Would multi-peril grassland insurance improve French suckler cow farm sustainability?

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**Abstract:** Objectives of this study are to analyse attractiveness of grassland insurance, its effect on self insurance under different public supports, and consequences of the insurance mix on profit distribution. A theoretical overview of the farm insurance problem is provided to better understand the decision drivers. Then, simulations have been performed thanks to a stochastic programming model. Results suggest that subsidies on insurance premium are necessary to maintain the protection level that farmers had with the calamity fund. Substitution between self insurance and market insurance induces a higher protection for extreme events but a lower one for intermediate loss of grassland production.

**Keywords:** risk, piecewise continuous profit function, self insurance, farm model, livestock production

1 **Introduction**

Suckler cow farms, also called cow-calf operations, consist in producing calves for later sale with a permanent herd of cows. They are an important feature of French agriculture in terms of beef production: 60% of the beef consumed in France comes from cow-calf production and one million of live calves are exported each year, mainly to Italy. The principal source of feed of those systems comes from grasslands which have numerous environmental assets, namely carbon storage that could partly compensate for greenhouse gas emissions generated by the livestock enterprise (Veysset et al., 2014; Soussana et al., 2010). However, the production of forages from grasslands is sensitive to weather conditions. In case of natural calamities, farmers could actually receive indemnities from a public fund. Until now, grassland production has indeed been considered as non insurable in France. Different market failures could explain the absence of private insurance. First, the correlation of many natural disaster risks across widespread geographical areas requires reinsurance which could be extremely costly for insurance companies (Miranda and Glauber, 1997). Second, risk exposure and weather related damages on grasslands are difficult to estimate: grass is an intermediate product which can be both grazed almost all year round and harvested at various periods. However, following other countries such as North America or Spain, the French government plans to progressively switch from this public calamity fund toward multi-peril grassland insurance in order to better control its budget and to offer farmers better compensation of production losses. Both technological developments such as estimation of pasture yield by satellite and negotiations regarding public reinsurance of the companies’ underwriting risk offer opportunities for the development of such an insurance. In accordance with Common Agricultural Policy (CAP) rules, a subsidy up to 65% of insurance premium paid by the farmer is planned in order to foster farmers’ participation. Farmers participation is indeed often well below the levels desired by policy-makers (Knight and Coble, 1997). In parallel, CAP payments will be modified after 2014. Single farm payments will be converted into a basic payment, a green payment and a redistributive payment. Convergence of basic and green payments towards more uniform payments per hectare, independently from agricultural production would certainly increase direct payments for most grassland based suckler cow farms. If a constant amount is added to all payoffs, relative variation of profit decreases. Additional direct payment could then modify farmers demand for insurance (Hennessy, 1998).

If private insurance and direct payments are substitutes for self insurance (note that insurance reduces the impact of unfavourable events on profit but not their probability), subsidies on insurance and additional CAP payments could generate detrimental effects on environment. Some studies on crop production argued indeed that more risk increasing chemicals are used when
insured (Horowitz and Lichtenberg, 1993). According to Tangermann (2011) "public policy should not absorb risk that farmers can manage themselves, be it on the farms or through market instruments”. This raises the question of the efficiency of public policy to support farm sustainability under production risks.

Knight and Coble (1997) explain that the effect of insurance on input use depend on risk preferences and input risk properties. Impacts of market insurance and public supports should then be analysed taking into account specificities of the studied systems. Few studies have dealt with the insurance issue in livestock production systems. Among them, Finger and Calanca (2011) estimate that the optimal level of nitrogen application on grasslands is maintained or increased for risk averse Swiss farmers when grassland insurance is available. Müller et al. (2011) demonstrate that if a cost-free rangeland production insurance is available, grassland protection (resting part of pasture area in rainy years) decreases in Namibia, resulting in a degradation of long term biomass production. However, in these studies, constraints and opportunities linked to livestock production are underestimated. Livestock production is considered, in the best case, as proportional to rangeland production at any time. In France, Suckler cow farmers have different on-farm options for managing grassland production variability. They encompass ex-ante options such as increasing grassland area per animal or diversifying forage production. Ex-post, farmers can limit impacts of unfavourable weather shocks thanks to adjustments of land management (area of grassland harvested, end use of dual purpose crops..), of feed supplementation or of selling periods (Lemaire et al., 2006). However, because of herd dynamics, current decisions depend on previous ones and influence futures ones. In addition, management possibilities are constrained by current farm structure: building, machinery and labours that are quasi-fixed inputs in the short run.

Objectives of this paper are 1/ to estimate attractiveness of grassland insurance under different public supports 2/ to analyse substitution between grassland insurance and self insurance and 3/ to assess their consequences on profit distribution. Focus is on a typical self insurance option: the creation of forage production overcapacity (the average herd forage demand is below forage production potential) or in other words the reduction of herd size on a given grassland area. Sustainability is assessed through the analysis of profit distribution and profit sensitivity to variation of grassland production and the estimation of greenhouse gases emissions.

The section 2 of this paper aims at providing a brief and global understanding of the insurance optimisation problem when herd size and market insurance level can be chosen simultaneously. In the literature, a two-states model is generally considered such as in Ehrlich and Becker (1972). Nonetheless, this representation is not well suited to model the grassland production risk issue. The intensity and the frequency of grassland production loss are indeed various and their impacts on profit not proportional to their intensity. Similar to Schlesinger (2000), the whole distribution of grassland production is considered. Following Brunette and Couture (2008), profit loss is a function of herd size. In addition, profit is modelled as a piecewise continuous function of grassland production for which self insurance and market insurance impact the curve breakpoints.

Section 3 is devoted to the simulation of market insurance impacts on production decisions and on farm sustainability under different public supports. It aims at providing quantified realistic results for French suckler cow farms based on grassland production. Bio-economic models give the opportunity to explicitly represent the production process and the decision making under risks (Hardaker, 2004). Stochastic dynamic modelling methods take into account the sequential decision process and optimise stock consumption (animal sales, grass feeding) over a very long time horizon (Kobayashi et al., 2007; Moxnes et al., 2001; Müller et al., 2011). Yet, these methods don’t suit well to production systems in which numerous controls are possible on both forage and herd.
management and for which farm structure constraints a lot stock evolution. Similar to Lien et al. (2007), a stochastic programming model is used in this study. Main advances of this model derive from the representation of between year dynamics, the introduction of an important number of grassland production states (necessary to investigate insurance issue), the endogenous grassland harvest and the modelling of fixed costs. Self insurance and market insurance are simultaneously estimated and analyzed under scenarios differing in terms of risk aversion level (neutral or moderately averse), grassland insurance availability and public supports (public calamity fund, subsidies on insurance premium or additional direct payment).

2 A theoretical overview of the insurance optimisation problem

We propose in this section an overview of the insurance decision problem when farmers can choose between market insurance and self insurance. Self insurance consists in decreasing herd size \( L \) to reduce feed purchase in case of low grassland production. In order to keep the problem as simple as possible, let’s suppose that herd size and animal live weight are constant over time. Let’s also assume that there is no dynamic, no hay stock and no adjustments of herd and grassland management after climatic conditions affect the final grassland production. To maintain herd production, farmers have then to purchase feed at price \( p \) if grassland production \( y \) falls below herd need \( \alpha L \). If \( y \) is above herd needs, profit doesn’t increase because hay surplus can’t be sold. If farmers decrease herd size, animal receipts which are proportional to herd size \( sL \) are cut whatever the grassland production level. Market insurance offers grassland yield risk protection through indemnity payments when production falls below a defined level \( \rho \). Assuming indemnity totally offset profit loss, profit is indifferent to variation of grassland production lying within \([0 ; \rho]\). To benefit from this service, an insurance premium \( ic \) is paid in all cases. Market insurance premium depends on the coverage level \( \rho \), the distribution \( f \) of grassland production below \( \rho \), the value of grassland production evaluated at purchased feed price \( p \) and the insurance loading cost \( \lambda \). The loading factor accounts for administrative costs, collecting information, generating profits and accumulation of reserves for the private company.

\[
ic(\rho) = \lambda \rho \int_0^\rho f(y)dy \tag{1}\]

Assume risk aversion is reflected in a von Neumann-Morgenstern utility function that is strictly increasing, concave, twice differentiable and separable. When both market and self insurance are available, expected utility of profit \( \Pi \) could be written as in equation 2. Shapes of profit sensitivity to grassland variation according to various insurance mixes are illustrated in figure 1.

\[
Eu(\Pi(\rho, L)) = \int_{\Pi_3(\cdot)} u[\Pi_1(\cdot)] f(y)dy + \int_{\Pi_2(\cdot)} u[\Pi_1(\cdot)] f(y)dy + \int_{\Pi_1(\cdot)} u[\Pi_2(\cdot)] f(y)dy \tag{2}\]

with

\[
\Pi = \begin{cases}
\Pi_1 = W_0 + sL - ic(\rho) & y \geq \alpha L \\
\Pi_2 = W_0 + sL - ic(\rho) - (\alpha L - y)\rho & \rho \leq y \leq \alpha L \\
\Pi_3 = W_0 + sL - ic(\rho) - (\alpha L - \rho)\rho & y \leq \rho
\end{cases} \tag{3}
\]

With \( W_0 \) being initial wealth
2.1 Impacts of grassland yield distribution, costs and receipt per animal on herd size

First, focus is made on the relationship between, in the one hand, herd size, and in the other hand, risk distribution, costs and receipt per animal. Let’s consider a farmer neutral to risk and without market insurance. Such a farmer would choose herd size in order to maximise expected profit. The discontinuity of profit is represented in a way similar to Gohin and Bureau (2006): additional feed costs are added only if grassland production falls below herd need.

\[ \Pi = W_0 + sL - \text{prob}(y < \alpha L)E((\alpha L - y)p; y < \alpha L) \]  

(4)

First order condition involves:

\[ \frac{\partial E(\Pi)}{\partial L} = 0 \rightarrow s = \frac{\partial \text{prob}(y < \alpha L)}{\partial L} E((\alpha L - y)p; y < \alpha L) + \text{prob}(y < \alpha L). \frac{\partial E((\alpha L - y)p; y < \alpha L)}{\partial L} \]  

(5)

Since profit is asymmetric, grassland production risk would impact on optimal herd size even under risk neutrality. The shape of the probability density function of grassland production will affect optimal herd size. Higher probability to obtain insufficient forage or higher slope of the cumulative distribution function at point L would decrease more herd size. Higher forage need per livestock unit, higher market feed price or lower receipt per animal will also increase the incentive to reduce herd size.

2.2 Impacts of market insurance cost on herd size

To analyse the effect of insurance cost and risk distribution on substitution between self insurance and market insurance in a simple way, let’s suppose that farmer is fully insured. Under such assumption, the level of market insurance coverage \( \rho \) equals herd forage needs \( \alpha L \). If grassland production falls below herd need, insurance indemnity will compensate supplementary feed cost. Profit is thus indifferent to grassland production variation: \( \Pi = W_0 + sL - ic \). In this case, when herd size and insurance are chosen simultaneously, the first order optimality conditions would give that receipt per livestock unit would be equal to the shadow price of market insurance, with \( F \) being the cumulative distribution of grassland production:

\[ s = \lambda F(\rho) \frac{dF(\rho)}{d\rho} \]  

(6)

Static comparative analysis gives that lower insurance loading cost or lower probability of low grassland production would foster market insurance but would reduce self insurance.

2.3 Impacts of risk preferences and initial wealth on self insurance and on market insurance

Let’s suppose now that costs to redistribute one euro from favourable states to unfavourable ones are the same for self insurance and market insurance. Since utility function is concave, market insurance which targets specifically the lowest state of profit (\( \Pi_3 \)) will be preferred to self insurance that splits redistribution between \( \Pi_2 \) and \( \Pi_3 \). The more risk averse the farmer, the more
concave the utility curve. Higher risk aversion level would accentuate the willingness to increase $\Pi_3$ rather than $\Pi_2$ and consequently, the preference toward market insurance.

If farmers exhibit Decreasing Absolute Aversion to Risk (DARA), this means that the lower the level of profit, the higher the penalty applied. Additional initial wealth will decrease relative variation of profit and then the global demand for insurance. If the same amount of wealth is added to $\Pi_3$ and $\Pi_2$, the relative impact of this measure will be higher on $\Pi_3$. As a consequence, additional direct payment will impact more on market insurance demand than on herd size reduction.

3 Simulation of production and market insurance decisions under different public supports and of their consequences on farm sustainability

3.1 Description of the stochastic programming model

This model is formulated to represent a French suckler cow enterprise based on grassland production, under grassland production risks. Cows calve for the first time at three years old and then once a year. Main products are 10 month-old males that will be fattened abroad and reproductive females are fattened on the farm. To represent farmers’ decision making, it is assumed that farmers anticipate that grassland production is variable and that they could adjust partly their production decisions when grassland production is known (Mosnier et al., 2011). Five states of forage yield are anticipated for each year of a two year planning horizon, that is to say 25 possible combinations of risk. Decisions to be optimized are divided into long run and short run decisions. Long run decisions such as barn and hay storage building capacities or initial herd state (final herd number and animal live weight must be equal to initial one) cannot be revised over the planning horizon. Short run decisions concern the annual purchase of grassland insurance, bimonthly decisions regarding animal sales, animal diet composition, animal energy intakes, purchases of feed stuff and the share of grassland area harvested. Optimal decisions are those that maximise the discounted expected utility of profit. Technically, this stochastic programming model is resolved by the non linear programming solver CONOPT run in GAMS-software package.

- The optimization program

Optimal decisions are those that maximise the objective function $Z$ which is defined as the discounted expected utility of profit ($\Pi$) over a finite planning horizon plus the discounted expected value of residual hay stock $E(SV_{T,T})$. The discount factor $r$ on future utility takes opportunity cost of capital. Its value is set to 0.04. The utility function can be either modelled by a functional form or be summarized by its central moments. The mean-variance is a strong and widely used analytical tool. However, this specification supposes that farmers have the same aversion for positive deviations from average profit as for negative ones. It overlooks the impact of production decisions on higher moments, in particular if producers may wish to reduce the likelihood of “downside” outcomes. Since this application is devoted to insurance, the left-hand tail of the distribution of profit is of particular importance. The functional form used here is the power function (7). It exhibits decreasing absolute risk aversion (DARA) and constant relative risk aversion (CRRA) as generally assumed. Relative risk aversion $\gamma$ is set to 2 which corresponds to a moderately averse farmer (Hardaker, 2004). Profit ($\Pi$) is scaled by maximum annual profit ($\pi_{max}= 40 \text{ k€}$). In order to have value on the same scale as stock variation, the inverse utility function is applied to the expected utility of profit.
Grass production, feed stock and animal production

Average yields ($y$) and forage quality characteristics are calculated bi-monthly. Although the distribution of both parameters varies, focus is on annual yield variability as do most multi-peril crop insurance programs. We assume that the same deviation to average yield occurs at the different seasons. The distribution of grassland production between years is summarized by five states of nature $[c_1,..,c_5]$: from severe loss ($c_1$: <-30 % of average yield) to high surplus ($c_5$: >30 % of average yield). Average deviations of grassland yield for the 5 states of nature and probability of occurrence of these states (table 1) are parameterized thanks to Isop\(^1\) over the period 1980-2010.

Table 1: Characteristics of the five state of nature for weather risks (from $c_1$ to $c_5$)

<table>
<thead>
<tr>
<th>Class variation</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>12 %</td>
<td>20 %</td>
<td>36 %</td>
<td>20 %</td>
<td>12 %</td>
</tr>
<tr>
<td>Average yield deviation</td>
<td>-40 %</td>
<td>-19 %</td>
<td>0 %</td>
<td>19 %</td>
<td>40 %</td>
</tr>
</tbody>
</table>

For the sake of simplicity, we consider 100 ha of grassland area that can be used either for grazing or haymaking. The quantity of standing grass available in one period corresponds to the balance between previous biomass stock, grass produced and grass exported (grazed or cut). Standing grass quantity is set to 0 during winter. The average share of land harvested at each period is optimized (and fixed) for the whole planning horizon. In order to take advantage of production surplus or to face production losses, between year adjustments of this area is allowed but limited at more or less 10 % of the total grassland area (Mosnier et al., 2013b). Stock of hay is defined as the balance between inputs (grass harvested and hay bought) and withdrawals (hay consumed) plus the stock remaining from the previous period. Defining initial stock is crucial since it will limit impact of grassland yield variation. In order to have a value consistent with the production system, initial stock is constrained to be equal to the expected hay surplus of years 1 and 2.

To cover the range of animal production, eight annual animal classes characterized by sex (male or female), age (from new born to mature) and production objective (fattening or lean) are introduced in the model. Classes are described by two endogenous dynamic variables: the number of animals and their average live weight. Herd management consists in controlling those dynamics thanks to animal sales, animal diet composition and diet energy content (Mosnier et al., 2009). The initial number of animals in each class is optimised. Herd size could vary over the planning horizon under the constraint that it would be equal to initial herd size at the end of the simulation.

 Costs and receipts

Costs are divided into costs that are fixed for the whole planning horizon and costs that could vary according years and grassland production level. Fixed costs encompass amortisation and maintenance costs for cattle barn (25 €/unit of livestock capacity), forage storage building (6 €/tDM of storage capacity). If herd size or forage stock fall below these capacities, fixed costs don’t decrease since farmers still have to finance their investment and their maintenance. Barn capacity is binding: herd size in winter cannot exceed barn capacity. It is not the case of hay storage capacity: if grass can’t be conserved inside the shed, additional costs are added to wrap grass into

\[ Z = \sum_{t=1}^{T} \left( \frac{1}{1-r} \right)^{r-1} \sum_{\xi \in \Pi} \frac{\prod_{s=1}^{T} \gamma_{s,t}}{\pi_{\text{max}}} \sum_{\tau} \text{prob}(\xi, \tau) \left( \frac{1}{1-r} \right)^{r} E(SV_{\tau,t}) \]  

\[ (7) \]

\(^1\) http://www.agreste.agriculture.gouv.fr/IMG/pdf/syntheseprairie0904.pdf
bales in plastic film (+20 €/tDM) so that they could be stored outside. Other fixed costs such as mechanisations, various management costs and financial costs are added. They are split into costs proportional to barn capacity (120 €/ha), and costs proportional to land unit (220 €/ha). This repartition was used as calibration parameter. Variable crop production costs include fertilizers for grassland (25 €/ha) and haymaking (90 €/ha). Animal production variable costs comprise value of purchased feeds (200 €/t of concentrate feed, 130 €/t of hay), litter (0.42 €/day/LSU), diverse costs (92 €/LU) such as veterinary, feed complementation (vitamins, minerals) and rapeseed meal. Over the period 2000-2012, 10-month-old males have been sold at 2.30 €/kg, lean cows at 1.61 €/kg and fattened cows at 1.73 €/kg (alive).

3.2 Scenarios

Scenarios are defined to analyse self insurance and market insurance according to different public policies. The baseline scenario (Base) is designed to reproduce current average farm situation. It corresponds to a farmer with a moderate aversion to risks, under current CAP payments; market grassland insurance is not available but farm is eligible to receive indemnity from the calamity funds. A similar scenario but without aversion to risk is added (Base_neutral). The three other scenarios introduce the possibility to subscribe multi peril grassland insurance. Farm can’t benefit more from the calamity funds. These scenarios differ in terms of subsidies on insurance premium and on direct payment as displayed in Table 2.

Table 2: main characteristics of scenarios

<table>
<thead>
<tr>
<th>Risk aversion</th>
<th>Calamity funds</th>
<th>Insurance</th>
<th>Ins_Sub</th>
<th>Ins_DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base_neutral</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Base</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>+15% of direct payment</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The characteristics of multi-peril insurance scheme are inspired by the scheme currently in test by a French insurance company. This scheme offers grassland yield risk protection through indemnity payments that are made whenever the grass yield accumulated between February and October falls below a predetermined level. This level depends on the yield coverage option chosen by the farmer. It is specified as percentages $\rho$ of the individual historic yield $Y$. Farmers can choose each year how many hectares they insure for the three levels of cover proposed: 70 %, 80 % and 90 %. The value $P$ of damages on grassland yield are estimated assuming a price of 120 € per ton of dry matter. The indemnity payment function is defined as follows:

$$\text{Indemnity} = \max \{0, \rho Y - Y_0\}.P$$  \hspace{1cm} (8)

The insurance premium is calculated based on the simulated distribution of grassland yield presented in the previous section. It is equal to the expected indemnity payment times a loading factor and a subsidy rate. According to the information we have regarding the current grassland insurance experimentation, for an insured capital of 680 €/ha of grassland and a coverage level of 70 %, insurance premium is around 25 €/ha. Consequently, for this study, the loading factor is set at 2.5 which could appear high but can be explained by the cost of grassland yield estimation, the important uncertainty regarding grassland distribution and the small number of farmers involved. Similar to the multi-peril crop insurance program in the USA and in accordance with the European CAP rules, premium subsidies are modulated according to coverage options: respectively 65 %, 40 % and 20 % of premium subsidies for coverage level of 70 %, 80 % and 90 %.
Based on the current legislation, farms are eligible to receive indemnity from the public calamity funds when yield falls below 70\% of average yield at the regional level and the value of the damage exceeds 13\% of theoretical farm sales. A unit of forage is estimated by the administration at 120 €/tDM provided that farmers could demonstrate that this amount of forage is necessary to feed cattle. Considering that expected indemnity from the calamity funds is more uncertain than indemnity from market insurance, we assume that its expected value is half of the one obtained from the market insurance with a 70\% level of cover.

3.3 Validation of model outputs for the baseline scenario

Validation of model results is undertaken for the Base simulation which is assumed to reflect the actual situation. To assess fitness of model outputs to observations, focus is made on average farm characteristics, on the sensitivity of gross margin to grassland production and on average greenhouse gases emissions. Production and economic results are compared with those of a previous analysis made on a panel of 291 French suckler cow farms over the period 2000-2009 (Mosnier et al., 2013a). This panel is extracted from the database “Réseaux d’Elevage pour le Conseil et la prospective” which is coordinated by the Livestock Institute and numerous local “Chambre d’Agriculture”. Simulated stocking rate (1.09 LSU/ha) matches with observation (1.12 LSU/ha) and animal sales are coherent: most calves are sold at 10 months old with a live weight of 388 kg for males; 60\% of culled cows are fattened. Regarding grassland management, 0.50 hectares per LSU are harvested in average to reach 1.80 t DM/ LSU which is close to observations (0.49 ha harvested per LSU to reach 1.79 t DM/ha). It enables to build a security stock of 25\% of average consumption, or, in other words, more than one extra month of forage stock.

In the empirical study, gross margin variation has been estimated for each farm as the differential between observed gross margin and average farm gross margin, cumulated for the current year and the following year (grassland variation affects not only current profit but also future ones). Variation of grassland yield is approximated by the variation of the amount of grass harvested per LSU (the quantity of grass produced is not measured). Sensitivity is analysed graphically. The same methodology is applied to the simulated results in order to have comparable values.

![Figure 2: comparison of variation of gross margin according to variation of grass harvested between simulation (Base scenario) and observations (Mosnier et al., 2013a)](image)

The shapes of the curves are similar between observation and simulation (figure 2). In both cases, gross margin is almost indifferent to positive variation of grass harvested by LSU and a decrease of 25\% of grass harvested induces a profit loss of 30 €/ha. Below -25\% of grass harvested by LSU, the simulated slope is steeper than the observed one. This could be explained by a maximal simulated reduction of grass harvested higher than the observed one. We consider that this difference is reasonable and that the inclusion of a year such as 2011 would have increased the maximal loss of grass harvested in spring.
3.4 Results

Without subsidies, market insurance is not attractive (table 3), except if the storage security stock has been depleted the previous year and if there is no opportunity to decrease herd size anymore. In this case, the 80 % coverage level receives preference but is limited to a small fraction of the grassland area. Consequently, self insurance and then production decisions are hardly affected by the introduction of market insurance. Thanks to the 65 % of subsidies on insurance premium, the totality of the area is insured the first year with the 70 % coverage level. Thanks to subsidies, premium is below 10 €/ha, a value that the majority of farmers surveyed in Mosnier et al. (2013b) finds fair (but that doesn’t signify that farmers are ready to subscribe such an insurance). The second year, the level of coverage increases following a year with negative grassland production variation. Substitution between self insurance and subsidised market insurance is significant: herd size increases from 1.09 LSU/ha to 1.13 LSU/ha. However substitution is only partial given the fact that a risk neutral farmer who, by definition, doesn’t insure his production (Base_neutral scenario), would have a stocking rate of 1.22 LSU/ha. It corroborates Mossin’s theorem (1968) which states that if the price of insurance includes a positive premium loading factor, then the partial insurance is optimal. Additional decoupled direct payment (Ins_DP) reduces slightly both self insurance (herd size increases by 0.4 LSU/ha which corresponds to an increase of 0.3 % of animal receipts) and market insurance (the coverage level is partly reduced; average insurance premium is reduced by 1.4 %). In section 2, we suggest that direct payment would impact more on market demand than on self insurance demand: it is true regarding their relative variation.

Table 3: Characteristics of production systems and insurance contracted according scenarios

<table>
<thead>
<tr>
<th></th>
<th>Base_neutral</th>
<th>Base</th>
<th>Insurance</th>
<th>Ins_DP</th>
<th>Ins_Sub</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
<td>mean</td>
<td>sd</td>
<td>mean</td>
</tr>
<tr>
<td>Objective value</td>
<td>547</td>
<td>508</td>
<td>491</td>
<td>509</td>
<td>515</td>
</tr>
<tr>
<td>Profit</td>
<td>278</td>
<td>57</td>
<td>257</td>
<td>30</td>
<td>266</td>
</tr>
<tr>
<td>Animal sales</td>
<td>821</td>
<td>10</td>
<td>739</td>
<td>13</td>
<td>741</td>
</tr>
<tr>
<td>Feed purchase</td>
<td>152</td>
<td>53</td>
<td>128</td>
<td>32</td>
<td>128</td>
</tr>
<tr>
<td>Public supports*</td>
<td>223</td>
<td>8</td>
<td>218</td>
<td>0</td>
<td>226</td>
</tr>
<tr>
<td>Herd size (LSU)</td>
<td>122.3</td>
<td>1.3</td>
<td>109.1</td>
<td>1.4</td>
<td>109.6</td>
</tr>
<tr>
<td>Ins. Coverage 70% t1 (ha)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6.7</td>
<td>70</td>
</tr>
<tr>
<td>Ins. Coverage 70% t2 (ha)</td>
<td>24</td>
<td>9.8</td>
<td>15</td>
<td>6.6</td>
<td></td>
</tr>
</tbody>
</table>

*direct payment + indemnities from the calamity fund + subsidies on insurance premium

Logically, risk aversion decreases average profit (table 5). Compared to the Base_neutral scenario, 12 € of average profit and 98 € of animal receipts are foregone in the Base scenario. In return, profit variability and sensitivity of profit to grassland production variations are reduced (figure 3). The introduction of non subsidised market insurance won’t benefit farmers since both average profit (-9 €/ha) and profit sensitivity to grassland yield are deteriorated. They don’t receive anymore indemnity from the calamity fund (-5 €/ha of public support) and have to pay 7.9 €/ha in average for a poorer coverage level (average indemnity from market insurance is 2.2 €/ha instead of 4.5 €/ha from calamity fund). Additional direct payment (Ins_DP) helps maintaining average profit but profit variability is still higher than in the baseline scenario. Subsidies on insurance (Ins_sub) are not high enough to keep average profit at the Base scenario level, in spite of higher direct public support (7 €/ha/year of subsidies on insurance premium instead of 5 €/ha/year of indemnity from the calamity fund). However, subsidies on insurance perform better than the calamity fund scheme to secure profit: standard deviation decreases as well as the lowest level of profit (from 99 €/ha in
the *Base* scenario if two very unfavourable grassland yields occur in a row to 138 €/ha in *Ins_sub*). Nonetheless, as pointed in section 2, substitution between market and self insurance induces a greater sensitivity of profit to intermediate loss of grass production. Notice that, contrary to the theoretical model presented in section 2, the slope of profit sensitivity to grassland variation for losses greater than 20 % is not null under insurance coverage level of 70 % of average yield (*Ins_sub*). First, losses between -19 % and -30 % are not indemnified. Second, grazed grassland has higher energy content than hay. Consequently, not only hay is purchased but also concentrate feed which is more expensive.

**Figure 3: Average sensitivity of annual profit to grassland yield variation**

![Graph showing average sensitivity of annual profit to grassland yield variation](image)

4 Conclusions

Objectives of this study were to analyse attractiveness of grassland insurance and substitution between grassland insurance and self insurance (herd size reduction) under different public supports. Assessing the consequences of the insurance mix on suckler cow farm sustainability was also at stake. To meet these objectives we first proposed a theoretical overview of the insurance issue when self insurance and market insurance can be chosen simultaneously. Secondly, we developed a discrete stochastic programming model to run simulations. Different scenarios were compared: with and without risk aversion, with or without the possibility to take out market insurances, with or without indemnity from the calamity fund, insurance premium subsidies, and additional direct payment.

The theoretical overview emphasized first that demand for market insurance would increase if marginal cost of market insurance decreases compared to the marginal cost of self insurance. Second the substitution between self insurance and market insurance would be more important as risk aversion gets higher. Eventually additional wealth would reduce more market insurance demand than self insurance under assumptions of decreasing absolute risk aversion and equal marginal costs. According to our simulations, non subsidised market insurances are not attractive for farmers, except following a very bad harvest when security stock is empty. Under average forage stock and risk preference, a high rate of subsidy is necessary to make a suckler cow farmer subscribe to market insurance. However, to estimate the global demand of insurance by farmers, further researches would be necessary to take into account their heterogeneity. Within the country, farmers experience indeed different climatic conditions, different on-farm self insurance options, different subjective probabilities and risk aversions. Farmers may for instance underestimate the probability of severe risks (Kunreuther, 1996).

Consequences of the insurance mix on farm sustainability have been assessed thanks to the comparison of average profit and variation of profit in response to grassland production. The
replacement of the current indemnities provided by the public calamity fund by non subsidised market insurance reduces all criteria of farm sustainability: average profit is cut because farmers have to pay for a service they had for free before, profit becomes more variable because farmers are not anymore insured against very important loss (market insurance is too expensive). Additional direct payment helps maintaining average profit to the current situation level but doesn’t decrease profit variability. Subsidies on insurance are not high enough to keep average profit level but secure more profit in case of very low grassland production. However, because of the significant substitution between market insurance and self insurance, profit becomes more sensitive to intermediate loss of grass production. Both subsidies and direct payment instruments are criticized because they are difficult to remove. Subsidies on insurance premium may be considered as transitory if loading cost of insurance companies decrease as they develop over time (if more farmers get involved or if indemnification procedures become more efficient) and if farmers demand increase over time when they would have experienced the benefits of being insured. However, it is also possible that insurance companies raise insurance premium because they take into account subsidies on insurance premium. Results from this analysis also suggest that the current public fund perform better than an insurance scheme plus additional public supports (insurance premium subsidies or additional direct payment). A more integrative welfare analysis would be necessary to take into account all administrative costs, producer and consumer surpluses.

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References


