ECONOMIC IMPACT OF PROSPECTIVE RISK MANAGEMENT INSTRUMENTS UNDER ALTERNATIVE POLICY SCENARIOS

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Abstract

The main objective was to assess the risk of farmers in the European Union and to analyze the impact of agricultural policy changes on the main components of income namely price and production risks. In order to achieve this, qualitative considerations and quantitative analyses covering the period 2004 – 2018 have been made. Future policy scenarios have been defined, taking into account likely Common Agricultural Policy developments, including possible outcomes of the Doha round of the WTO negotiations. Subsequently, the economic impact of policy scenarios in conjunction with a set of prospective risk management instruments for the European Union are determined.

Keywords

Policy scenarios, Risk Management Instruments, Portfolio analysis

1 Introduction

The projected World Trade Organisation (WTO) and Common Agricultural Policy (CAP) policy scenarios, has created an awareness amongst farmers and policy makers of the need to quantify the altered risk exposure, some of which being catastrophic and disruptive, and study the scope for better risk management opportunities.

In general, it will be impossible to say whether the net effect of the introduction of a new risk management instrument will increase or reduce either the mean or the variance of net returns. It depends on how the interactions with other risks on the farm and with other risk management instruments work out. All we can be sure of is that, if the decisions are taken rationally, the farmer's utility should not go down and would normally remain the same only if he or she found the new instrument unattractive. Thus the merit of adding any risky prospect into an existing farm business cannot be assessed without considering the potential impact on the risk-efficiency of net returns from the whole portfolio of farm-specific risky prospects (including any off-farm investments or income-earning ventures). This is true whether the added prospect is in the form of a new production activity, a new policy, or a new risk management instrument. And, in making an evaluation, it is necessary to take account of the stochastic dependencies, such as the correlations, between the new activity and the existing ones. Therefore the goal of the current research is to study the economic impact of policy scenarios in conjunction with a set of prospective risk management instruments for the European Union at farm level.

In order to achieve this qualitative considerations and quantitative analyses covering period 2004 – 2018 have been made. At first, future policy scenarios have been defined, taking into account likely Common Agricultural Policy developments, including possible outcomes of Doha round of the WTO negotiations. Results of qualitative analysis have been converted into quantitative values which were a basis for simulations of farm incomes with the use of the farm level Monte-Carlo simulation model set up for the purposes of the project. Then, simulation results are used as inputs in a whole-farm model to provide insight into the impact of (new) instruments on farm income volatility.

2 Policy scenarios

Traditional CAP-based market price support measures, including wide ranging intervention, have played an important role in reducing price risk in EU agriculture. The successive reforms (1992, 1999, 2003) have gradually turned more of this support to direct payments, which from 2006 on are mostly decoupled. The provisions of the forthcoming new commitments within WTO may force the EU to a further liberalization of market policy[1] .

Enhanced market access and lower internal prices strengthen the links with world market developments and, in general, (have and will) increase the price risk in EU farming. On the other hand, decoupled direct payments increasingly insulate farmer's incomes from production and price variability. Further decreases in institutional prices, limitations on intervention purchases and enhanced external competition may radically increase the exposure of EU farmers to price risk. Even though world market prices may increase and become less variable as a result of farm and trade policy reform, e.g. due to WTO agreement, volatility of EU prices is expected to be greater than in a more protective policy environment.

The WTO commitments mainly set constraints on the form of CAP support. While the magnitude of total support being delivered to EU agriculture has not changed substantially since the 1990-ies, the forms of the support have evolved significantly[2]. The CAP reform of 2003 which decoupled most direct payments turning them into green box category is deemed to anticipate much of the new targets of the Doha Round. Nevertheless, the ultimate outcomes of the Doha round may potentially put new pressures on the CAP. In particular the withdrawal of export subsidies and provisions within the market access pillar may be conducive to new substantial rearrangements in the CAP, affecting some CMOs more than others.

Another driving force influencing future policy choices will certainly be accelerated debate on the EU budget and changing public expectations and increasing scrutiny as regards the role and the efficiency of the CAP.

The pattern of agricultural policy changes in a long-term shows a gradual liberalization, which very likely will continue in the future. Such assumption was a foundation for the policy scenarios formulation (Table 1). Base scenario represents the historic reference reflecting the present policies and market conditions in years 2002-2004 (Base). Most likely scenario reflects the policies and market situation as expected in 2013 (ML13). It assumes continuation of existing (2006) policies, with some minor changes, including 10% modulation of direct payments. For the year 2018 there were two scenarios constructed, which refer to probable CAP evolution mainly induced by the prospective new WTO deal - Likely A and Likely B, both including further liberalization of market policies, full decoupling of direct support and shift of budgetary funds out of the pillar 1, so called modulation (LikA18 and LikB18). They differ in terms of the degree of liberalization: LikB18 assumes greater reduction in market price support and in the direct support (20% mandatory modulation instead of 10% in LikB18 and ceiling of 100 thousand EUR of direct payments per farm, compared with no such limits in LikA18). In addition to scenarios considered as "likely" also two extreme scenarios for 2018 – Lib18 (a complete removal of subsidies for agricultural sector) and Protectionist (return to the Agenda 2000 type of policy) were created for comparisons (Pro18).

Table 1: Policy scenarios.

Year	Scenario	Description
2004	Base	Historic reference
2013	ML13	Luxembourg 2003 policy implemented (sugar reform), no substantive policy changes, modulation -10%
2018	LikA18	Higher support level, full de-coupling, mandatory modulation -10%
	LikB18	Lower support level, full de-coupling, ceiling 100,000 euro, mandatory modulation -20%
	Lib18	Non-tariff market protection measures removed, no direct payments
	Pro18	Return to "pre-CAP" reform type of policy - stronger market protection

For each time frame in conjunction with future policy scenario a set of specific assumption were made regarding prices and yields.

[1] See eg. Swinbank A. (2005), Developments in the WTO and Implications for CAP, Conference Paper, The University of Reading.

[2] OECD (2005) Agricultural Policies in OECD Countries: Monitoring and Evaluation (to be published in July 2007)

Prices of agricultural commodities are determined by applying price projections for the EU and World market for the years 2007-2016, the estimates of nominal protection coefficient for EU farm prices from PSE calculations and the estimates of the impact of liberalization of farm and trade policies world wide on the level of World market prices by OECD (2007) and FAPRI (2005). It was assumed that with no change in the CAP the internal EU prices would develop in line with the price projections for the EU market presented by OECD-FAO (2007) Agricultural Outlook 2007-2016. Partial liberalization of market and trade policy would in a long term bring EU prices closer to the World market prices, but the scope of price changes would depend on a commodity and the initial distance between the respective prices . In the Liberal (2018) scenario full alignment of EU prices with World market prices is expected, whilst in Protectionist scenario it is assumed that prices "return" to the pre-reform level (i.e., sugar) or increase above the baseline (Table 2).

Table 2: EU Price change indices for policy scenarios (2005 = 100)

Commodities	OECD-FAO (2007) Projection		Assumed price change indices (2005 = 100)				
	Price 2005 (EUR)	Price 2013 (2005=100)	Most likely 2018	Likely A 2018 - higher protection	Likely B 2018 - lower protection	Liberal 2018	Protectionist 2018
Wheat	118,35	99,3	99,3	99,1	99,1	94,2	109,0
Coarse grains (barley)	104,35	102	102	101	101	96	111
Corn	130,61	95	95	93,6	93,6	89	103
Oilseed	251,63	99	99	100	100	95	110
Potatoes	115	100	100	100	100	95	105
Sugar-beet	46,72	56	56	56	47	43	100

Future yields level have been determined through extrapolation of past trends in the period 1992-2004 with some corrections based on country experts judgement on the pace of technological change, efficiency improvements and other factors in each sector and member state. A simplifying assumption on neutrality of policy scenarios for yields level and variability has been made. Thus an adverse effect of decreases in farm support for yield improvement is deemed to be counterbalanced by induced improvements in efficiency and technology. Future volatility of yields in each policy scenario (as measured by the coefficient of variation) are assumed to be equal to that in the base period (Table 3).

Table 3: Assumed rates of annual yield increase and yield forecast for selected commodities.

	Yields	Wheat	Rye	Barley	Potatoes	Sugar beets	Oilseed rape
Poland	Rate of increase	2,0%	0,9%	1,3%	2,0%	2,0%	0,5%
	Mean 2002-2004	38,4	24,5	31,7	189,3	427,0	23,5
	2018	50,7	27,8	38,0	249,8	563,4	25,2
Hungary	Rate of increase	1,5%	2,0%	1,5%	1,5%	2,6%	1,0%
	Mean 2002-2004	37,6	20,7	31,7	183,3	418,3	19,5
	2018	46,3	27,3	39,0	225,8	599,2	22,5
Spain	Rate of increase	1,5%	2,0%	2,0%	1,8%	1,8%	.
	Mean 2002-2004	29,9	17,3	29,5	276,3	669,7	.
	2018	36,8	22,9	39,0	354,7	589,7	.
Nether-lands	Rate of increase	0,5%	1,0%	1,0%	1,0%	1,0%	0,5%
	Mean 2002-2004	84,8	49,3	59,9	438,7	611,7	.
	2018	90,9	56,7	68,9	504,2	703,1	.
Germany	Rate of increase	1,5%	1,9%	1,33%	3,0%	1,2%	2,2%
	Mean 2002-2004	71,9	51,5	57,4	398,3	577,3	33,5
	2018	89,0	67,0	69,1	602,4	682,2	45,4

3 Whole farm risk programming

Risky decision problems are often handled by means of portfolio optimisation. Portfolio analysis for farm planning requires the inclusion of the normal range of risky production activities and should comprise the probability distribution of per unit net revenue for each activity and the stochastic dependencies between those activities.

Markowitz (1959) and Freund (1956) showed that quadratic risk programming (QRP) can be used to maximise the expected income of a risk-averse decision-maker subject to a set of resource and other constraints including a parametric constraint on the variance of income. The model can also be formulated to minimize the variance subject to a parametric constraint on expected income, or to expected constant absolute risk aversion (CARA) utility maximization with parametric variation in absolute risk aversion. All three should give identical solutions.

QRP restrictively uses the first two moments (i.e. mean and variance) of each risky activity and the first co-moment (i.e. covariance) between the risky activities. The obtained optimal portfolio with respect to income or wealth is usually held to be a reasonable approximation provided that the distribution of income or wealth is not very skewed. Note that the activity per unit net revenues may not have to be normal distributed for the distribution of farm income or wealth to be more or less normal. Under some particular assumptions, it is exact, e.g. when the distribution of income is normal and the utility function is negative exponential (Freund, 1956) or when the utility function is quadratic (Anderson et al., 1977). The risky alternatives can subsequently be ranked by applying the stochastic efficiency with respect to a function method (SERF). This method allows comparing the alternatives in terms of certainty equivalents (CE) over the range of risk aversion of interest. SERF works by identifying utility-efficient alternatives for ranges of risk attitudes and can be applied to any utility function.
As an alternative, a non-parametric risk-programming method is free of distribution assumptions and includes the joint distribution by means of so-called "states of nature" (i.e., specific combinations and probabilities of possible outcomes). Utility-efficient programming (UEP) is one of the non-parametric methods applied in farm portfolio analysis (Hardaker et al., 2004). The UEP is formulated as follows:

$$\max E[U] = p\,U(z,r),\ r \text{ varied}, \qquad (1)$$

subject to:

$$Ax \leq b \qquad (2)$$

$$Cx - Iz = f \qquad (3)$$

$$x \geq 0 \qquad (4)$$

where: $E[U]$ is expected utility, p is vector of probabilities for states of nature (often assumed equi-probable), $U(z,r)$ is a vector of utilities of net income where the utility function is defined for a measure of risk aversion, r, A is a matrix of technical coefficient, x is a vector of activity levels, b is a vector of resource stocks, C is a matrix of GMs for S states of nature, I is a identity matrix, z is a vector of net incomes for each state of nature S, f is a vector of fixed costs.

The described risk programming model can be augmented to optimize the portfolio of crops grown in the coming year, including options to insure a shortfall of the long-term average (in case of yield or revenue insurance) or an insurance scheme based on an index.

The objective of yield insurance is to reduce the fluctuations in income caused by yield variations. Yield insurance indemnifies any insured farmer in any year in which yield falls below a specified level (coverage level). This strike level is defined as a farm-specific percentage of the expected yield per hectare (Halcrow, 1949). Crop revenue in case of yield insurance equals:

$$IR_{qn} = R_{qn} - IP_{qn} + PInd_{qn} \cdot (\overline{Y}_{qn} \cdot C - Y_{qn}), \quad if\ Y_{qn} < \overline{Y}_{qn} \cdot C \qquad (5)$$

where IR_{qn} is revenue of crop q in case if insurance applied on farm n; R_{qn} is observed revenue of crop q on farm n, which is calculated as: $R_{qn}=Y_{qn}P_{qn}$, where Y_{qn} is observed yield of crop q on farm n and P_{qn} is observed price of crop q on farm n; IP_{qn} is insurance premium of crop q on farm n; $PInd_{qn}$ is indemnity price of crop q on farm n (indemnity price per unit in Euro per hectare eligible for indemnification which can be established by the farmer or can be nominated by the insurance company; in each case always at the beginning of the contract year), $\overline{Y}_{qn}$ is average yield of crop q on farm n; and C is coverage level.

Insuring revenue of a given crop implies insuring the product of price and yield of that crop. For revenue insurance it is important to consider the joint distribution of prices and yields. Farm total revenue from crops with crop revenue insurance equals (Kaylen et al., 1989):

$$IR_{qn} = R_{qn} - IP_{qn} + (\overline{R}_{qn} \cdot C - R_{qn}), \quad if\ R_{qn} < \overline{R}_{qn} \cdot C \tag{6}$$

where $\overline{R}_{qn}$ is average revenue of crop *q* on farm *n* that is calculated as: $\overline{R}_n = \overline{Y}_n \cdot \overline{P}_n$.

Besides indemnity based insurance schemes, also index-based insurance are of interest in the current study. In this insurance scheme, the premiums and payouts are based on the weather records of the locality in which the insurance is sold (Halcrow, 1949). Payouts to a farmer are triggered if weather, in terms of some measurable criterion, is below the certain limits of tolerance. Weather index based insurance would be adapted more easily to an area in which one or two weather factors such as precipitation and temperature are generally limiting and are highly significant in projecting crop yields (Halcrow, 1949). So any applied index only accounts for a certain amount of the weather risk (i.e. basis risk). Basis risk refers to the inadequate stochastic dependency between the actual weather risk exposure of the buyer and the outcome of the weather underlying the hedging instrument. In term of risk programming, index insurance products can be incorporated by assuming that only a certain percentage of observed adverse years are eligible for compensation reflecting the associated basis risk.

4 Results

Different farming systems per member state were selected for in-depth analysis. Specialised cereals, oilseed and protein crop farms (FADN typology 13) were included in the analysis for Hungary, Poland and Spain, whereas general field cropping farms (FADN typology 14) were considered for Germany and the Netherlands. Since average farm size differs considerably between those member states this was taken into account.

Constraints and variable costs for the main crops are determined individually for each farming system modeled. Crops considered are wheat, rye, barley, oats, triticale, maize, other cereals, potatoes, sugar beet, rapeseed and sunflowers. However, not all crops are common in certain regions. For example, rapeseed is hardly cultivated in Spain while sunflowers are, whereas the opposite holds for the Netherlands. Specificity of the farming system (e.g., possibility of irrigation, quality of soils which is not shown in FADN data, but observed crop selection provides some information) as well as normative sources of information are taken into account. The joint future performance distribution were derived from a Monte Carlo simulation model which depended strongly on the assumptions made as well as the quality of the entry data, largely coming from the FADN database.

The pattern of changes in the level of expected farm income across scenarios is similar for the five case farms under investigation if expected income is optimised (Table 4). On the long run expected farm incomes increase under protectionist policy (Pro18) but are depressed if liberalisation is assumed (Lib18). The impacts of alternatively policy scenarios on the optimal farm plan (i.e., level of activities) were not substantial. The allotted acreage in the farm plan of cash crops such as sugar beet and potato, which were the most profitable cropping activities considered, corresponded to the maximum proportion allowed. This is to say when decisions are made assuming risk neutrality whereby farmer are not willing to forego a part of the expected income in order to avoid the risks associated with the cultivation of these risky cash crops. As a result, general field cropping farming systems (FADN typology 14) which farm plan can constitute a relative large proportion of these cash crops have a more volatile farm income than specialised cereals, oilseed and protein farms (FADN typology 13). The coefficient of variation as well as the probability of a negative farm income are for the two general field cropping case farms considerable. Both effects originate from volatile crop revenues in conjunction with relative high cost causing a relative low expected farm income.

Table 4: Linear programming results (risk neutral).

Member state	Farm size [1]	Farming system [2]		Scenarios					
				Base	ML 13	LikA18	LikB18	Lib18	Pro18
Germany	≥40 and <100	14	E (euro)	30,540	10,803	26,146	20,917	12,863	50,150
			CV (%)	109	395	210	292	501	104
			P<0 (%)	17	47	37	44	49	17
Hungary	≥8 and <16	13	E (euro)	25,425	28,344	29,848	29,360	19,543	34,523
			CV (%)	57	60	67	72	106	54
			P<0 (%)	0	0	0	0	14	0
Netherlands	≥40 and <100	14	E (euro)	9,521	-10,583	-6,418	-8,488	-9,288	-7,666
			CV (%)	529	-492	-946	-716	-654	-833
			P<0 (%)	50	61	60	60	60	60
Poland	≥8 and <16	13	E (euro)	18,567	21,051	21,553	21,117	13,871	23,604
			CV (%)	24	24	25	26	39	25
			P<0 (%)	0	0	0	0	0	0
Spain	≥16 and <40	13	E (euro)	18,411	13,716	14,881	12,669	2,712	19,150
			CV (%)	42	65	65	76	357	54
			P<0 (%)	0	5	5	12	39	3

[1] European Size Unit.

[2] Farming systems: 13 = specialised cereals, oilseed and protein farm; 14 = specialised arable farm.

To evaluate the impact of insurance within an optimal farm portfolio context three additional optimizations were run. In each optimization only insured activities were considered, being either yield, revenue or index insurance. Note that in the current analysis the strike level is set at 80% of the mean, implying a deductible of 20%. The risk reducing impact of the three insurance schemes under investigation in terms of CV is presented in Table 5. It was assumed that the chance of payments via the index insurance was 75% if actual losses were incurred (i.e., basis risk).

Table 6.3: Impact of alternative insurance options (CV,%).

Member state	Farm size [1]	Farming system [2]	Insurance option	Scenarios Base	ML 13	LikA18	LikB18	Lib18	Pro18
Germany	≥40 and <100	14	No	109	395	210	292	501	104
			Yield	100	350	188	267	-46	93
			Revenue	89	312	166	227	390	82
			Index	107	378	201	309	488	99
Hungary	≥8 and <16	13	No	57	60	67	72	106	54
			Yield	51	54	59	65	99	46
			Revenue	45	48	53	58	86	42
			Index	54	58	64	69	103	50
Netherlands	≥40 and <100	14	No	529	-492	-946	-716	-654	-833
			Yield	495	-461	-882	-670	-613	-780
			Revenue	406	-379	-725	-551	-504	-640
			Index	499	-477	-926	-699	-638	-815
Poland	≥8 and <16	13	No	24	24	25	26	39	25
			Yield	20	20	21	22	34	20
			Revenue	20	20	21	22	32	20
			Index	23	22	23	24	36	22
Spain	≥16 and <40	13	No	42	65	65	76	357	54
			Yield	21	34	20	32	28	50
			Revenue	21	32	20	32	24	50
			Index	23	36	22	37	30	58

[1] European Size Unit.

[2] Farming systems: 13 = specialised cereals, oilseed and protein farm; 14 = specialised arable farm.

The relevance of insurance contracts in terms of its risk reducing impact can be derived by comparing the CV's obtained with and without insurance. For all case farms and scenarios the revenue-coverage contract was most effective, and reduced CV on average by about 22%, followed by yield insurance (-13%) and index insurance (-5%). The efficacy was more or less independent from the scenario considered. Also the impacts of (alternative) insurance contract on the optimal farm plan were not substantial. Obtained results are counterintuitive if efficacy of insurance - being either yield, revenue or index insurance - is expressed in terms of its risk reducing impact on the probability of negative farm income. The probability of a negative farm income hardly reduces and sometimes increases if crops are insured. These results can be explained by the fact that this parameter captures the efficacy partially. Extreme negative yields and revenues are indemnified, but in case of low expected incomes relative to its variability already moderate adverse years will generate negative farm incomes because of the premiums to be paid. In general, from the results it can be seen that the net effect of the introduction of a new risk-management instrument will affect the variability of farm incomes, as theory suggests. Of course, the efficacy can be expressed in alternative means. All we can be sure of is that, if the decisions are taken rationally, the farmer's utility should not go down and would normally remain the same only if he found the new instrument unattractive.

The pure premiums, also referred to as expected claim cost or actuarially fair premium, for each type of insurance given a particular farming system are presented in Table 6. Note that converting the pure premium into a gross rate requires the addition of the loading, which is intended to cover transaction costs and allowance for contingencies and profit.

Table 6: Premium of alternative insurance options (Euro per hectare).

Member state	Farm size [1]	Farming system [2]	Insurance option	Scenarios					
				Base	ML 13	LikA18	LikB18	Lib18	Pro18
Germany	≥40 and <100	14							
			Yield	84	103	118	100	47	118
			Revenue	171	207	265	288	310	237
			Index	52	65	73	58	61	73
Hungary	≥8 and <16	13							
			Yield	44	55	61	63	61	63
			Revenue	79	91	104	109	114	92
			Index	22	27	31	31	30	31
Netherlands	≥40 and <100	14							
			Yield	76	85	87	89	89	89
			Revenue	324	345	391	404	407	415
			Index	49	54	56	57	57	57
Poland	≥8 and <16	13							
			Yield	164	187	201	199	180	201
			Revenue	14	15	16	17	18	17
			Index	71	81	86	87	86	87
Spain	≥16 and <40	13							
			Yield	29	34	38	23	38	38
			Revenue	31	34	37	34	38	41
			Index	15	17	19	18	19	19

[1] European Size Unit.

[2] Farming systems: 13 = specialised cereals, oilseed and protein farm; 14 = specialised arable farm.

Levels of pure premiums per hectare differed between case farms and were affected by the alternatively policy scenarios. On the long run expected premiums increased under protectionist policies as well as more liberal policies. For German and Dutch case farms premiums charged for the revenue-coverage contract exceeded those for yield insurance and index insurance. Revenue insurance premiums on general field cropping farming systems, with more volatile cash crops (i.e., price variation), were higher than those on specialised cereals, oilseed and protein farms (i.e., relative low variation).

According to the model, the trade off between risk and profit was at a fairly low rate given moderate risk-averse decision makers (E,V results are not presented). The optimal expected farm incomes were slightly lower under risk aversion than under risk neutrality. Again some counterintuitive results were obtained if the impact of risk aversion is expressed in terms of its risk reducing effect on the probability of negative farm income. This can be explained by the fact that the expected utility is maximized and not the probability of a negative farm income is minimized. Comparing the E,V results with the UEP results showed that there are few differences between the two and the differences which do occur are mainly trivial. In general, it was observed, that if a farmer was more risk-averse, he was more prone to choose a production plan comprising more less-profitable lower-variance crops (wheat instead of potato) compared to the optimal plan achieved.

5 Conclusions and discussion

From the scenario analysis it can be concluded farm risk exposure differed between the assumed future scenarios substantially. The pattern of changes in the level of expected farm income across scenarios is similar for the five case farms under investigation. On the long run expected farm incomes increase under more protectionist policies but are depressed if liberalization is assumed.

Yet, the impacts of alternatively policy scenarios on the optimal farm plan were not substantial. The optimal farm plan of general field cropping farming systems as well as specialized cereals, oilseed and protein farms is marginally altered. The amount of cash crops cultivated - which are characterized by higher but more volatile outcomes – is more affected by agronomic constraints rather than future policy scenarios.

Diversification as a risk management tool has its limitations. The analysis of the case-specific trade-off between the expected gross margins and risk provided an indication of the efficiency of farm diversification. This is to say when decisions are made assuming risk neutrality or moderate risk aversion whereby farmers are not willing to forego a part of the expected income in order to avoid the risks associated with the cultivation of more risky cash crops. Substantial volatility remains despite prospective risk management instruments considered. Farming is in general a risky business since crop yields and prices are relatively volatile in comparison to the expected farm income.

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