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From total farm to household risk: implication for risk management

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Modeling the farm level impact of risk management programs, policies and instruments is traditionally been done on a farm-level basis. Hence, farm simulation models typically use the behavioural assumption of profit or utility maximization is risk aversion taken into account. However, abundant – albeit indirect – evidence from different literature sources suggest that minimization of household risk – being the chance of falling below a certain threshold level of household cash flow – might be more realistic behavioural assumption. In this paper, we present concepts of operational, financial, total farm and household risk. Further, using a stochastic simulation model on two typical Belgian dairy farms, we illustrate possible farmers responses in the presence or absence of farm income stabilization mechanisms. Although some limitations to the current model are mentioned, the results already suggests the usefulness of considering household risk when assessing the impact of risk management programs, policies and instruments.

Keywords: Household risk, typical dairy farms, stochastic simulation, household buffering capacity

JEL classification:

1. INTRODUCTION

There are many reported uses of a whole-farm simulation model to investigate the risk-corrected impact of choices. Such analyses may be used to support a decision by an individual farmer about what crop mix to plant next season or whether to engage in contract farming or not. Alternatively, they may be used to evaluate the impact of proposed policy instruments such as public insurance (e.g. Lien and Hardaker, 2001). Usually, these models calculate a distribution around a mean value for one or more farm output parameters, such as net farm income or net cash flow. Then, risk ranking techniques such as coefficient of variation (CV) analysis, stochastic dominance, or stochastic efficiency with respect to a function (SERF) are used to determine the optimal choice (given the decision maker's level of risk aversion).

We, however, argue that extending traditional farm-level income stability analyses to household-level income stability analyses might be very useful. There are a number of reasons why we argue for this approach, most of which are of positive, rather than normative, nature. In section 2, we provide a very brief literature overview on the need to go beyond the farm operational level when doing micro-economic analyses. In section 3, we present the concepts of operational, financial, total farm ad household risk and derive operational risk measures for all these layers. Further, we draw on a working paper of our own, stating that changes in operational risk might be off-set by changes in financial risk, as already argued by Gabriel and baker (1980) and by household buffering activities. We aim to demonstrate that a good understanding of the net impact of programs and policies related to risk in agriculture can benefit from the consideration of the household level. We thereby extend the *holistic approach* to risk management (OECD, 2008; Anton and Kimura, 2009)

In section 4, we use a farm simulation model, TIPICAL, which we extend to include a measure of household income and two typical North-Belgian dairy farms, to empirically illustrate (1) the concepts of operational, financial, total farm and household risk and (2) to illustrate that a typical household might be off-setting decreases on operational risk by assuming more financial risk and/or by lowering its household buffer capacity.

Section 5 discusses the potential implications and the limitation of our current paper. Section 6 provides some preliminary conclusions.

2. THE IMPORTANCE OF CONSIDERING HOUSEHOLD RISK

To the best of our knowledge, it is very uncommon in the agricultural economics literature on risk analysis and risk management to include a measure of household risk or consider the household as the entity of interest. We argue, however, that there are several reasons for including such households risk measure. First, it is evident that, since the largest proportion of farms in the European Union are family farms, farm risks have consequences on the household as well. Accordingly, many farmers already implement income stabilization strategies at the household level, rather than at the farm level. Many farm households, for instance, attract income from both agricultural and non-agricultural sources. To compare the benefits of such risk management strategies with strategies and instruments targeted at price and yield instability, a measure of total household risk is needed.

Second, one of the main aims for the Common Agricultural Policy (CAP) is, as described in the treaty of Rome, to guarantee a sufficient level of welfare and wellbeing for the farm households. Thus, rather than stabilizing income from farming, the ultimate goal of the CAP is to ensure that the incomes of farm household are both sufficient and stable (REF). Risk management tools and risk assessment models that lack a measure of total household risk are, hence, insufficient to evaluate the full capacity of risk management strategies and policies to obtain this goal.

Third, the underlying assumption of models using a measure of farm income, i.e. that farm households maximize farm income, is no longer tenable (Freshwater and Jette-Nantel, 2011).

3. CONCEPTS OF OPERATIONAL, FINANCIAL, TOTAL FARM AND HOUSEHOLD RISK AND THEORETICAL IMPLICATIONS

By extending farm-level risk analysis to the household level, we disclose three layers of risk: (i) at the operating level, (ii) at the total farm level, and (iii) at the household level. To describe these layers, we will successively introduce the concepts of operational risk, financial risk, total farm risk, and finally total household risk. The risk concepts elaborated by Gabriel and Baker (1980) served as a foundation for this description. We also refer to our working paper (Wauters, 2012), in which these concepts are described.

3.1. Operational risk

Operational risk (OR) is the risk inherent to the farm operation and is independent of the way in which the farm operations are financed (Gabriel and Baker, 1980).[1] The two major causes for operational risk are unexpected variability in prices and production. External sources for such variations are the market, which produces price variability for inputs and outputs, policy, which can shift market conditions and thus move prices and environmental conditions, most notably the weather and pest, that can cause major bumps in crop production and diseases or that cause unanticipated shifts in animal production. Operational risk is reflected in the variation of any economic result parameter that reflects operating activities but is insensitive to the farm financing decision; examples include the rate of return on assets (ROA), the rate of return on labour (ROL), or net income. We choose to refrain from using accounting (accrual-based) parameters to define OR and alternatively suggest using the operating cash flow. Our reasoning is twofold; on the one hand, the financial situation at a farm is more realistically reflected in cash-based concepts than accrual-based concepts, and on the other hand does this choice facilitate the transition to total household risk. Operating cash flow (CF_{OP}) is defined as:

$$CF_{OP} = \text{operating receipts} - \text{operating expenses} \quad (1)$$

where operating receipts include dairy returns, government payments and other farm returns, and operating expenses include dairy related expenses (e.g. purchased feed, veterinary and medicine), crop related expenses (e.g. fertilizer, pesticides), general expenses (e.g. maintenance machinery and buildings, electricity), labour expenses, and land rents.

3.2. Financial risk

Financial risk (FR) is the additional risk from the use of debt. It encompasses the risk of cash insolvency and includes the risk of being unable to meet financial obligations, most notably interest payment and debt-servicing. It is more formally defined as the additional variability of the operating cash flow due to the fixed financial obligations inherent in the use of credit. It is measured as the difference between the variability of operating cash flow without debt financing and the variability of operating cash flow with debt financing.

[1] Gabriel and Baker (1980) use the term business risk. We, however, prefer the term operational risk, to reflect its source in the day-to-day operational activities on the farm. The use of the term operational is not new either, see for instance Hoag (2009).

3.3. Total farm risk

Total farm risk (TFR) comprises operational risk and financial risk. The relationship between the two sources of risk can be additive relationship (Gabriel and Baker, 1980) or multiplicative (REF). It can be shown straightforwardly that both expressions amount to the same measure for total farm risk. Regardless of the relationship chosen, TFR is always greater than or equal to OR. TFR is reflected in the variation of any result parameter that reflects operating activities and is sensitive to the farm financing decision such as the rate of return on equity (ROE). We operationalize TFR by looking at the variation of total farm cash flow (CF_{TF}), which is defined as the difference between operating cash flow on the one hand and financing (CF_{FIN}) and investment cash flow (CF_{INV}) on the other:

$$CF_{TF} = CF_{OP} - CF_{FIN} - CF_{INV} \tag{2}$$

In equation 2, financing and investment cash flow are defined by the following equations

$$CF_{FIN} = \text{interest on savings} - \text{interest paid} - \text{principal payments} \tag{3}$$

$$CF_{INV} = \text{sale of assets} - \text{purchase of assets} \tag{4}$$

3.4. Household risk

Total household risk (THR) is the risk of insufficient cash generation to cover the net household expenses (outside the farm). To operationalize THR we define total household cash flow (CF_{TH}) as:

$$CF_{TH} = \text{farm cash receipts} + \text{household cash receipts} - \text{household expenses} \tag{5}$$

where household cash receipts include off-farm income and private liquidity, and household expenses comprise family living expenses and private debt servicing or rent payment. The link between THR and TFR is ambiguous (as opposed to the OR—TFR relationship). To cope with TFR, the household can create a buffer, e.g. by off-farm income providing a relatively stable part of the household income or use private sources of liquidity. However, when off-farm income is absent, or when off-farm income is earned in a high-risk profession, off-farm income may increase THR, compared to TFR. Furthermore, household expenses are a risky element of THR as well, since many unpredictable circumstance such as diseases, disasters, fines, … may induce an unanticipated rise in households expenses. The use of debt for private expenses, such as the farm house or a car imposes financial household risk as well.

The relationship between TFR and THR, may be expressed as an additive or a multiplicative relationship. In the additive relationship, THR is expressed as the risk associated with the difference between household receipts (cash generated on-farm and off-farm) and the household expenses of the farm family. Ideally, a farm household would aim to maximize this difference, with an absolute minimum of 0. This is the approach followed in this paper.

Alternatively, THR may be expressed as the ratio of household receipts to household expenses. A farm household aims to maximize this ratio, with an absolute minimum of 1.

3.5. Operational risk measures

After describing the output parameters that reflect the three layers of risk, the next step is choosing a suitable definition of risk to represent the riskiness entailed in the variability of these parameters. There are three common definitions of risk, (i) the variability of outcomes, (ii) the chance of a bad outcome or (iii) uncertainty of outcomes (Hardaker, 2000). The risk measures corresponding to these concepts are respectively (i) the variance, standard deviation or coefficient of variation (CV), (ii) Value at Risk (VaR) and (iii) the whole distribution in the form of a probability density or cumulative density function. While the CV is an easy to understand concept and is dimensionless, only two moments (the mean and its standard deviation) are being used to compare the whole risk distribution, such that valuable information might be lost (especially when result parameters are not normally distributed). The VaR measure has the advantage over the CV that it embraces a threshold concept; for instance a minimum threshold for return, or a maximum bearable risk can be defined. Presenting the whole distribution on the other hand present the whole story there is to tell, but fails to allow an easy comparison of the level of riskiness of different distributions. We will not enter the discussion to decide which measure is the most suitable to represent risk, therefore in this paper we will present our results making use of all three concepts. Using the CV is a convenient way to represent risk, while using the whole distribution is probably the most correct way to take risk into account in models for instance. However, at the level of the farm, decision makers are most concerned about possible adverse outcomes that have severe consequences for the well-being of the family of even for the continuance of the farm business. Hence, the VaR as a complement to other, more commonly used risk measures, is a very useful measure to assess the impact of risky decisions on a farm.

3.6. Theoretical implications

Given the presented concepts of operational, financial, total farm and household risk, and using the idea that a more realistic farm household behavioural assumption is minimizing total household risk – i.e., the minimization of the chance of falling below a certain threshold level of household cash flow – Wauters (2012) showed analytically that a trade-off may exist between operational risk, financial risk and household buffering capacity. More specifically, if threshold level z on household cash flow may be defined, and a maximum allowable probability of falling below that threshold level of δ, the following equation holds

$$\frac{\sigma_1}{CF} + \sqrt{\delta}\left(\frac{I_F}{CF} - \frac{R_F}{CF} - \frac{L_F}{CF} - \frac{OFW}{CF} - \frac{L_P}{CF} - \frac{R_P}{CF} + \frac{I_P}{CF} + \frac{Z}{CF}\right) \leq \sqrt{\delta} \quad (6)$$

where σ_1 is standard deviation of farm cash flow, CF is average cash flow, I_F is farm debit servicing, R_F are farm liquidity reserves, L_F are new farm loans, OFW is off-farm wage after taxes, L_P are private new loans, R_P are private liquidity reserves and I_P is private debt servicing. This equation has a variety of implications.

1. Farmers willing to attain their behavioural goal might just as well decide to obtain additional cash from off-farm employment or might temporarily cut household expenses (thereby lowering z) or any other measure that is *not* targeted towards stabilization of the farm cash flow.
2. Programs and policies designed to stabilize farm cash flow (e.g., crop insurance subsidies, direct payments or price support programs) might induce farmer responses that are unanticipated when using farm income maximization as behavioural assumption. A decrease in operational risk for instance (reflected in a decrease of σ_1/CF) might result in an increase in borrowing, a decrease in private liquidity assets, a decrease in off-farm employment, or any other adjustment that satisfies the objective function, rather than a farm level reallocation.

In our study, we aim to investigate whether these theoretical implications might be confirmed by empirical evidence. The goal of this paper is mainly to present the different concepts.

4. EMPIRICAL ILLUSTRATION

4.1. Methodology and data

The dairy farm model used as a basis in this study is the Technology Impact and Policy Impact Calculation model, TIPICAL (Hemme, 2000). This model is extended in multiple ways, the overall approach is as follows:

3. The existing (deterministic) model TIPICAL is extended to encompass our concepts of operational, total farm and total household risk
4. Two typical North-Belgium dairy farms are inserted into the TIPICAL model
5. Critical input variables that represent the major sources of variability on a dairy farm are made stochastic, turning the model into a stochastic budgeting model
6. Several scenarios are programmed into the stochastic typical farm model, reflecting alternative risk management strategies
7. The different risk management scenarios are compared on the basis of CV and VaR measures and the distributions of the operational, total farm and total household risk measures are presented.

TIPICAL, a whole farm simulation model, forms the basis of the widely used and validated, International Farm Comparison Network (IFCN). This network is devoted to a better understanding of milk production worldwide, with a main focus on the economic aspects. TIPICAL is a calculation model that calculates, starting from a whole farm as input, different output parameters. We extended TIPICAL to the household level by including private liquidity, off-farm income and typical family living budgets to calculate total household cash flow, aside from operating and total farm cash flow. This extension allows us to compare alternative risk management strategies on both a total farm risk and total household risk basis.

The typical farm concept that is used in the IFCN, is a concept closely related to the model farm (Thomson en Bahhady, 1995a, b; Thomson et al. 1995) or the representative farm (Elliott, 1928; Plaxico en Tweeten, 1963; Harold, 1963). A typical farm is a fictional farm, that is however very realistic – it could exist – and thus can act as model for the respective sector. Inside the IFCN, it is developed using the typical farm approach, that is, using an expert panel combined with micro- and macro-data from national and regional statistics. Using a whole-farm simulation model, combined with a typical – or representative – farm, is a widely used approach to investigate possible impact of strategies, technologies and policies (e.g. Richardson et al., 2000, Escalante and Barry, 2001; Stokes et al., 2000). The farms used in this study are representative for the Belgium-North region. The first farm, denoted BE-45, is an overall representative farm for the North-Belgian dairy sector, and has 45 dairy cows, accompanied by a considerable pig fattening enterprise. The second farm, BE-85, represents a large North-Belgian dairy farm with 85 dairy cows and a small cash crop enterprise. Summary statistics regarding the typical farms are presented in Table 1.

Table 1. Summary statistics of two typical North-Belgium dairy farms

Variable	Unit	Dairy farm BE-45	Dairy farm BE-85
Land base	ha	40	60
Number of dairy cows	#	45	85
Milk quota owned	tonnes	350	550
Number of family members working on the farm	AWU	1.5	1.5
Operating Cash Flow	€	114,350	136,753
Total Farm Cash Flow	€	88,568	40,927
Total Household Cash Flow	€	55,668	8,027

Source: own calculations

The TIPICAL model is turned into a stochastic budgeting model by simulating different price and production risks with Pert distributions, using the risk analysis add-in for Excel @Risk developed by Palisade Corporation. Different degrees of financial risk are simulated by varying the farm level capital structure. The Pert distribution—constructed by defining a minimum, most likely and maximum value—is chosen for the sake of simplicity[2] and because it

[2] Risk distributions are modeled in a simple way in this analysis and are based on historical data. One can argue that this oversimplifies the risk situation at the farm/household. However, we believe that this simplification does not undermines the main messages in this paper. One could also question the relevance of historical data to reflect future risks, however, this is not the main focus of the paper, we would only like to represent risk levels that are plausible for the typical farm and furthermore focus on the effects of risk management strategies.

is intuitive to understand. The Pert distribution was chosen in favor of the triangular distribution, because more weight is attached to the most likely estimate and because the triangular distribution tends to over emphasize extremes. Another advantage of the Pert distribution is that it allows different risk management scenarios to be construct in a transparent way by simply changing the minimum, most likely, and maximum values.

There is quite a lot of research devoted to deriving probability distributions for stochastic variables, such as prices and production, for use in a farm simulation model. Hardaker and Lien (2010) elaborate the differences between the objectivists' view (derive probabilities from objective frequencies) and the subjectivists' view (conceptualization of a probability as a subjective probability) and provide multiple arguments in favor of the latter. Due to time constraints and because appropriate data was available, we will however derive our probabilities using Belgian FADN data (Eurostat, 2000) for the period 2005—2008. This panel data collection is stratified to ensure representativeness regarding profitability of all agricultural regions and farm sizes within Belgium. For this paper, only farms that have a dairy activity were withheld. To construct the Pert distributions, a minimum, most likely and maximum value need to be specified for the selected variables. The variables that are made uncertain are: milk yield, milk price, cull cow price, dairy related expenses, purchased dairy feed (concentrate), veterinary and medicine, general expenses, contract labour, energy costs, and the interest rate for long term loans. The most likely value was set at the original expert's estimate; the minimum and maximum values were obtained from the pooled panel data. To account for extreme, implausible values in the dataset, the minimum was set at the 10th percentile and the maximum at the 90th percentile. Given the limited timeframe of the available data (2005—2008), dependencies between the variables were not estimated and hence excluded from the simulation model. Possible dependencies that could be modeled include those between milk price and milk production, and between the operational costs. The minimum, most likely, and maximum values of the uncertain variables are presented in Table 2.

Table 2. Minimum, most likely and maximum values of the selected uncertain variables for two typical dairy farms

Variable	Unit	Dairy farm BE-45			Dairy farm BE-85		
		Min	ML	Max	Min	ML	Max
Operational level							
Milk yield	kg/cow/year	4,936	7,900	8,775	4,936	8,500	8,775
Milk price	€/kg	0.24	0.26	0.41	0.24	0.26	0.41
Cull cow price (live weight)	€/kg	0.80	1.00	1.47	0.80	1.00	1.47
Purchased concentrate feed	€/year	9,585	26,300	37,035	18,105	39,415	69,955
Veterinary and medicine	€/year	1,269	3,900	8,124	2,397	6,600	15,346
Contract labour	€/year	5,426	10,000	23,631	10,248	16,000	44,636
Energy costs	€/year	3,209	12,000	20,383	6,061	17,800	38,502
Total farm level							
Interest rate for long term loans	%	3.13	5.80	7.13	1.45	2.30	3.31
Leverage (debt/equity)	%	.	22	.	.	231	.

Total household level							
Off-farm income	€/year	0	0	0	0	0	0
Family living costs	€/year	24,675	32,900	41,125	32,900	32,900	32,900

Notes: The leverage ratio (debt/equity) is not modeled using a Pert distribution, but simply allowed to vary. Hence, no minimum and maximum values were specified. Source: own calculations

We will model risk management strategies at three levels, i.e. the (i) operational, (ii) total farm, and (iii) total household level.[3] Due to space constraints, we will model the three risk management strategies in full for the typical farm BE-45 and only the household level strategy for farm BE-85 (this choice will be further motivated below). The changes with respect to the base scenario that represent the different risk management strategies will be elaborated below.

At the *operational level*, potential risk management strategies are lowering production costs, insurance, or government intervention. Here, we model that the dairy farmer takes measures to make his milk yield more stable by lowering the risk for extreme temperatures in summer. We reflected this measure by increasing the minimum value of milk yield by 25%. Another operating measure is modeled, namely we assume that the farmer sells his milk trough a contract instead of through the spot market. This was reflected by making the milk price fixed at 31 eurocents. This value is higher than the most likely estimate provided by the expert, but comes remains fixed and hence does not allow the price to reach the high level of 41 eurocent in the base scenario.

Farm level risk management strategies include strategies at the operating, financing and investment level. Possible ventures are the operating measures previously mentioned, postponing a payment to a supplier or the bank, using emergency funds, getting a new loan from the bank, or postponing an investment. Here, we focus on coping with financial risk by on the hand lowering the most likely value to 4.5%, on the other hand we make the interest rate less risky by changing the minimum and maximum to 4% and 5% respectively.

At the *household level*, potential risk management strategies include attracting off-farm income, using private reserves, lowering private consumption, or postponing private investments. Here, we model off-farm income[4] by assuming that one family member can at least have a part-time job outside the farm (Table 1 reveals that 1.5 family members (expressed in AWU) work on the farm). We assume for the minimum that a half-time job generates a yearly wage of €12,500, the most likely value represents a full-time job generating €20,000, and the maximum value a full-time job with a €25,000 wage.

Table 3. Scenario construction modeling risk management strategies for farm BE-45 at different levels

Variable (unit)	*Operating level risk management*	*Farm level risk management*	*Household level risk management*

[3] One limitation of our analysis relates to the fact that we investigate the impact of risk management strategies separately, while a producer may well choose to combine different strategies.
[4] A second limitation of our analysis is that we do not account for market effects. When a large amount of producers engage in off-farm employment for instance, this will most likely affect productivity and thus market prices.

	Min	ML	Max	Min	ML	Max	Min	ML	Max
Operational level									
Milk yield (kg/cow/year)	**6,170**	7,900	8,775	**6,170**	7,900	8,775	4,936	8,500	8,775
Milk price (€/kg)	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**	**0.31**	0.24	0.26	0.41
Cull cow price (€/kg)	0.80	1.00	1.47	0.80	1.00	1.47	0.80	1.00	1.47
Purchased feed (€/year)	9,585	26,300	37,035	9,585	26,300	37,035	9,585	26,300	37,035
Veterinary, medicine (€/year)	1,269	3,900	8,124	1,269	3,900	8,124	1,269	3,900	8,124
Contract labour (€/year)	5,426	10,000	23,631	5,426	10,000	23,631	5,426	10,000	23,631
Energy costs (€/year)	3,209	12,000	20,383	3,209	12,000	20,383	3,209	12,000	20,383
Total farm level									
Interest rate loans (%)	3.13	5.80	7.13	**4.00**	**4.50**	**5.00**	3.13	5.80	7.13
Leverage (debt/equity; %)	.	22	.	.	22	.	.	22	.
Total household level									
Off-farm income (€/year)	0	0	0	0	0	0	**12,500**	**20,000**	**25,000**
Family living costs (€/year)	24,675	32,900	41,125	24,675	32,900	41,125	24,675	32,900	41,125

Notes: values in **bold** represent changes with regard to the base scenario (see Table 2). Source: own calculations

4.2. Results and discussion

First, we will focus on the representative farm BE-45. When looking at the coefficients of variation of the base scenario—i.e. without any risk management strategies—in Table 4, we see the obvious result that risk at the operating level is transferred to the farm level: at the operating level the CV is 12.2% and upon accounting for financial risk, the CV rises to 15.6% at the farm level. Because in the base scenario, no risk management strategy was present at the household level, the CV rises to 24.9% at the household level due to the variable family living expenses that increase the standard deviation and lower the mean of household cash flow. When we introduce the operating level risk management strategy, we evidently see the operating level CV dropping from 12.2% to 7.5%; this risk reduction is furthermore transferred to the farm and household level. The farm level risk management strategy on the other hand has no clear impact (the lower CV of 9.2% could be entirely accounted to simulation variation), this is probably due to the low leverage of the farm, with a debt/equity ratio of only 22%. The household risk management strategy on the other hand, has a clear impact on the household level risk, the CV drops from 24.9% to 18.8%. Here we see that there is an important impact at household level, but there is none at farm level (the CV's of the operating and farm level cash flows are the same as the base scenario). Therefore, when only looking at the farm level to analyze risk or income volatility, important differences at the household level are missed that do have an important impact.

Table 4 Coefficients of variation (%) of different output variables of farm BE-45, according alternative risk management strategies

Output variable		Risk management strategy at		
	Base scenario	Operating level	Farm level	Household level
Operating Cash Flow	12.2	7.5	7.4	12.1
Total Farm Cash Flow	15.6	9.4	9.2	15.5

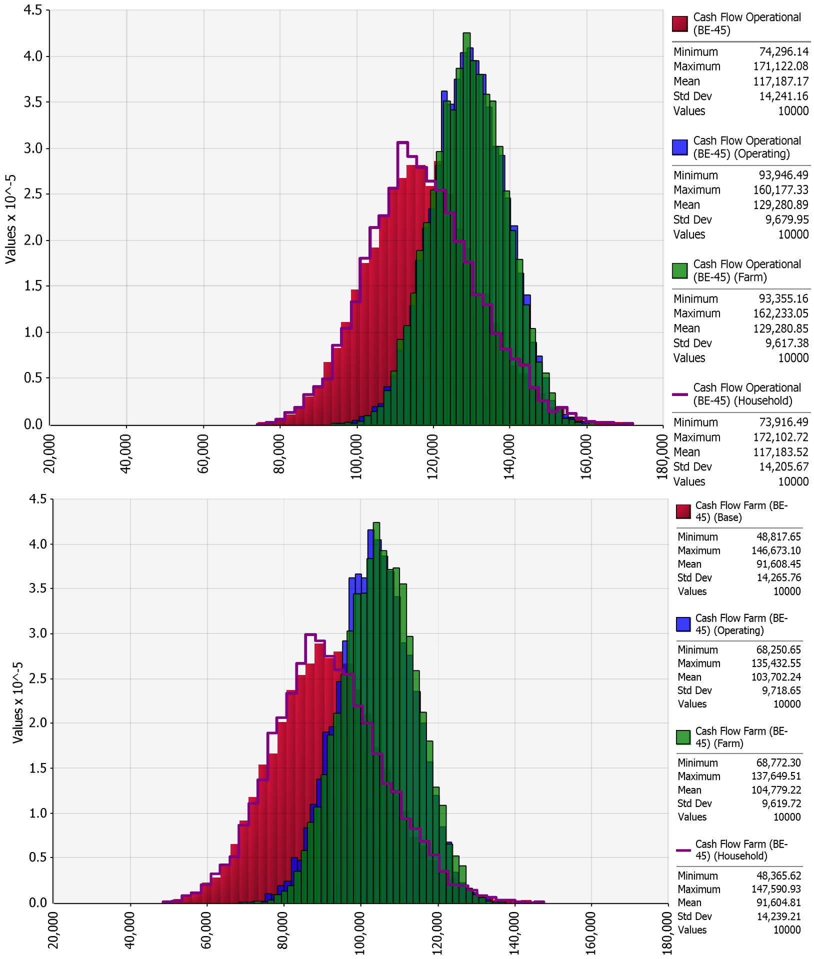
Total Household Cash Flow	24.9	14.4	14.1	18.8

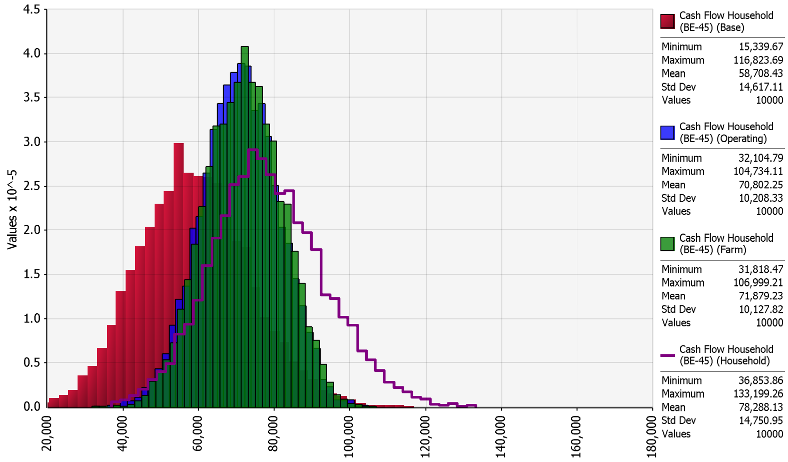
Source: own calculations

The story just elaborated using CV's, can also be visualized by making use of probability density distributions; these are presented below in

Figure 1.

Figure 1 Probability density distributions of operating, total farm and total household cash flow of farm BE-45 following different risk management strategies.





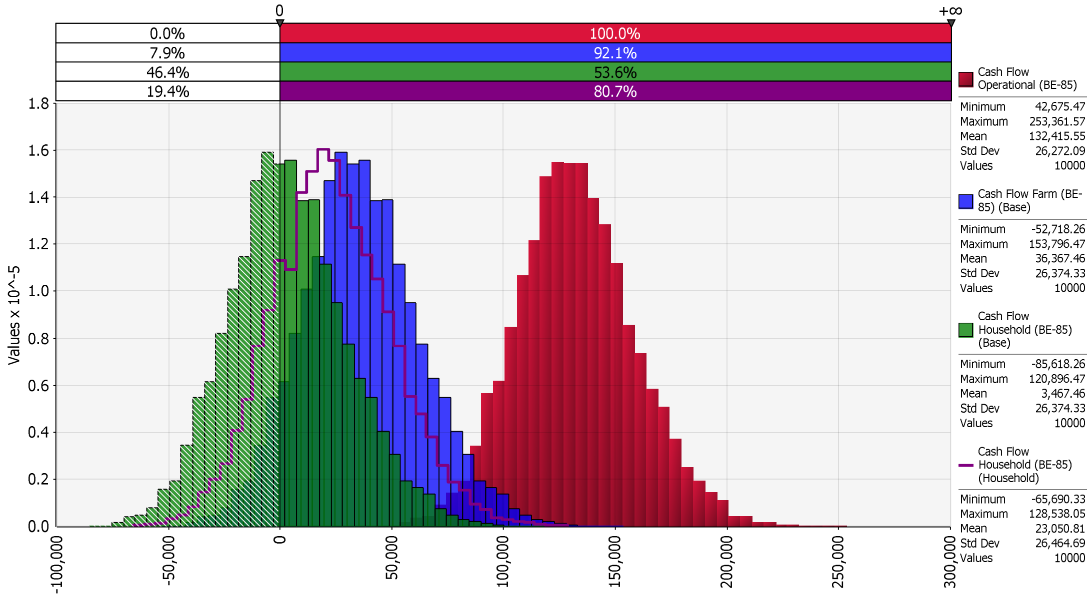
The red curve presents the base scenario, the blue curve a risk management stratgy at the operating level, the green curve a strategy ath the farm level and the purple curve a household-level strategy. (Source: own elaboration)

The probability density curves in

Figure 1 reveal that for farm BE-45 there is no risk for a negative cash flow (at any level). Let us therefore turn focus to the bigger farm BE-85, where the farm-level and household-level cash flows are lower compared to BE-45 (see Table 1).

The probability density functions of the operating, farm, and household cash flows in the base scenario are presented in Figure 2 (in red, blue and green respectively). Evidently, we see that as we move from the operational risk layer to the household risk layer, the mean of the distribution is shifted to the left. The shape of the distribution, however, remains more or less similar. This results in an increase in risk, because for the CV measures the denominator increases and because the VaR measures—the chance of a negative cash flow presented at the top of Figure 2—increase respectively from 0%, over 8% to 46%. This situation makes introducing risk management strategies more relevant compared to farm BE-45 because when insufficient cash flow is generated, coping strategies are needed. The purple curve in Figure 2 represents the distribution of household cash flow of farm BE-85 in the scenario were off-farm income is obtained as a household-level risk management. Once again, we clearly see that a farm might face the same level of operational and/or farm risk, but that this might mask important differences at household level: whereas the farm-level VaR remains at 8% regardless of the risk management strategy, the household-level VaR is lowered from 46% to 19%. We argue that the most relevant level where income volatility (or risk) is sensed by a farmer, is the household level—not the farm level—therefore the relevant risk that is taken into account by the farmer (or the farm household) is the total household risk, in this example 46%, and not the total farm risk, here 8%.

Figure 2 Probability density curves of the operating (red), farm-level (blue) and household-level (green) cash flow for farm BE-85.



The purple curve represents the density of the household-level cash flow in the case where off-farm income is obtained as a household-level risk management strategy. At the top, corresponding Value at Risk measures are presented as the chance of a negative cash flow (source: own elaboration)

5. Conclusion

Our typical farm applications suggest the usefulness of extending income stability analyses to household income stability. Evidently, it is shown that volatility in agricultural output and input market prices affect not only farms, but may also have differential consequences on household income stability. Further, it broadens the range of instruments and strategies that both farmers and policymakers can employ to manage risks. Risk management strategies at the household level have a direct impact at the household level, but this impact is not apparent at the farm level. The potential influence of off-farm income on household income stability, for instance, suggests that rural development policies, offering greater off-farm employment possibilities may have a far better influence on the stability of farmer incomes than policies directed at stabilizing agricultural markets (that might have more public costs or could be even market disturbing). Farm extension may also benefit from extending farm management tools to the household level. The empirical applications in this paper clearly show that price, production and financial farm risks may have substantial adverse effects on household incomes, of which farmers may not be aware. Another consequence of household-level risk management strategies is that there might be a risk balancing happening at household level, similar to the risk balancing at farm level elaborated by Gabriel and Baker (1980). A relative stable/buffered household cash flow (e.g. due to off-farm income earned by the farmer’s spouse) might induce farmers to undertake more risky farming business. This could be because of the prospect of higher payoffs (upside risk), or alternatively because due to the buffer the farmer engages in farming activities that he likes but that might not be the most efficient/un-risky activities. In short, the farming activity might thus be more risky than would be rational from an economic perspective, but reasonable from a household view.

6. REFERENCES

Anton, J., Kimura, S. (2009). Farm level analysis of risk and risk management strategies and polocies: evidence from German crop farms. Contributed paper at the International Asssociation of Agricultural Economists Conference, Beijing, China, August 16-22

Elliott, F.F. (1928). The "representative firm idea applied to research and extension in agricultural economics. *Journal of Farm Economics* 10 (4): 483-498

Escalante, C. L., Barry, P. J. (2001). Farm level evidence on the risk balancing hypothesis from Illinois grain farms, American Agricultural Economics Association Annual Meeting, August 5-8, Chicago, USA: American Agricultural Economics Association.

Eurostat (2000). Manual on the economic accounts for agriculture and forestry EAA/EAF 97. Luxembourg, Luxembourg: European Communities.

Freshwater, D., Jette-Nantel, S. (2011). Risk management and the role of off-farm income. Version 2.1, January 12, 2011. Kentucky, USA: University of Kentucky.

Gabriel, S. C., Baker, C. B. (1980). Concepts of business and financial risk. *American Journal of Agicultural Economics* 62: 560-564.

Hardaker, J. B. (2000). Some issues in dealing with risk in agriculture. Working paper, New England, Australia: University of New England, Graduate School of Agricultural and Resource Economics.

Hardaker, J. B., Lien, G. (2010). Probabilities for decision analysis in agriculture and rural resource economics: The need for a paradigm change. *Agricultural Systems* 103: 345-350.

Hemme, T. (2000). IFCN – A concept for international analysis of the policy and technology impacts in agriculture. Dissertation. Landbauforschung Völkenrode, Special Issue 215. Völkenrode, Germany: Georg-August-Universität Göttingen.

Hoag, D. L. (ed.) (2009). *Applied risk management in agriculture.* Boca Rotan, USA: CRC Press - Taylor & Francis Group.

Lien, G., Hardaker, J. B. (2001). Whole-farm planning under uncertainty: Impacts of subsidy scheme and utility function on portfolio choice in Norwegian agriculture. European Review of Agricultural Economics 28: 17-36.

OECD (2008). An assessment of risk exposure in agriculture: a literature review. Paris

Plaxico, J.S., Tweeten, L.G. (1963). Representative farms for policy and projection research. *Journal of Farm Economics* 45 (5): 1458-1465

Richardson, J. W., Klose, S. L., Gray, A. W. (2000). An applied procedure for estimating and simulating multivariate empirical (MVE) probability distributions in farm-level risk assessment and policy analysis. Journal of Agricultural and Applied Economics 32: 299-315.

Stokes, J.R., Coble, K.H., Dismukes, R. (2000). Producer behavior in the presence of an income stabilization program. *Agricultural Finance Review* 60: 33-59

Thomson, E.F., Bahhady, F.A. (1995a). A model-farm approach to research on crop-livestock integration – I. Conceptual framework and methods. *Agricultural systems* 49: 1-16

Thomson, E.F., Bahhady, F.A. (1995b). A model-farm approach to research on crop-livestock integration – II. Experimental results. *Agricultural systems* 49: 17-30

Thomson, E.F., Bahhady, F.A., Nordblom, T.L., Harris, H.C. (1995). A model-farm approach to research on crop-livestock integration – III. Benefits of crop-livestock integration and a critique of the approach. *Agricultural systems* 49: 1-16