THE FEASIBILITY OF FARM REVENUE INSURANCE IN AUSTRALIA

Miranda P.M. Meuwissen¹, Ruud B.M. Huirne¹, J. Brian Hardaker¹/²

¹ Department of Economics and Management, Wageningen Agricultural University, The Netherlands
² Graduate School of Agricultural and Resource Economics, University of New England, Australia

ABSTRACT

Arrow (1965) stated that making markets for trading risk more complete can be socially beneficial. Within this perspective, we discuss the feasibility of farm revenue insurance for Australian agriculture. The feasibility is first discussed from an insurer's point of view. Well-known problems of moral hazard, adverse selection and systemic risk are central. Then, the feasibility is studied from a farmer’s point of view. A simulation model illustrates that gross revenue insurance can be both cheaper and more effective than separate price and yield insurance schemes. We argue that due to the systemic nature of price and yields risks within years and the positive correlation between years, some public-private partnership for reinsurance may be necessary for insurers to enter the gross revenue insurance market. Pros and cons of alternative forms of a public-private partnership are discussed. Once insurers can deal with the systemic risk problem, we conclude that there are opportunities for crop gross revenue insurance schemes, especially if based on area yields and on observed spot market prices. For insurance schemes to cover individual farmer’s yields and prices, we regard the concept of coinsurance as crucial. With respect to livestock commodities, we argue that yields are difficult to include in an insurance scheme and we propose aspects of further research in the field of price and rainfall insurance.

Key words: Farm revenue insurance; income stability; public/private partnership
1. Introduction

Agricultural risk markets are not complete. For example, in most developed countries, arable farmers can insure against loss of crop production caused by only a few pre-specified environmental risk factors. For livestock farms usually no low-yield insurance exist, but stock mortality insurance from specific accidental causes is generally available. Price risks can be managed to some extent by forward contracting or by hedging on futures markets. The latter option, however, is available for very few commodities⁠¹ and can also be subject to considerable basis risk. Moreover, revenue insurance is usually not available, leaving the farmer with the risk of facing low prices and low yields at the same time.

As Kenneth Arrow pointed out (e.g. Arrow, 1965, Lecture 3), making markets for trading risk more complete can be socially beneficial. First, any contract in risk between any two parties makes them both better off, so that the sum of many such contracts makes society better off. In addition, the possibility of shifting risk by such means as insurance permits individuals to engage in risky activities which they would not otherwise undertake. That way, the expected return to society is increased over what would prevail if individual agents were constrained to accept only those risks they could afford to bear themselves. In this vein, this paper studies the feasibility of making the market for risk in Australian agriculture more complete by the introduction of farm revenue insurance for crop and livestock commodities. The study is based on similar work we have done in the European Union.

An ideal farm revenue insurance scheme would cover a combination of the gross revenues of several commodities on the farm. If all insurance options existed it is likely that insuring gross revenue (i.e. the product of price and yield) would be both cheaper and more useful than separate price and yield insurance.

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¹ The Sydney Futures Exchange currently trades wool of different grades (i.e. broad, fine, and greasy wool) and wheat. Futures contracts for beef, bullock, live cattle, and fat lambs were in existence (around the eighties) but have all been suspended. To the extent that Australian farmers sell their products on international markets, they may be able to hedge effectively on overseas futures markets such as the Chicago Board of Trade.
This paper begins with a brief summary of experiences with revenue insurance schemes in Canada and the US. In Section 3 farm revenue insurance schemes are examined from an insurers’ point of view. In Section 4 the extent to which such schemes may appeal to individual farmers is discussed. In this section, a quantitative illustration of the impact of a gross revenue insurance scheme on a farmer’s income is presented. Data originate from European agriculture. The question of ‘where to from here’ is addressed in section 5.

2. Related experiences in Canada and the US

In Canada, a gross revenue insurance plan (GRIP) existed from 1991 till 1996. Though a basic GRIP program was established, five different formulae were introduced for different provinces of Canada. The basic formula was a gross revenue insurance plus crop insurance program. Basic revenue coverage was offered by establishing a target revenue comprised of individual long-run average yields and a 15-year indexed moving average price. Indemnities were equal to the difference between actual farm revenue and the target revenue less any crop insurance indeminites, regardless of whether the farmer was enrolled in crop insurance.

Most different from the basic GRIP program were the area-based approaches in which target revenues were the same for a whole area and in which farmers received an indemnity only if area revenues fell below the area target revenue. Two variations were in place: a commodity-specific area-based approach and an area-based approach which defined a crop portfolio for specific risk regions (Turvey and Chen, 1994).

GRIP was abandoned in 1996. The major problem of the scheme was the use of the 15-year moving average to establish price levels. When the program started, commodity prices were low and using a 15-year moving average ensured high guaranteed prices (because of the high prices in the late 1970s that were included in the average). When prices declined still further, the use of a long-run moving average resulted in decreasing guaranteed prices and the scheme turned out to be a short-run remedy for farmers hoping to receive high guaranteed levels of price. Another problem was that (in the basic GRIP formula) indemnities were paid on individual yield risks, but premiums were typically based on area averages (e.g.
all farmers insuring corn paid the same rate) with only some rating adjustment for loss experience. This can lead to adverse selection since premiums do not reflect the risks faced by individual farmers.

In the US, three different revenue insurance products have been introduced since 1996 (Goodwin and Ker, 1998): the income protection plan (IP), the crop revenue coverage (CRC) and the revenue assurance program (RA). IP offers a crop revenue guarantee based upon individual farm yields and forecast prices. The farmer receives an indemnity if actual revenues (based on realised individual farm yields and futures prices) fall beneath the revenue guarantee.

RA provides a guaranteed minimum level of revenue, the amount determined by individual farm yields and futures prices (adjusted for the local historical basis). As with IP, indemnities are paid if actual revenues fall beneath the revenue guarantee. RA provides an option for ‘whole-farm’ insurance in that producers insuring both corn and soybean receive significant premium discounts. RA utilises market-based measures of price risks available in options markets, whereas IP and CRC utilise historical futures prices.

CRC contains two components. The first, similar to IP, offers a revenue guarantee based on price expectations and farmers’ expected yields. The second component offers ‘replacement coverage’, whereby coverage can increase during the season if prices rise. If a producer has a short crop and the price is higher at harvest than the pre-harvest projection, the producer’s crop insurance indemnity is paid on the higher harvest-time price, allowing the farmer to buy ‘replacement’ bushels in the market place.

The above-mentioned revenue insurance schemes all refer to major crop commodities (i.e. no livestock) and in all schemes governments play (or played) a substantial role. In the Canadian scheme, farmers only paid 33% of the insurance premiums. In the US schemes, the federal government subsidises an even larger part of the premiums, i.e. on average they pay 40¢ of each dollar of producers’ premiums. The federal government also subsidises administrative costs (private companies receive 24.5¢ for each dollar of premiums to cover these costs) and reinsurance. It is therefore arguable that these schemes are really subsidy schemes in disguise, presumably intended to avoid World Trade Organisation rules limiting direct production subsidies to farmers.
3. Farm revenue insurance; the insurer’s point of view

Commercial insurers will offer those insurance products which they can sell at a profit without facing unbearable risk. The fact that fully commercial farm revenue insurance schemes have not evolved in Australia (or, it seems, anywhere else) can be explained in terms of the problems normally inherent in such schemes. As discussed further below, these problems relate to adverse selection, moral hazard and systemic risk. Evidently, these problems have to be solved in the design of any farm revenue insurance scheme for it to be viable for the insurer.

3.1 Problems stemming from asymmetric information

Asymmetric information exists when the would-be insured knows more about the risk being insured than does the insurer. Such asymmetry of information can lead to unacceptable problems for the insurer of adverse selection and moral hazard. Moral hazard occurs when an individual purchases an insurance policy and as a result of having purchased that policy alters his/her behaviour (production or management practices) so as to increase the potential magnitude of a loss and/or the probability of a loss. Adverse selection occurs when those who purchase insurance face a higher risk than those who do not, so that rates struck on aggregate data underestimate the cost of indemnities to the insurer (Barnett et al., 1999). To minimise the problems arising from asymmetric information an insurance scheme should ideally cover only (Rejda, 1992):

- Accidental and unintentional losses. If losses are influenced by the management of the insured, problems of moral hazard are likely to arise;

- Measures for which proper risk classification and rate making is possible. This requires the availability of sufficient and reliable data; and

- Losses that are determinable and measurable. For a proper loss assessment, the amount of loss and the extent to which the loss was caused by an insured event need to be unambiguous.

In practice, all these conditions may not be fully satisfied, yet it may still be possible to develop a workable farm revenue insurance scheme attractive to insurers. In this respect the concept of
coinsurance, discussed by Arrow (1965, lecture 3), plays an important role. With coinsurance (for example in the form of deductibles, co-payments or no-claim bonuses) the insurer pays only some proportion of the loss. Such devices reduce moral hazard, but they also reduce the amount of risks that farmers can trade. In this regard Arrow argues that, if without the devices just described there would be a complete absence of risk shifting, it might be best to use the tools and have at least some shifting of risk. No-claim bonuses are somewhat different from deductibles and co-payments, but are also a form of coinsurance.

The possible asymmetric information problems of a farm revenue insurance scheme need to be solved for all the commodities included in each insurance contract. For each commodity there are aspects of yield and price involved.

Yield

Yields can be calculated on an individual farm or field basis, or on an area basis. Area-based yields refer to the aggregated yields of multiple farmers in a certain area, for example a shire.

Yields calculated on an area basis cannot be influenced much by the individual farmer and could therefor be a good basis for insurance (Miranda, 1991). However, the latter is only true if the area yields can be measured reliably. Furthermore, for reasons of basis risk for farmers contemplating buying insurance, area-yield data can only be used in insurance contracts in areas where the yields are highly correlated across farms.

If individual farm yields are to be used, insurance instruments such as deductibles, no-claim bonuses, monitoring the behaviour of individual insureds (good farming practices), and the monitoring of crops and livestock just before or at harvest time are necessary to reduce moral hazard problems inherent to the use of farm-level data.

With respect to the insurance of crop yields, the weather and soil conditions at the time of planting should also be monitored. If farmers plant their crops later than normal and/or under less than optimal conditions, the insured level of gross revenue should be adjusted downwards. In this way, the required ratio between premiums collected and expected indemnity payments can be maintained.
With respect to livestock commodities, the insurance of low yields is likely to face problems for several reasons:

- Most livestock commodities do not have a clear ‘harvesting’ time, as with crops. Livestock farms produce output throughout the year (e.g. poultry farms with layer hens), at intermittent intervals, as with sheep and beef production, or have a multi-year production cycle (e.g. beef cattle). Moreover, the timing of ‘harvesting’ for some livestock systems is quite flexible. Both aspects may allow insured farmers to manipulate the timing of sales in order to make an unjustified claim on the insurer. There are also likely to be related complications in selecting the moment the insurance policy is to be written and in determining the period in the future to which it is to apply.

- For intensive livestock, such as pigs and poultry, and for intensive grazing livestock, such as dairy cows, yield fluctuations are usually not very large. The fluctuations that do occur are much more a management issue than for crops (for which weather related events usually cause most of the fluctuation), implying extra difficulties of moral hazard for the would-be insurer.

- For more extensive grazing livestock, such as sheep and beef cattle, low pasture yields lead to multiple sources of loss, such as costs of hand feed (own or bought feed), costs of agistment, losses because stock need to be sold (or shot), and, in the case of breeding stock, replaced later (probably at much higher prices), and losses because of lower productivity and higher mortality of animals retained. These multiple sources of loss make it difficult or impossible to disentangle accidental losses due to low pasture yields from those due to management and imply huge moral hazard problems for a would-be insurer of livestock revenue.

**Prices**

To account for price effects in a revenue insurance scheme, reliable measures are needed of the actual price for the relevant grades of each insured commodity at harvest or sale time. Prices realised by individual farmers can be problematical since they may be too strongly influenced by the management of the insured. Observed spot market prices can be useful for well-functioning markets with good reporting systems. Well-functioning markets are those with high transparency indicated by a high
degree of market integration, meaning that prices for the same commodity in different places are closely similar.

The quality of any commodity at harvest or sale time can be less than the quality agreed upon in the insurance contract. This loss of quality can be due to seasonal effects, but also due to ‘bad management’. If loss of quality is excluded from coverage, the insurance scheme provides less protection for the farmer. On the other hand, including loss of quality can clearly involve large moral hazard problems.

In rating an insurance product that includes price risks, the following aspects are important:

- Due to the existence of price cycles (especially with respect to livestock commodities), insurers should use as much actual market information as possible, as well as all relevant historical price data. Futures markets may be helpful instruments, since futures prices reflect all market information available.
- Price cycles are a reason for resetting the prices on which the insured level of gross revenue is based each year.
- If commodities are not reasonably uniform and a wide variety of different grades (and different prices) exist, the establishment of an appropriate price for an individual farmer may be difficult.

Gross revenue insurance

In addition to the aspects discussed for price and yield separately, insuring gross revenue earned from the production of a given commodity also implies a need for information on the joint distribution of prices and yields. Since prices and yields may not be stochastically independent, considerable information is needed to derive the full joint distribution. An extra difficulty arises if the nature of that stochastic dependency changes over time, e.g. as a result of market liberalisation in other countries.
3.2 Systemic risk

Price and yield risks are systemic, meaning that multiple insureds can suffer losses at the same time (Barnett et al., 1999). Insurance companies have problems pooling such risks themselves and adequate reinsurance capacity is not usually available when the scale of the systemic risk is large. An extra difficulty may arise in Australian agriculture from the positive serial correlation of yields between years. For example, droughts that last for 4 to 6 years can occur.

For these reasons, some form of public-private partnership\(^2\) may well be necessary for insurers to enter this farm revenue insurance market.\(^3\) There are two main ways (or a combination of the two) in which governments might become involved: they could agree to provide some reinsurance coverage to insurance companies at zero costs, or they could provide reinsurance at fully commercial rates. Both alternatives have pros and cons, which will be discussed below.

Governments provide reinsurance at zero costs

Arguments in favour of this option include:

- Governments already provide free disaster relief. An insurance system in which governments provide reinsurance of ‘disastrous’ outcomes is likely to be more efficient than current disaster relief for such events as severe bush fires or widespread floods or droughts. Disaster relief is very ad hoc and often involves problems of ‘who receives the money’. There are also considerable administrative costs incurred to set up special agencies to organise and provide the disaster relief.

By providing reinsurance, governments can use the experience and capacity of insurance

\(^2\) Such arrangements exist for property flood risk in many US States allowing insurers to cover these risks in many cases. Had such a system been in place in NSW the recent row over storm and flood damage claims in Wollongong would have been avoided.

\(^3\) The idea of official support for insurance is not new. According to Bernstein (1996, p. 92), the Emperor Claudius (10 BC –AD 54), eager to boost the corn trade, made himself a one-man, premium-free insurance company by taking personal responsibility for storm losses incurred by Roman merchants.
companies in dealing with moral hazard and adverse selection and in handling large numbers of claims.

- Although free reinsurance is a form of subsidy and therefore a potential source of economic distortion, a case can be made that some modest subsidy is appropriate to correct for the market failure in the provision of insurance markets for farmers. Farmers are risk averse while society as a whole may be assumed to be more or less risk indifferent so far as farm income risks are concerned (because the risks are negligible when nationally spread across all members of the society). It is socially preferable that farmers allocate their resources more nearly to the point where expected marginal costs and expected marginal returns are equal. Because risk-averse farmers will generally stop short of the social optimum, a small subsidy, embodied in reinsurance, may be socially beneficial. Other social advantages from insurance schemes coming into existence include more reliable repayment of loans by farmers, less human, animal and environmental distress after the occurrence of disasters, and more stability of rural businesses as a consequence of more stable expenditures on farm inputs and family consumption.

- Having the government financially involved may address a moral hazard problem in government behaviour; many catastrophes (e.g. losses from floods) can be either prevented or magnified by government policies (or lack thereof). Having governments financially responsible for some losses might be an incentive for them to put into place appropriate hazard management measures (Cutler and Zeckhauser, 1997).

Governments provide reinsurance at fully commercial rates

An argument in favour of this option is that governments can potentially provide reinsurance more economically than can private market reinsurers (even assuming the private sector could provide the needed capacity). Governments have substantial advantages because of their deep credit capacity and their unique position as the largest social entity in a country. These advantages enable them to diversify claims inter-temporally and to spread risks broadly (Lewis and Murdock, 1996; Priest, 1996; Cutler and Zeckhauser, 1997).
Comments on both options

The following comments apply to both options:

- Governments providing reinsurance may induce problems of moral hazard in the behaviour of insurance companies if the latter are able to off-load onto government their responsibility to manage their businesses properly. Such problems can be minimised by coinsurance arrangements whereby governments reinsure only part of the risks underwritten by the insurers.

- Coinsurance agreements between governments and insurers could be based on a limited stop loss and/or a quota share basis.

- Since governments have no experience in the reinsurance market, they may suffer from rent-seeking behaviour by insurers unless they are able to ensure that they have access to the same information as the companies about insured risks and losses.

- The need for government participation in reinsurance will be reduced if ways can be found to deepen reinsurance markets (Jaffee and Russell, 1997). Indications of possible future developments in this field include the existence of so-called catastrophe bonds for general insurance and a derivative product on the Chicago Board of Trade for the Iowa State corn yield (Canter et al., 1996; Lamm, 1997; Miranda and Glauber, 1997). To the extent that governments provide reinsurance for less than fully commercial rates, such capital market developments for agricultural insurance are likely to be inhibited.

4. Farm revenue insurance; a farmer’s point of view

The reason why farmers may be willing to buy farm revenue insurance is that they are risk averse. They are therefore willing to pay a premium to avoid losses, especially catastrophic losses that threaten the survival of their farm businesses. Although it is possible to make some theoretical estimates, the willingness of farmers to pay for specific forms of farm revenue insurance cover can only be established with confidence by pilot testing. In practice, if governments subsidise insurance to
some extent, the likelihood that insurers will set premiums at levels that farmers will find attractive will be higher. Moreover, insurers will be able to offer cover at attractive rates only if they are able to develop contracts that substantially overcome the problems of adverse selection and moral hazard discussed above.

In addition to the level of risk aversion of farmers, another important factor that will influence the extent to which a scheme will appeal to farmers includes the ad-hoc support provided by governments in case of disasters. If governments continue to provide free disaster relief, the incentive for farmers to buy insurance will be less. If governments, however, make clear that disaster assistance is only available for insured farmers (through the reinsurance capacity provided by the governments), this will be an incentive to insure. In case governments provide reinsurance at zero costs, political pressure to provide free disaster relief will be less.4

Another factor of importance is the level of risk reduction provided by an insurance scheme. The results of the simulation study (see appendix) show that the level of risk reduction varies according to the variability of, and correlation between, prices and yields. See appendix for background information on the simulation model for a European case study and a more detailed discussion of the results.

Two remaining factors that will play a role in determining the extent to which a farm revenue insurance scheme will appeal to an individual farmer are the availability of other risk management strategies, and a farmer’s perception of the risk of low revenues.

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4 If farmers still believe that governments would help them with free disaster relief, farmers could for example be obliged to register at insurance companies against an administrative fee. All registered farmers would then receive indemnities for the catastrophic part of losses; it would be up to an individual farmer to insure against the remaining part of the loss.
5. Where to from here?

What then can be said about the feasibility of farm revenue insurance?

Revenue insurance compared to separate price and yield schemes

From a farmer’s point of view, a farm revenue insurance might be more appealing than separate price and yield schemes, since a farm revenue scheme covers losses at a higher level of aggregation, i.e. closer to the whole-farm income, and, hence, to the welfare of a farm family. If there are only a few commodities for which gross revenue insurance would be feasible, farm revenue insurance reduces towards a commodity-wise gross revenue insurance (which still has a higher aggregation level than separate price and yield schemes). Simulation results show that gross revenue insurance can be cheaper than separate price and yield insurance schemes.

Applicability of to Australian agriculture

As discussed above, insurance companies are unlikely to enter the farm revenue insurance market without some level of government involvement. The reason for this is the systemic nature of price and yield risks within years and the positive correlations between years.

With this proviso, it seems likely that crop revenue insurance might be a possibility provided the moral hazard and adverse selection problems are effectively addressed. There are well-know ways of dealing with these problems in other forms of insurance that should be applicable to crop revenue insurance. The practical feasibility of any such schemes for crop commodities would need to be pilot tested. In pilot tests the profitability to insurers, the liability of government and the appeal to farmers can all be clarified. In setting up pilot tests it is crucial for later implementation that governments are involved to no more than the necessary minimum extent, using transparent rules for such aspects as stop losses, i.e. from the beginning on there should be no asymmetric information between insurers and governments.
It seems clear that including *livestock* commodities (i.e. a large part of Australian agriculture) in a revenue scheme is problematical. Severe problems of moral hazard are likely to exist for the yield part of the revenue of both intensive and more extensive grazing livestock. Our conclusion is supported by the experience in other countries, i.e. none of the existing revenue schemes in the US includes livestock (the same was true for the gross revenue insurance program that existed in Canada). However, consistent with the notion that more complete risk-sharing arrangements are always desirable, it would be worth re-examining the feasibility of other forms of contract for livestock farmers such as price insurance and rainfall insurance.

Further research

Further research should be carried out on the following aspects:

- More statistical analyses of data is needed with respect to such aspect as:
  - Joint distributions of prices and yields;
  - Correlations between individual and area yields;
  - Price variability within years;
  - The opportunities to use Chicago Board of Trade futures and commodity prices as measures of insurable price.

- There is a need to examine possibilities of extending risk-sharing tools to livestock farmers (e.g. price insurance and rainfall insurance). Important aspects with respect to price insurance include:
  - The effect of increasing vertical integration on the transparency of price information;
  - The fact that, apparently, few Australian farmers hedge on futures markets. This may be attributed to several causes. One is the unfamiliarity with the operation of such markets. Insurers may therefore have an opportunity to ‘retail’ the risk-sharing opportunities of hedging on futures markets as part of a general farm insurance cover. Another possible reason is that the diversity of the types of products may create a too high basis risk for hedging to be attractive to many farmers. However, what is basis risk for individual farmers might represent opportunities for risk spreading by an insurer.
• Simulation studies need to be done relating specifically to Australia to cover a broad range of insurance topics, for example with respect to the effect of area-based insurance schemes and the impact of the availability and uptake of new insurance products on the overall risk management strategies adopted by farmers.

• There is a need to assess the availability of accurate data on which to base insurance premiums and indemnities.
References


Appendix The simulation model

I.1 Short description of the model

The simulation model that we developed in our study is a very straightforward model that can be used to illustrate the effect of various types of insurance schemes on the farmer’s income. Different types of insurance include separate price and yield schemes, and gross revenue insurance. The model is a Monte Carlo simulation model that runs with @Risk in Excel. We define income as net return to labour and management \( NR_{f,c,t} \):

\[
NR_{f,c,t} = Y_{f,c,t} \times P_{f,c,t} - Y_{f,c,t} \times VC_{f,c,t} - FC_{f,c,t}
\]

with \( Y_{f,c,t} \) representing the actual yield of farmer \( f \) of commodity \( c \) (of a certain grade), \( P_{f,c,t} \) the actual price of that commodity, \( VC \) the variable costs, and \( FC \) the fixed costs. If a farmer buys insurance, the net return to labour and management is diminished by a premium \( PR_{f,c,t} \) and increased by an indemnity (if triggered) \( I_{f,c,t} \). In the model, premiums are based on loss costs \( (LC) \), which reflect the expected frequency of indemnity payments and the expected severity of the payments (both given a certain deductible \( d \)). For the various types of insurance, the following formulas apply:

Yield insurance:

\[
PR_{f,c,t} = LC_c (f(Y_{f,c,t}), d\%_f) \times \bar{Y}_{(f),c} \times el\%_f \times P_c
\]

\[
Tr_{f,c,t} = Y_{(\theta),c,t} < Y_{ins_{f,c,t}}
\]

with \( Y_{ins_{f,c,t}} = (1 - d\%_f) \times \bar{Y}_{(\theta),c} \)

\[
I_{f,c,t} = (Y_{ins_{f,c,t}} - Y_{(\theta),c,t}) \times el\%_f \times P_c
\]

With: \( f(Y_{(\theta),c}) \) the distribution of yields of commodity \( c \) (based on either individual farm data or area data)

\( \bar{Y}_{(f),c} \) average yields of commodity \( c \) (based on either individual farm data or area data)
el%f the election percentage\(^5\) chosen by farmer \(f\)

\(\overline{P}_c\) the average observed price of commodity \(c\) (of a certain grade)

\(Tr_{f,c,t}\) the level that triggers a payment

\(Y_{0,c}\) the actual level of yields of commodity \(c\) (either farm-based or area-based)

\(Y_{ins,f,c}\) the level of yields insured by farmer \(f\)

\(P_{c,t}\) the actual observed price for commodity \(c\) (of a certain grade)

Price insurance:

\[
PR_{f,c,t} = LC_e \left( f(P_c), d%_f \right) \cdot \overline{P}_c \cdot el%_f \cdot \overline{Y}_{(f)e}
\]

\(Tr_{f,c,t} = P_{c,t} < P_{ins,f,c}\)

with \(P_{ins,f,c} = (1 - d%_f) \cdot \overline{P}_c\)

\(I_{f,c,t} = (P_{ins,f,c} - P_{c,t}) \cdot el%_f \cdot Y_{0,c,t}\)

With: \(f(P_c)\) the distribution of prices of commodity \(c\) (of a certain grade)

\(P_{ins,f,c}\) the price level of commodity \(c\) (of a certain grade) insured by farmer \(f\)

Gross revenue insurance:

\[
PR_{f,c,t} = LC_e \left( f(Y_{(f)e} \cdot P_c), d%_f \right) \cdot el%_f \cdot \left( \overline{Y}_{(f)e} \cdot \overline{P}_c \right)
\]

\(Tr_{f,c,t} = (Y_{(f)c,t} \cdot P_{c,t}) < R_{ins,f,c}\)

with \(R_{ins,f,c} = (1 - d%_f) \cdot \left( \overline{Y}_{0,c} \cdot \overline{P}_c \right)\)

\(I_{f,c,t} = (R_{ins,f,c} - (Y_{(f)c,t} \cdot P_{c,t})) \cdot el%_f\)

With: \(f(Y_{0,c} \cdot P_c)\) the distribution of gross revenues of commodity \(c\) (of a certain grade), in which yields

\(^5\) The election percentage is the percentage against which yield shortfalls (larger than the deductible) are indemnified. In individually based schemes, the election percentage is generally lower than 1 to prevent moral hazard, i.e. if the price at which yield shortfalls are indemnified is always lower than the actual market price, farmers always have an incentive to produce the highest yield possible, also if yields become lower than the guarantee level.
are either farm-based or area-based

\[ R_{m,f,c} \] the level of gross revenue of commodity \( c \) (of a certain grade) insured by farmer \( f \)

1.2 Data European agriculture

We analysed price and yield data. In the net return function, the variable and fixed costs are set to zero. For the yield distributions of various commodities, a large panel data set, containing individual farm yield data from the period 1989-1995 (FADN Information European Commission), is analysed. The data set includes annual data from six EU countries (Denmark, France, Germany (BRD), Greece, Italy and the Netherlands) and four agricultural commodities (wheat, potatoes, sugar beet, and milk). The total data set consists of 49 regions and about 13,000 farms. From the data, cumulative distribution functions (CDFs) for individual farm yields as well as for area yields have been derived. Because of the short time span, no trend effect is included.

For the price distributions Eurostat data on prices at country level from the period 1986-1995 were analysed and also transformed into CDFs.

1.3 Results

The principles of various insurance schemes are illustrated for potatoes in the region of Baden-Württemberg (West Germany). For potatoes, no price support is available. Results are shown for a no-insurance situation, a situation with both price and yield insurance, and a situation with gross revenue insurance. The results shown in table I.1 under ‘Historic data’ are those in which the yield and price distributions are based on the data analysed, and in which correlations (among farm and area yields, farm and observed prices, and yields and prices) are assumed to be zero.

Because the risk of catastrophically low yields and prices may not be sufficiently represented in the data of 7 years, the second part of table I.1 (under ‘Including catastrophic risk’) shows results with an increased variability of prices and yields. These results are the basis for the results in the third and fourth part of the table, in which the correlations have been changed. For all simulations, the deductible is set to 20% of the average price/yield/revenue, and the election percentage to 90%.
### Table I.1 Results of simulation (1000 @Risk iterations)

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<tr>
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<th>CV NR&lt;sup&gt;1&lt;/sup&gt; (%)</th>
<th>%&lt; 25%&lt;sup&gt;2&lt;/sup&gt; (%)</th>
<th>Loss cost&lt;sup&gt;3&lt;/sup&gt; (%)</th>
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</thead>
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<td></td>
<td></td>
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<tr>
<td>No insurance</td>
<td>51.9</td>
<td>0.5</td>
<td>0</td>
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<tr>
<td>Yield and price insurance — yield: farm-based</td>
<td>49.8</td>
<td>0.0</td>
<td>5.5</td>
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<tr>
<td></td>
<td>— yield: area-based</td>
<td>52.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Gross revenue insurance — yield: farm-based</td>
<td>49.2</td>
<td>0.0</td>
<td>6.3</td>
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<td></td>
<td>— yield: area-based</td>
<td>52.0</td>
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</tr>
<tr>
<td><strong>Including catastrophic risk&lt;sup&gt;5&lt;/sup&gt;</strong></td>
<td></td>
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<tr>
<td>No insurance</td>
<td>102.4</td>
<td>22.0</td>
<td>0</td>
</tr>
<tr>
<td>Yield and price insurance — yield: farm-based</td>
<td>101.2</td>
<td>20.0</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td>— yield: area-based</td>
<td>104.5</td>
<td>22.7</td>
</tr>
<tr>
<td>Gross revenue insurance — yield: farm-based</td>
<td>95.3</td>
<td>14.2</td>
<td>24.2</td>
</tr>
<tr>
<td></td>
<td>— yield: area-based</td>
<td>103.8</td>
<td>22.9</td>
</tr>
<tr>
<td><strong>Correlation between farm and observed prices = + 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No insurance</td>
<td>102.5</td>
<td>20.1</td>
<td>0</td>
</tr>
<tr>
<td>Yield and price insurance — yield: farm-based</td>
<td>89.3</td>
<td>14.2</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td>— yield: area-based</td>
<td>100.7</td>
<td>17.2</td>
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<tr>
<td>Gross revenue insurance — yield: farm-based</td>
<td>88.7</td>
<td>0.0</td>
<td>24.2</td>
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<td></td>
<td>— yield: area-based</td>
<td>96.0</td>
<td>14.2</td>
</tr>
<tr>
<td><strong>Correlation between farm and observed prices = + 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No insurance</td>
<td>33.3</td>
<td>0.0</td>
<td>0</td>
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<td>30.0</td>
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<td>59.0</td>
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<td>42.1</td>
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<td>29.7</td>
<td>0.0</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>— yield: area-based</td>
<td>41.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1) Coefficient of variance (CV): (sd/mean)*100%
2) Frequency (%) of NR being less than 25% of the average NR without insurance
3) During all simulations, it is checked whether the loss costs result in sufficient premium. This is done by monitoring the loss ratio (i.e. the ratio between indemnities paid and premiums received); this ratio has to be equal to 1 (assuming zero profit and administrative costs for insurance companies)
4) CVs: farm yields: 31.8%; area yields: 8.6%; farm prices: 38.7; observed prices: 27.1
5) CVs: farm yields: 62.2%; area yields: 51.9%; farm prices: 67.2; observed prices: 58.9
Table I.1 shows that (see first part of table I.1):
- Farm-based schemes are more expensive than area-based schemes, but the farm-based schemes have also a larger effect on the income variability and the chance of low outcomes.

With increasing variability (compare the 1st part of the table with the 2nd):
- Gross revenue insurance becomes cheaper than separate price and yield insurance schemes;
- The impact of the gross revenue insurance is larger than that of the separate schemes.

If farm and observed prices are positively correlated: (compare 2nd and 3rd part of the table):
- The effect of all insurance schemes becomes bigger, but especially that of the gross revenue insurance scheme with farm-based yields.

If also prices and farm yields become—in this case negatively—correlated (compare 3rd and 4th part of table):
- The relative effects of the insurance schemes stay about the same, but the gross revenue insurance scheme with farm-based yields becomes much cheaper.

Figure I.1 shows the cumulative distribution function of the net return to labour and management with and without insurance (NRins and NR respectively). The ‘with’ insurance situation refers to a gross revenue insurance scheme in which yields are farm-based. The price and yield distribution include catastrophic risks and farm and observed prices are positively correlated (as in the 3rd part of table I.1).

The expected value of the net return to management and labour is slightly higher (i.e. 0.8%) in the situation with insurance when compared to the situation without insurance (note that profit and administrative costs are assumed to be zero). The CV, however, is much lower (14%), as is the chance of very low outcomes. Only a farmer who is indifferent to risk will be more or less indifferent between the two options; a farmer who is indifferent to risk bases choice on the expected value. Farmers who are sufficiently risk averse will prefer the situation with insurance.
Figure I.1 Net return to labour and management (with and without insurance)