-active signalling of food-related hazards. As a basic step, this paper examines the relation of international trade to the emergence of food risks. Related publications explore the perceptions of stakeholders of emerging risks (Bakker et al.,2006), the lessons from incidents to food safety and animal health in the last decade (Hagenaar et al.,2006), and current perspectives on emerging risks from food science (Kleter et al., 2006).

This study is part of an extensive research programme on emerging risks in the food chain, which aims to develop methods for pro-active signalling of food-related hazards. A more pro-active approach to risk prevention, so the programme assumes, could prevent or make harmless the potential hazards before they have developed into problematic risks.

Timely identification of risks in food supply provides consumers, firms and governments with opportunities to take preventive measures that reduce the risk or the impact of the hazard. The presumption underlying efforts on emerging risks, which aim to find signals of risks before they rise in significance, is that (national) welfare is maximised if prevention is based on the earliest possible identification of risk. The decision on prevention is fraught with uncertainty because it is impossible to accurately predict the spread and impact of arising hazards. The economic rationale for emerging risk identification is that, at the national level, the expected benefits of prevention outweigh the

costs of searching risk and early prevention. For these benefits and costs, there are many possible yardsticks, both social (trust, legitimacy) and economical (welfare, income).

Emerging risk identification is still in its early, exploratory phases. Previous work at VWA has resulted in a preliminary analytical framework, the environment-host analysis (see figure 1.1). It was proposed under the PERIAPT project, and takes a broad perspective on food safety in search of signals for new hazards. There are now two basic principles that guide future work. First, it is critical to seek for signals outside of the food supply chain. VWA (2005:14) suggests that proper control of emerging risk requires 'much more knowledge or information than is available within the production chain only.' Second, the work must be interdisciplinary in order to be effective.

There are many economic features in the framework. This study touches on several while focusing on trade. It makes contributions to the research agenda for the programme from the perspective of international economics and trade. For that purpose, the paper assesses the relation between the risks identified in the cases examined under the programme 2005, and international trade flows. In addition, it gives directions for a theoretical framework on the economic signalling of emerging risk.
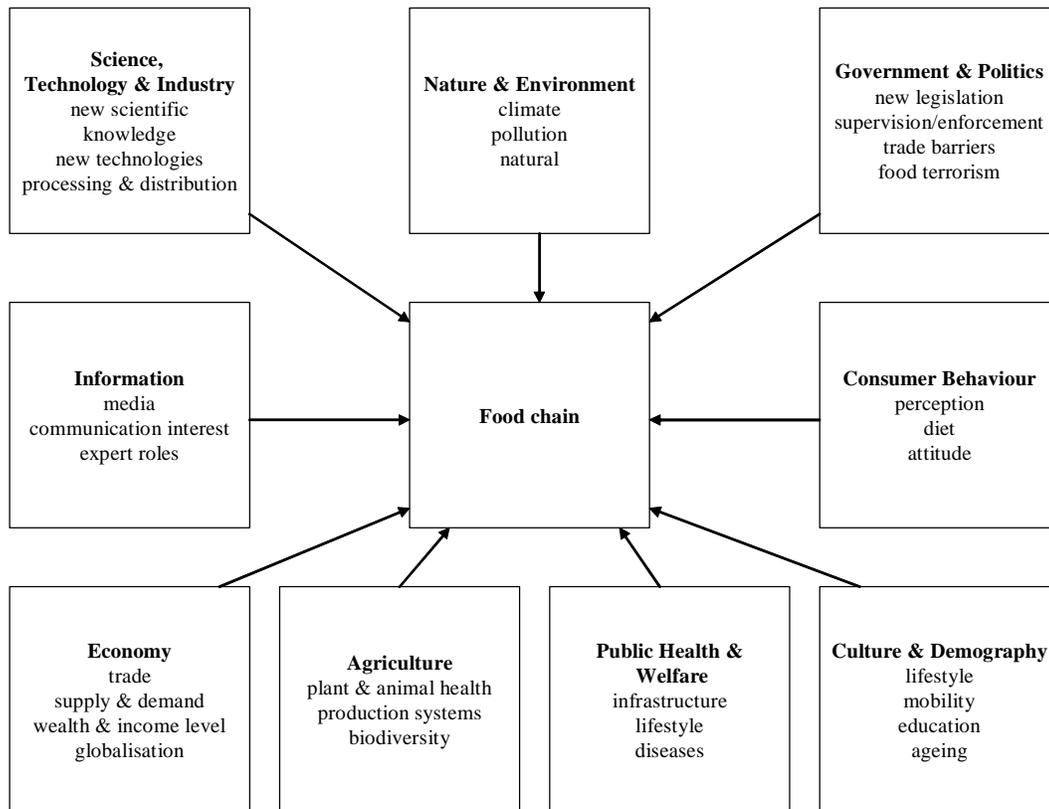

Figure 1.1   Host environment of the food supply chain regarding emerging risks
Source: VWA (2005: 38).
Note: bold, influential sector; standard, critical factor.

12

1.2 Research questions

The general research question is the following:

'What are the implications of international trade for the emergence of food risks?'

In responding to this stock-taking question, the research covers a range of aspects, including the general aspects of trade, international chains, quality management, and food safety, and more detailed aspects regarding particular food products, such as treated in the various case studies. It examines what contributions economic theory can make to further advance existing thought on how to arrive at pro-active signalling of emerging risk.
Emerging risk is defined for our current purpose as:

'a potential food or feed borne or diet-related hazard that may become a risk for human health in the (near) future. Emerging risks can result from three different types of hazards such as: an unidentified new form of known hazard (e.g. unidentified mycotoxin, avian influenza); a not well-known hazard (e.g. acrylamide, endocrine disrupter); a well known re-emerging hazard (e.g. Brucellosis, obesity). Excluded are the unidentified hazards of which nothing is known and the well-characterised hazards that are presently controlled.' (VWA, 2005:12).

1.3 Approach

The methods applied in this research were literature review and data analysis. Under the programme, several cases have been examined with the purpose of learning from the unforeseen hazards in the past. For the purposes of this study, we focus on the case of antibiotics in farmed shrimp, because it provides a useful illustration of how international policies and markets affect risk. An in-depth analysis better suits our purpose than a cross-cutting analysis of all cases.

2.   The scope of emerging risks in international trade

This chapter takes stock of the possible relations between consumer health hazards and the international trade in agricultural products and food. In addition, A framework is sketched for the economic analysis of food risks in international trade. The contribution from economics to the challenge of pro-active signalling will dwell upon that literature. Two subjects are of particular importance to the purpose of emerging risk identification: first, the discussion on what explains the production and marketing of safe food, or the lack thereof; second, the issue of how governments should intervene in situations when the market transactions of consumers and producers do not deliver safe enough food.

   Golan et al. (2000) from USDA's Economic Research Service, provide a useful introduction to the economics of food safety, in terms of scope and concepts. The line of reasoning has an orientation on market failure and the subsequent need for government intervention:

1.   Consumers value food safety.
2.   In consumer demand, preferences for food safety are understated for two possible reasons.
     a.   The level of safety and quality of food can in many instances not be observed through appearance or experience, which gives rise to information problems.
     b.   Consumers base their consumption decisions on private benefits and costs, ignoring social costs such as those related to illness and productivity loss.
3.   The occurrence of information problems and understated demand is reflected in producer behaviour with relation to food safety.
     a.   The benefits of taking costly preventive measures or of solving the information problem may not outweigh the costs.
     b.   Sellers have incentives to put the information asymmetry to their benefit by cheating on buyers.
4.   The result of the forces at play is that the free market outcome deviates from the outcome that is best for society, i.e. the outcome that maximises welfare.
5.   Possible instruments to overcome the problem, and to achieve the best market outcome are: liability (I sue you!); information exchange and education, e.g. through labelling strategies, consumer awareness programmes, et cetera; and government regulation.

   The paragraph reads as a refreshment course in the dismal science (which is how economics was known in the 19th century before JS Mill produced convincing arguments on the virtues of liberal markets): consumers enter the stage as naive subjects who passively refrain from seeking information on the veritable attributes of food; producers cheat where they can. In reality, producers do not minimise the amount of resources spent on food safety. Often the voluntary requirements on food quality and safety are more stringent than regulatory standards. Consumers have strong preferences regarding quality

and safety attributes of food, although these are not always revealed in their purchases (Sterrenberg and Dagevos, 2003; Beekman et al., 2003). The truth is that the lion share of food produced and sold complies with legal standards. Illustrative is the inspector's rule of thumb: the detection of illegal goods and practices targets a mere 5% of supply.

Recent insight into the decisions of food firms with respect to food safety focus on issues of organisation, information and trust: the more food producers integrate their activities (under labels, in supply chains, or in integrated firms), the more they are induced to pay due attention to the prevention and signalling of risk.

2.1   Trade flows and the spread of risk

Food supply became a truly global affair over the past decades, resulting in extensive international trade of agricultural and food products. Over time, as trade barriers are being gradually broken down and economic growth in the developing countries continues, the consumers in North-West Europe will become even more intertwined with producers all over the world. Trade flows potentially transmit food related risk between countries. This section relates international trade to consumer health hazards in the EU.

First of all, trade moves or spreads hazards that originate in the processes of production and processing; the activity of trading adds comparatively little risk. The hazards that emerge during the activity of trading and transport are mainly related to the biological degradation of products caused, for instance, by insufficient refrigeration. A study on the relation of import and risk should not gaze at the shipments of goods but must take aspects of food production and processing duly into account.

In this scope, 'trade' means the legal exchange of goods. The contribution of illegal trade to food risk lies outside the scope of this study, as well as other ways for hazards to be transmitted from abroad. The Dutch are a travelling lot, and tourists returning from their holidays abroad are a source of foreign pathogens, especially when they have caught an infection or bring foodstuff back. Movements of game are another source for the spread of potential pathogens across international borders.

Reliable data on the contribution of each of the risk pathways are unavailable or can be obtained only at high cost. A possible approach to a quantitative comparison of risk pathways makes use of expert groups and numerical ranking. Gallagher et al. (2002) describe the method in relation to an assessment of import risk for food and mouth disease in Europe. Similar approaches may be applied to unlock current expertise on new and unidentified consumer hazards in Dutch food supply.

Trade analysis may bear useful information for the purpose of emerging risk identification. The key challenge is to find relevant concepts and approaches. This section describes several general concepts that are of potential use as indicators with the purpose of listing alternatives that require more in-depth analysis. More detail on methods and data sources is provided in appendix 2.

Import penetration and vertical specialisation
The Netherlands are vulnerable for importing food risk as a result of its trade position. By the volume of imports, the Netherlands is the 6th largest importer of agricultural and food

products in the world. The lion's share of trade consists of imports from other EU countries; in some product groups third countries are the dominant source of origin. Rotterdam harbour and Schiphol airport are pivotal entry points for transhipments into the European hinterland. Demand in domestic markets is another import driver of imports. The import penetration, the ratio of imports to total domestic demand, for all agricultural (including horticultural) products in the Netherlands was above 90% in the 1990s (Bijman et al., 1997). As the import penetration tends to rise, the market share of goods produced abroad is still expanding.

The Netherlands are the largest net exporter (the balance exports minus imports) of agricultural and food products in the world. Many export industries (floriculture, processed food) depend on the importation of raw material and semi-manufactures. In the process, imported flows and domestic flows are mixed, which results in a potential loss of traceability. The public access to information in that area is often incomplete or unavailable - a shortcoming that has been recorded in the poultry industry under the CARMA project.[1] In view of risk management, e.g. on bacterial contamination in the case of the poultry industry, it is of utmost importance to understand how imports relate to exports. An economic measure for the dependency of export industries on imported goods is the vertical specialisation measure, described in Hummels, Ishi en Yi (2001).

Time-series of import penetration and vertical specialisation could serve their purpose in the identification of emerging risk. Leading questions for the interpretation of such indicators include: How do the composition and origin of trade evolve over time? How does the import dependency develop in the industries, and to what extent are changes driven by the import share in exports?

Projections of agriculture and food trade
The anticipation of change is the core of preventive risk management. Trade follows economic principles drivers, which renders it to an extent predictable. In the short run, trade flows are driven by factors including exchange rate movements, consumer demand, and productivity differences between countries. In the long, trade flows are the reflection of the allocation of factors of production and their prices. Trade patterns are influenced by trade policies and agricultural policies. Important factors are policies made under the World Trade Organisation (WTO) and under bilateral agreements. Specifically in the trade of agriculture and food products there are risk reducing measures such as veterinary restriction and technical requirements regarding the safety of goods for the health of consumers, and the productive stock of animals and plants.

One can think of two sets of indicators. First, the monitoring of changing patterns of regional specialisation and trade. One possible measure is the extensive goods margin, which Kehoe and Ruhl (2003) developed in order to pinpoint rapid growth of new goods and countries of origin in the data. In basic terms, the approach is to monitor export growth of certain combinations of products and markets or PMCs (of the form: good *i* shipped from country of origin *r* to destination *s*), for which trade in reference year was nonexistent or very limited. Figure 2.1, which gives two time-series on EU imports of farmed salmon,

---

[1] CARMA is a multidisciplinary research programme on campylobacter risk management and assessment. See http://www.rivm.nl/carma/index_eng.html for more information.

shows how a growth orientation to trade data provides a strongly complementary perspective to volume based information.

The second set of indicators would seek to anticipate changes in the pattern of international specialisation and trade by keeping a keen eye on the drivers of trade discussed above. In addition, an infinite spectrum of international trends is of potential relevance for emerging risk identification. By way of example, think of the regulatory attention on environmental protection in the industrialised countries in the 1990s. In the face of rising production costs in the North, resource-intensive industries moved into the developing countries (Dasgupta et al., 2002). The reallocation caused changes to the risk profile of the latter.
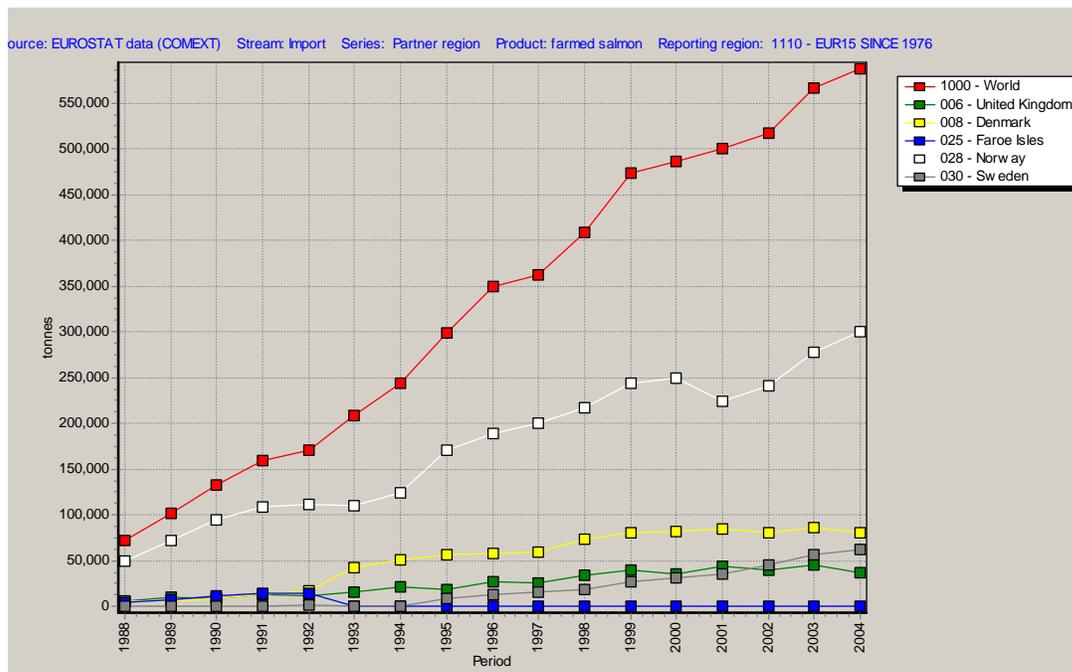

Figure 2.1a   EU imports of farmed salmon, 1988-2004: Top 5 trade partners
Source: COMEXT.
Note. It is assumed that all data for canned and preserved salmon refer to wild fish.

Standards in trade reduce the transfer of risk
In order to limit the transfer of risk in trade, governments and firms attach technical requirements to the importation agricultural products and food.

Standards are a collection of legal requirements, guidelines from acknowledged expert bodies and handbooks for the implementation of quality assurance systems in food production. Most address food production, processing and transportation. Governments often set minimum legal standards. Firms, in response, often cooperate in order to organise or anchor standards in supply chains. This is a self-enforcing process: leading food firms maintain standards above legal standards for themselves and chain partners, in order to anticipate future regulation, and to differentiate the market vis-à-vis competitors. In

17

complete industries in the EU, traceability was implemented long before it became a compulsory element under the General Food Law on 1 January 2005.

Technical requirements in the field of food safety are a limiting factor in international agricultural trade. There are numerous examples of countries that restrict imports under reference to consumer health protection. As for the impact of food safety standards, studies at the World Bank find possibly large trade losses that are out of proportion to the benefits in terms of lives saved (Otsuki et al., 2001; Wilson et al., 2003). From the perspective of emerging risk identification, trade restriction is a possible and desirable risk-reducing factor. Its effectiveness in risk control depends on whether the trade restrictions indeed address a potential hazard that matches the perceptions of risk in the importing country.
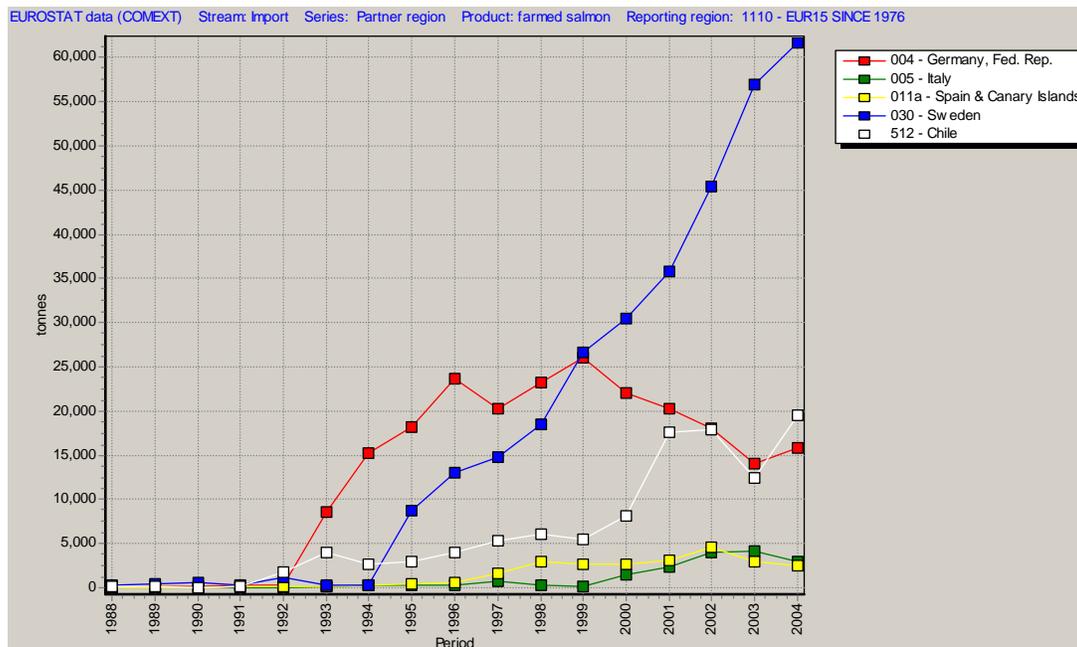
Figure 2.1b EU imports of farmed salmon, 1988-2004: Top 5 fastest growers
Source: COMEXT.
Note. It is assumed that all data for canned and preserved salmon refer to wild fish.

2.2 Information exchange and trust

A typical characteristic of food products is that they are characterised by many attributes that cannot be observed by the consumer. These refer to the biological and chemical composition of the food, the additives used, and the circumstances under which it was produced.

Information on risk control is a key concept in the economics of food safety because the level of food safety often cannot be observed by the buyer unless at a high cost. Economists analyse the costs of observing the true quality of a product under three sets of attributes - search, experience and credence. Search attributes such as colour can be

inspected prior to purchase. Experience attributes such as taste can be observed in consumption. The characteristics that are not verifiable until they are revealed by experts or other professional services are referred to as credence attributes. Food safety characteristics generally are in the set of credence attributes, i.e. consumers cannot observe food safety directly. In order to create trust in the safety of food supply, governments enforce minimum levels of food safety, and producers resort to private arrangements such as quality assurance systems under third party verification. However, the incentives for food risk prevention differ across firms, as the expected benefits and costs of risk prevention differ (by market segment, managerial capacity, et cetera). Firms choose an optimal level of risk prevention, but that effort is not observable by the regulator. In other words, firms have an information advantage that they may use strategically vis-à-vis consumers, competitors or regulators. Many food safety problems can be reduced to this asymmetry of information between producer and consumer or between producer and regulator.

Where limited communication of product attributes is allowed, producers have incentives to oversupply products of poor quality or safety - the 'lemons' argument taken from George Akerlof.[1] For a move towards consumption of safe products, buyers need to be able to distinguish safe from unsafe products. To producers this poses serious challenges on product communications, more so for those located at a distance from consumer markets.

The credibility of signals about the quality and the safety of exports is crucial in this regard. One may think of at least two options for effective signalling: first, the development of a label or grading system that is credible to buyers that maintain more stringent requirements, supported by an organisation based on the concept of traceability; second, to seek integration upwards into the product chain under a brand name with a credible reputation of safety (see Keyzer and Merbis, 2001). The other option on signalling implies the development of institutions that generate credible quality signals. Public policy has an important role to play here.

Signalling quality and safety
Signals of quality or safety need to provide credible and effective guidance in the buyers market. In the control and command sphere, signal problems can be addressed with the banning of unsafe products from a market, by enforcing technical requirements for minimum safety standards, or by taxing unsafe products. Explored here is one specific solution to the information problem, i.e. labelling, which functions as a market instrument to influence buyer behaviour through communication.

The main policy question is the extent to which labelling is an effective tool to address externalities in production and consumption. According to Golan et al. (2000), and Kuyvenhoven and Bigman (2001), information-based policies as labelling and the like are too weak to bring private choices in accord with social choices. The effectiveness of labelling as an instrument does not stretch beyond the communication of quality and

---

[1] 'The Market for Lemons: Quality Uncertainty and the Market Mechanism' is a 1970 paper by the economist George Akerlof. It discusses information asymmetry, which occurs when the seller knows more about a good than the buyer.

process characteristics to consumers that do not imply health hazards as such. Governments have three choices with regard to labelling and market failures: enforce mandatory labelling; facilitate voluntary labelling; or opt for other policy measures. The ultimate choice depends on the benefits and costs of each approach.

The credibility of the quality signal is increasingly important to exporters as it build trust with the buyers. There is a tendency to enhance credibility by seeking certification from respected standardising organisations such as ISO and to enhance trust in a standard or label via an accreditation by firms like SGS. Governments have important contributions to make to credibility of quality signals, with services like the provision of testing facilities, government accreditation and the implementation of (international) product standards. Economies of scale and scope, and the need to address co-ordination problems between individual producers, provide sufficient argument for government initiative. For the firms involved, the implementation of a label requires contractual relations between buyers and suppliers to be rearranged, as discussed below.

Information and trust in relation to emerging risk
The more food firm cooperate the less likely is the emergence of risk. The economic literature on food safety argues that the type of (supply chain) relation between producers and buyers can determine their decisions towards the prevention of food safety hazards. The importance of vertical integration, which involves cooperation between firms in various links of the supply chain, is particularly eminent, for two main reasons. First, more integrated supply chains (through shared standards on processes and production methods or mergers) are generally better organised to manage risk. Food firms often choose to integrate activities for the actual purpose of delivering constant volume and quality. Integration in supply is one approach to reducing variability and uncertainty in supply.[1] In the European meat industry, it is common that firms cooperate on a shared quality assurance system.[2] The pattern is common in all large fresh industries. Second, the economic incentive for safe food supply is stronger for firms and supply chains that operate close to consumer markets, such as retailers or branded food firms. There simply is more at stake: a food scandal can damage a firm's reputation as a trustworthy supplier, and even affect sales in an entire product group. In addition, larger firms have more social objectives (following from corporate social responsibility and marketing motives in general), in such areas as safety, and obesity.

An indicator of vertical integration will have great practical use for emerging risks identification: firms that are well-embedded in integrated supply chains are more likely to be trusted on their private interests in preventing consumer health hazards. The first steps in the design of an indicator of vertical integration have been made in recent applied research for the Ministry of LNV. Deneux et al., (2005) provide Dutch food firms with a food risk profile based on an examination of determinants of performance in the field of food safety. The study applies contributions by Poole and Garcia Martinez to the discipline

---

[1] There are many economic rationales for vertical integration, all can be deducted to shaping principal-agent relations. Hennessy (1996) stresses the solutions provided to information problems in food supply. Game theory is the standard tool in the analysis of principal-agent relations.
[2] See Bredahl et al., (2001) for a discussion on the UK meat industry; Bondt et al. (2003) for the Dutch pig meat industry.

20

of industrial organisation, which is the analysis of firm behaviour as the result of factors of production (including organisation) and market forces. The risk profile in Deneux et al. consists of three elements: the sort of processes and the technology involved; the business strategy with respect to outlet, standards and the 'culture of quality' in a firm; the extent of trust and openness in the relations of the firm with suppliers, buyers and stakeholders such as consumer organisations and the media. Applied to Dutch food firms, the study finds four high-risk industries: meat, eggs, fisheries products and ready-to-eat meals.

Emerging risks in international food supply chains
       A risk profile for Dutch food firms that operate in international food supply chains will have to take account of certain specific features involving imports of agriculture and food products.
1.   Operational infrastructure. Dutch imports are largely composed of raw material from developing countries and industrialised countries, and processed products from the industrialised countries, mainly EU member states. Raw materials such as sugar, grains, rice, nuts and fisheries products are imported mainly for further processing in the Dutch food industry. The state of technology in primary production, a critical phase in terms of hazard analysis, differs widely.
2.   Outlets and standards: The imported fresh produce enters on direct orders from buyers in the Netherlands (or elsewhere if goods are transhipped). Retailers and a central auction control the imports of fresh fruit and vegetables, and they maintain stringent standards on food safety and plant health. It seems likely that much of this flow qualifies as low-risk.
3.   Information and trust: The feed industry is a large importer of raw material. Perceptions of quality assurance in the feed industry are unquestionably poor, which reflects lacks of information on the origin and composition of raw material flows in this industry.

2.3   Conclusion

There are three types of exchanges in international trade, and valuable information on emerging risk identification can be obtained on each of the exchanges:
1.   shipments of goods and services;
2.   transfer of hazards from origin to destination;
3.   exchange of information on product characteristics and processes and production methods.

       Trade analysis may bear useful information for the purpose of emerging risk identification. Several relevant concepts and approaches have been suggested for further scrutiny.
       An indicator of vertical integration will have great practical use for emerging risks identification: firms that are well-embedded in integrated supply chains are more likely to be trusted on their private interests in preventing consumer health hazards.

3. Perspectives from the case studies

Under the programme, several cases have been examined with the purpose of learning from the unforeseen hazards in the past. The table provides a summary. For the purposes of this study, we focus on the case on antibiotics in farmed shrimp (no. 7), because it provides the best illustration of how international policies and markets affect risk. An in-depth analysis better suits our purpose than a cross-cutting analysis of all cases.

No.	Case	(Traded) products covered	Trade partners covered (import origin)	Comments, risk hypotheses
1	Avian Influenza - outbreak Netherlands 2004	Poultry meat, eggs	None explicitly covered; implications for BE, DE, others	Increased risk from organic/free-range holdings in high-density region. No consumer health hazard
2	Dioxin in pork meat - contaminated milk & meat	Pork meat, marl clay	Germany (clay)	Contaminated input in food industry, imported. Detected before products on market
3	PCBs et cetera in farmed fish	Farmed salmon	Scotland, Faroer Is., USA, Canada, Chile	Contaminated fish feed
4	BSE crisis in the UK	Exported meat	UK meat export markets, disrupted EU market	Reconstruction of BSE outbreak. Animal feed-borne transmission of disease
5	Fumonisin occurrences worldwide	Maize	Importers US, EU; consumers in South Africa, China, exporters UK, DK	Hazards (cancer risk) enter food chain through maize consumption, and contaminated feedstuff. EU regulatory tolerance reduced. EU-grown maize exceeds tolerance level
6	PFCs in fish	Fish: coastal, farmed	Belgium, Germany, other unspecified	Unregulated use of PFCs; Environmental contamination, e.g. fishing ground near coastal PFC processing plants. potential consumer health hazard
7	Antibiotics in cultured shrimp	Shrimp Prawn Akiami paste	SE Asia	Production in low-income setting: Lack of harmonized regulation

Figure 3.1   Case material from Emerging Risk 2005
Source: Hagenaars et al. (2006) and Kleter et al. (2006).

22

Antibiotics in aquaculture fish and shrimp

The case describes the occurrence of chemical hazards from veterinary medicines in shrimp and fish produced in aquaculture in Southeast Asia (see Annex 1). Contamination of shrimp with antibiotic residues apparently has had impact on consumer perception of food safety. The case focuses on how risk enters the food chain at the stage of production. In terms of drivers of risk, attention goes out to policies (and their lack of international convergence), and to cost-effective expansion of aquaculture industries in the developing country context. There is little attention for private quality assurance and safety control measures. In fact, possible incentives for preventive measures from downstream partners in the supply chain are not mentioned.

The risks from antibiotic residues are well-known and detectable but the case makes several points in relation to emerging risk. One, it is possible that science causes hazards to 'emerge' (rise in significance) as a result of improved detection methods. Two, an identified hazard in an industry could flag for other potential concern.

The authors elaborate on the second point by listing a number of indicators (in fact, 'suspicious' conditions in production), which include:
- lack of internationally harmonized legislation and quality assurance;
- illegal use or easy access to antibiotics;
- sharp increase in production and trade of farmed fish or shrimp.

Figure 3.2, which shows the annual value of EU shrimp imports from Southeast Asia and China between 1988 and 2004, clearly shows that the problems with contaminants marked the end of years of rapid trade expansion. The explanatory power of trade flows seems to differ. The Southeast Asian countries, Thailand especially, saw their traded shrimp volumes grow explosively throughout the 1990s. Peaking in 1998, the Southeast Asian countries gradually lost ground to Chinese exporters in the late 1990s and early years of the present decade.

3.1 International dimensions

The cases described differ in the extent to which they account for (international) trade flows. A scan of the cases does result, however, in a smorgasbord of topics that are of potential interest to emerging risk identification.
- Trade transfers goods, risk and information;
- Trade is an important vector of risk but not the only one;
- There is a possible trade-off between (short term) economic interests and risk prevention. The protection of trade interests sometimes compromises risk prevention;
- Consumers respond to a rise in perceived risk by means of a temporary shift in their consumption pattern. Import demand reduces by consequence, which creates excess supply in the country of origin. Products will move somewhere, however, and risk is possibly diverted to the home market, or other export markets or informal/illegal markets. In case the market repercussions from a scare are big, and the financial

position of producers comes under pressure, this can induce further reduction of preventive measures.

- Prevention based on the information on shipped goods will often arise too late. There are better chances of pro-active signalling in relation to production;
- The single fact of the lack of harmonisation of policies between exporter and EU is not a cause for emerging risk concern;
- The conditions under which goods are traded have a predictive value for emerging risk, unlike trade data as such. Focus should lie on a profile of the firms involved, and their contractual relations.

3.2 Deriving signals from trade data

The case study on antibiotics in cultured shrimp (Kleter et al., 2006) poses that sharp increases in production and trade are potentially relevant indicators of emerging risk. The reasoning behind a signal of rapid increases in export flow and production is that the innovations required to expand supply might introduce risk into the process. Before I examine this recommendation into more detail, it is useful to consider other possible indicators based on trade data. Sharp declines in trade volume may bear equally useful information. Sudden and dramatic drops in traded volume will imply that buyers substitute to other suppliers or other products. Trade policies could drive such shifts. In the case of shrimp, the EU ban on Thai shrimp in the mid-1990s supported rapid growth of Chinese exports into the EU. In general, trade policies (tariff barriers and technical trade barriers or non-tariff measures) are important drivers of global patterns of specialisation in production, and, by consequence, of the direction and volume trade of global trade. Large variability in trade may also bear useful information. Fluctuations in trade volume over time could signal that spot market transactions dominate over contractual transactions within supply chain.

In the case of shrimp, the rapid rise of EU imports from Southeast Asia and China may have indicated emerging food safety problems. The reasoning behind a signal of rapid increases in export flow and production is that the innovations required to expand supply might introduce risk into the process. In the case of shrimp aquaculture in Southeast Asia, most of the supply expansion in shrimp aquaculture from the 1980s on has been the result of productivity growth. Although some additional water and land (and labour) resources have been brought into shrimp farming, the biggest effect has come from an intensification of aquaculture activity (Lebel et al., 2002). As a result, the disease pressure in shrimp production increased, some pathogens spreading easily amongst the shrimp population. Heavy application of antibiotics was the main preventive measure, resulting in food safety problems of two kinds: antibiotic resistant bacterial strains in the environment resistance, and residues of veterinary medicine on the shrimp resulting in a possible toxic effect from human consumption.

Shrimp imports from Southeast Asia, including China, into the EU more than tripled over the one and a half decade between 1998 and 2003. Total imports from the Top 4 Southeast Asian exporters (Indonesia, Malaysia, Vietnam and Thailand) and China into the EU12 amounted to nearly 70 million ton in 2004 (see figure 3.2). Thailand was the main

24

supplier of shrimp in the EU in the late 1980s and early 1990s but never fully recovered from an outbreak of shrimp disease in 1995. This proved a major stimulus for competing traders from China, Malaysia and Indonesia. After the breakdown year 2002, which followed the detected contamination of chloramphenicol and nitrofurans in Asian shrimp in 2001, exports from Indonesia and Malaysia swiftly recovered while other countries stagnated.

Retrospectively, we may ask to what extent the trade data could have served as a signal for the then emerging risk. At first glance, the data suggest that both incidents (Thailand 1995 and China/SE Asia 2001) followed years of strong trade growth. Thai imports into EU12 expanded at an annual rate of 9% in the 5 years before the shrimp disease outbreak. The 2001 detections of antibiotic residues on EU border controls in imports from China, Vietnam and Indonesia followed a veritable trade explosion at annual average growth rates of, respectively 40%, 26% and 24%, over half a decade. Given that Malaysian shrimp did not encounter similar problems, it appears meaningful that shrimp trade from Malaysia into the EU expanded much more gradually over time.

In order to examine the intuitive relation between the trade and the risk, we must account for three relations: trade growth and production; rising demand and quality of the product; and producer responses to emerging risk.

First, there is not a one-on-one relation between trade and production. The aggregate shrimp imports from SE Asia into the EU12 have expanded faster than the production. Between 1988 and 2004, shrimp imports were growing at an average rate of 5% per annum. Figure 3.3 plots the growth of both shrimp exports into EU12 and shrimp supply. The diagram allows a pair wise comparison of scores on an index (volumes in the base year 1988 have been set to 100), for each country and each year. Prime conclusion from the table is that trade (mean index 223, standard deviation 154) is much more volatile than production (mean index 154, standard deviation 70). Supply growth follows developments in world shrimp demand, which is expanding much more gradual than import demand from the EU12. As the diagram clearly shows, the patterns varies largely across countries.

Second, the expansion in trade volume could serve as a signal for (sufficient) product quality. Asian shrimp has been in increasing demand in the EU12 throughout the 1990s, an era that raised consumer concerns over safety and food. In general, given the limited number of calamities, the industry has done fairly well in accommodating to such concern. Hence, the emergence of incidents relating to antibiotics in the years 2001-02 cannot be explained purely under the intensification hypothesis. Kleter et al. (2006) introduce an additional explanation that traces the incidents to improved analytical (laboratory) methods in the EU. Improvements in the methods of detection evoked the setting of a more stringent standard on residue limits, at a level more refined than export countries could verify. As products failed to meet the standard, consumer organisations raised bold concerns over health hazards, and consumer trust in the authorities eroded.

The above example illustrates the need to examine, for the years under study, the trade data in a broad context. Relations to take into account include the changes in the perspective of consumers and regulators in the EU on the food safety in products and production methods. Important follow-up questions include: Were there any changes to standards and regulations? To what extent did the detection analytics improve? How and why have consumer perceptions of risk and safety evolved over time?

Third, the presence of risk induces producers to innovate over time. By consequence, trade signals must be interpreted within the context of dynamic food industries. Ways of dealing with risk touch on the core of firm decision making. Kleter et al. (2006) describe how shrimp farms apply veterinary medicines to suppress disease pressure and maximise productivity in the shrimp ponds. They also describe a first round economic effect that involves changed consumer perceptions on the hazards of shrimp consumption and reduced demand. In a second round effect, producers and traders respond to the declined long-term profitability in the sector. The innovations in the process and organisation of production and trade are driven by the private costs and benefits to food safety requirements. Some firms have voluntarily implemented quality management systems to reduce costs in the first place, with enhanced quality and safety as by-products (Caswell, 1998:417).

A key point for emerging risk identification is that the optimal mode of production differs in situations with or without the presence of risk. Hennessy, Roosen and Jensen (2004) demonstrate this in a paper on cattle industries in the United States. Farmers alter their practices of moving cattle around the region once cattle trade is allowed, which entails an increased risk of introducing infectious disease. The analysis of trade developments over time must account for industrial dynamics in general and responses to the presence of risk in particular.

Risk has altered the organisation of the shrimp industries in Asia (Macfadyen et al., 2003). Reardon et al. (2001) relate the adjustment of producers in developing countries towards compliance of food quality and safety measures to the organisation of the industry. Large 'agribusiness' firms will often be involved in standardisation on their own accord, so that they in a sense 'privatise' the public regulations, perhaps even up to stricter than necessary levels. Possible strategies involve tight chain-control measures. The typical medium-scale domestic firm is a 'standard-taker': a firm that expects assistance from government in the adjustment process, which might entail co-operation at sector level or with importing agents. Small-scale firms are at risk to end up in a situation of lock in. To name two reasons: investments may require a certain scale of production to support technology and access to credit; a system of small-scale suppliers may entail too much risk to food-processing plants when standardisation increases at the plant (Farina and Reardon, 2000). It is expected therefore that in fragmented supplier markets increased regulation will induce further concentration in supply.

The analysis of trade developments over time must also account for changes in the structure of production. Important follow-up questions include: Is there any evidence that producers responded to the presence of risk? How has the organisation of production and trade evolved? The indicative use of trade data for emerging risks often involves time series analysis. Examples illustrate the need to examine, for the years under study, the trade data in a broad context in order to prevent the analyst from picking up the wrong signal.
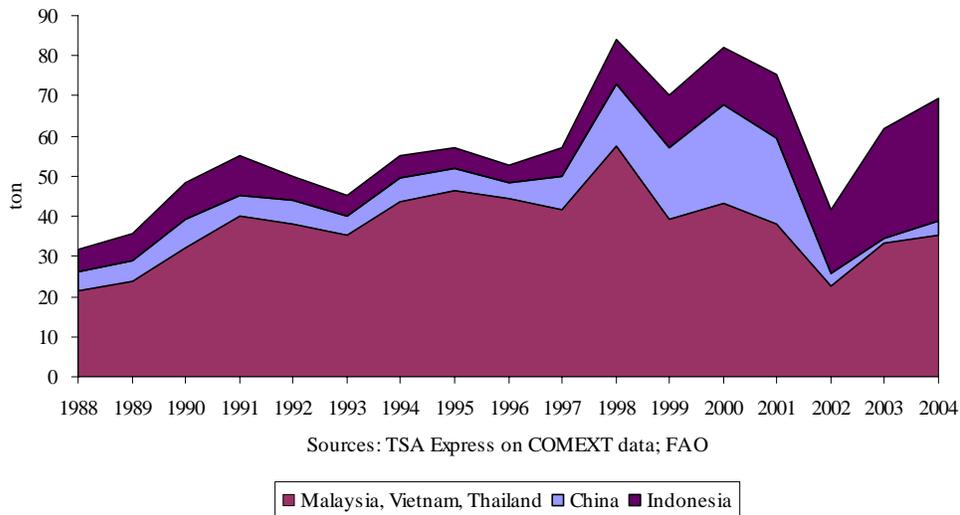
Figure 3.2   Asian shrimp imports triple in 15 years
Note: Imports into EU12 from China, Malaysia, Indonesia, Vietnam and Thailand (tons, 1988-2004).
Jan'02: EU ban on import from China (lifted Aug'04).
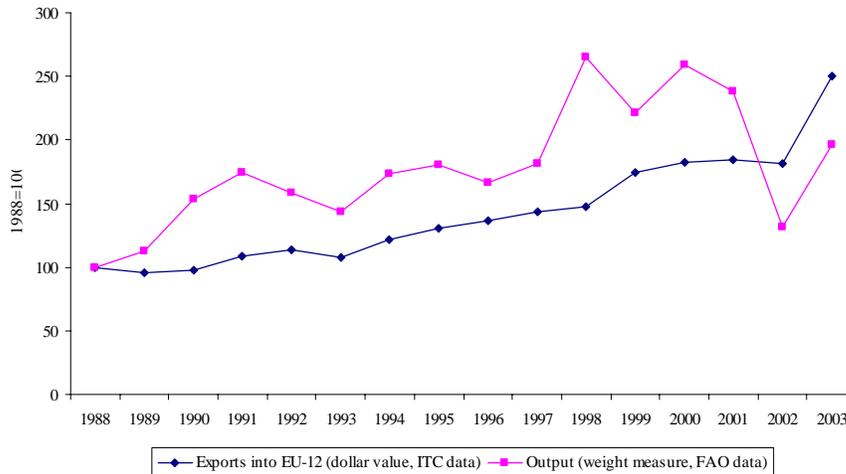Sep'02-Mar'03: Complete control of all imports from VN, TH, IDN.

Figure 3.3   Growth of shrimp output in China and SE Asia and export into EU-12, 1998-2003, indexed

3.3   Constructing signals from risk data

In our quest for a signal on emerging risk, we wish to explore the usefulness of a quantitative indicator. For the purpose of analysis, we will apply an approximation of food-related hazards in the EU: data on notifications of chemical hazards from RASFF. The rapid alert system for food and feed (RASFF) data are a database operated by the European Food Safety Authority (EFSA), which support an early warning system with the

27

cooperation of the countries in Western Europe. The purpose of RASFF is to share information on topical and prospected food hazards among the contributing countries, which are the EU and other countries in northwest Europe.

What information on emerging risk is contained in RASFF data?

Hazard awareness
RASFF, or any other source of product detention or risk data, reflects the cumulative and scientific knowledge on hazards that are acknowledged. It measures those hazards in the food chain on which there is *general* awareness in the body of European scientists that advise EFSA.

Hazardous trade
Data enter the RASFF database as product-market-hazard combinations that warn risk authorities essentially on the potential entry of hazardous trade flows into their territories, not on the emergence of hazards per se. The hazards never encountered at inspection - because proper preventive measures are in place - do not appear in the database.

The spread of hazards in food supply
In theory, a set of technical relations on input and output can predict the spread of current contaminations in the notifications throughout food supply. Rather than giving information on the assessment of emerging risk proper, these relations may support risk management on the short/medium term, and can be especially useful to pinpoint potential 'oil stain' hazards, i.e. product groups that are used widely throughout food supply. There is a strong analogy with epidemiology here.

Trend analysis
Figure 3.4 shows the number of monthly notifications in RASFF on chemical contamination, for the fisheries and spices and the total number for all products.[1] The total number of contaminations tends to grow slowly over time. There are four possible explanations for this tendency:
1.   EU/EFTA members trade more contaminated products; or
2.   food safety authorities are more alert on information regarding contamination; or
3.   they report better on the available information;
4.   a trend breach.

The likelihood of contamination
Examination of the increased contaminated trade hypothesis (1) involves two interacting variables that are likely to change with time: contamination per ton of shipped goods (possible directions are downwards and upwards), and the volume of trade (upwards). The results from border inspections of merchandise trade contain some level of information on the likelihood of importing risk for the product-market combinations (PMCs) under inspection. To see this, we take a statistical perspective on the spread of hazards throughout food supply. Think of total food (and feed and additives) output as a stock, and

---

[1] Gijs Kleter and Marnix Poelman kindly made the data available for this analysis.

of food (et cetera) exports as the selection from stock shipped abroad. If we assume that contaminated flows are spread randomly throughout stock, as explained below, the likelihood of exporting contaminated flow is simply the fraction of exports in output. Now, border inspections on imports provide information on contaminants in this subset, and we can determine statistically how much information the subset contains on the full sample. The information will be of the following kind: based on previous experience the likelihood of producing contaminated supply for product A in market B is x%. Then we are again at the level of output, which to my opinion is the proper realm for signalling emerging risk.

How can statistical information on the likelihood of contamination in output assist to get signals on emerging risk when the data reflect known hazards? Economic theory predicts where risk emerges. If firms operate rationally, they will pursue prevention of food risk up to the point where the expected benefit of reducing risk in food supply (bigger sales revenues over time) equals the cost of preventive measures. A strong statistical likelihood of contamination should, then, raise questions on the cost/benefit ratio of preventive measures, and on the economic environment. As discussed elsewhere, the extent of cooperation of firms in supply chains or producer organisations is a potential determinant of the cost/benefit ratio, or indicator of a risk.

The improved representation hypothesis (2) is especially relevant for two veterinary drugs (nitrofurans and chloramphenicol), for which the EU reduced its regulatory tolerances during the course of 2003-04, and raised sharper sanctions on contaminated shipments. EFSA has reported, in its report over 2004, that as a result of increased inspection, the frequency of notifications on these drugs first stepped up, and then dropped. Hypothesis (3) involves an aspect of learning, which seems unlikely to have large impact given the long history of food safety awareness in the EU. One major event fuels the importance of the trend breach hypothesis (4): the accession of 10 countries in Central and Eastern Europe to the EU as of 1 May, 2004. Their share in the number of notification is too low to affect the trend.
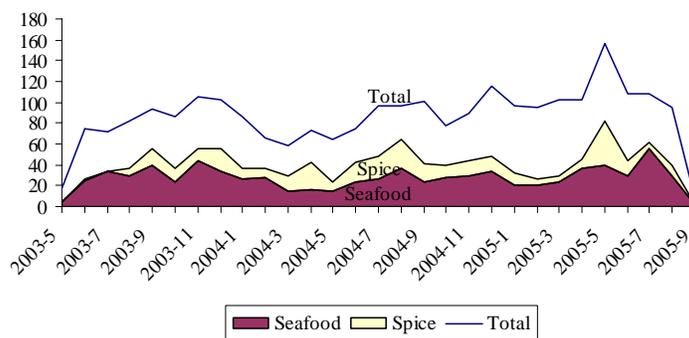

Figure 3.4   Monthly notifications of chemical contamination in RASFF

4. Discussion and conclusions

4.1   Comment on the PERIAPT framework

Emerging risk identification refers to a 'system or procedure aimed at proactively identifying and preventing potential hazard from becoming a risk.' (VWA, 2005:12). The core challenge in emerging risk identification is to turn uncertainty proper over compromises to food safety into a probabilistic risk, upon which preventive policies can be based.

Emerging risk identification is still in its early, exploratory phases. Previous work at VWA has resulted in an analytical framework, the environment-host analysis (see figure 1.1). It was proposed under the PERIAPT project, and takes a broad perspective on food safety in search of signals for new hazards. My reading is that there are now two basic principles that guide future work. First, it is critical to seek for signals both within and outside of the food supply chain. VWA (2005:14) suggests that proper control of emerging risk requires 'much more knowledge or information than is available within the production chain only'. Second, the work must be interdisciplinary in order to be effective.

The preliminary PERIAPT framework makes several contributions. First, it allows risk (to the economist: uncertainty) to be defined in a broad sense, and thus accommodates non-technical definitions and perceptions of risk. Second, it shifts the focus in risk assessment away from the mere identification of risk, towards understanding the drivers of risk. Third, it steers towards interdisciplinary approaches to risk identification but firmly grounded in mono-disciplinary expertise.

If the current framework would be brought into reality, I ask myself, what would be the result and how would it work? It would probably take shape as a network of academics, professionals and volunteering consumers who, on the basis of a common definition of emerging risk and division of labour, raise flags whenever they encounter conspicuous events, announcements or data. Flags must be interpreted and ranked, then debated, and finally given due follow-up.

What such a framework could use is theory. With dozens or thousands of flags raised per day, little has more practical use in the follow-up than hypotheses on how hazards and probabilities emerge. Good hypotheses on where to expect hazards (and where not) are necessary in order to be able to target a follow up to the stocktaking stage of emerging risk identification.

Economics can provide instrumental perspectives to further advance existing thought on how to arrive at pro-active signalling of emerging risk. The same will apply to other social sciences, notably sociology and psychology. Understanding risk creating and risk reducing behaviour is pivotal for the identification of emerging risks. First, producers and consumers have many incentives to behave well, in the sense that their (private) choices regarding the prevention of food hazards are aligned, full or in part, with public objectives. Thus, economics may help to manage the number of flags that cause deep concern.

Second, economics teaches that markets - and the consumers and producers who participate - are dynamic, and that ways of dealing with risk touch on the core of economic decision making. Thus, an economic perspective to emerging risk will prevent a too static approach.

Extension to the PERIAPT framework
The discussion above results in an extension to the PERIAPT framework: figure 4.1 brings the box 'food chain', in the core of figure 1.1, to life. It schematically depicts the (international) food supply chain as consisting of firms in a supply chain (retailers, suppliers and traders of a product that may contain a health hazard), transactions between the firms in a chain, and consumers. The transactions consist of *all* the exchanges in trade: the shipment of good; a potential hazard; the information exchange between buyers and sellers (e.g. about the quality and safety of the product) and the contractual relation between the two parties (e.g. on quality standards, liability). Transport may also be included as a fifth element, as a health hazard may appear during a transaction (although that probability is small).

government regulations

Consumers

o firms in a chain

___ transaction
-Product
-Potential health hazard
-information (on quality)
-agreement (on e.g. quality standards)
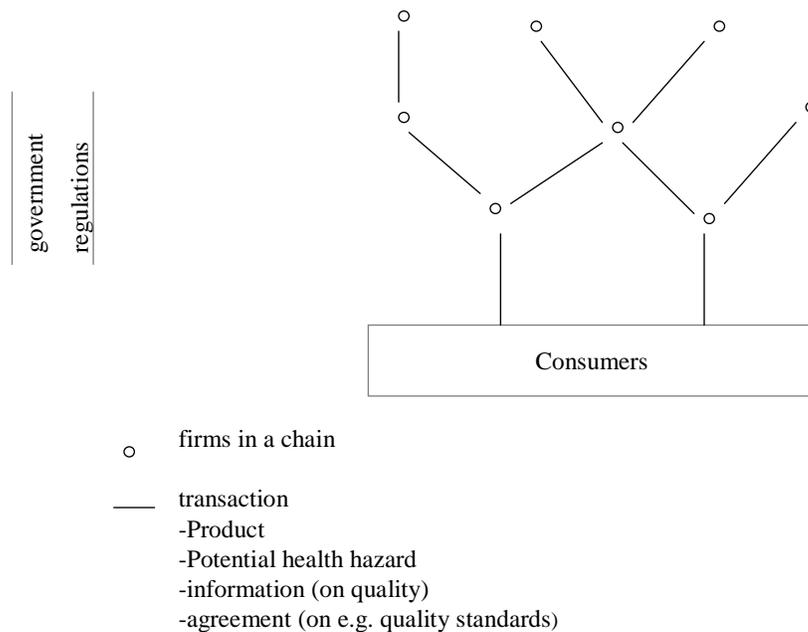
Figure 4.1   Schematic representation of a food chain

Behaviour serves as a starting point for possible indicators
Consumer health hazards (or potential hazards) do not arise out of the blue, and must in many instances be related to the behaviour of firms or consumers. To name one example of the 'human factor', the avian influenza case in Hagenaars et al. (2006) reported farmers

31

who (intended or unintended) did not report on conspicuous disease incidents in their flock, thus obstructing passive surveillance on the infectious bird disease. An incident of imported aquaculture shrimp that exceeded allowed levels of antibiotic residues, examined in chapter 3, provides an example of traders who distribute goods of which safety guarantee is not water tight.

The attitudes and behaviour of agents in the food chain are a potential target point for intervention by the risk managing authorities. Firms that are well-embedded in integrated supply chains are more likely to be trusted on their private interests in preventing consumer health hazards (Achterbosch, 2005). For example, liabilities are known to affect the private incentives for risk prevention: in the US and UK, companies voluntarily strive for compliance with food safety standards defined either by the government or authoritative institutions due to the legal environment in which claims can be imposed on them for any health damage caused by infringement of these standards or by negligence. The studies mentioned above point to the need for a general understanding of the human factor in why and how risks arise.

This renders the understanding of the motives and incentives for preventive action within the food supply chain of strategic value to the food authorities. Relevant issues include the following: under what conditions can we expect that producers and consumers decisions will align with public objectives (i.e. with due care and diligence on prevention and signalling potential food related risk)?; under what conditions do their private interests deviate 'to a worrying extent' from public objectives?

Integration and the disclosure of information on risk
This paper suggests a link between the role of information, trust and perceptions and the extent to which food firms engage in prevention of consumer hazards. As discussed in section 2.3, information on risk control is a key concept in the economics of food safety because the level of food safety often cannot be observed by the buyer unless at a high cost. Many food safety problems can be reduced to this asymmetry of information between producer and consumer or between producer and regulator.

More cooperation in the food production and supply chains will, in theory, result in bigger drive for prevention and transparency. How does this affect consumer trust in the food industry and authorities, and can that reduce the vulnerability of the food system for widespread scares?

From a supply side perspective, it is relevant to examine the communication on hazard-related information within the supply chain. Specific issues that are relevant include how producers deal with information asymmetries in their source base, and the scope of private quality/safety assurance systems like HACCP. The characteristics of firms in a chain are important to predict their behaviour. Questions such as 'will they comply with food safety standards' pertain to these. Because firms express and reveal their behaviour through market transactions, the characteristics of the transactions are equally important. Firms in a chain may commit to comply with food safety standards, cooperate and trust each other and share information. That is the situation where the need for monitoring by regulatory authorities reduces, and the risk of health hazards being passed down to consumers decreases. Labelling can make transactions of information more transparent and visible.

32

At the consumer end of the chain is where health hazards have their potential impact. Consumer behaviour towards risk in general, and emerging risks in particular, are affected by their perception of the health hazard as well as the firms in a chain (e.g. their trustworthiness) (Bakker and Beekman, 2005). Extreme cases of behaviour are careless consumption and contributions to the size of a food scandal. In case consumers respond to a perceived health hazard, the firms who sell their products to the consumers receive first blame. They have a reputation to keep up. This can be transferred back (upwards) to the other firms in a chain. In some ways, this can be perceived as a self-regulating system. It is important to examine this degree of self-regulation in international trade transactions, which come with all degrees of information, agreement (and trust).

Theoretical building blocks for data filtering
The above issues require a more thorough analysis of the behaviour of producers and regulators towards food risk control, and consumers towards unobservable food safety attributes. Recent contributions to the economic literature on food safety show progress in the direction of an integrated framework by applying game theory.[1] Game theory, which was introduced in VWA (2005), is a useful tool to analyse strategic interaction between producers, consumers and food authorities under specific conditions.

An example of strategic interaction between firms and regulators in emerging risk identification is the following. Assume that firms simultaneously produce output and also a level of risk control (joint production). The most important input for risk control is information on various risk factors in relation to the production process, the flow of material input, and the environment. The firm's analysis of critical control points determines what risk-related information is collected and how it is interpreted. However, authorities' interpretation of what is useful risk-related information can differ from that of the firm. Waste flows, identified as a key area of concern for emerging risk identification, provide an example: while HACCP plans typically address the management of waste only within the firm gate, authorities take large interest in the flow of waste outside the gate. For the regulator, the challenge is to align the management of risk-related information within the firm to its objectives. Firms, however, have an economic incentive to limit the disclosure on risk-related information to the regulator. Although not specific for new or known risks, the issue of managing risk-related information is more sensitive in relation to emerging risk identification because of the wide scope of possible indicators.

In addition, insights from behavioural economics may be particularly useful to bridge the gap between sociological insight on risk perceptions and economic insights on risk related behaviour. This economic discipline analyses 'irrational' valuation and perceptions of risks and probabilities by human beings. One of the findings that can be applied to food risks is that people perceive the probability of a loss (e.g, disease or death) as much more risky than conventional (rational) theory would predict. This has direct implications for the

---

[1] In an application of game theory to food safety issues, Bo-Hyan (2004) firms seek to minimise costs for complying with the legal food safety standard. Within a setting characterised by information asymmetry - the regulator has no exact knowledge on the level of risk control in the firm, which differs across firms - he examines the most appropriate regulatory instruments to ensure food safety. A key assumption is that the productivities of risk control differ across firms. The incentives to comply with regulation are stronger in more efficient firms than inefficient firms.

orientation of emerging risk identification, which from consumers' perception would be better oriented towards prevention of incidents rather than raising the average level of food safety. Consumer response to an incident is not straightforward, however, and depends both on perceived risk and perceived benefits. For example, a recent study examines fish consumption in France as a complicated decision for consumers to choose between two credence health attributes: a health benefit related to trans-fatty acids, and a health risk from methyl mercury contamination (Marette et al., 2006). In general, consumers appear more concerned about avoiding risks than about obtaining benefits, and 23 to 60 percent of the respondents did not alter consumption after they were informed on the health benefits and risks. Yet the order of presenting information appeared relevant: consumers better absorb information on potential health benefits if the health risks are disclosed in second instance. The obvious analogy to emerging risks is that the profile of an incident in a food (e.g. methyl mercury contamination in fish) is affected by consumers' perception on benefits. If only to acknowledge this interaction between credence attributes, consumer behaviour is one of the required elements in emerging risk identification.

4.2   Conclusion

This study examines the implications of international trade for the emergence of new food risks. In responding to this stock-taking question, the research covers a range of aspects, including the general aspects of trade, international chains, quality management, and food safety, and more detailed aspects regarding particular food products, such as treated in the various case studies.

The main conclusion is that economic theory can provide instrumental perspectives to further advance existing thought on how to arrive at pro-active signalling of emerging risk. Understanding risk creating and risk reducing behaviour is pivotal for the identification of emerging risks. Basically, economics can assist in assessing and ranking conspicuous findings inside and outside the food chain. Several economic developments, including (international) trade, are useful as possible indicators but they require careful scrutiny.

It is suggested that the following topics receive further scrutiny as preparatory work for purpose of pro-active signalling of emerging risk:
-    Under what conditions can we expect that producers and consumers decisions will align with public objectives (i.e. with due care and diligence on prevention and signalling potential food related risk)? Under what conditions do their private interests deviate 'to a worrying extent' from public objectives?
-    The role of information, trust and perceptions. More cooperation in the food production and supply chains will, in theory, result in bigger drive for prevention and transparency. How does this affect consumer trust in the food industry and authorities, and can that reduce the vulnerability of the food system for widespread scares?
-    Some form of decision support system is a requirement for an operational structure of emerging risk identification.

The above issues require a more thorough analysis of the behaviour of producers and consumers in order to effectively interpret and rank the signals in emerging risk identification. Various fields of economics provide useful methods and insights for that purpose.

References

Achterbosch, T.J., *Import en emerging risk in de voedselketen*. (Unpublished). LEI, The Hague, 2005.

Bakker, E. de and. V.Beekman, *Visies op voedselgevaren*. LEI, Den Haag, 2005.

Beekman, V., M. Bracke, T. van Gaasbeek and S. van der Kroon, *Begint een beter dierenwelzijn bij ons zelf? Een verkenning van de mogelijkheden voor verbetering van dierenwelzijn door marktwerking*. LEI, Den Haag, 2003.

Bijman, W.J.J., R.J.M. van Tulder and L.M. van Vliet, *Agribusiness, R&D en Internationalisatie: Internationaliseringstrategieën van agro-ondernemingen en de betekenis voor het eigen kennismanagement*. Nationale Raad voor Landbouwkundig Onderzoek, 1997.

Bo-Hyun, C., *Three studies on the economics of food safety*. PhD thesis. Ohio State University, 2004.

Bondt et al., *Prikkels voor naleving van voedselveiligheidseisen*. LEI, Den Haag, 2003.

Bondt, N., S. Deneux, J. van der Roest, G. Splinter, S. Tromp and K. de Vlieger, *Nederlandse levensmiddelenketens*. LEI, Den Haag, 2005.

Bredahl, M. E. ,James R.Northen, A. Boecker, and M.A. Normile, 'Quality demand sparks the growth of quality assurance firms in the European food sector'. In: Regmi, Anita (ed.) *The changing structure of global food consumption and trade*. ERS-USDA, Washington DC, 2001.

Caswell, J., 'Valuing the benefits and costs of improved food safety and nutrition'. In: *Australian Journal of Agricultural and Resource Economics* 42 (1998) 4, pp. 409-424.

Deneux, S., I. van der Fels-Klerx, S. Tromp and K. de Vlieger, *Factoren van invloed op voedselveiligheid*. LEI, Den Haag, 2005.

Dasgupta, S., C. Meisner, D. Wheeler and Y. Jin, 'Agricultural trade, development and toxic risk'. In: *World Development* 30 (2002) 8, pp. 1401-1412.

Gallagher, E., L. Kelly, M. Wooldridge, J. Ryan and Y. Leforban, 'Estimating the risk of importation of foot-and-mouth disease into Europe'. In: *The Veterinary Record* 25 (2002) 150 pp. 769-772(4).

Golan, E., F. Kuchler and L. Mitchell, 'Economics of food labeling'. In: *Economic Research Service. U.S.D.A., Agricultural Economics Report* 793 (200). Washington D.C.: U.S. Department of Agriculture.

Gollier, C., *'The economics of risk and time'.* MIT Press, Cambridge, 2001.

Hagenaars, T.J., A.R.W. Elbers, G. Kleter, F. Kreft, S.P.J. van Leeuwen, C. Waalwijk, L.A.P. Hoogenboom and H.J.P. Marvin, *Pro-active approaches to the identification of emerging risks in the food chain: Retrospective case studies*. ASG, Lelystad, 2006.

Hennessy, D.A., 'Information asymmetry as a reason for food industry vertical integration'. In: *Agricultural Economics* 78 (1996) 4, pp. 1034-1043.

Hennessy, D., J. Roosen, H. Jensen and, *Infectious disease, productivity, and scale in open and closed animal production systems.* CARD working paper. Iowa State University, Ames, 2004.

Hummels, D., J. Ishii and Kei-Mu Yi, 'The nature and growth of vertical specialization in world trade'. *Journal of International Economics* 54 (2001), pp. 75-96.

Johansson, Per-Olov., *Introduction to modern welfare economics.* Cambridge University Press, Cambridge, 1991.

Kehoe, T. and J.K.J. Ruhl., *How important is the new goods margin in international trade?* Research report 324. Federal Reserve Bank of Minneapolis, 2003.

Keyzer, M. and M. Merbis, *SPS standards and developing countries: the need for differentiation.* Paper prepared for the workshop Capacity building in developing countries with regard to non-tariff trade barriers. Organised by the Dutch Ministry of Agriculture, Nature Management and Fisheries. The Hague, 2001.

Kleter, G., M. Poelman, M. Groot and H. Marvin, *Inventory of possible 'emerging hazards' and an analysis of critical factors*. 2006.

Kuyvenhoven, A. and D. Bigman, *Technical standards in a liberalized agri-food system: institutional implications for developing countries*. Paper prepared for the workshop Capacity building in developing countries with regard to non-tariff trade barriers. Organised by the Dutch Ministry of Agriculture, Nature Management and Fisheries. The Hague, 2001.

Lebel, L. et al., *Industrial transformation and shrimp aquaculture in Thailand and Vietnam: Pathways to ecological, social and economic sustainability?* Ambio 31 (2002) 4, pp. 311-323.

Lieshout, M. van and C. van Woerkum, *In relatie tot reputatie.* Wageningen Universiteit, 2004.

Macfadyen, G., R. Banks, M. Phillips, G. Haylor, L. Mazaudier and P. Salz, *Background paper on international seafood trade and poverty.* Poseidon. Accessible at www.enaca.org, 2003.

Marette, S., J. Roossen, S. Blanchemanche, and P. Verger, *Health information and the choice of fish species.* An experiment measuring the impact of risk and benefit information. CARD working paper no. 421. Iowa State University, 2006.

Otsuki, T., J.S. Wilson and M. Sewadeh, 'Saving two in a billion quantifying the trade effect of European food safety standards on African exports'. In: *Food Policy* 26 (2001) 5, pp. 495-514.

Reardon, T. and E. Farina, 'The rise of private food quality and safety standards: Illustrations from Brazil'. In: *International Food and Agribusiness Management Review*. (2003).

Reardon, T., J.-M. Codron, L. Busch, J. Bingen and C. Harris, 'Global change in agrifood grades and standards: Agribusiness strategic responses in developing countries'. In: *International Food and Agribusiness Management Review* 2(2001) 3.

Sterrenberg, L. and H. Dagevos (ed.), *Burgers en consumenten.* Rathenau Instituut, Den Haag, 2003.

Wilson, J. S., T. Otsuki and B. Majumdsar. 'Balancing food safety and risk: do drug residue limits affect international trade in beef?' *Journal International Trade & Economic Development* 12 (2003) 4, pp. 377-402.

Voedsel en Waren Autoriteit (VWA). *'Emerging risks identification in food and feed for human health.'* The Hague 2005. Accessible on www.periapt.net

Bakker, E. de and V. Beekman, *Visies op voedselgevaren: De percepties van emerging risks onder stakeholders in de voedselketen.* (Perspectives on food hazards: Perceptions of emerging risks among stakeholders in the food supply chain). Report 7.06.12. LEI, The Hague, 2006.

Hagenaars, T.J., A.R.W. Elbers, G. Kleter, F. Kreft, S.P.J. van Leeuwen, C. Waalwijk, L.A.P. Hoogenboom and H.J.P. Marvin, *Pro-active approaches to the identification of emerging risks in the food chain: Retrospective case studies.* ASG, Lelystad, 2006.

Kleter, G., M. Poelman, M. Groot, H. Marvin. *Inventory of possible 'emerging hazards' and an analysis of critical factors.* RIKILT, Wageningen, 2006.

Appendix 1.   The case of chloramphenicol contamination in shrimp trade

Table A1.1 provides a timeline of the regulatory measures taken by the EU regarding antibiotics in shrimp. In summary, the EU established controls on all shrimp imports from some countries after it had been observed that consignments from these countries contained either CAP or nitrofurans. Moreover, imports from China were temporarily suspended. During the same period, there were also a number of measures that pertained to, for example, poultry and other seafoods, which are not further treated here. These measures were subsequently lifted after the exporting nations had established the necessary controls and guarantees, and the EU member states' controls had been favorable.

Table A1.1 Timeline of regulatory measures

Date dd-mm-yyyy	Measure	Background
19-09-2001	Complete control of all imported consignments of shrimp from Vietnam and China for the presence of CAP	Measure was instigated by reports on contamination of shrimps by CAP. Decision can be revised based on guarantees and results of controls.
27-09-2001	Same as for 2001/699/EC, for shrimp from Indonesia	Same as for 2001/699/EC
30-01-2002	Suspension of imports of shrimp from China	Measure was based on shortcomings of Chinese local situation noted during an EU-inspection
27-03-2002	Complete control of all imported consignments of shrimp from Vietnam for the presence of nitrofurans	Measure was instigated by reports on contamination of shrimps by nitrofurans. Decision can be revised based on guarantees and results of controls.
27-03-2002	Same as for 2002/250/EC, for shrimp from Thailand	Same as for 2002/250/EC
02-10-2002	Revocation of controls on imports of Vietnamese shrimp	Results of controls and guarantees by Vietnamese authorities led to this revocation
20-12-2002	Revocation of suspension of imports of Chinese fisheries products *except for shrimps, eel, and fish from aquaculture*	Suspension revoked for some products based on positive results of controls and guarantees from Chinese government. For shrimp and eel, no distinction can be made between caught and reared animals.

Date *dd-mm-yyyy*	Measure	Background
24-06-2003	Revocation of 2002/251 for imports from Thailand	Revocation is based on favorable results of controls and guarantees from the Thai authorities
22-07-2003	Revocation of 2001/705/EC for imports from Indonesia	Revocation is based on favorable results of controls and guarantees from the Indonesian authorities
26-08-2004	Addition of processed and peeled shrimps to list of products allowed for imports, if accompanied by Chinese certificate	China has introduced systematic and complete safety checks, among others with regard to CAP and nitrofurans

Figure 1   Historic measures of the EU regarding antibiotics in shrimps

a):Decisions are accessible through EUR-LEX (europa.eu.int/eur-lex/en/search/search_lif.html)

Appendix 2. Empirical measures and indicators in trade

Import penetration
The import penetration is the ratio of imports to total domestic demand. The Organization for Economic Cooperation and Development (OECD) annually reports import penetration rates, including for The Netherlands, in the OECD Economic Outlook (e.g. annex table 54 in report no. 76). To be of use in emerging risk identification, import penetration rates would need to be more detailed than OECD provides, e.g. at the product level (pastry, seafood, etcetera). In principle the required data are available at CBS, Dutch statistical service, which maintains a database on input and output of Dutch businesses. This input-output table is a matrix that states, by industry, the sectoral origin of all deliveries, and sectoral destination of output. If required, there is an option to extend this data with surveys of representative firms.

An approximation of import penetration uses supply balances for agricultural products, an annual co-production of LEI, CBS and product boards. A supply balance provides overviews of domestic production (Y) en imports (M) - which make total supply - together with domestic consumption or use (C), exports (E) plus changes in stock.

The import penetration is approximated by the ratio M/C, the vertical specialisation by the ratio M/E. Where M/C ratios exceed 100 per cent, these are indications that imports into the sector are re-exported, possibly after some processing has taken place. We see this in the poultry meat and beef meat sectors.

Vertical specialisation is a measure to describe the dependency of export industries on imported goods (Hummels, Ishi and Yi, 2001). The ration M/E is an approximation for vertical specialisation. However, available data and the supply balance approach fall short of producing useful information. A rising trend implies that the growth of import exceeds export expansion. This is confirmed by the stable development of exports (often expressed as share of total supply, i.e. the ration E/(Y+M)). 60 per cent of total supply of the product groups is being exported.

Extensive goods margin
The extensive goods margin (Kehoe en Ruhl, 2003) provides a measure for the rise of new goods or countries of origin in trade data. Basically, the method is to track export growth of certain combinations of products and markets (PMCs) over time. Fast growing PMCs have large extensive goods margins, and explosive growth could lead risk managers to revise estimates of potential hazard.

Tracking trade is easy when consistent datasets are applied over time, although these are not always available for all time-spans of interest. The pivotal trick is the selection of which PMCs are relevant. Of interest are PMCs that are traded in small volume at the beginning of measurement. For the selection, there is a need to develop criteria. Estimates of extensive goods margin requires highly detailed trade statistics in many-year time-series, according to international classifications. Perfect trade data are nonexistent, particularly with regard to imports and exports between the EU countries. Sound datasets include COMEXT for EU trade and ITC for world trade. LEI applies both datasets, using the copyrighted interface SITA.