Supply chain damage due to animal feed contamination; scenario analyses for processing industries

MIRANDA P.M. MEUWISSEN[1,2], ALEX L.A. VAN ANDEL[1], MARCEL A.P.M. VAN ASSELDONK[2] AND RUUD B.M. HUIRNE[2]

[1]Business Economics, Wageningen University, Hollandseweg 1, 6706 KN Wageningen, The Netherlands, +31 317 483857, miranda.meuwissen@wur.nl

[2]Institute for Risk Management in Agriculture, Wageningen University

Abstract

Widespread, not well quantified, chain damages from feed crises complicate the task for insurers to establish adequate product liability covers for animal feed producers. This paper assesses direct and indirect damages for dairy processors and pig and poultry slaughterhouses in the Netherlands. Based on expert elicitation, the expected total number of processing sites affected during a feed crisis is 15, almost 20%. Assuming publicly available data per type of processing industry, expected direct damage in the most likely scenario is Euro 24 million per crisis. More detailed figures were obtained through individual company assessments for which results are reported as indices (most likely = 100), for reasons of confidentiality. Direct damage indices are 100:3:259 for most likely, best case and worst case scenarios respectively. In the most likely scenario, 6% of direct damage is traced to products from contaminated farms. The remaining 94% is from mixing contaminated products with other (intermediate) products during various phases of processing. Indirect damage is on average perceived not to exceed direct damage. Scenario results are useful in current stakeholder debates on sharing damage burdens of animal feed crises across supply chain partners.

Key words: Direct damage; Indirect damage; Product liability insurance; Livestock supply chains

1. Introduction

Animal feed contaminations can cause severe disruptions in livestock supply chains. This was for instance the case in the Netherlands in 2002 when pig and cattle feed was found to be contaminated with medroxy-progestron-acetaat (MPA). Many feed companies, farms and processors became involved and damage was claimed to be around Euro 100 million (Dutch Lower House, 2002). In the following years, affected businesses attempted to file claims with feed companies but liability issues were hard to solve, among others because of problems of identifying responsible feed producers and in demonstrating their guilt. As a consequence, only very few damages were indemnified.

In the course of 2007, following MPA and some other feed crises, processing companies started to require animal feed producers to increase their product liability insurance covers. The idea of this mainly being that such extended insurance covers would at least increase the chance of "proper indemnification" for claimants further along the chain. The size of the covers required were Euro 75 million per crisis. In order to press animal feed producers to increase their product liability covers, processing companies even stated that they would stop processing milk, hogs etc. from livestock farmers who would still buy feed from producers who were not able to demonstrate extended insurance cover. For many animal feed producers, however, increasing the liability cover proved not to be possible, or only at a very high price. Insurance companies were very hesitant in providing extended covers, mainly because of the catastrophic nature of the risk and potential problems of asymmetric information. At the other hand, also feed producers were not eager to extend their insurance. They argued that risks were substantially reduced due to the implementation of a series of risk prevention and loss mitigation measures[1]. Also, they questioned the fairness of putting all chain damages on their burden, as the size of damages is also determined by processing decisions further along the chain. Following these debates, processors somewhat loosened the "Euro 75 million requirement" and rephrased it as "animal feed producers should have *adequate* levels of product liability insurance cover".

In this framework, there is a strong need for quantitative insight into supply chain damage caused by animal feed contaminations. Would, for instance, a cover of Euro 75 million be "adequate" to cover direct damages of farmers, processors and other partners of the chain? Damage figures of recent animal feed crises have not been described very well. Also, risk analyses of animal feed contaminations mostly focus on technical issues, see for instance Stärk et al. (2002) and damage figures are limited to the feed and farm level (Van Asseldonk et al., 2006; Meuwissen et al., 2008). This paper focuses on the so-called *post-harvest* part of the chain. More specifically, the objective of this paper is to quantify processing companies' *direct and indirect damage* due to animal feed contamination. Although indirect damage is generally not covered by product liability insurance schemes, more transparency about the size of this damage is likely to benefit the "fairness and loss burden" discussions among chain partners. In the paper, a number of scenarios is evaluated for which starting points have been derived from Van Asseldonk et al. (2006). Scenarios are for compound feed, which comprises 70% of the total amount of animal feed produced in the Netherlands. Processors include dairy processors and pig and poultry slaughterhouses operating in the Netherlands.

2. Dairy, hog and broiler chains

[1] These include (1) *public initiatives*: Regulation 178/2002/EC (General Food Law); Directive 2002/32/EC (undesirable substances in animal feed); Commission Decision 2004/217 (prohibited materials for animal nutrition); Directive 183/2005/EC (requirements for feed hygiene); (2) *sector initiatives*: GMP plus HACCP (2002); only usage of accredited products based on risk assessment (2003); implementation of procedures for recall, early warning and tracking and tracing (2003); and (3) *industry initiatives*: TrusQ (2003) and SafeFeed (2005), which are groups of animal feed producers who aim to further deepen GMP plus HACCP principles.

Why do insurance companies regard animal feed contaminations as a catastrophic risk? In order to understand this, some insight is needed into dairy, hog and broiler chains in the Netherlands. First of all, into the production of compound feed itself. Compound feed consists of many animal feed ingredients[2]. This implies that a single contaminated batch can be proportioned into multiple compound feed batches, possibly dispersed among many compound feed producers. About 100 producers (Table 1) distribute feed to almost 30,000 farms, who in turn deliver their produce to more than 80 processing sites. Annual turnover of these sites ranges from more than Euro 100 million for broiler slaughterhouses to more than Euro 300 million for hog slaughterhouses. If something "goes wrong" in any of the stages, one can easily imagine that many other stages get involved and damage can be considerable. Interrelationships with other livestock chains can even cause multiple chains to become affected. Some interrelationships between dairy and pork supply chains are illustrated in Figure 1. It is for instance shown that pork processors use lactose from dairy processing as part of pork products.

The Netherlands being an export country further adds to the potential catastrophic nature of feed contaminations. The net exporting situation is illustrated by the "degrees of self sufficiency" in Table 1. If national production is balanced with national consumption, this degree is equal to 100%. The 227% for pigs, for instance, implies that 56%, i.e. 117/227, of produce is exported. Export markets, especially countries outside the EU, often react very strongly on product contaminations and they might for instance close their border for a considerable period of time, thereby causing severe market distortions and price declines for Dutch producers.

[2] For instance, a major type of pig feed consists on average of 2% sugar beet molasses, 4% peas, 4% barley, 3% maize products, 5% palm kernels, 10% rapeseed meal, 5% rye, 5% soya bean products, 30% wheat, 2% wheat products, 8% wheat feedmeal, 25% triticale and 1% sunflower seed meal.

Besides "risk factors" also many risk prevention and risk mitigation measures exist. For feed producers examples of such measures were mentioned in footnote 1. Similar initiatives apply to other stages of the chain. Such measures diminish the chance of feed contaminations becoming catastrophic.

[Table 1]

[Figure 1]

3. Damage identification and previous crises

Damage from crises such as livestock epidemics and food safety crises can be classified into direct damage and indirect damage. Although definitions vary somewhat across literature, *direct damage* generally refers to risk mitigation and to the value of destructed livestock and contaminated products. *Indirect damage* mostly refers to less tangible issues such as "price impact" and "loss of image". Table 2 shows which direct and indirect damage components can occur from animal feed crises across livestock supply chains. Processors, for instance, are likely to face direct damage from collecting and destructing intermediate and final products, costs of tracking and tracing, and losses from temporary business interruption. Indirect damage can occur from widespread product recalls, products being returned by customers, decreased demand, and efforts needed to retrieve export markets.

In our paper, direct and indirect damages are largely defined as in product liability insurance schemes, i.e. direct damage refers to *contaminated* products as well as to products *mixed with* contaminated products, while indirect damage relates to *non*-contaminated products. Product liability insurance schemes generally cover direct damages; indirect damages are mostly excluded. As substantial variety exists in exact definitions of damages covered by liability insurance schemes, components listed in Table 2 may not be comprehensive. For instance, there can be subtle differences between "collection and destruction of contaminated products" and "product recall"; liability policies generally consider the first as risk mitigation which is covered by the policy, while for the latter, i.e. the wider product recall, separate product recall insurances need to be bought.

Damage figures from feed crises in the past have not been categorised very well. For a number of crises these data are not available at all (bottom part of Table 3). Only MPA-2002 damage data do distinguish between various chain partners. The more technical data of feed crises (upper part of Table 3) show that compound feed was involved in 5 crises (out of 6) and that there is considerable variation in the duration of a crisis[3]. Parameters also show that contaminations are mostly notified at farm level. Only for the two most recent crises, i.e. bone fragments in 2004 and dioxin in 2006, contaminations were already detected at the feed level and processors were not directly involved.

[Table 2]

[Table 3]

4. Materials and methods

Scenario development

In defining scenarios to assess processing industries' damage from feed contaminations, key variables are number of contaminated farms, type of farms and the number of days during which contaminated products are processed. Number and type of farms directly relates to the potential amount of produce supplied to processors. For instance, from a slaughterhouse perspective, the amount of animals supplied from hog and broiler farms is larger than the amounts coming from sow and laying hen farms. For the parameterisation of the variables, data from the compound feed risk analysis carried out by Van Asseldonk et al. (2006) were taken as a starting point. They found for instance that a feed crisis involves on average 659 farms, lasts on average for 7 days and is likely to equally affect cattle, pig and poultry sectors.

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[3] Note that the definition of "duration" varies across crises, depending on the data available. For instance in case of Dioxin-2003 "duration" (i.e. 23 days) refers to the number of days in which allowable levels were exceeded, while for Dioxin-2006 "duration" (i.e. 17 days) covers the whole period from discovering the contamination until release of all farms.

The shorter duration of a crisis (compared to actual lengths of crises as reported in Table 3) was attributed to substantial risk reducing effects of prevention and mitigation measures lately introduced.

In our study, mean, 5% and 95% percentiles of farm numbers and crises' duration[4] were interpreted as "most likely", "best case" and "worst case" scenarios for processors respectively (Table 4). Farm numbers (1/3 cattle, 1/3 pigs, 1/3 poultry) were further specified to subsectors based on relative frequencies, i.e. 91% dairy, 68% hog and 33% broiler farms (Agricultural Data, 2007). Crises' duration was interpreted as the number of days during which contaminated products are processed. It was furthermore assumed that contaminated farms are equally spread across the Netherlands and that produce which is mixed with contaminated products is always regarded as being contaminated. Sensitivity analyses were defined with regard to the most likely scenario.

Scenario evaluation

Direct and indirect damage figures per scenario and what-if analysis were assessed through expert elicitation. Figure 2 shows the various assessments made. For contaminated products, experts first estimated the number of affected processing sites per crisis from their own company perspective. Next, they carried out detailed analyses in order to estimate company-specific number of batches involved, type and value of products affected and farm-consumer lead times. For non-contaminated products, experts assessed potential amounts of returned products, decreased demand figures and the costs of efforts needed to retrieve markets.

Much of the elicited information is confidential. Output is therefore presented in various formats. In the "aggregated analysis" of direct damage (Figure 2), the 50%-percentile of the elicited number of processing sites is multiplied by the duration of a crisis and the

[4] Van Asseldonk et al. (2006) developed a stochastic simulation model. Multiple iterations generated 25,000 possible crisis outcomes. 5% of outcomes was below the 5%-percentile of farms affected and duration of crises and 5% of outcomes exceeded the 95%-percentile.

average turnover per site per day. In this way, output is in absolute numbers (Euro), but part of the elicited information, such as number of batches involved, is not used. Moreover, assuming the 50%-percentile is overestimating damage in some sectors while underestimating it in other sectors. Also, it is implicitly assumed that damage only occurs on those days in which contaminated products are being processed and that the complete turnover during these days is lost. In contrast, in the "detailed analysis", all elicited expert information of direct damage is used, but, for confidentiality reasons, output is presented as indices (most likely = 100). Similarly, assessments of indirect damage are as indices, for which direct damage = 100. As these assessments were more complex, experts focused on most likely and worst case scenarios.

Experts (n=8) originated from 4 processing companies representing dairy processors and pig and poultry slaughterhouses with market shares ranging from 20% to 80% of Dutch markets. Experts were consulted in 3 rounds: 2 individual meetings and a plenary session. In the plenary session there was group consensus per sector. All meetings took place in autumn 2007 during which period no animal feed crises occurred.

[Table 4]

[Figure 2]

5. Results

Number of processing sites affected

For two sectors involved in our analyses, i.e. "sector 2" and "sector 3", the exact size of a feed crisis hardly seems to matter: the expected number of processing sites affected remains identical across scenarios and what-if analyses, respectively 3 and 6 (Table 5). For "sector 1" however strong differences exist, varying from 2 affected sites in the optimistic scenario to 15 in the worst case scenario. What-if analyses also show that for all sectors the effect of a reduced number of livestock farms involved in a crisis ("less farms") is expected to be larger than a reduced number of days in which contaminated products are processed ("less days"). For instance, in "sector 1" reducing the number of farms leads to an expected decrease in number of processing sites affected from 6 (most likely) to 3 (less farms), while reducing the number of days does not reduce the expected number of sites at all.

Direct damage

In the "aggregated analysis", total direct damage per crisis ranges from Euro 24 million in the most likely scenario to Euro 1 and Euro 105 million in the best case and worst case scenario respectively (Table 6). Direct damage is highest for pig slaughterhouses, which relates to their relatively high amounts of turnover per day, as was mentioned in Table 1.

In the "detailed analysis", relative differences between most likely and worst case scenarios are much smaller, i.e. for summed direct damages per crisis 100:259, compared to Euro 24 million versus Euro 105 million in the "aggregated analysis". In the aggregated analysis 15 sites (i.e. 3 sectors x 5 sites per sector) are assumed to encounter "full turnover damages" during 30 days, while in the detailed analysis the number of sites is higher (24) but sites clearly manage to have not all batches involved. In the worst case scenario, damages increase relatively most for dairy processors, i.e. from 100 (most likely) to 358 (worst case). Relative differences for slaughterhouses are 100:202 (pig slaughtering) and 100:219 (poultry slaughtering). What-if analyses show that, in contrast to our findings for the expected number of affected processing sites, the number of days of processing contaminated products does significantly impact the size of direct damages in both ways, i.e. when reducing the number of days as well as when increasing the number of days. Table 6 (lower part) furthermore shows that across the various scenarios and what-if analyses minimally 85% of direct damage is expected to be due to the mixing of products during processing. From the total amount of produce affected, the percentage already consumed ranges from 2% in the best case scenario to 66% in the worst case scenario.

Indirect damage

Experts' opinions on indirect damages vary considerably, both with regard to damage components applicable as well as with regard to the expected extent of damages (Table 7). With regard to the non-contaminated products, "sector 1" expects indirect damage to only occur from returned products[5]. Experts of the other two sectors, however, also expect damages due to less demand and due to the need to retrieve (export) markets. In the most likely scenario, "sector 1" and "sector 3" expect indirect damages to be around 26% and 5% of direct damage respectively. "Sector 2" expects indirect damages to be about 3 times as high as direct damages. Similarly, "sector 2" expects larger damage in the worst case scenario. Based on market shares, weighted averages for indirect damage as a percentage of direct damage include 34% in the most likely scenario and 105% in the worst case scenario.

[Table 5]

[Table 6]

[Table 7]

6. Conclusions and future outlook

Main conclusions

The catastrophic nature of chain damages from feed crises and the little well specified damage data available from previous crises complicate the task for chain partners and liability insurers to establish the adequate size of product liability insurance covers for animal feed producers. This paper focused on estimating direct and indirect damages for processors in livestock supply chains, more specifically dairy processors and pig and poultry slaughterhouses in the Netherlands. Main conclusions of the elicitations are as follows:

(1) In the "aggregated analysis", partly based on public sector data and with straightforward assumptions with regard to damage faced, direct damage of processing industries is

[5] Sector numbers in Table 5 and Table 7 do not necessarily match.

estimated to be Euro 24 million in the most likely scenario and Euro 105 million in the worst case scenario. In contrast, company-specific expert assessments in the "detailed analysis" lead to direct damage indices of 100:259 in the most likely and worst case scenario respectively. Clearly, processing companies have ways to manage crises and to make extreme situations "less extreme". Insurers need to consider such aspects when determining the insured liabilities across chain partners.

(2) Crucial factors in determining processors' direct damage from feed crises are (i) the number of days of actually processing contaminated products; and (ii) the amount of products mixed. Increasing the number of "processing days" from 1 and 7 days to 30 days (while keeping the number of contaminated farms constant to 659), leads direct damage indices to increase from 12 and 100 to 233 respectively. With regard to mixed products, results show that across all scenarios and what-if analyses evaluated, minimally 85% of direct damage can be attributed to produce mixed with products from contaminated farms. These findings imply that premium rates can be lower for those chains which transparently minimise the potential number of "processing days" and produce mixed.

(3) From the various processors considered, differences across scenarios are largest for dairy processors. For instance, when comparing the most like and worst case scenario, the index of dairy processors' direct damage increases from 100 to 358. For slaughterhouses, these differences are 100 and 202 for pig slaughterhouses and 100 and 219 for poultry slaughterhouses. For dairy processors however analyses included multiple processing stages.

(4) Feed crises are expected to affect the complete product portfolio of processors, i.e. contaminated products (direct damage) as well as non-contaminated products (indirect damage). Indirect damage is mostly expected from non-contaminated products being returned by customers. The expected size of indirect damages as a percentage of direct

damages strongly varies across processors. A proper understanding of indirect damage is likely to facilitate product liability, i.e. direct damage, pleas.

(5) Provided insights into direct and indirect damages are useful in current stakeholder debates on sharing damage burdens of compound feed contaminations across supply chain partners. It however needs to be considered that (i) direct damages for pork and chicken processors beyond slaughterhouses, and damages for retailers and consumers have not been included; (ii) direct damage figures possibly do not reflect 100% of the market as market shares of experts' industries are between 20% and 80%; and (iii) juridical issues influencing the eventual size of claims and indemnifications have not been considered.

Future outlook

Results of this study also highlight issues for further research in the "chain liability arena":

- Incentives for rapid disclosure. Results show that time is an important factor in determining the expected size of processors' direct damage. A rapid disclosure of a feed contamination might significantly reduce the size of damages in the chain. Insurance companies might therefore design product liability insurance schemes that include "rapid disclosure incentives" such as linking the size of indemnity payments to the number of livestock farms already supplied with contaminated feed. Similar incentives are in practice in risk financing tools for epidemic disease outbreaks, see for instance Meuwissen et al. (2006).
- Crisis liability cover for a group of feed producers. In establishing premium levels, insurance companies do not only consider expected damages in the most likely scenario; they also assess damages in more extreme cases, i.e. the "maximum estimated loss". As it is not likely that each feed producer in the Netherlands is able to cause "a worst case scenario", high risk loadings per individual producer likely lead to disproportionate

premium levels. Crisis covers, i.e. excess covers, for a group of more or less homogeneous animal feed producers might be a feasible solution. From January 1, 2006, six animal feed producers united under TrusQ (see also footnote 1) have already been insured in this way for product liability claims up to Euro 75 million per animal feed crisis.

Definition of risk profiles. Results from this study reflect *sector* damages. For individual rating of feed producers, for instance for establishing excess covers for "homogeneous producers" (previous point), more insight is needed into individual risk profiles. Which feed producers are more at risk than others and which feed producers are more likely to cause extensive chain damages than others? Parameters such as animal feed type produced and scale of production seem useful to consider.

Indemnification schemes for damages due to food safety crises. Recovering direct damage from feed crises by filing liability claims often appears to be a long and complex procedure. In addition, due to numerous factors, eventual indemnities received are often below anticipated levels. In contrast to "hoping for liability claims to be successful", indemnification schemes for damage due to food safety issues might be more effective. In order to prevent asymmetric information problems, proper design of such schemes is needed, including subrogation principles for insurers to be adequately able to recover indemnities from liable parties.

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Table 1: Farm and processor characteristics of dairy, hog and broiler supply chains[1].

	Dairy	Hogs	Broilers
Number of compound feed producers	- - - - - - - 98 - - - - - - -		
Number of farms	22,301	7,963	674
Animals per farm	61	688	58,394
Annual production	7,417 kg milk/ dairy cow	91 kg[2]/hog 3.05 hogs/place	2.1 kg[2]/broiler 7 broilers/place
Delivery pattern to processors[3]	Once per 3 days	Once per 2 weeks	Once per 7 weeks
Number of processing companies[4]	15	9	15
Number of processing sites[4]	50	16	17
Production (1000 ton/year)	11,600	1,283	884
Turnover (mln euro/year)	5,100	1,784	701
Average turnover per site (mln euro/year)	279,452	305,395	112,973
Degree of self sufficiency[5]	Fresh products: 84% Cheese: 208% Condense: 231% Milk powder: 40%	Pork: 227%	Chicken: 161%

[1]Sources: Agricultural Data (2007), Agricultural Economic Data (2007), Bunte et al. (2003), Dairy Product Board (2007), Quantitative Information Livestock (2007).

[2]Slaughter weight.

[3]Farm-specific patterns depend on among others farm size.

[4]For dairy referring to processing activities, for hogs and broilers referring to slaughtering activities.

[5]Defined as products produced over products consumed, i.e. percentages > 100% indicate net exports.

Table 2: Direct and indirect damage components from feed crises.

	Feed producers	Farmers	Processors	Distribution channel	Consumer
Direct damage[1]					
Collection and destruction[2]	x	x	x	-	-
Tracking and tracing	x	x	x	x	-
Business interruption	x	x	x	x	-
Cost of illness	-	-	-	-	x
Indirect damage[1]					
Product recall[3]	x	-	x	x	-
Returned products[4]	x	-	x	x	-
Decreased demand	x	x	x	x	-
Retrieving (export) markets	x	x	x	x	-

[1]Direct damage relates to contaminated products including mixed products; *in*direct damage relates to *non*-contaminated products.

[2]At the level of feed producers, farmers and processors this includes collection and destruction of feed, livestock and livestock products, and intermediate and final products respectively.

[3]Refers to recalling *non*-contaminated products for reasons of restoring customer confidence.

[4]During crises, (national and international) customers often return products to their suppliers, even if the particular products are not contaminated.

Table 3: Recent animal feed crises, type of feed involved, number of farms affected and reported damage for food supply chains in the Netherlands[1].

	Dioxin 1999	MPA 2002	Dioxin 2003	Dioxin 2004	Bone fragments 2004	Dioxin 2006
Type of feed[2]	Compound	Compound Wet	Compound	Wet	Compound Wet	Compound
Duration (days)[3]	15	59	23	11	16	17
Farms affected[4]	1,821	685	237	196	0	275
Notification[5]	Farm	Farm	Feed	Farm	Feed	Feed
Products processed	Yes	Yes	Yes	Yes	No	No
Reported damage (million euro)[6]						
Feed producers	n.a.	33	n.a.	n.a.	n.a.	n.a.
Farmers	n.a.	35	n.a.	0.15	n.a.	n.a.
Processors	38.5	25-50	n.a.	n.a.	n.a.	0.9
Other reported issues	Limited export	Retrieving export	n.a.	Limited export	n.a.	Limited export

[1]n.a.=not available.

[2]Wet feed includes feed such as wheat starch, brewers' grains, sugar beet pulp, potato cutting and whey.

[3]For the various crises, days include Dioxin-1999: days contaminated products were spread throughout the chain; MPA-2002: days from first notification of fertility problems until identification of all farms supplied with contaminated wet feed (much shorter for other traces); Dioxin-2003: days in which dioxin levels in supplied bread meal were proven to be above allowable levels; Dioxin-2004: days from first notification of exceeded dioxin limits in milk to identification of the causing factor, i.e. sorting clay; Bone fragments-2004: days from first RASFF-notification until enforcement of strict monitoring program; Dioxin-2006: days between discovery of contamination and release of farms.

[4]Product Board Animal Feed. Dioxin-1999 farms were mostly in Belgium.

[5]For the various crises, notification was due to Dioxin-1999: decreased egg production and hatching; MPA-2002: sow fertility problems; Dioxin-2003: government sampling; Dioxin-2004: regular milk sampling; Bone fragments-2004: government sampling (Early Warning System); Dioxin-2006: government sampling.

[6]Various sources. No distinction between direct and indirect losses. MPA damage originates from Dutch Lower House (2002).

Table 4: Description of scenarios and what-if analyses.

	Scenarios			What-if analyses[1]			
	Most likely	Best case	Worst case	Less farms	More farms	Less days	More days
Farms[2]	659	37	2210	37	2210	659	659
- Dairy	199	11	688	11	688	199	199
- Hogs	150	8	503	8	503	150	150
- Broilers	72	4	241	4	241	72	72
Days[3]	7	1	30	7	7	1	30

[1]What-if analyses are with respect to most likely scenario.

Table 5: Elicited number of processing sites affected by a feed crisis.

	Scenarios			What-if analyses[1]			
	Most likely	Best case	Worst case	Less farms	More farms	Less days	More days
Sector 1	6	2	15	3	10	6	10
Sector 2	3	1	3	2	3	3	3
Sector 3	6	1	6	2	6	3	6
Total per crisis	**15**	**4**	**24**	**7**	**19**	**12**	**19**
50%-percentile	5	1	5	2	5	3	5

[1]What-if analyses are with respect to most likely scenario.

Table 6: Direct damage for aggregated analysis (million euro) and detailed analysis (index).

	Scenarios			What-if analyses[1]			
	Most likely	Best case	Worst case	Less farms	More farms	Less days	More days
Aggregated analysis							
Dairy processing (mln Euro)	10	< 1	42	4	10	1	42
Pig slaughtering (mln Euro)	11	< 1	46	4	11	1	46
Poultry slaughtering (mln Euro)	4	< 1	17	2	4	<1	17
Sum per crisis (mln euro)	**24**	**1**	**105**	**10**	**24**	**2**	**105**
Detailed analysis							
Dairy processing (index)	100	4	358	50	167	18	286
Pig slaughtering (index)	100	3	202	33	100	8	202
Poultry slaughtering (index)	100	7	219	67	100	20	219
Sum per crisis (index)[2]	**100**	**3**	**259**	**42**	**124**	**12**	**233**
- Contaminated (%)	6	2	13	1	15	8	4
- Mixed (%)	94	98	87	99	85	92	96
- Correction for products already consumed (%)	-16	-2	-66	-19	-17	-2	-64

[1]What-if analyses are with respect to most likely scenario.

[2]Corrected for products already consumed.

Table 7: Elicited relevance of indirect damage components and size of indirect damage[1].

	Indirect damage components			Indirect damage
	Returned products	Decreased demand	Retrieving (export) markets	
Most likely scenario				Direct damage = 100
Sector 1	x	-	-	26
Sector 2	x	x	x	291
Sector 3	x	x	x	5
Sum per crisis[2]				**34**
Worst case scenario				Direct damage = 100
Sector 1	x	-	-	46
Sector 2	x	x	x	531
Sector 3	x	x	x	99
Sum per crisis[2]				**105**

[1]Relevant components are marked with "x". Indirect damage is expressed relative to direct damage.

[2]Weighted average of sector indices. Weights are based on market shares.

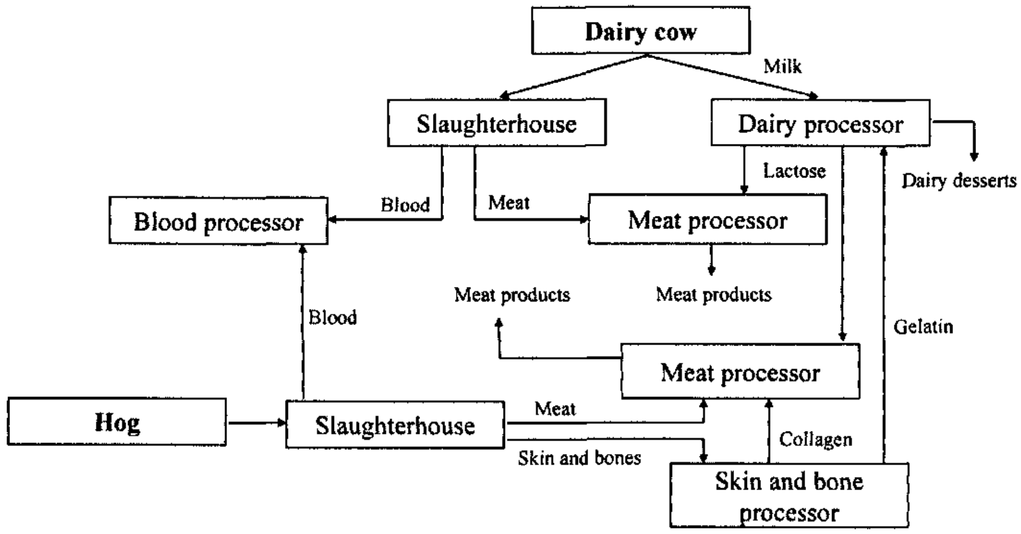

Figure 1: Illustration of interrelationships in dairy and pork supply chains.

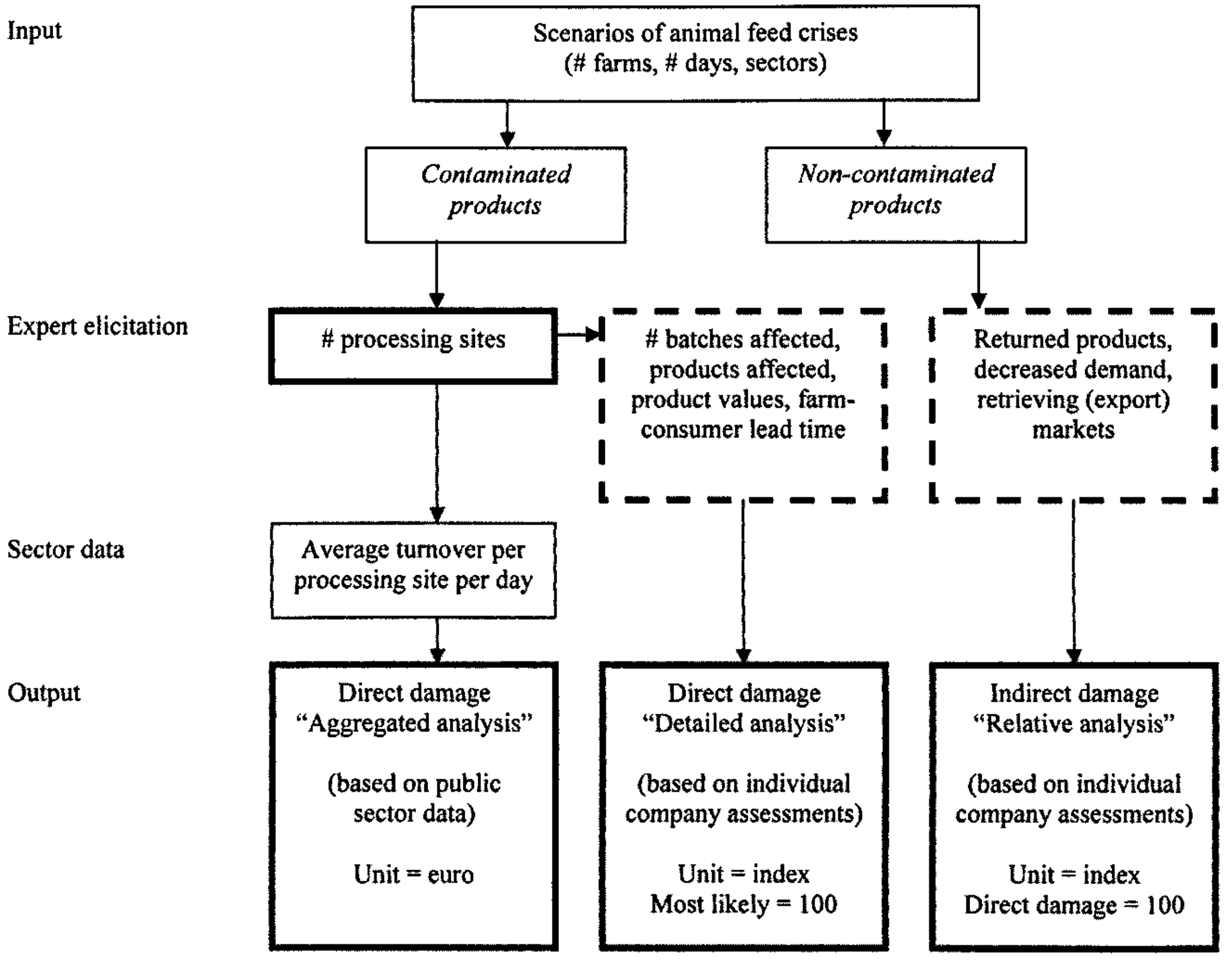

Figure 2: Types of analyses used to estimate processing industries' damage from feed crises. (Dashed boxes indicate confidential figures, bold boxes are reported in this paper.)