Modelling the impact of compulsory FMD insurance

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Abstract

This paper compares two ways of financing the combating of Foot and Mouth Disease (FMD) in the EU and uses a simulation model to determine the welfare and production implications of the two systems. The two systems analysed are (i) financing by the tax payers, resembling the system currently in place, and (ii) a compulsory insurance scheme where all costs are converted into regionally differentiated insurance premiums that are paid by the producers. The analysis indicates that welfare gains may be realised by shifting from the former to the latter financing system.

Keywords: Foot and mouth disease, insurance scheme

JEL classification: D61, Q18.

1. Introduction

In this paper, we compare two ways of financing the combating of Foot and Mouth Disease (FMD) in the EU and use a simulation model to determine the welfare and production implications of the two systems. The two systems analysed are (i) a purely tax financed system, where all costs for preventive measures and combating of FMD outbreaks are financed by the member state governments and partly reimbursed by the EU, and (ii) a compulsory insurance scheme where all costs are converted into regionally differentiated insurance premiums that are paid by the producers.

The *first* of the analysed systems represents a stylised version of the policy that is presently applied in the EU. There is a common policy for combating infectious animal diseases and the measures applied follow, since 1992, a stamping out strategy with culling and disposal of infected livestock and the preventive killing of animals that have been in contact with infected herds or were on contiguous farms. Under the present policy, national governments bear almost all the costs connected to the outbreak. Part of those costs is reimbursed from the EU budget providing that certain measures are taken to control the outbreak. In the analysis we disregard, for the sake of simplicity, that some insurance schemes are already running in different member states and assume that the entire cost is carried by national governments and the EU. This simplification can be justified by the fact that national insurance schemes are of minor importance so far.

The *second* system is analysed to explore an alternative to the present policy. The choice of this particular option can be motivated as follows. Although government involvement in the *eradication* of an infectious disease can be justified on efficiency grounds, because freedom from infectious diseases is a public good, the same does not apply to the government responsibility for *financing* the eradication policy. The present system implies that manageable risks are not reflected in the cost of production. The result is that too much risky production is generated and the allocation of production between regions and countries is affected as well. Howe and Whittaker (1997) have argued that the present policy acts as a free insurance of last resort. In addition, the fact that a part of the eradication costs is reimbursed from the EU budget creates a substantial redistribution between Member States as risk for outbreak varies considerably among them.

Liability assignment could constitute an alternative option for financing eradication. However, this solution is not suitable in the case of FMD — causation is not always clear and the liable party may not be able to pay the damages. Private first-party insurance could be an alternative to liabilities but as uninsured farmers would otherwise lack the incentive to limit the disease, only compulsory insurance would be efficient. As insurance companies show little interest in sectors where basic statistical data is not available an exigency fund seems to be a possible option. Such a fund would in reality operate as a compulsory insurance scheme. A Veterinary Fund already exists in the EU. However, it is not a fund in the proper sense of the word, merely a line in the EU budget. The total spending on eradication of infectious diseases has vastly exceeded allocated means. Accordingly, this paper will analyse some implications of an introduction of a compulsory insurance scheme assuming that the *full cost* of eradication is included in the insurance premium, i.e. paid by the producer. It should be pointed out, however, that the question of what is the best way to design alternative risk financing instruments for covering the costs of eradication of epizootic diseases is a very complicated one, and this paper does not aspire to resolve it. The ambition is only to illustrate implications of one particular option that can be deemed reasonable. For more discussion see for instance Asseldonk, et al. (2003).

This paper has four sections: In the first section, we describe the scenarios analysed, and the assumptions underlying the analysis are carefully explained. In the following section, a brief overview of relevant parts of the CAPRI modelling system is given. In the third section, the results of the modelling exercise are presented, and in the last section we conclude with some policy implications.

2. Background for constructing the scenarios

In order to explore the implications of the compulsory insurance scheme, one must first establish the premiums. In a usual insurance system such premiums depend on past events. In fact, one of the important conditions for insurability of risk is the availability of reliable information on the probability and the magnitude of future outbreaks. However, lack of sufficient data and the fact that the FMD situation world-wide has deteriorated significantly during recent years (Ryan, 2001), making historical data even less reliable predictors of the future, imply that calculations of the premium cannot be based on statistically sound grounds. Instead, a hypothetical case has been developed in co-operation with experts on veterinary medicine, based on the experiences from the analysis carried out in Ds 2002:31. Based on the costs of eradication in this scenario, see below for details, the insurance premiums were calculated for Sweden. The premiums in all regions in the EU were, subsequently, based on the cost estimates for Sweden modified with respect to risk, see below.

The study (Ds 2002:31) assumed one outbreak of the disease per 30 years, each affecting 500 average size farms, or equivalently, 1% of the livestock being affected every 30 years. That assumption was arrived at after consulting veterinarian experts, i.e. people with knowledge and understanding of current and future probabilities, at the Swedish Board of Agriculture and the Swedish National Veterinary Institute (SVA). The cost per animal included full repayment to the farmer of the value of culled animals and reimbursement of business interruption costs.Government costs included costs for destruction of the animals and disinfecting facilities. The costs for other sectors (slaughterhouses, traders, and tourist facilities) were assumed to be 30% of the direct cost for agriculture. The costs were annualised using an interest rate of 4%. Table 2.1 shows the annual cost for FMD outbreaks in Sweden resulting from the assumptions above. Those costs were used as a basis for computing the costs for FMD in all regions of the EU.

As a comparison, Blake, Sinclair and Sugiyarto (2001) compute the costs of the outbreak in the UK 2001, and find that the direct and indirect impact on tourism is significantly larger than the impact on agriculture and food trade taken together. Thompson et al. (2002) also compute the costs of the UK outbreak, and arrive at similar numbers, although they compute a somewhat smaller impact on the tourism sector than Blake, Sinclair and Sugiyarto. However, the outbreak in 2001 was one of the largest recorded (Blake, Sinclair and Sugiyarto), and it seems reasonable that smaller outbreaks have more than proportionally less impact on tourism. In addition, both studies cited above note that expenditure and resources lost from agriculture and tourism will be used elsewhere, thus reducing the impact. Blake, Sinclair and Sugiyarto use a CGE model to quantify that effect.

Table 2.1: Assumed annual costs for FMD in Sweden

Animal kind	Annual cost per head (EUR)
Dairy cows	1.23
Heifers, bulls and steers	0.80
Calves	0.39
Suckler cows	0.83
Sows	0.36
Pigs for fattening	0.17
Ewes and goats	0.26

Source: DS 2002:31 and veterinary expertise constructing scenarios for the EU level

The specific features of the FMD disease can provide some guidance for constructing scenarios at the EU level. FMD is an epizootic, an acute infectious viral animal disease. The virus is present in several varieties and it affects most animals in agricultural production, such as cattle, pigs and sheep. Airborne spread of the disease can occur and the animals can also pick up the virus from direct contact as well as from contaminated foodstuffs used as feed. The magnitude of an outbreak is influenced by a number of factors. The most important are livestock density, what kind of animals gets the infection first, the transport of animals and the movement of people in the area, the breeding method, climatic conditions (moisture, wind) and the delay between outbreak and measures taken. The determining factor in limiting the outbreak is prompt identification and an effective surveillance program. In this study we only consider stocking density, because regionalised data on average stocking densities is readily available, and it is a factor that can be influenced by producers. Moreover, if a common compulsory insurance scheme were to be introduced, it would have to be based on easily available data. There is no precise information or knowledge at the EU level about how livestock density affects the magnitude and the distribution of the FMD. Although more detailed studies at micro-level are available, more complex relationships cannot easily be used for an approximation of the relationship between risk and a single parameter. Hence, the calculations are based on alternative assumptions and should merely be seen as an illustration of the effects of different risk scenarios.

To probe the range of possible effects of introducing compulsory FMD insurance for livestock, five scenarios were constructed. In all scenarios premiums depend on stocking density in order to capture the impact of density on the probability of spread. The scenarios differ with respect to assumptions about *spreading of infection* and *infection probability*. All the scenarios share the assumptions that spreading of the disease depends only on stocking density, and that the composition of the herd (different kinds of animals) does not influence the spreading. It is well known that different kinds of animals *do* have a different impact on how the disease is spread. If available, more detailed information on such relationships could easily be incorporated in the calculations. Furthermore, it was assumed that each animal should bear its own cost, i.e. costs of eradication of the disease are not pooled between different livestock categories but covered within each category. This implies that the premium is lower for a pig than for a dairy cow.

The scenarios can be inscribed in a two-by-two matrix (table 2.2), where the rows represent different assumptions about how infection spreads and the columns different assumptions about infection probability. How insurance premiums were adjusted depending on assumptions is discussed in detail below the table.

Table 2.2. Simulated scenarios

	Probability of infection is 1% of the herd every 30 years in Sweden	Probability of infection is 1% of the herd every 30 years in the EU
Premium depends linearly on stocking density	FMD1	FMD3
Premium depends on squared stocking density	FMD2	FMD4
Premium is identical in all regions in the EU	FMD5	

As argued above, stocking density affects the spread of the disease. Unfortunately, no data is available to *estimate* the dependence of the spread of the disease on stocking density. Instead, three different forms of functional relationships were used, all based on the quadratic form

$$p_{ri} = a_i + b_i q_r + c_i q_r^2 \qquad (1)$$

where the premium *p* for animal kind *i* in region *r* depends on stocking density *q* and the three parameters *a*, *b* and *c*. The stocking density *q* is the total number of FMD-susceptible animals per square kilometre of land in region *r*, i.e. it is animal density, not herd density. This is a rather flexible definition that could be used to approximate, within a limited range, also other functional forms. As we base all scenarios on the cost for Sweden in (Ds 2002:31), we only have a single piece of information, sufficient for determining only one of the parameters. It would indeed be desirable to obtain some information also on how the cost *changes* when stocking density changes.

Three different functions used were obtained by using, in turn, each of the parameters alone, thus obtaining for ($a>0$, $b=c=0$) a constant premium, identical in all regions, for ($b>0$, $a=c=0$) a premium that depends linearly on stocking density with intercept zero, and for ($c>0$, $a=b=0$) a premium that depends only on the squared stocking density. These relationships can be motivated for example by assuming that the probability that a new infection starts is the same for all animals, and then varying the principles for spreading this new infection to surrounding farms.

The simplest possibility is that the premium is the same in all regions as in FMD5. This could be the case if the disease is spread from each infected animal to a constant number of other animals regardless of the number of animals in the region (e.g. every animal would have to pay for its own destruction/replacement and for 100 "neighbouring animals"). This is not a very realistic representation of how the disease spreads, as the number of farms affected would depend also on stocking density.

The next more complex (from a mathematical point of view) possibility is linear dependence, arising for example when a circle is drawn around the infected farm and the *radius* of the circle does not depend on stocking density. Then the number of animals within the circle, affected by measures, will be proportional to stocking density, as will the cost *per animal*.

Yet another possibility is that by drawing a circle around an infected farm, enclosing all animals to be destroyed or quarantined, the *area* of that circle is proportional to stocking density. In this case, the number of animals in the area, and hence the cost per animal, will depend on the square stocking density. That could be a reasonable case if we imagine that the spreading velocity of the disease depends on stocking density. It is easy to think of good reasons for cubic and exponential forms as well, by assuming that the radius of the circle depends linearly (or some higher order of expression) on stocking density, for example by the hypothesis that the number of transports to and from farms in the area is an important means of spreading the disease, and that the number of transports is proportional to stocking density. Due to the limited space and limited empirical information, we limit the study to the quadratic form given above.

As pointed out above, the *probability of infection*, i.e. the frequency by which FMD outbreaks occur (columns in table 2.2), was a second parameter that was varied while constructing the scenarios. The following two assumptions were considered: (1) the expert judgement that 1% of the animals are infected every 30 years applies only to Sweden on average, and (2) the judgement applies to the entire EU. Those two assumptions do, in combination with the different spreading functions, imply very different annual costs for FMD, because most Swedish regions have a stocking density below EU average.

Assumption (1) is actually the assumption that each year each animal kind i in Sweden on average costs k_i Euro per head and year, with the amounts k_i corresponding to the numbers in table 2.1. Now, this amount has to equal the sum of premium payments in all Swedish regions divided by the total number of animals of that kind in Sweden. With the notation introduced above, letting x_{ri} be the number of animals of kind i in region r, this is written

$$k_i = \sum_r p_{ri} x_{ri} \Big/ \sum_r x_{ri} \qquad (r \in SE) \tag{2}$$

The sums are taken over the set of all regions in Sweden ($r \in SE$). If the expression for p_{ri}, according to equation (1) is substituted into equation (2), the non-zero parameter (a, b or c, respectively) can be solved for in each of the functional relationships that have been described above. Inserting this parameter back into equation (1) enables calculation of the value of the premium in different regions. This procedure can be repeated with assumption (2) by taking the sums over all regions in the EU instead of regions in Sweden only. This gives different values for k_i and as a result different levels of premiums.

In the case where the functional relationship only contains the constant a, assumptions (1) and (2) are equivalent. In contrast, if the function is linear ($b>0$) the average premiums per head in the EU under assumption (2) will be exactly those in table 2.1, whereas they will be about seven times higher under assumption (1), when the numbers in table 2.1 are assumed to hold for Sweden. This is because the average stocking density is seven times higher in the EU than in Sweden. If we use only the quadratic term in the function for p, i.e. ($c>0$), the average premium per animal in the EU will also be precisely the amounts in table 2.1 under assumption (2), but under assumption (1) they will be very much higher (the average will instead hold for Sweden). In the latter case, a few densely stocked regions in the EU pay the major share of the sum of premiums in the EU. The regional premium amounts are presented in somewhat greater detail in the next section.

Figure 1 illustrates the principle behind the premium calculations. Point A is stocking density in Sweden and cost per animal from DS 2002:31, B is average EU stocking density and cost per animal from DS 2002:31, C is the cost per animal in Asseldonk et al (2003) plotted to the stocking density in the relevant regions of the Netherlands (source CAPRI). Scenario FMD1 was constructed by computing the straight line from the origin through A, FMD2 by fitting a quadratic function with only one parameter to run through the origin and A (thus yielding an extremely high premium at a stocking density as in some Dutch regions), FMD3 by fitting a straight line through the origin and B, FMD4 by fitting a quadratic function of only one parameter to the origin and B, and finally FMD5 by choosing the constant function that runs through A (and B). One can easily conceive of functions involving more parameters, like the dashed line in the figure. However, too little data is available to estimate such a function, and hence the analysis is carried out for illustrative examples of premium functions. With increasing experience of factors influencing risk, more detailed criteria can be used. The figure is not to scale.

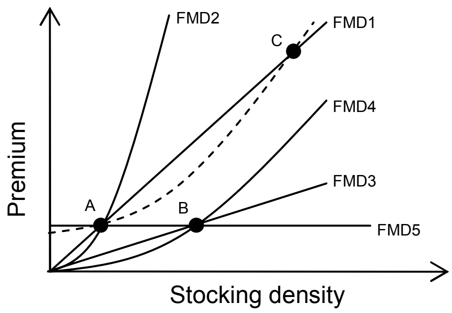


Figure 1: Computation of insurance premium as a function of stocking densities in the scenarios.

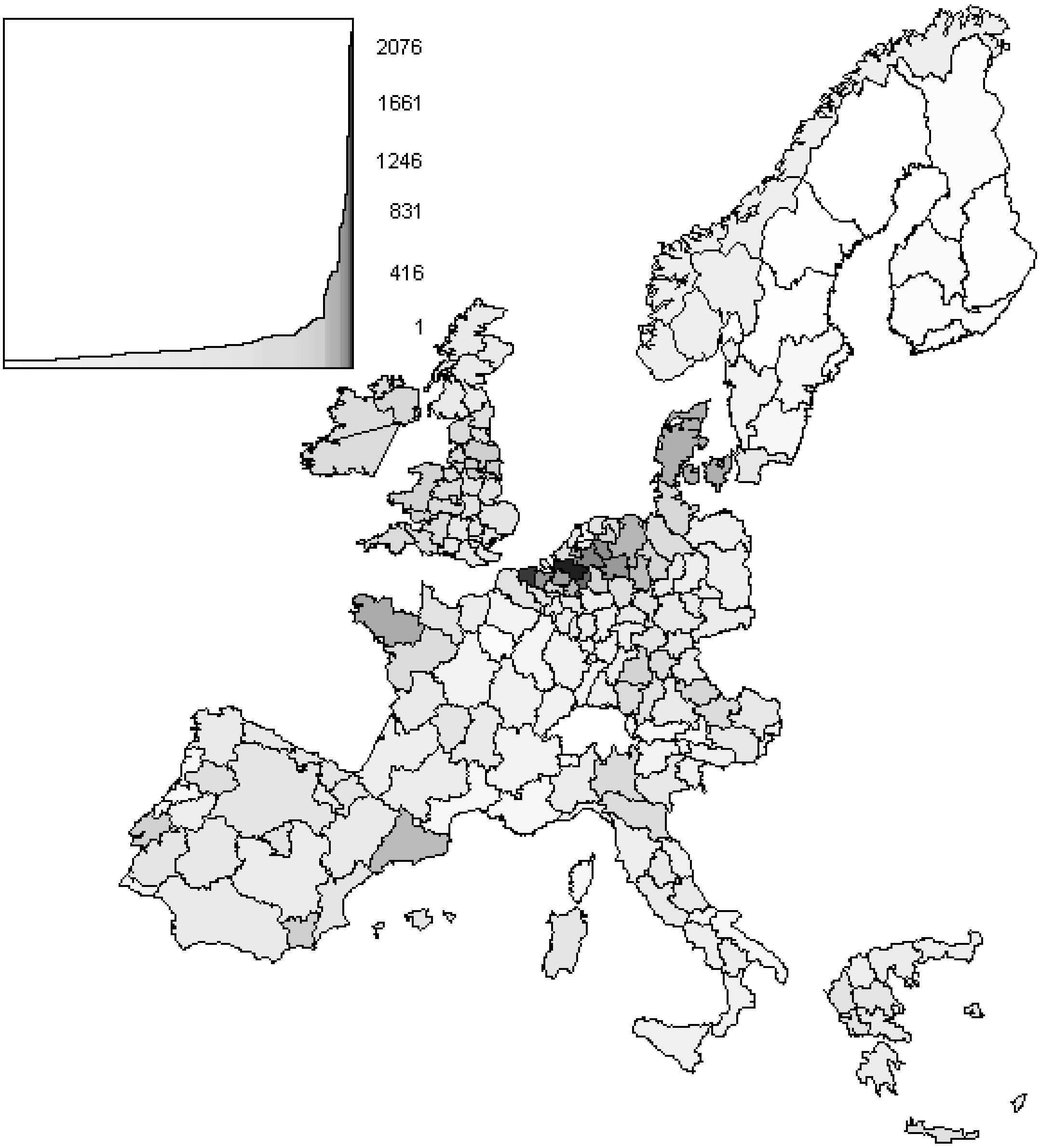
Each of the five scenarios was implemented for the model base year, which is the average of 2000, 2001 and 2002, and as the model is comparative static, the results can be roughly interpreted as answering the question "what would have been the situation in 2001 if a compulsory insurance program had been in place?" Each scenario is compared to a reference scenario, which is simply the base year where *the taxpayers have to pay the insurance premium instead of the producer*. As the model is a partial one, this does not influence the model solution, but only the welfare analysis of the results.

It should be kept in mind that because we use a different set of assumptions about how the risk depends upon certain measurable parameters, the cost for FMD in the reference scenario will be different for each insurance scenario analysed. Accordingly, there is no common reference scenario but each insurance scenario is compared with a reference scenario of its own.

3. Regional distribution of animals and premiums

The regional premium amounts are endogenous to the model in the sense that if the number of animals in a region is reduced, the density is reduced and consequently the premium is reduced (except for FMD5). The adjustment of the premium amount is done by iteratively changing the premium and solving the model. In that way, the premium amount is considered fixed in the economic optimisation problem of the producer. Hence, the final premium amounts could also be considered as model *results*. Anyway, we choose to present them in this section, and leave the results section for the presentation of effects on welfare, financing and production.

Map 1 shows the stocking density at the regional level in Europe in the reference scenario. The darker the colour, the higher the stocking density. The highest densities are found in Noord-Brabant in the Netherlands, with more than 2000 animals per square kilometre on average, whereas in many regions, white on the map, the density is less than one. In the GINI diagram on the left hand side of the map, the regions are ordered from the lowest density (left) to the highest, with a bar whose height and colour are proportional to density. The strongly convex shape of the upper contour in the GINI diagram indicates the uneven distribution of the animals over the land area.



Map 1. Stocking densities of the EU in the base year.

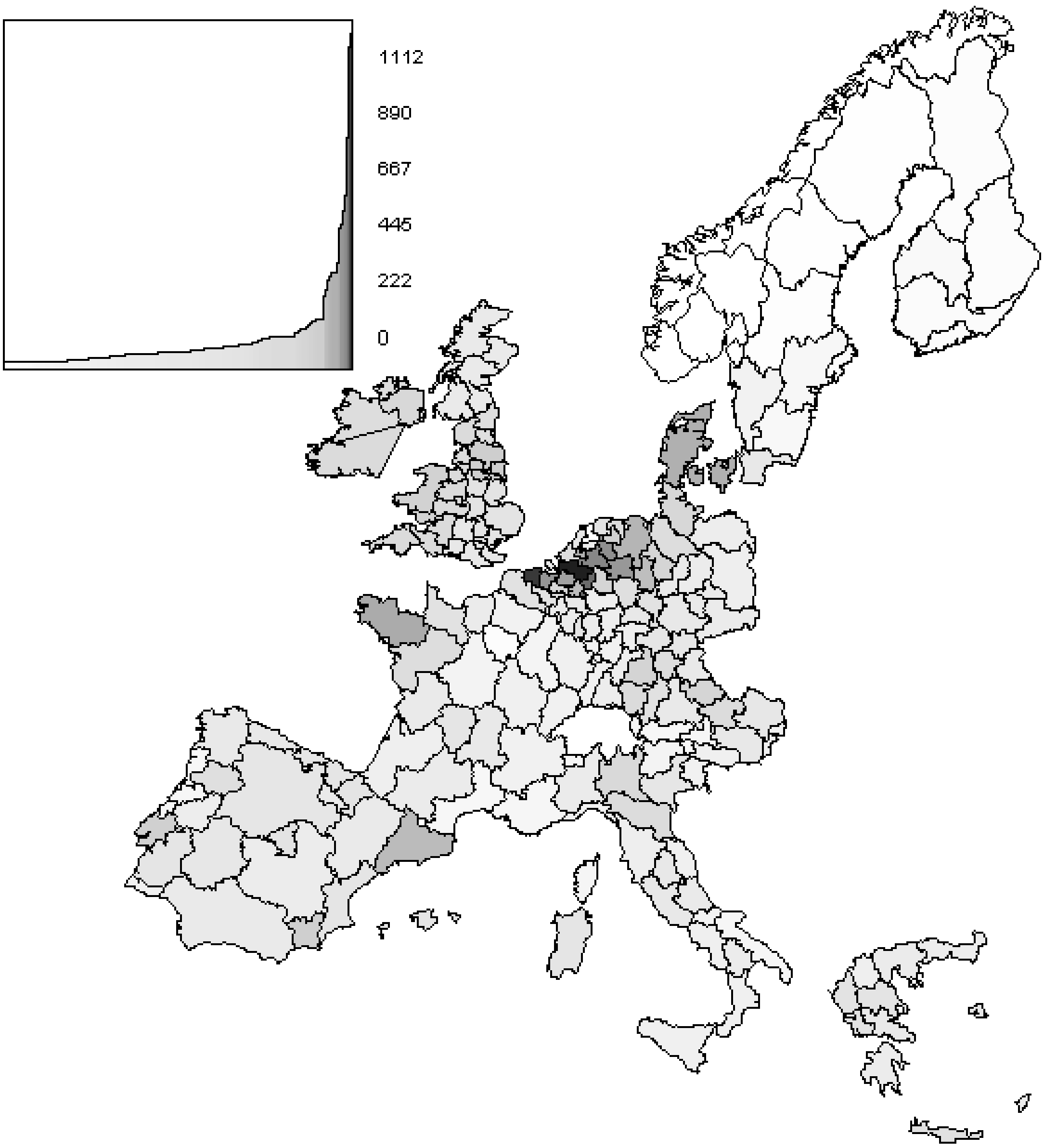
Table 2.3 shows how the premium amounts for different animal kinds vary in the scenarios. Obviously, the second scenario leads to prohibitive insurance costs in a few regions, and rather high average costs. In the other scenarios, though, the average EU premiums are not very high, at least not compared to the direct payments that apply in many cases (suckler cows, bulls and steers, and slaughter premiums). A small number of regions have significantly higher risks with this risk model.

Table 2.3: Premium amounts (costs for FMD). The first number is the lowest premium in any region, the number in the middle is the EU average, and the right is the highest value in any region. Amounts in EUR/head per year.

Animal kind	FMD1:	FMD2	FMD3:	FMD4:
Dairy cows	0 ≤ 8 ≤ 72	0 ≤ 75 ≤ 2346	0 ≤ 1 ≤ 11	0 ≤ 1 ≤ 35
Heifers, bulls and steers	2 ≤ 5 ≤ 44	0 ≤ 27 ≤ 1389	0 ≤ 1 ≤ 8	0 ≤ 1 ≤ 26
Calves	1 ≤ 3 ≤ 21	0 ≤ 15 ≤ 651	0 ≤ 0 ≤ 315	0 ≤ 0 ≤ 9
Suckler cows	2 ≤ 3 ≤ 36	0 ≤ 10 ≤ 978	0 ≤ 1 ≤ 11	0 ≤ 1 ≤ 50
Sows	1 ≤ 3 ≤ 13	0 ≤ 23 ≤ 322	0 ≤ 0 ≤ 2	0 ≤ 0 ≤ 3
Pigs for fattening	0 ≤ 1 ≤ 6	0 ≤ 8 ≤ 149	0 ≤ 0 ≤ 1	0 ≤ 0 ≤ 1
Ewes and goats	1 ≤ 1 ≤ 17	0 ≤ 3 ≤ 610	0 ≤ 0 ≤ 4	0 ≤ 0 ≤ 32

Source: Own calculations and simulations with CAPRI.

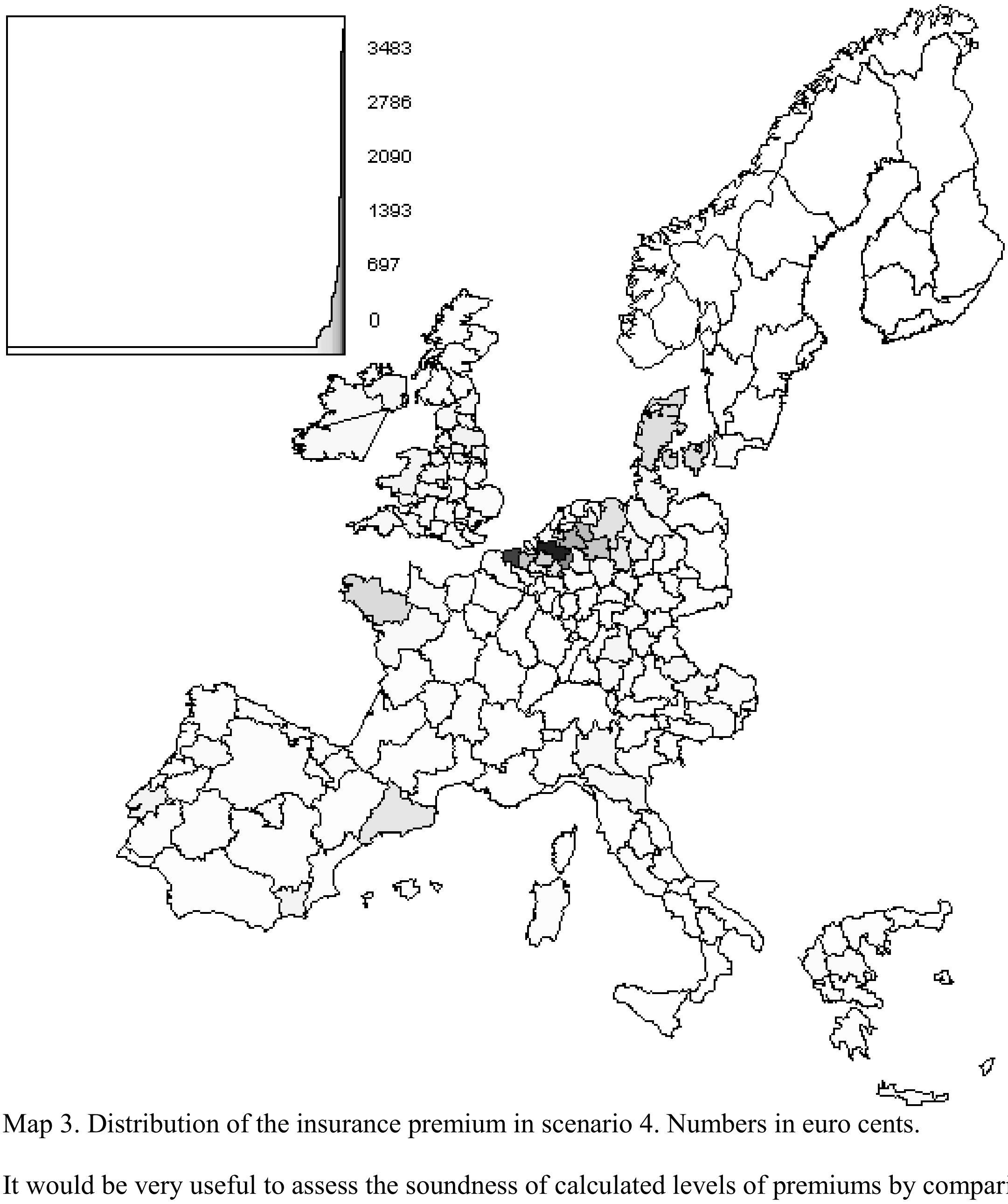
The following two maps illustrate the premium distributions. In scenario 5, the distribution is trivial (flat), so this map is omitted. Furthermore, the choice of risk level, i.e. the difference between scenario 1 and 3 and between 2 and 4 is only a matter of scaling, and as the colours of the maps are automatically fitted to the span of the data, the map for scenario 1 would be identical to that of scenario 3, and that of scenario 2 would be identical to that of scenario 4. Consequently, the maps for 1 and 2 are omitted. The premium amounts are different for different animal species. In order to reduce the number of maps to print, distributional maps for dairy cow premiums are used as examples, and the reader is referred to relations of table 2.1 to get an idea of the distribution of the premiums for the other animal kinds.



Map 2. Distribution of the insurance premium for dairy cows in scenario 3. Numbers in euro cents.

In the GINI diagram of map 2, showing the spatial distributions of the insurance premiums for dairy cows in scenario 3, it can be seen that in a few regions, the premiums are much higher than average. Those regions have darker colour on the map. In most regions in scenario 3, the insurance premium will be much less than one euro per animal and year, and in the most densely stocked region, Noord Brabant, it will be about 11 Euro per head. In scenario 1, where the premium function is calibrated to a certain infection frequency for Sweden, the premiums are about seven times higher in all regions than in scenario 3, which still is not very much money in any region except for the regions with the highest stocking densities (about 72 euro per dairy cow in Noord-Brabant, see also table 2.3). As the premium is proportional to stocking density in this scenario, the difference in premiums is a direct effect of the fact that in some few regions, husbandry is very intensive in terms of animals per land area.

The distribution of premiums over regions is much more askew when stocking densities enter the risk function with their square, as in scenarios 2 and 4. This is evident in map 3. A relation of 1:2000 regarding stocking density translates into a 1:4000000 relation in premiums if only the quadratic term is considered. In those scenarios, then, a few densely stocked regions are responsible for the major share of the costs for FMD. In Noord Brabant, the premium per dairy cow amounts to about 35 euro per head and year in scenario 4, whereas it is close to zero in almost all other regions. In scenario 2, where the square risk function is calibrated to the assumption that 1% of the animals in Sweden are infected every 30 years, this implies prohibitive risk premiums in the most densely stocked regions, with insurance premiums of more than 2000 euro per dairy cow.



Map 3. Distribution of the insurance premium in scenario 4. Numbers in euro cents.

It would be very useful to assess the soundness of calculated levels of premiums by comparing with other studies. Unfortunately, we are not aware of any such studies at the EU level. Assseldonk et al (2003) conduct Monte Carlo based simulations for the Netherlands subdivided into two regions. It seems (after minor recalculations) that the level of premiums the authors arrive at for milk cows is EUR 5.50 for the region with lower livestock density and EUR 56 for the region with higher density. The latter figure is in the same order of magnitude as our figure of EUR 70 in FMD1. It should be noted that our model contains more than two regions in the Netherlands. The region in our model with EUR 70 per head is the most densely stocked sub-region of the region for which Asseldonk et al. impliy a cost of EUR 56 per head. Thence, FMD1 is the scenario that best fits the Swedish (DS 2002:31) and Dutch (Asseldonk et al. 2003) studies, and should be regarded as the main scenario, with the other scenarios serving as sensitivity analyses. FMD2 is not very plausible, because in a few regions the premiums are high enough to replace all animals each year, and in FMD3 and FMD4, the premiums are far lower than the costs suggested by the two studies cited above.

4. The CAPRI modelling system

The introduction of a compulsory FMD insurance was analysed using the CAPRI modelling system. CAPRI is being developed at the Institute for Agricultural Policy, Sociology and Market Research at the University of Bonn, Germany. Most of the material in this paper is based on the overview in Wieck et al. (2004). However, as the system is constantly evolving, some new material has been added. An extensive documentation can be found in Britz 2004, and on the website of the CAPSTRAT project. The CAPRI modelling system is designed as a projection and simulation tool for the agricultural sector of the EU based on:

- A *physical consistency framework*, building upon balances for agricultural area, young animals and feed requirements for animals as well as nutrient requirements for crops, realised as constraints in the regional supply models. The market model ensures closed fat and protein balances for processed dairy products.
- *Economic accounting principles* according to the definition of the Economic Accounts for Agriculture (EAA). The model covers all outputs and inputs included in the national EAAs, with revenues and costs broken down consistently to regions and production activities.
- A *detailed policy description*. The regional supply models capture all relevant payment schemes with their respective ceilings as well as set-aside obligations and sales quotas. The market side covers tariffs, TRQs, intervention purchases and subsidised exports.
- *Behavioural functions* and allocation steering are strictly in *line with micro-economic theory*. Functional forms are chosen to be globally well behaved, allowing for a consistent welfare analysis.

The model distinguishes a supply and a market module, which are iteratively coupled. The *supply module* consists of about 200 aggregate quadratic programming models at NUTS 2 level, working with exogenous prices during each iteration (NUTS is a system of administrative regions used by Eurostat, the official statistics agency of the EU. NUTS 0 is the member states of the union, and NUTS 1, 2, 3 and so on represent regionalisations of finer geographical resolution). After being solved, the results of these NUTS 2 models – crop areas, herd sizes, input/output coefficients etc. – are aggregated into Member State level models, which are then calibrated to these results by using techniques borrowed from Positive Mathematical Programming (see Heckelei and Wolff 2003 for a critical review). Next, prices on young animals are determined by linking these Member State models into a non-spatial EU model with market balances for young animals. Afterwards, supply and feed demand functions of the *market module* are calibrated to the results from the supply module. Solving the market model delivers producer prices at Member State level, which drive the next iteration. Equally, in between iterations, premiums for activities are adjusted if ceilings are overshot according to the rules laid down in the Common Market Organisations. At this point, the FMD insurance premiums are also recalculated to reflect stocking densities in the last iteration. The recomputed insurance and CAP premiums enter the supply model in the next iteration as a shift in the gross margin of the production activities.

The *market module* breaks down the world into 12 country aggregates and the EU Member States, each featuring systems of supply, human consumption, feed and processing functions. The world market aggregates are EU, East European Candidate Countries, Mediterranean countries, U.S., Canada, Australia & New Zealand, Free Trade Developing Countries, High Tariff Traders (like Japan), India, China, ACP countries, Rest of the World. The parameters of the functions are derived from elasticity's of other studies and modelling systems, and calibrated to projected quantities and prices in the simulation year, where the choice of the *functional form* (normalised quadratic for feed and supply, Generalised Leontief Expenditure function for human consumption) and *further restrictions* (homogeneity of degree zero in prices, symmetry, correct curvature) ensure regularity. Accordingly, the demand system allows for the calculation of welfare changes for the consumers. The *processing stage of dairy products* for the EU Member states comprises balancing equations for fat and protein ensuring that processed products use up exactly the amount of fat and protein comprised in the raw milk. Production of processed dairy products is then driven by the difference between the dairy product's market price and the value of its fat and protein content, based on a normalised quadratic profit function. Lastly, prices of raw milk are equal to its fat and protein content valued with fat and protein prices.

Policy instruments in the market module include bilateral tariffs (ad-valorem and specific), Producer/Consumer Support Estimate price wedges (PSE/CSE) and important bilateral agreements as well as globally or bilaterally allocated tariff rate quotas (TRQs) for the EU and the 12 country aggregates. Additionally, intervention sales and subsidised exports under World Trade Organisation (WTO) commitment restrictions are explicitly modelled for the EU.

The *Armington assumption*, i.e. that imported and domestically produced goods are imperfect substitutes (e.g. Armington 1969), drives the composition of demand from domestic sales and the different import origins depending on price relations and thus determines *bilateral trade flows*. The model comprises a two-stage Armington system: the top level determines the composition of total demand from imports and domestic sales, the lower stage the import shares from different origins. Product markets are hence directly linked by import flows and prices, where observed in the base year. Accordingly, no uniform world market price is found in the system. In the current analysis, the top stage substitution elasticities for meat were all set to 4.0 except beef where it was set to 2.0, and the lower stage substitution elasticities were set to 6.0. This implies that most products are good substitutes regardless of origin, but that imports from different sources outside the EU are more perfect substitutes to one another than are imports in general to domestic products. Products from different sources *within* the EU are considered perfect substitutes.

5. Results

Though the premiums differ strongly between scenarios, there is very little effect on production except in scenario 2, where production is all but wiped out in some Dutch regions. Even in scenario 4, production is seriously affected only in West-Flaandern and Noord-Brabant in the Netherlands, where the sheep and goat insurance premium of about 30 euro causes a strong decrease of 65 and 34 percent, respectively, in those animals, and where the number of suckler cows is reduced by about 6% in response to an insurance premium of 47 and 50 euro per head, respectively. Note that the insurance premiums for suckler cows could be compared to the direct payments from the common agricultural policy of about 150 and 80 euro per head, respectively, for those regions. Qualitatively the model slightly reduces production compared to the reference scenarios where the premiums are high. Total animal production decreases, which in turn causes the prices of the outputs to rise, and those of intermediate inputs like fodder (including cereals) to fall. In fact, the rising output prices counteract the cost of the insurance premium, so that in some regions with low premiums, production may even increase.

An overview of herd size changes between scenarios is given in table 5.1 below. In that table it can be seen that the decrease is precisely 90% for several animal kinds in the second scenario. That means that the model has run into a technical bound. The results for those regions are thus almost useless, indicating that the model is unsuited to simulate insurance premiums of 1000 euro and more. Furthermore, the results show that in all scenarios except scenario 2, the total effect in the EU is small, always less than 0.5%. This indicates that if stocking density really is a major determinant of infection risk, then a small number of regions, mainly in the Netherlands and Belgium, are likely to be affected by an insurance policy.

The most interesting effects can be observed in the welfare analysis. Even though the quantitative effects on production are small in all scenarios, the principle that the one causing the costs pays the costs results in reallocation among the Member States. Currently, the costs of an outbreak of FMD are paid partly by the Member State and partly by the EU. In the simulations, it has been assumed that the member state pays 40% of the costs with the remaining 60% being paid from the EU budget. Member States have been assumed to contribute to the EU budget in proportion to their Gross National Income. Member States with low stocking density currently pay a larger share of the total EU costs for FMD than what is actually caused by the producers in that country, whereas the opposite is true for regions with high stocking densities. Introducing the compulsory insurance also provides incentives to reduce the total costs for FMD. In the simulations this is only possible by reallocating production. In reality, on-farm management practices are strongly influencing the risk of infection and spreading of the disease, letting us assume that the potential reduction of the FMD risk is greater than the modelling results indicate. Introducing the compulsory insurance indirectly shifts the burden of the costs from taxpayers to producers. The reduction of the tax burden that results in the model if the cost for the insurance scheme is shifted from the taxpayer to the producer is shown in table 5.2.

Table 5.1: Herd sizes in scenarios compared to reference scenario, per cent. The first number denotes largest decrease in any region, the mid number is EU average change, the last is the largest increase in herd size in any region.

Animal kind	FMD1	FMD2	FMD3	FMD4	FMD5
Dairy cows	-2 < 0 < 1	-70 < 0 < 9	-0.5 < 0 < 0	-1 < 0 < 0	0 < 0 < 0
Heifers, bulls and steers	-4 < 0 < 2	-90 < 0 < 9	-1 < 0 < 1	-4 < 0 < 1	0 < 0 < 1
Calves	-4 < 0 < 1*	-90 < -1 < 33	-1 < 0 < 2	-3 < 0 < 3	-1 < 0 < 1
Suckler cows	-5 < 0 < 0	-80 < -2 < 4	-1 < 0 < 0	-6 < 0 < 0	0 < 0 < 0
Sows	-3 < 0 < 4	-70 < -3 < 5	0 < 0 < 0*	-1 < 0 < 0	0 < 0 < 0
Pigs for fattening	-5 < 0 < 1	-90 < -4 < 10	-1 < 0 < 1	-1 < 0 < 1	0 < 0 < 0
Ewes and goats	-35 < 0 < 3	-90 < 0 < 14	-8 < 0 < 0	-65 < 0 < 3	0 < 0 < 0

Source: Simulations with CAPRI

Table 5.2. Taxes saved with compulsory insurance compared to completely tax financed FMD combating. Million euro per year.

	FMD1	FMD2	FMD3	FMD4	FMD5
EU total	768	7941	121	119	121
Belgium & Lux.	49	832	7	12	4
Denmark	37	316	5	4	4
Germany	162	1491	25	22	27
Austria	15	130	2	2	3
Netherlands	95	1748	14	24	7
France	125	1117	20	17	22
Portugal	10	77	2	1	2
Spain	62	455	10	8	13
Greece	12	90	2	2	3
Italy	78	697	12	11	15
Ireland	17	85	3	2	3
Finland	7	73	1	1	2
Sweden	13	132	2	2	3
UK	86	696	15	12	15

Source: Simulations with CAPRI

Budget outlays in the model consist, apart from the cost for combating FMD, mainly of direct payments, export subsidies and intervention purchases. Those other costs of the common agricultural policy (CAP) remain largely unchanged in all the scenarios, because production is very little influenced and because most direct payments have ceilings that stabilise the total amount paid even when production fluctuates. Therefore, the changes in tax burden reported in table 5.2 are almost completely due to the changed financing of FMD combating. The numbers in the table are the differences between tax payer cost in each insurance scenario and the corresponding reference scenario. In the reference scenarios, tax payer costs for each country are computed as 40% of the expected cost of FMD outbreaks plus the country's share (computed as GDP shares) of the EU budget, including 60% of the expected cost of FMD in all EU countries. In the insurance scenarios, it is only the country's share of the total cost for CAP measures in the EU, whereas the insurance is paid by the producers. Thus, the tax saving depends to 40% on the expected cost of FMD in the country and to 60% of the size of the economy. It can be seen that member states with the highest tax payer costs are the larger Member States: Germany, France, Italy and the UK, as well as the Member States with high stocking densities: the Netherlands and Belgium.

Furthermore, we see that the stronger the risk is assumed to depend on the stocking density, the higher the costs of FMD in densely stocked member states turn out. This is especially obvious if the cost of FMD in the Netherlands is compared between scenarios 3, 4 and 5. In scenario 5, where the premium does not depend on stocking density at all, the annual cost for FMD is seven million Euro. If a linear relationship is assumed, then the annual cost turns out to be twice as high, or 14 million Euro, and if the quadratic relationship is assumed, the cost is 24 million Euro per year. For a member state with lower average stocking density, the converse is observed. Note that in scenarios 3, 4 and 5 the premium function was set up so that the total cost for the EU was the same in all three scenarios, so the effects just mentioned are pure redistributions between member states. The reader may object that the total tax saving for the EU turns out lower in scenario 4 than in scenarios 3 and 5. This is due to changes in agricultural production in scenario 4, when the premiums are rather high for some animal kinds (see table 2.3).

In most cases, agricultural income is reduced when the cost for combating FMD is shifted to the industry. Calculations of the change in income are shown in table 5.3. However, agricultural income does not decrease in all member states in all scenarios, but in some cases there are actually minor income increases. That is because the increased cost leads to slightly higher prices, and in regions with low stocking densities – and therefore low premiums – those price rises are sufficient to offset the negative effect of the premium. Of course, this effect can only occur if the premium depends in some way on stocking density, and is stronger in the quadratic scenarios 2 and 4.

Table 5.3. Change of agricultural income* with compulsory insurance compared to completely tax financed FMD combating. Million euro per year. Negative number = loss of income.

	FMD1	FMD2	FMD3	FMD4	FMD5
EU total	-419	-556	-120	-124	-111
Belgium & Lux.	-64	-434	-11	-21	-3
Danmark	-51	-268	-9	-6	-5
Germany	-50	221	-17	-12	-20
Austria	3	114	0	1	-2
Netherlands	-151	-1616	-23	-47	-6
France	-49	108	-24	-23	-22
Portugal	-3	59	-3	-2	-4
Spain	-24	485	-19	-11	-26
Greece	-8	66	-7	-6	-8
Italy	22	451	-2	-2	-2
Ireland	-15	42	-4	-1	-5
Finland	2	45	-1	-1	-2
Sweden	4	82	0	0	-2
UK	-33	91	-1	6	-3

* *Gross value added plus direct payments minus insurance premiums.*

If the taxpayers' gains in table 5.2 are compared to the producer losses in table 5.3, it is clear that in the scenarios 3, 4 and 5, where the premiums are low, the insurance is merely a redistribution of money between taxpayers and producers. All taxpayers in the EU together save about 120 million euro and the producers lose about the same amount in all three scenarios. It is important to notice that even if there is no dependence of the risk upon animal stocking density, as in scenario 5, the shift of responsibility for the costs from taxpayers to producers alone is enough to cause some redistribution between member states.

In scenarios 1 and 2, where the premium amounts are much higher, the incentive to shift animals to regions with lower premiums is strong and leads to a cost saving. This manifests itself in tables 5.2 and 5.3 in that the taxpayers gain more than the producers lose when the insurance is introduced. In the extreme (and implausible) scenario 2, with high costs and a square risk function, this has a radical effect: The taxpayers save almost eight billion euro, while the producers lose only 556 million. That perhaps surprisingly small producer loss is due to the price effect: Animal output prices rise significantly, and the inputs gets significantly cheaper. That also implies strong effects on the consumption side, where the higher meat prices induce a welfare loss for consumers that is not offset by lower prices for crop outputs, and also losses for the processing industries when processed volumes are reduced. In the other scenarios, production is little influenced, so price changes are in the range of less than plus or minus one percent.

If *agricultural income*, *money metric* for consumers and *processing industry profits* are added and *tax payer costs subtracted*, a measure of overall welfare is obtained. Table 5.4 shows the difference in that measure between the insurance and the reference scenarios. In each scenario, there is an overall welfare gain, although small. In scenarios 3, 4 and 5 it is 37, 38 and 26 million euro per year respectively. Only in the quite extreme scenario 2, the difference to reference is significant, 3.4 billion euro. Only Denmark and the Netherlands lose overall welfare in that scenario. More interesting is the redistribution between Member States, which in some cases is greater than the overall welfare change. Germany, Austria, France, Italy, Finland, Sweden and the UK show net welfare gains in all scenarios, whereas Denmark, the Netherlands, Greece and Ireland lose in all scenarios except in scenario 2. For the three remaining member states Belgium (with Luxembourg), Portugal and Spain, the net effect depends on the choice of functional form for the risk function.

Table 5.4. Welfare* gain with compulsory insurance compared to completely tax financed FMD combating. Million euro per year.

	FMD1	FMD2	FMD3	FMD4	FMD5
EU total	28	3357	37	38	26
Belgium & Lux.	-24	172	-2	-8	2
Denmark	-21	-24	-3	-2	-1
Germany	52	824	20	24	15
Austria	9	150	2	2	0
Netherlands	-69	-68	-8	-22	2
France	29	580	10	13	6
Portugal	-1	34	-1	0	-1
Spain	-6	407	-5	1	-11
Greece	-6	60	-3	-2	-4
Italy	42	590	12	14	8
Ireland	-3	90	-2	-1	-3
Finland	6	78	1	1	0
Sweden	11	133	3	3	1
UK	9	331	14	17	12

* *Welfare is defined as money metric for consumers plus agricultural income plus processing industry profits minus taxpayer outlays.*

6. Summary and conclusions

This paper aims at comparing the impact of a hypothetical compulsory insurance scheme where the premiums are related to some of the manageable risks in production (stocking density and number of animals) with the present EU policy. Impact on production, welfare and distribution between regions and member states is analysed under different risk scenarios.

According to the analysis in the paper, introduction of the compulsory insurance scheme would improve social welfare, as the most risky production would decrease or reallocate to regions with lower risks (lower density). This result is consistent with economic theory. Our analysis has ignored the transaction costs involved in collecting premiums (or levies). If such costs are significant, the welfare gain will be reduced.

The impact is, *in general*, quite small but it should be observed that we analyse only one disease. It does not make much sense to limit compulsory insurance to one disease. Other infectious diseases (e.g. swine fever) with risks related to stocking density should be covered by such a scheme if applied. In such a case, the impact would be larger. However, even when only one disease is analysed, the impact on the most affected regions, i.e. those with highest livestock density, is not negligible. The most significant impact of the insurance scheme would be a substantial redistribution of welfare and budgetary flows between the Member States, from member states with high stocking densities like the Netherlands, Belgium and Denmark, to large countries with lower stocking densities like Germany, France and Italy.

There are major uncertainties involved in estimating the total annual cost of FMD. However, our results are not critically dependent on the correct level of the total costs, as the objective is to analyse welfare gains stemming from a system that distributes the costs in relation to the livestock density.

The analysis in this paper is based on very simplified assumptions and the results, accordingly, should be treated with caution. Nevertheless, we believe that the results are solid enough to contribute to the discussion on how the future policy for eradication of infectious diseases should be formulated, in particular how costs should be paid. The alternative risk-financing instrument explored in this paper would, if introduced, result in a welfare gain. This could constitute an argument for a reform. However, in order for the gains to materialise, the premiums need to be correctly related to the risk factors. The results of model experiments indicate that the welfare gains are strongly dependent on how risks are connected to production. Our analysis does not aspire to have provided a reliable way of making the connection rather it indicates a strong need for further research in this area.

Such a further research seems, furthermore, motivated by the fact that the risk of outbreaks of infectious livestock diseases is likely to increase in the future, especially in view of the recent and upcoming enlargements of the EU.

The alternative risk financing instrument explored in this paper implied that the producer paid the full cost of eradication of FMD. Such an alternative is efficient if the producer is the only one who can manage risks connected to the disease, or if he/she is the one who can avoid them at the lowest cost. Producers can do a lot to affect the risk. By the choice of the location of the production but also by conduct on the farm, producers are able to mitigate the risk. However, the cost of the outbreak also depends strongly on the conduct of the public authorities in the member states where the outbreak takes place. Prompt identification and an effective surveillance program are crucial for limiting the number of animals that have to be culled. However, the present system, where a large part of the costs is paid by a common budget is not efficient as it limits incentives both for farmers and for national governments to apply costly precautionary measures.

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