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On the effectiveness of mutual funds to cope with lasting market risks:

The case of FMD in Brittany

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Abstract

Foot and Mouth disease, like other epizootic outbreaks, can have wide and lasting impacts exceeding the agricultural field. Within Europe various ad hoc *policies exist to cope with these consequences. In this paper we develop a dynamic CGE model allowing us to simulate a FMD outbreak, its economic consequences and the effect of the implementation of a mutual fund as a structural risk management policy. Our results show that a financial support to farmers thanks to the mutual fund may encourage a quicker recovery from the market losses, especially helping to rebuild the cattle herds after a period of trade bans. However, counterproductive effects may be encountered in the case of mandatory participation of farmers to finance the mutual fund.*

Keywords: dynamic CGE, catastrophic event, animal disease, risk management policy

JEL classification: Q11, Q18.

1. INTRODUCTION

Epidemic outbreaks are uncertain events of great concern for agriculture and related sectors. Animal diseases, such as foot and mouth disease (FMD), can quickly cause large production and economic damages in livestock-intensive regions (Blake et al. 2002). Because of the high transmissibility of the disease, consumption scares and potential trade bans, economic consequences of the disease may also have a significant and lasting impact on the whole food chain at the regional or national level, including disease-free areas. These important costs raise the issue of risk management policies in Europe. Although direct losses are usually covered by public subsidies for infected farms, market disruptions due to disease crises only benefit from very specific and *ad hoc* supports. However, the definition of structural policies of risk management in agriculture tends to provide a more standardized management system for the agricultural sector. Among other measures, the creation of mutual funds is intended to provide exceptional financial support in case of economic and trade losses due to animal diseases. The objective of this study is to evaluate the effectiveness of these mutual funds and to which extent they can limit losses of markets and enable the agricultural sector to regain its competitiveness quickly. This research work aims at computing the effects of this risk management tool on the value added in the food chain and on the whole regional welfare through a dynamic computable general equilibrium (CGE) model.

Recent French and European policies aim at providing structural support for exceptional events such as FMD outbreaks (Cafiero et al. 2007). After a catastrophic market event, a major challenge for farmers is the access to credit, especially when the level of assets is low and even if the prospects for recovery are good. This has a direct impact on the ability of livestock farms to rebuild their herds and their production capacity quickly, especially in the presence of imperfections in some factor markets. As a consequence, on the long run it may also cause heavy losses for downstream industries, especially in livestock-intensive regions. The current literature highlights the credit constraints of farmers (Blancard et al. 2006), and has also long focused on issues of income securitization, including CAT bonds or income insurance (Mahul, 2001, Schaufele et al. 2010, Mussel and Martin, 2001). The contribution of this study is to evaluate the ability of mandatory precautionary savings (mutual funds) to release credit constraints in a distorted market. This study brings new insights for the design of risk management policies with public-private participation. A particular focus will be given to the ability of farmers to take an active role in the management of catastrophic economic events through the creation of mutual funds, which are designed to support the agricultural activity in case of a catastrophic event

The modelling framework consists of a dynamic CGE model for a single region, including two particular features. On the one hand we give the explicit specification of all livestock sectors and their herds, so that the dynamic biological constraints are perfectly captured in the analysis, and we also specify rigidities in labour and capital markets (respectively minimum wages and investment constraints) to reflect better the various productive, financial and institutional constraints in the economy. On the other hand, the mutual fund is modelled as mandatory savings with subsidised interest rate and it is fed by livestock farmers at the steady state. Then we may be able to highlight the effects of the implementation of mutual funds as a risk management policy to face the market effects of a potential FMD outbreak.

The dynamic CGE model is applied to Brittany which is the most livestock-intensive French region. Both a production shock (public decision to cull 10 per cent of the total cattle herd as a response to a FMD outbreak) and a trade shock (preventive sanitary ban on the movement of live animals) are simulated. Then we assess the economic consequences of this one-time period shock over a 15-year horizon.

2. MODELLING FRAMEWORK

In order to study the effects of the implementation of a mutual fund aiming to limit the economic losses due to a FMD outbreak, we use a dynamic CGE model developed by Gohin and Rault (Gohin A., Rault., 2012), built on former studies on livestock (Philippidis and Hubbard, 2005), featuring the specific intertemporal decisions of farmers in the presence of cattle dynamics (Zhao et al, 2006), and imperfections on factor markets. The main elements of this model are developed in this section, as well as some new elements relative to the implementation of the mutual fund.

1.1. Main dynamics and the livestock sectors

The basic structure of our dynamic CGE model is standard for a single country model in an open economy (Devarajan and Go, 1998; Vellinga, 2007). Two main types of dynamics are implemented. First, we classically consider that the main intertemporal decision is the behaviour towards capital accumulation. In addition, we introduce the cattle stocks as factors of production in the economy, and we define their dynamics.

Producers in each *j* sector are assumed to maximize their intertemporal profit π, more precisely the discounted value of their future profits minus investment costs, as follows:

$$\max \ \pi_j = \sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t \left(WK_{j,t}.K_{j,t} - PI_{j,t}\left(1+\frac{\phi_j}{2}\frac{I_{j,t}}{K_{j,t}}\right).I_{j,t} \right)$$

$$s.t. \quad K_{j,t+1} = K_{j,t}.(1-\delta_{j,t}) + I_{j,t} \quad ; \quad K_{j,0} = \overline{K}_{j,0}$$

Where $K_{j,t}$ is the stock of physical capital and $WK_{j,t}$ the capital income, $I_{j,t}$ is the investment level (the corresponding net price is $PI_{j,t}$), and ϕ_j is the non negative parameter governing $\frac{\phi_j}{2}\frac{I_{j,t}}{K_{j,t}}$ which represents the marginal cost of capital.

Producers' objective function is constrained by the intertemporal investment decisions, which relate to capital accumulation over time. These capital dynamics are defined by $K_{j,t+1} = K_{j,t}.(1-\delta_{j,t}) + I_{j,t}$ where $\delta_{j,t}$ is the annual depreciation rate of capital.

The resolution of this program producer leads to determine the first order condition defining the optimal level of current investment:

$$WK_{j,t+1} + (1-\delta_{j,t})PI_{j,t+1} = (1+r)PI_{j,t} +$$

$$\phi_j \left((1+r)PI_{j,t}\left(\frac{I_{j,t}}{K_{j,t}}\right) - (1-\delta_{j,t})PI_{j,t+1}\left(\frac{I_{j,t+1}}{K_{j,t+1}}\right) - \frac{PI_{j,t+1}}{2}\left(\frac{I_{j,t+1}}{K_{j,t+1}}\right)^2 \right)$$

If we assume that there are no capital transaction costs ($\phi_j = 0$), this equation simply represents the equality between the marginal cost of current investment at time *t* evaluated at the next period and the marginal revenue of that current investment at time *t+1*.

To sum up, the main dynamics of our model occur because of the depreciation of the capital good and the associated investment. In the particular case of livestock producers, we also need to take into account the dynamic nature of the breeding cycles and the fact that the cattle stocks are factors of production and not simply an intermediate consumption.

To achieve this, we consider six different cattle stocks or herds: male and female calves (year-born animals), bulls and heifers (under two years old), and dairy and suckler cows. These herds are used by nine different activities due to the distinction between raising and fattening activities. The activities together supply four types of products: bovine for slaughter, milk, organic manure and live animals. The links between herds, activities and products are described in table 1. Productions in italic stand for live animals.

Table 1. Disaggregation of the cattle sector

Activities	Herds	Types of Production
Dairy cows	Dairy cows	Milk, bovine for slaughter, *dairy cows, male & female calves*, organic manure
Suckler cows	Suckler cows	Bovine for slaughter, *suckler cows*, *male & female calves*, organic manure
Raising male calves	Male calves	*Bulls*, organic manure
Raising female calves	Female calves	*Heifers*, organic manure
Fattening male calves	Male calves	Bovine for slaughter, organic manure
Fattening female calves	Female calves	Bovine for slaughter, organic manure
Raising heifers	Heifers	*Dairy cows, suckler cows*, organic manure
Fattening heifers	Heifers	Bovine for slaughter, organic manure
Fattening bulls	Bulls	Bovine for slaughter, organic manure

Source: own elaboration

In a similar way to the capital dynamics, we assume that each herd stands for animal capital that depreciates over time and that may be maintained by investment. As a consequence, cattle dynamics are defined by $H_{j,t+1} = H_{j,t}.(1-\delta h_{j,t}) + IH_{j,t}$ where $H_{j,t}$ is the level of the herd held by activity *j* at the beginning of period *t*, $IH_{j,t}$ is the investment level reflecting the effort level of obtaining new herd. The parameter δh is the depreciation rate of the considered herd. Annually for young animals $\delta h = 1$ as these herds represent only temporary states in the life cycle of the animals (e.g. after one year each calf becomes a young heifer or bull). For dairy and suckler cows δh reflects the culling of cows decided by cattle farmers based on the lower productivity of old animals or for sanitary reasons($\delta h < 1$).

Note that due to data constraints, our approach suffers from two limitations: animal breeds are not distinguished, and the yearly time step of the model leads to a rather simplified biological cycle.

Including the cattle dynamics as a dynamic constraint for livestock producers gives an additional condition for the optimisation problem:

$$WH_{j,t+1} + (1-\delta h_{j,t})PH_{j,t+1} = (1+r)PH_{j,t}$$

Where $PH_{j,t}$ is the purchase price of new animals and $WH_{j,t}$ the herd return in the *j* activities. In the particular case of young animals, the renewal of the herd is complete each year as $\delta h_{j,t}$ is null. This all permits to determine the domestic demand and supply of live animals.

Turning to the demand side, we assume the existence of one representative consumer maximizing an intertemporal utility function subject to intertemporal budget constraints. This representative consumer also participates in the financial capital market by saving at the same exogenous interest rate. In the steady state, we assume that domestic savings equal domestic investment, so that the net debt of our economy with other regions remains unchanged. This assumption means that the exchange rate with other regions is fixed, which is justified in our application as Breton products are mostly traded within France.

In a dynamic perspective, the determination of expectations by economic agents takes a central place. In this article, we assume that all economic agents have rational expectations, meaning that in a standard context they do not suffer from any lack of information in order to adapt their decisions to the current economic context. This assumption fits best with a scenario of FMD outbreak since this kind of rare event is quite unpredictable, and producers do not make their production decisions taking into account such a hypothetical and unpredictable epidemic outbreak.

1.2. Imperfect factor markets

To reflect better the economic and financial structure of our economy, we specify constraints on the financial capital market and on the labour market.

In the program previously explained, producers face no constraints when investing. They may invest more than the current profit if they expect an increase of future capital returns; they have a full access to credit, which is barely realistic. As in our model we focus on the real side of the economy, we specify a reduced form constraint on investment to act as a brake on credit access. The program of producers is then subject to another constraint on investment which is:

$$I_{j,t} \leq I_{j,0} \cdot \left(\alpha . \frac{WK_{j,t}}{WK_{j,0}} + \beta \right)$$

Current investment by firms is constrained if current capital return decreases below a threshold level. Parameters α and β are reduced form parameters governing the severity of the investment constraint, and $WK_{j,0}$ is the capital return at steady state. This reduced form constraint allows us to impose investment restrictions on sectors facing a drop of their capital return. By calibrating the parameters α and β, we can make investment more or less constrained. For example, if a FMD outbreak leads to a temporarily decrease of activity, the current profit decreases. Firms may face difficulties in financing their current investment despite potential future positive prospects following the resolution of the FMD outbreak.

Turning to the labour market, we introduce the possibility of involuntary unemployment. To achieve this, we impose labour returns not to fall below their base value. This means that wages cannot decrease, or in other words that the existence of minimum wages is an institutional constraint below which demand for labour cannot be satisfied. This induces rigidities in the labour market; a temporary decrease in labour supply leads to additional unemployment due to the existence of a minimum wage, and on the contrary an increase in labour supply first leads to full employment and then to wage increase.

1.3. Modelling of mutual funds

The implementation of a mandatory mutual fund extended to all cattle farmers aims at participating to the change from *ad hoc* emergency assistance systems to more structural policies involving farmers themselves. In other words, it results in a long term policy which permits not only to support time to time the agricultural revenue during market crises, but also to impose mandatory precautionary savings when market conditions are profitable.

Two economic tools are implied in this risk management policy. On the one hand, the precautionary savings are imposed as a tax on agricultural production in order to finance the mutual fund, and on the other hand a subsidy is activated to help maintain a minimum income level. Formally, the mutual fund can be considered as a capital stock whose evolution is governed by both contributions from farmers and support given to sectors in crisis. It can be modelled as follows.

$$MF_t = \sum_j \tau P.Y_{j,t} - \sum_j K_{j,t}^{MF} + MF_{t-1}.(1+\sigma_t) \quad ; \quad MF_0 = 0$$

Where MF_t is the mutual fund, σ_t is the annual interest rate of this fund (potentially publicly subsidized). The sum of the savings collected in the *j* activities is represented by $\sum_j \tau P.Y_{j,t}$, where τ represents the fixed proportion of capital which is deducted to the farmer profit in order to supply the mutual fund. At the opposite, $K_{j,t}^{MF}$ represents the amount taken from the mutual fund to compensate the *j* farmers for a catastrophic market event. In summary, the mutual fund is managed as a financial reserve, which public participation is the payment of interest on those savings. By calibrating the saving rate and the minimum income to activate the subsidy, we can simulate the effect of various policies, to which we turn now.

3. SIMULATION AND RESULTS

In this section we detail our simulations. We first give a brief overview of the data used and of the scenario of FMD outbreak and policy responses to the market effects. Then we analyse the results of the simulations, disentangling the effects of the mutual fund policy from the market effects of the FMD outbreak.

1.4. Data and simulation

Our model is applied to the Brittany region in France, for which we built a social accounting matrix for the year 2003. The SAM has a high disaggregation level including 52 activities and 54 products (of which respectively 23 and 24 agricultural sectors and products). Each activity can be multi-output, such as the dairy cow activity producing milk, bovine for slaughter, new born calves and organic manure.

We simulate the occurrence of a FMD outbreak at the first period of simulation. To do this, we impose a fall of the cattle herd by 10% due to both the consequences of the disease and of the sanitary measures to prevent its extent. In addition, we assume that all movements of live livestock between Brittany and other regions are prohibited the year of the FMD outbreak (period 1 of simulation). From the second year of simulation, we consider that the region has returned to a disease-free status, consequently that no more animals are culled, and the trade bans no longer apply. Note that in order to restrict our analysis on the agricultural and related sectors, we deliberately do not simulate any loss of consumption of beef or dairy products although they may occur in reality.

Concerning the calibration of the mutual fund, we first assume a production income threshold equivalent to 90% of the production income at steady state. This threshold serves in the decision of activation of a release of liquidities from the mutual fund to support farm activity. Concretely, a financial support from the mutual fund is given to the farmer when its production income falls below this threshold. In addition, we decide that the mandatory precautionary saving is equivalent to a tax of 0,5% of annual income. This assumption permits to differentiate the level of savings among participants depending on their volume of activity rather than a fixed amount imposed independently to all participants. We precise that in our simulation, agents participating in the mutual fund are all livestock farmers.

1.5. Induced effects of the implementation of mutual funds

The constitution of mutual funds permits to the implementation of precautionary savings for farmers as a mandatory measure has market effects, even in the absence of sanitary crisis. Indeed, the strong incentive or the obligation for farmers to participate in the establishment of precautionary savings makes this participation equivalent to a tax on agricultural production. As a result, its implementation tends to induce a change in market equilibriums. Indeed, a levy on farmers' incomes has mechanical effect as a disincentive to produce. In our simulation, we implement mandatory participation set at 0.5% of annual income of farmers over 10 years, as shown in table 2 and table 3.

Table 2: Constitution of the mutual fund

period	1	2	3	4	5	10
Mutual fund constitution	17	34	52	71	91	206
Annual precaut. savings	17	16	16	16	16	16

Source: own elaboration

On the one side, the annual mandatory savings increased by a public interest rate permit to create a growing mutual fund, with a quite stable participation level of farmers.

Table 3: production and price effect of the mandatory mutual fund (in % with respect to the initial steady state)

period	1	2	3	4	5	10
production						
milk/dairy prod.		-0,46	-0,62	-0,73	-0,82	-1,06
cattle/beef		-0,39	-0,74	-0,92	-1,08	-1,58
price						
milk		0,19	0,25	0,30	0,33	0,44
cattle		0,12	0,23	0,27	0,30	0,43

Source: own elaboration

On the other side, this taxation induces a modification of the behaviour of the farmers. Over a 10-year period, the overall production of cattle for beef decreases by -1,58% and the production of milk by -1,06%, confirming the fact that the tax implementation generates an additional cost which has counterproductive effects for farmers. These slight falls in production mean reductions of the size of the herds. Obviously, the decreases in production induces some increases in prices of about +0,4% for both milk and cattle.

Table 4: impacts on net value added for livestock activities and related industries (in % with respect to the initial steady state)

period	1	2	3	4	5	10
raising male calves	-2,00	-1,72	-1,87	-2,03	-2,18	-2,73
raising female calves	-1,00	-1,80	-2,08	-2,36	-2,60	-3,43
raising heifers	-0,89	-1,55	-1,73	-1,85	-1,99	-2,46
fattenig male calves	-0,55	-0,91	-0,81	-0,83	-0,86	-0,94
fattening female calves	-0,54	-0,81	-0,63	-0,58	-0,53	-0,30
fattening heifers	-0,56	-0,94	-1,05	-1,11	-1,18	-1,45
fattening bulls	-0,56	-0,39	-1,32	-1,51	-1,71	-2,42
suckler cows	-0,64	-0,88	-3,12	-4,78	-6,05	-10,66
dairy cows	-0,85	-0,97	-1,00	-1,03	-1,06	-1,13
beef industry	-0,01	-0,55	-1,01	-1,20	-1,34	-1,78
dairy industry	-0,01	-0,51	-0,68	-0,79	-0,88	-1,11

Source : own elaboration

Now turning to the effects on value added, we first obviously observe that the production decrease induces a global loss of value added for both farm sectors and food sectors. More precisely, thanks to the table 4 we disentangle variable effects over the 9 livestock activities defined in the model. Indeed, the greatest loss is observed for the suckler cow activity (-10,66%) in comparison to other sectors losing in a range of 0,30 to 3,43%. This can be explained by the fact that this particular activity, whose main selling output is cow beef (except the production of live calves), has a very small size in our economy, about 20 times smaller than the dairy cows activity. As a consequence, including an incompressible financial charge has a huge weigh and it leads farmers to disinvest as to try to maintain their valuation of production factors. This has side effects on other activities, explaining why raising activities are more impacted than the fattening ones, since less raised bovines enter the suckler herd. The mandatory savings have also downstream impacts, as the decrease in farm production constitutes a loss of agricultural raw material for the beef and dairy industries.

More generally, this simulation of the implementation of mandatory precautionary savings leads to a double conclusion. First, public regulation needs to define a maximum level for the financial reserve of the mutual fund after which precautionary savings are not needed. As a consequence farmers are not charged indefinitely for the benefit of a mutual fund that grows and nobody benefits from, this to avoid long term growing counterproductive effects. Second, as the mutual fund is a financial support to help recover the livestock activities when a sanitary crisis occurs, the risk management policy needs to take into account those negative effects; mandatory savings may be suspended while farmers rebuild their production capacity.

1.6. Effectiveness of the risk management tool

In this section we examine the effect of the implementation of a mutual fund when a FMD outbreak occurs. In order to analyse its economic impact, we compare three simulations corresponding to three different cases. We first report results of the impacts of the FMD outbreak in the absence of risk management policy. Then we analyse the same situation including a totally public support to farmers, equivalent to authorise for subsidies from the mutual fund without any counterpart for the farmers to pay off for that financial help (i.e. no mandatory savings to bail out the losses in the mutual fund). Finally we compute the consequences of a full implementation of the mutual fund, including both the financial support when farm income falls below the defined threshold and the mandatory savings for farmers finance the mutual fund.

- Herd structure and market effects

Table 5: impact on herd structure (% with respect to the initial steady state)

period	1	2	3	4	5	15
no risk management policy						
dairy cows	-10	5,84	-3,13	-3,79	-3,47	-1,13
suckler cows	-10	57,88	6,16	-16,22	-22,42	-33,35
male calves	-10	-29,00	-11,38	-17,19	-15,63	-8,55
female calves	-10	-34,15	-23,03	-21,38	-19,62	-11,28
heifers	-10	-21,37	-15,96	-12,39	-11,04	-5,90
bulls	-10	-10,00	-18,34	-5,99	-9,30	0,20
public support						
dairy cows	-10	5,72	-3,26	-3,74	-3,54	-1,23
suckler cows	-10	58,58	8,16	-9,54	-11,80	-10,78
male calves	-10	-18,69	-10,86	-11,41	-10,51	-5,47
female calves	-10	-20,27	-13,42	-12,75	-11,97	-7,37
heifers	-10	-21,37	-13,62	-10,87	-9,34	-4,34
bulls	-10	-10,00	-14,78	-8,06	-7,99	-1,70
mixed public/private system						
dairy cows	-10	5,64	-3,75	-4,37	-4,32	-2,48
suckler cows	-10	59,07	8,19	-9,81	-12,14	-11,41
male calves	-10	-18,97	-11,07	-11,98	-11,35	-6,94
female calves	-10	-20,51	-13,72	-13,12	-12,47	-9,25
heifers	-10	-21,37	-13,88	-11,57	-10,16	-5,93
bulls	-10	-10,00	-15,18	-8,72	-9,22	-4,72

Source : own elaboration

On table 5 are reported the evolutions of the cattle after the FMD outbreak in the three scenarios of simulation. As already explained, on first period we simulate that 10% of the herd is culled because of the presence of the disease. To understand the dynamic evolutions of the herds, one may be aware that Brittany traditionally imports calves and heifers and export young cows. So turning to the second period and in the absence of any management policy, we first notice that both suckler and dairy cow livestock increase. This is explained by the fact that Brittany traditionally exports cows. As movements of live animals are banned the year of the FMD outbreak, those stocks are not sold outside the region. Therefore, the year after, these cows participate to the quick recovery of the herds, and even to make it grow higher than the pre-FMD levels.

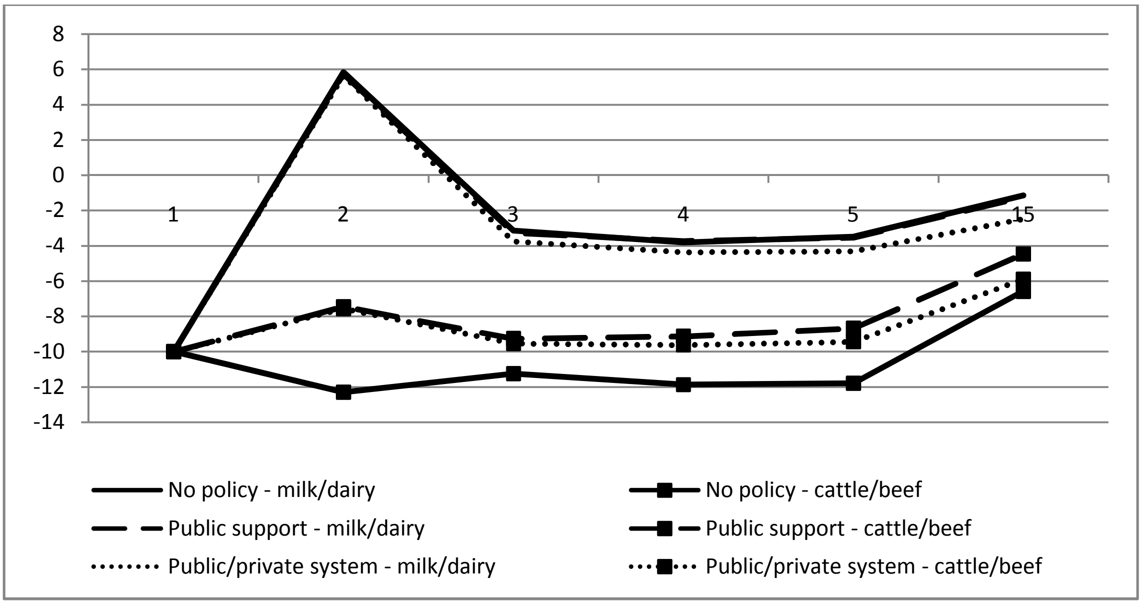
In parallel, on period 2 the herds of calves and heifers decrease as a result to the bans on import in the first period. Those deficits of young livestock result in lasting lacks of animals until the end of simulation. Indeed, the decrease of calves on second period results in a decrease of heifers on third period and so on. Thereafter, until the end of simulation, herds tend to reach slowly their initial value. One may wonder why the missing stocks are not completely filled with imports. Our simulations show that this is due to the limitation in investment capacity that prevents from massive expenditures to rebuild the herds. In the case of suckler cows, because of constraints on factor markets the activity tends to be much less profitable, driving farmers to prefer heifers to enter the dairy sector rather than the suckler one.

As a conclusion, our first simulation shows that a one-period shock due to a FMD outbreak causes dynamic long term variations of the herd structures, which may last all the more that factor markets are constrained. Comparing those raw effects with the evolution of the cattle in presence of risk management policies, we observe some significant differences. They are the most observable in period 2 for calves, where in both setting the subsidy helps to limit the loss of animals (-19% and -20% in comparison to respectively -29% and -34%) by the release of capital to import more young cattle (see table 8). On third period the subsidy mainly has the same target. Helping a quicker recovery of the young herd, the subsidy participates in the long run rebuilding of the whole cattle. Indeed, the lower loss of calves in the second period permits to obtain more young heifers and bulls on third period and so on. By this way, the deficit of cattle in the end of simulation is lower thanks to the financial support to farm activity.

However, we observe a slight difference between the public system and the participative one where farmers participate in precautionary savings (there they are more repayment of aid paid as an advance on cash). This result confirms the counterproductive effects of the implementation of mandatory savings/repayments.

Focusing on market impacts for the livestock sector and downstream industries (see figure 6), the culling of 10% of the regional livestock in the initial period of simulation obviously induces 10% losses of productions in livestock farms and therefore in dairy and beef industries in the absence of imports. This has a mechanical consequence on agricultural prices (see table 7) which increase y about 4%. As already observed with the cattle dynamics, the main effect of the policy is to help provide new animals. As a consequence, the cattle and the beef supplies are less impacted when a risk management policy is implemented. Thanks to this table we still observe that obviously, the mandatory precautionary savings tend to slightly lower the production levels.

Figure 6: impact on production (% with respect to the initial steady state)



Source : own elaboration

The same way, the implementation of support policy during a FMD outbreak tends to smooth price evolutions. Lowering levels of production induce increases in price, and the benefit of the financial help for farmers to maintain their activity permits to obtain smaller price variations.

Production results from other agricultural activities are not detailed in this article; let us just mention that due to the increase in price for beef, demand lowers to the benefit of other meat (pig). In addition, the lowering production of cattle, due to the decreased herd, induces a lower demand for feed and fodder. As a result, we observe marginal land use changes due to the FMD outbreak.

- Net value added and regional welfare consequences

In terms of welfare effects, the implementation of a subsidizing system has a significant positive effect on net value added in agriculture, and as a consequence in the related industries. Indeed, except the case of dairy farms which benefit from more cows producing more milk (because of export bans the year of FMD), cattle sectors for beef production suffer a loss of -196M€ of value added the year of the outbreak and -251M€ the year after due to ban restrictions and credit limitations. When a financial support to revenue is settled, those losses of income are largely reduced. The most striking result is when no farm participation is required, the cattle sector does not face any loss of net value at the FMD period. This can be explained by the fact that since imports for the renewal of the herd are banned, the totality of the subsidy is used to compensate for the income loss due to the decreasing production. However, this subsidy absolutely does not benefit to the beef industry, because they still fail at acquiring a missing cattle. This explains why in the first period the only benefit from the management policy goes to the agricultural activity (+0,63% in comparison to -4,31%) although the food industries suffer from the same level of loss.

In second period, the effects of the management policy are much more efficient for the whole sector and not only the livestock farms thanks to the reopening of borders. Indeed, the subsidy still permits to limit the loss of value added in the cattle sector (-5,56% in comparison to -19,66%), and additional income now permits to help rebuild the herds. As a consequence, more cattle is available for beef processing and beef industries can now enjoy the benefits of the agricultural support, their value added decreasing only by -8,16% in comparison to -16,23% without risk management policy. On the long run, no significant effects are observed due to our definition of simulation (production income is subsidized if it falls below 10% under its base value).

Table 7: impacts on net value added (M€ and %with respect to the initial steady state)

period	1	2	3	4	5	15
no risk management policy						
dairy cows	37	4	-1	-11	-9	-2
	3,28%	0,34%	-0,86%	-0,98%	-0,81%	-0,17%
other cattle	-196	-251	-171	-152	-145	-89
	-15,41%	-19,66%	-13,44%	-11,90%	-11,34%	-6,97%
agriculture	-171	-242	-189	-171	-161	-94
	-4,31%	-6,09%	-4,75%	-4,30%	-4,06%	-2,36%
dairy industry	-21	13	-6	-7	-7	-2
	-10,77%	6,87%	-3,02%	-3,77%	-3,44%	-1,07%
beef industry	-27	-27	-2	-22	-22	-1
	-16,39%	-16,23%	-12,38%	-13,32%	-13,18%	-5,85%
food industries	-4	-1	-24	-27	-26	-1
	-1,67%	-0,40%	-1,01%	-1,13%	-1,10%	-0,42%
public support						
dairy cows	3,27%	1,73%	-0,90%	-1,06%	-1,00%	-0,35%
other cattle		-5,56%	-8,49%	-7,96%	-7,38%	-4,28%
agriculture	0,63%	-1,10%	-3,15%	-3,04%	-2,82%	-1,53%
dairy industry	-10,77%	6,74%	-3,16%	-3,71%	-3,51%	-1,17%
beef industry	-16,39%	-8,16%	-10,99%	-10,63%	-9,86%	-3,91%
industries	-1,68%	0,10%	-0,94%	-0,96%	-0,89%	-0,32%
mixed public/private system						
dairy cows	2,46%	0,76%	-1,91%	-2,11%	-2,11%	-1,63%
other cattle	-0,71%	-6,04%	-9,00%	-8,80%	-8,40%	-6,12%
total agriculture	0,17%	-1,53%	-3,61%	-3,62%	-3,48%	-2,53%
dairy industry	-10,77%	6,64%	-3,68%	-4,36%	-4,32%	-2,44%
beef industry	-16,39%	-8,34%	-11,35%	-11,25%	-10,82%	-5,48%
food industries	-1,67%	0,09%	-1,00%	-1,04%	-1,01%	-0,52%

Source : own elaboration

Concerning the possible participation of farmers to this financial support through precautionary savings, again the results on net value added show that this levy has counterproductive effects and it tends to lower the benefit of the exceptional subsidy. On the long run, net values added are even comparable or lower than in the total absence of any risk management policy. Indeed, the dairy activity (through the production of milk) does not suffer much from the FMD crisis, but its participation to the repayment/saving for the public support to the cattle activity tends to lower its production level. In addition to credit limitations and the effort to rebuild the herds, other cattle sectors face this extra constraint for a higher lasting rebuilding period.

In those two scenarios of management systems involving farmers' participation or not, some important amouns are transferred to help support agricultural activity and limit the market effect of the FMD outbreak, as shown on table 8. As indicated, the subsidy is only activated when production income falls below 10% under its base value; this explains why the level of subsidies is mainly observable in the first times after the outbreak occurs. Nevertheless, the remaining subsidy that is allowed until the end of simulation is mainly devoted to the suckler cow activity, for which the acquisition of new cows is not only limited by credit constraints but also by the fact that the usage of cows is more profitable for milk production.

Table 8: Annual financial transfers in the two types of management policies (M€)

period	1	2	3	4	5	15
public support						
subsidy	131,00	112,00	17,16	6,69	4,60	0,32
mixed public/private system						
subsidy	137,00	115,00	20,49	8,35	5,75	0,63
savings	16,07	16,05	14,96	14,95	14,95	15,01

Source : own elaboration

Some regional macroeconomic impacts in the end of simulations are reported in table 9. At the end of simulation, the value of land diminishes due to the reduced cattle sizes. Thanks to a public support, the fall of value of land can be smoothed (-73,08M€ / -94,80M€). This public support also permits to limit the impacts on financial capital and on the cattle herd value. However, this kind of policy has a cost; if the production effects of the policy permit to limit the increase of the debt, the public support to livestock sectors needs to be financed, increasing the debt (payment of the loan interests on the mutual fund). Moreover, the total amount spent through this public management policy is 277M€, which can also be added to the debt. Nevertheless, this risk management strategy permits to limit the loss of discounted welfare of the representative household (930,53M€ / 1228,96M€), which represents an aggregate of the annual equivalent variations.

In the case of a full implementation of a mutual fund system, where the support to farm activity is partly financed by farmers themselves though annual savings, we distinguish mixed macroeconomic effects. On the one hand, the mandatory savings/repayments permit to limit the public expenditure, which is reduced by about 102M€ while farmers support now about 57% of the entire cost.

Table 9: macroeconomic impacts (M€)

	no risk management policy	Public support	mixed public/private system
value of land	-94,80	-73,08	-120,84
value of physical capital	-376,04	-278,18	-381,92
value of cattle herd	-66,39	-33,80	-49,22
value of foreign debt (out of mut. f.)	245,31	260,14	100,19
policy public cost		277,83	175,85
policy farm cost			237,20
discounted welfare	-1228,96	-930,53	-1097,58

Source : own elaboration

As a consequence, the value of the general debt is much lower than with the only public support. Logically, the levy on farm production tends to limit the effects of the policy on the value of the cattle herd. More striking are the falls in the value of land and in the value of physical capital. This can be explained by the fact that farmers bear the cost of the FMD outbreak through mandatory savings. On the one hand, the subsidies from the mutual fund can help rebuild –to a limited extent– the herds, and on the other hand the savings/repayments induce much lower amounts to value the land factor and physical capital investment.

4. Conclusion

In this study we experience the implementation of a risk management policy for the lasting market effects of a potential FMD outbreak. More precisely, we introduce mutual funds, a mixed public-private management system, and we analyze their ability to cope with such a catastrophic event. On the basis of a dynamic CGE framework, we highlight the fact that potential losses are great and that the implementation of any management policy, totally public or with the participation of farmers themselves, can smooth he effects of the catastrophic shock.

Nevertheless we also show that the risk management policy has a non trivial cost. We underline that if this cost is totally supported be the regional public authorities, the global debt amount may reach high levels. On the other hand, intending to finance the exceptional supports by farmers themselves may also have significant repercussions on the farm activity and income, since farmers are all the more weakened by this mandatory participation that they already face high constraints to rebuild their production capacity quickly (credit, wages).

These results highlight the catastrophic nature of a FMD outbreak, and they indicate that the successful constitution of mutual funds to cope with this kind of hazard depend on two main factors. First, public authority may pay attention to a right calibration of the level of participation to the fund in order to avoid counterproductive effects. Second, a sufficient delay should be left to farmers after the market crisis and before participating anew to the fund, this delay permitting to recover more safely from the losses induced by the disease. In addition, our analysis shows that the financial help to farmers does not benefit the whole sector when a trade ban is imposed, because the cattle cannot be renewed so that the food industries do not benefit from that help at all.

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