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RISK RELATED NON-PRICE EFFECTS OF THE CAP ARABLE CROP REGIME: RESULTS FROM AN FADN SAMPLE

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This paper is the third of a series of five papers on the measurement of decoupling under Activity 6 of the Programme of Work 2001-2002 of the Committee for Agriculture. It has been written by Paolo Sckokai of the Istituto di Economia Agroalimentare, Università Cattolica in Piacenza Italy. It follows the conceptual framework defined in [COM/AGR/APM/TD/WP(2000)14/FINAL] declassified at the 26-28 September 2000 session of the APM and the detailed project proposals defined in [AGR/CA/APM(2001)26] presented in the 30th session of the APM in November 2001. It contains a study of the non-price effects of the CAP arable crop regime, based on data from FADN.

This paper was first discussed at the Working Party on Agricultural Policies and Markets of the Committee for Agriculture held on 21-23 May 2002 and the Technical Meeting on Decoupling that took place on the 21st May, just prior to that APM. It was revised subsequently and declassified by the Working Party on Agricultural Policies and Markets of the Committee for Agriculture at their meeting held on 31 March to 2 April 2003.

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NON-PRICE EFFECTS OF THE CAP ARABLE CROP REGIME: RESULTS FROM A FADN SAMPLE

1. Introduction

The conceptual framework of this paper is based on the OECD paper on decoupling (OECD, 2001), which reviews the scientific literature on both the theoretical definition of decoupling and on its empirical measure. It tries to broaden the concept of decoupling, covering a wide range of mechanisms through which policies affect production and trade, which are sometimes neglected in the literature. Among these mechanisms, risk is potentially important.

Hennessy (1998) developed a comprehensive neo-classical framework for the analysis of agricultural income support policies under price uncertainty, analysing the behaviour of a competitive firm which maximises the expected utility of profit. Assuming farmers are risk averse, he defines two kinds of effects that would not arise in a certain world. These effects under uncertainty are additional to the standard *relative price effect* of policies under certainty, and are defined as:

a) *Wealth effect*. If the policy affects the total wealth of the farmer, this change in wealth may affect the farmers' response to risk. The way in which wealth affects production decisions depends on individual risk preferences. If one assumes *Decreasing Absolute Risk Aversion (DARA)*, a common approach in modelling risk that assumes people are more willing to take on risk as their wealth increases, it is easy to show that wealth-enhancing policies would generate additional incentives to produce.

b) *Insurance Effect*. If the policy reduces the degree of risk faced by the farmer, this will have a positive effect on production. It can be shown that a government scheme that increases payments when prices fall and reduces payments when prices rise will increase production if there is partial income compensation for the price movements.

It is on this theoretical basis, that this paper seeks to provide an empirical measure of the (absolute and relative) size of these three effects (the relative price effect, the wealth effect and the insurance effect) for a specific policy package: the arable crop regime of the Common Agricultural Policy (CAP) of the European Union (EU).

In recent years, some comprehensive attempts at modelling the effects of the CAP arable crop regime have been made available (Oude Lansink and Peerlings, 1996; Guyomard *et al*., 1996; Moro and Sckokai, 1999). All of these studies have tried to take into account the partially "decoupled" nature of the compensatory payments introduced in 1992, typically modelling the land allocation mechanisms. However, one of the most important characteristics of these analyses is the assumption of risk neutrality, a common hypothesis in most studies based on applied duality theory, which does not allow the authors to explicitly take into account the impact of farmers' attitudes to risk.

Recently, Coyle (1992 and 1999) has proposed an extension of duality models applied to agricultural production in order to incorporate both price and output uncertainty, assuming mean-variance risk preferences. This framework, although limited to the price uncertainty component under *Constant Absolute Risk Aversion (CARA)*, has been recently applied by Oude Lansink (1999) to analyse the land allocation decisions of Dutch arable crop farms, but this study does not tackle directly the specific issues raised by the MacSharry package, since the model is estimated using data that refer to the pre-reform period.

In this paper, the model by Moro and Sckokai (1999) is extended in order to account for the price uncertainty faced by EU arable crop producers, adapting the framework proposed by Coyle (1992 and 1999) to their specific decision-making structure. This model allows the relevant elasticities of output, variable input demands and land allocations with respect to all the exogenous variables to be derived, taking into account the impact of farmers' attitudes to risk. Thus, the model represents a significant improvement with respect to the measures of the relative price effect, wealth effect and insurance effect of agricultural policies available in the literature. In fact, the dual approach implies a representation of the agricultural technology which is more flexible than in Hennessy (1998) and Mullen *et al.* (2001). Further, parameters are estimated on a large number of individual farm observations, an important consideration in analysing risk preferences. This is in contrast to calibration on a single farm observation (Hennessy, 1998) or on average regional data (Mullen *et al.*, 2001). This large number of individual observations will allow the verification of the statistical properties of the results.

For the empirical application, a normalised quadratic expected utility function will be estimated, applied to a sample of specialised arable crop farms from the Italian Farm Accounting Data Network (FADN)[1]. In order to investigate the behaviour of different group of farmers, the analysis will be carried out for three different sub-samples, distinguished by size. There are several reasons for this: the first, and most obvious given the objective of this paper, is that farmers managing farms of different size are likely to display different risk preferences; the second is that, among specialised arable crop farms, the production technology may change significantly as size changes.[2]

2. Policy background

The 1992 and 1999 reforms of the CAP represent a major shift in the way the EU provides income support to farmers. This is especially true for arable crops (cereals, oilseeds and protein crops), since, after the recent reforms, guaranteed prices for cereals have been reduced more or less to world price levels, while income support is provided through per-hectare payments. At present, the three basic policy tools of the arable crop regime are:

(a) The *intervention price* for cereals, not in place for oilseeds and protein crops. This price, regardless the significant reduction since the early 1990s, continues to act as an effective minimum price through the management of public cereal stocks.

(b) The *per hectare payments*, based on yearly acreage declarations and computed by multiplying a basic per tonne amount by an historical regional yield for the 1986-91 period. The details of the regionalisation scheme, including definitions of the regions for which the reference yield is calculated, are managed by each member state subject to approval by the EU Commission. These

1. Clearly, since the empirical application is carried out on the Italian FADN data, our results cannot be generalised to the whole EU.

2. The main technological differences among farms of different size typically relate to capital endowment. In fact, while large farms normally own all the necessary equipment for field operations, including the most sophisticated machine, small farms tend to rely on rented equipment, provided by specialised firms that execute most field operations. This clearly entails a drastically different cost structure, especially in terms of the proportion of variable versus fixed costs.

payments are crop specific for large farmers ("professional producer" scheme) while they are non-crop specific for small farmers ("small producer" scheme).

(c) The *compulsory set-aside*, relevant only for large "professional producers". Professional producers are obliged to take out of production a fixed percentage of land allocated to program crops. This set aside percentage is established every year by the EU Commission and is related to anticipated market conditions.

The above policy set-up was established with the 1992 reform (the so-called MacSharry package). The recent Agenda 2000 reform has not changed the basic structure of the regime, but reduced intervention prices further and increased cereal area payments. Oilseeds payments will be progressively aligned with cereal payments, but the possibility of differentiating both maize payments and irrigated area payments has been maintained.

In this context, one can characterise the above three effects as follows:

(a) The *relative price/payment effect* comes from both the average expected prices and the per-hectare aids. In fact, *cereals expected prices* are influenced by the presence of both the intervention price and the related border measures (import tariffs, tariff rate quotas, …). This creates a truncated distribution for output price, affecting both the average expected prices, which turn out to be higher than the corresponding world market prices, and price variability. The supply inducing impact of the MacSharry compensatory payments under certainty stems from their "partially" decoupled nature — although current production plays no role in determining their level, they typically affect marginal production decisions through the land allocation mechanism.

(b) As outlined above, the *wealth effect* depends on individual risk preferences. If it is assumed that such preferences are not of the CARA (Constant Absolute Risk Aversion) type, the wealth effect comes from those policy tools that affect farm income and therefore farmer total wealth. In the CAP arable crop regime, income/wealth is potentially increased by both higher expected prices relative to world prices, and area payments. Under the DARA assumption, this implies a positive production response by farmers.

(c) The *insurance effect* is not directly embodied in the policy set-up, since payments are not price contingent[3]. However, a measure of the insurance effect can be inferred by simulating the impact of a package such as the recent Agenda 2000 reform. This can be done for the particular structure of farm earnings under the CAP arable crop regime. In fact, after the MacSharry reform, each producer has two distinct farm income sources: the "per hectare aid" component, a certain amount tied only to his/her land allocation decisions, and the "market" component, which has two possible sources of uncertainty, market prices and yields. This structure was supposed to favour farm income stabilisation, with part of the income guaranteed by the per-hectare payments. This was designed to compensate not only for revenue losses due to the intervention price reduction, but also for the increased price volatility caused by the progressive realignment of institutional prices to world levels. The Agenda 2000 reform has reduced intervention prices and granted an increase in

3. The only price contingent tool of the CAP arable crop regime is actually the set-aside percentage, which is established every year according to market conditions. This means that, when international prices are high, and consequently public stock levels tend to be low, the set-aside requirement is typically lower than under more difficult market conditions. However, because of the peculiar structure of the policy package, the impact of a lower set-aside requirement on farm payments is ambiguous, since, ceteris paribus, it relaxes the land constraint, thus allowing farmers to allocate more land to program crops, but cropped land receives a lower per hectare payment. In general, this means that the set-aside percentage may not act to mitigate risk, since payments may move in the same direction as expected prices.

area payments. This is intended to mitigate the incidence of the risky component of farm income by establishing a link between expected price reduction and the corresponding increase in price volatility, and the increase in government payments.

3. Method

3.1. The model

(d) The theoretical model is derived form non-linear mean-variance risk preferences. The optimisation programme defines optimal inputs use and allocation of land under per hectare payments and stochastic output prices. Input demand and output supply equations can be obtained extending results in Coyle (1999). These expressions and the empirical specification of the model are developed in Annex 1.

3.2. The data

The data used for the present study are taken from the Italian Farm Accounting Data Network (FADN) for the period 1993-99 (seven years). Thus, the data refer specifically to the period after the 1992 reform, but before Agenda 2000; this implies that the estimated parameters are specific for the MacSharry policy environment. The database contains more than 4 000 yearly observations for specialised crop farms (29 000 for the seven years), of which approximately 27% participate in the "professional producer" scheme (7 805 observations). The sample was restricted to this class of producers because full-time farmers' income may be more reasonably approximated by farm profit and "wealth" can be identified in farm assets. If the class of small producers were included, a large portion of part-time farmers would be found. The risk behaviour of small producers should be analysed taking into account their off-farm sources of income/wealth, for which the FADN does not provide any data[4]. Finally, the farms in the database are not included every year, so the panel is incomplete.

The database provides most of the variables needed to estimate the model defined in equation (9) in the Annex: crop production, livestock production, output prices, land allocations, capital asset values, family labour, hired labour (number of hours and hourly wages), variable input costs by category (seeds, fertilisers, chemicals, water, …). Variable input prices are not provided by the FADN; thus, regional input price indexes have been taken from the official statistics. Initial wealth has been approximated by the value of farm equity.

The data on per-hectare aids has been taken from the official regionalisation plans established each year by the Italian Ministry of Agriculture. These plans are very detailed, since reference yields are different for each province and, inside each province, for three different levels of altitude. Thus, in Italy we have 275 different levels of per-hectare aids, which implies significant cross-sectional variability. This is another reason why the analysis of individual farm data is particularly valuable, since such variability allows the farm response to the policy instruments to be identified precisely.

The initial data set is very disaggregated, especially in terms of number of outputs and number of variable inputs; thus, to make the estimation feasible, aggregates are required. Five output categories have been defined. These are maize, other cereals, durum wheat, oilseeds and other field crops, each with their

4. The exclusion of the off-farm sources of income/wealth from our analysis is of course a potential source of bias for all farms, even if they are managed by full-time farmers. For this reason, our results concerning risk preferences should be interpreted with some caution.

respective land allocations; the first four of these represent those crops for which the CAP reform guarantees different levels of per-hectare aids[5]. Two variable inputs (seeds and chemicals and other inputs) and five quasi-fixed inputs (capital, total land, family labour, set-aside percentage, and a technological trend) have also been generated. It was decided to incorporate hired labour in the aggregate "other inputs" to avoid problems of corner solutions for inputs, since less than 50% of farms in the sample utilise it. The price of "other inputs" is the numeraire in the normalised quadratic specification. The aggregates have been generated as Divisia indexes, while short run profit has been calculated as the sum of total gross sales and total CAP aids minus total variable costs[6].

After this aggregation, the original "professional producers" FADN sample was further reduced through the elimination of those farms that presented some "severe outliers" in the key variables needed for the estimation: output quantities, land allocations and output prices.7 The final sample includes 6858 observations, that, as mentioned in the introduction, have been split into three sub-samples according to farms size: less than 20 hectares (2 505 observations), between 20 and 40 (2 137 observations.) and more than 40 (2 216 observations)8.

However, before carrying any estimation, three important problems must to be dealt with: the construction of expected prices and their covariance matrix, the presence of corner solutions for some outputs and the incompleteness of the panel in the database. The technical details on these issues are presented in Annex 1.

3.3 Simulations

Given the model set up, the estimation output provides an immediate framework for analysing the three types of effects of a policy change. In fact, the elasticity matrix provides the following:

(a) The *wealth effect* as the change in output due to a change in initial wealth, controlling all the other variables.

(b) The *insurance effect* as the change in output due to a change in one or more elements of the variance-covariance matrix of output prices, controlling all the other variables.

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5. Protein crops play a marginal role in this sample, thus they have not been considered in the analysis.

6. Given the different variance of our observations, we need to account for heteroscedasticity. In our estimation procedure, we have calculated the standard errors of the parameter estimates using a heteroscedastic-consistent variance-covariance matrix, as computed by the econometric software TSP 4.5.

7. For prices, we have considered as "severe outliers" those data falling out of the range defined by the sample mean and five standard deviations. For land allocations and output quantities, we have computed crop yields and we have considered as "severe outliers" those data falling out of some "reasonable" agronomic range. The general idea of this procedure is to eliminate those observations that are likely to come from some errors in plugging in the basic data, or from some exceptional events, like a weather disaster.

8. This subdivision, which is based on total farm land available for agricultural uses, is totally arbitrary, since our objective was just to obtain three samples of approximately the same size. However, estimating the same model over the whole sample and using dummy variables to identify these same three categories of farms, the null hypothesis that the CRRA coefficient and some other key parameters could be the same for all farms was strongly rejected.

(c) The *relative price/payment effect* as the change in output due to a change in expected output prices and/or area payments and/or the set-aside percentage, controlling all the other variables. This allows the impact of the three main policy tools to be evaluated separately.

The above approach may be misleading, since we are not considering a concrete policy package, but a simple change in one exogenous variable, while the CAP actually affects all these variables at the same time, through a change in its basic policy tools (intervention prices, area payments, set-aside percentage). Thus, an alternative approach is to simulate the impact of an Agenda 2000-type of shock, with a decrease in cereal intervention prices partially compensated by an increase in cereal area payments9, assuming that the estimated parameters/elasticities are still valid under the new policy environment. This hypothesis seems quite reasonable, given that the recent reform did not change the structure of the policy package, only changing the level of the instruments.

In practice, the three models were shocked with a 5% reduction in cereal intervention prices, and the expected prices and the expected elements of the variance-covariance matrix were recalculated given this lower truncation level of the price distribution.[10] Partial farm income compensation is provided through a proportional increase in cereal payments comprising 50% of the computed reduction in the means of the expected price distributions. Under this scenario, the following has been derived:

(a) The *total effect* of the reform, shocking the three models with all the changes at the same time (expected prices, area payments, expected elements of the variance-covariance matrix, final expected profit and final expected wealth).

(b) The *insurance effect*, shocking the three models with the changes in price variability only, controlling for both the level of wealth and the level of prices and payments.

(c) The *relative price effect*, shocking the three models with the changes in prices and payments only, controlling for both the level of wealth and the level of price variability.

(d) The *wealth effect*, shocking the model with the changes in wealth only, controlling for all the other variables.

In addition, in order to compare some of the results obtained from our three samples with the simulations carried out in some related studies being done as part of the same OECD project, we computed the “Total production ratios” as defined in OECD (2002)[11]. In our application, these ratios measure the degree of “coupling” with respect to production of the CAP payments for arable crops, under the assumption of DARA risk preferences. In practice, the denominator of the ratio is calculated shocking the model with a 1% increase in expected prices and computing the corresponding increase in production (which of course depends also on the impact of this change on price variability), while the numerator is

9. As is well known, the actual Agenda 2000 package was much more complex, since it involved, for example, the realignment of oilseed payments. However, in this exercise, we are not interested in simulating the impact of the reform, while we just wish to analyse the size of the relative price, insurance and wealth effects with a policy change that involves all of them.

10. The impact on expected prices and its expected variability is simply recomputed through the Chavas and Holt (1990) procedure, which means that farmers adjust their expectations evaluating the past relationships between minimum prices and actual market prices. Of course, this cannot be interpreted as a true market impact of the intervention price reduction, since this depends on market equilibrium and, for example, on the level of public stocks.

11. The Total production ratios are defined as the ratio of the impact on production per dollar of support of a given PSE category (payment based on output, payments based on area, payments based on historical entitlements,..) to the impact per dollar of market price support, given in the form of a single ad valorem non prohibitive tariff.

computed as the increase in production obtained shocking the model with the same total support, given on a per hectare basis. These simulations have been carried out for all crops in the three models.

4. Results and discussion

4.1. Risk aversion coefficients and elasticities

For space reasons, the full estimation results of our two-stage systems are not reported.[12] However, the three sets of first stage probit models present a strong goodness of fit: the fraction of correct predictions ranges, for all three samples, from 65 to 87% and at least 75% of the parameters are statistically significant at the 5% level. The single-equation R^2*'s* of the estimated systems are not entirely satisfactory, since they range, in all three samples, from 20 to 50%, but this is a common result when dealing with farm data. However, it is remarkable that, in each system, more than 50% of the estimated parameters are significant, with a maximum of 60% for medium farms.

The first set of results concerns risk preferences. In all three samples, the Wald test that all variance and covariance coefficients are jointly equal to zero rejects the null hypothesis of risk neutrality. The estimated CRRA coefficients (reported in Table 1) show that, for all farms, we can confirm the hypothesis of risk averse behaviour, even though there are important differences among the three samples. In fact, small farms turn out to be the most risk averse, with α_R being equal to 3.29, while the degree of (relative) risk aversion decreases with size: for medium farms α_R becomes lower than 1 (0.72) and for large farms it becomes virtually 0, since the estimated 0.06 value is not statistically significant This type of behaviour seems reasonable, since, given the definition of CRRA, we can certainly assume that, for a one percent change in wealth, its marginal utility decreases more rapidly at lower levels of wealth (small farms) than at higher levels (large farms); this simply means that wealthier farmers are more willing to take on risk. Moreover, for the same level of initial wealth, larger farms have a more favourable cost structure, which, on average, make them more willing to take on risk.

In Tables A1-A3 price and payment elasticities at the mean point are reported for the three samples. The statistical quality of these results is very good for medium and large farms, where almost 100% of the elasticities are significant, while for small farms this percentage reduces to 65%. These values tend to confirm some of the results obtained by Moro and Sckokai (1999) under the hypothesis of risk neutrality.

The signs of own-price elasticities are always consistent with theory, since convexity was imposed by means of the “Cholesky decomposition”. In all samples, durum wheat supply turns out to be elastic, while the other crops show inelastic supply[13]. However, the most interesting results are those relating to elasticities involving the CAP area payments and the land allocation functions.

In all three samples, the supply of all arable crops shows a positive and significant response to own-payments which is normally inelastic. This clearly implies a likely incentive to production, and shows once again that the CAP reform tools are not fully decoupled. However, the payment responsiveness is always lower than the corresponding price responsiveness, and this may be due to the fact that production is influenced mainly indirectly by the aids, through land allocation decisions. Finally, most cross-

12. Detailed estimation results are available from the author.

13. In the small farms sample, oilseeds also had a very elastic response to both the “own price” and the “own compensatory payment”, but these strange results are probably due to the very limited number of observations concerning oilseeds

elasticities with respect to compensatory payments are negative and significant, showing some important substitution effects.

Table 1. Estimated relative risk aversion coefficients*

Small farms (<20 ha)	3.292
	(0.884)
Medium farms (20-40 ha)	0.716
	(0.197)
Large farms (>40 ha)	0.059
	(0.434)

*asymptotic standard errors in parenthesis

Similar considerations arise from the analysis of the elasticities of land allocations. In all three samples, they are strongly responsive to prices of their respective crops and they are positively influenced by the area payments. It is interesting to note that, in general, land allocation elasticities with respect to compensatory payments are smaller than the corresponding supply elasticities, which implies that payments generate some incentives to increase yields. This results contradicts those in Moro and Sckokai (1999) who found the opposite behaviour under risk neutrality. A possible interpretation of these results is that, when we take into account risk effects, the increase in a typical non-risky element of the producer objective function (the area payment) may stimulate farmers to adopt some more costly intensive techniques.

Tables A4-A6 reports elasticities with respect to the risk related explanatory variables: expected output price variances and covariances[14], and initial wealth. In this case, the proportion of significant elasticities is higher for medium farms (around 55%) and lower for small and large farms (around 45%). However, these results demonstrate that these variables are important in explaining farmers' choices.

As one can expect, the output response to wealth is always positive, since farmers' risk preferences are of the DARA type. The size of these elasticities tends to be larger for medium and large farms as compared to small farms. This seems to suggest that, in explaining the wealth effects, what matters is the absolute change in wealth, which, for the same percentage change, is clearly larger for medium and large farms. However, these elasticities are always low and consequently, as will be seen in the next paragraph, the impact of the wealth effect of a policy change turns out to be very small, given that the change in profit is normally negligible as compared to farmers' wealth.

The signs of variance and covariance elasticities are mostly consistent with the expectations, since, for example, most output and land allocation own-variance elasticities are negative, and most covariance elasticities are very low in value. However, in a multi-output framework, one has to judge the impact of price volatility on output as the impact of the whole variance-covariance matrix. As will be seen, this global impact can actually be very important.

14. Variance and covariance elasticities represent the percentage change in the dependent variable (output, input, land allocation) given a 1% change in output price variances or covariances. Thus, for example, one expects that, under risk aversion, a 1% increase in the own output price variance (which means higher price volatility) should generate a decrease in the corresponding output.

4.2. Risk effects and production ratios

The key results of this paper are reported in Table 2, where results of a simulated 5% decrease in cereal intervention prices (for maize, durum wheat and other cereals), partially compensated by an increase in area payments, are shown for all three samples[15]. The relative price and payment effects are presented separately, distinguishing the own-price/payment and the cross price/payment components.

In all samples, the impact of the simulated policy change leads to a small decrease in average profit as the increase in area payments does not offset the decrease in expected prices. A small increase in wealth variability is also seen, since the risk-reducing effect of area payments, which are not stochastic, is offset by the increase in price volatility. In fact, all expected price variances and covariances increase, because of the reduced minimum prices, an important element affecting output choices.

In all three samples, the policy change generates a significant decrease in maize output, that, for small and medium farms, is basically the result of the insurance effect (higher price variability reduces output), while for large farms there is also a significant contribution of the relative price effect. The own-price and own-payment effects have the expected behaviour: the first is negative, while the second is positive and smaller than the first, since supply is typically less responsive to payments than to prices. What changes from one case to another is the sign and the size of the cross-effects. The cross-price effect is negative for small farms, thus reinforcing the own-price effect, while it is positive for medium and large farms, even though, given its small size, it does not change the sign of the total price effect. The cross-payment effect shows the same qualitative behaviour, since for small farms it reinforces the positive effect of own-payment, while for medium and large farms it has the opposite sign; however, in this case the size of the cross-payment effect is relatively larger, such that the sign of the total payment effect is reversed. The wealth effect is negative, as expected with a decrease in final wealth under DARA, but also very small (the order of magnitude is 10^{-4}), since the average increase in profit only marginally affects the level of total wealth.

15. Simulations could be carried out also for different years, and, of course, results would be sensitive to the market situation, especially to the relative position of the average market prices with respect to the intervention prices, which clearly affects the impact of a policy change on the expected price distribution. However, the fact that our farm samples are an unbalanced panel makes comparability among different years very difficult, since the means computed in Table 2 are strongly influenced by differences in the composition of the sample. Thus, we have chosen to examine the 1999 results because, having computed expected output prices and their corresponding expected variance-covariance matrix using the methodology illustrated in equations (10)-(12), the use of the observations in the last year of the sample guarantees a longer history of output prices and makes the expectations of farmers more accurate.

Table 2. Output impact of policy simulations* for 1999 farms (means over the corresponding samples)

	Baseline	Total effect	Relative price effect			Relative payment effect			Insurance effect	Wealth effect
			Own-price	Cross-price	Total	Own-paym.	Cross-paym.	Total		
Small farms (<20 ha)										
Maize (t)	25.484	-3.057	-0.078	-0.027	-0.105	0.011	0.019	0.030	-2.981	0.000
% change		-12.00%	-0.31%	-0.11%	-0.41%	0.04%	0.07%	0.12%	-11.70%	0.00%
Durum wheat (t)	6.281	-0.018	-0.020	-0.050	-0.070	0.015	0.007	0.023	0.029	0.000
% change		-0.29%	-0.32%	-0.79%	-1.11%	0.24%	0.12%	0.36%	0.46%	0.00%
Other cereals (t)	7.071	0.189	0.000	0.007	0.007	0.000	-0.002	-0.002	0.184	0.000
% change		2.67%	0.00%	0.10%	0.10%	0.00%	-0.03%	-0.03%	2.60%	0.00%
Oilseeds (constant €)	1637.633	72.529	0.000	27.214	27.214	0.000	-8.052	-8.052	53.379	-0.010
% change		4.43%	0.00%	1.66%	1.66%	0.00%	-0.49%	-0.49%	3.26%	0.00%
Medium farms (20-40 ha)										
Maize (t)	73.012	-1.147	-0.038	0.028	-0.010	0.011	-0.030	-0.019	-1.118	0.000
% change		-1.57%	-0.05%	0.04%	-0.01%	0.01%	-0.04%	-0.03%	-1.53%	0.00%
Durum wheat (t)	15.390	0.496	-0.069	0.079	0.010	0.077	-0.031	0.046	0.440	0.000
% change		3.22%	-0.45%	0.51%	0.06%	0.50%	-0.20%	0.30%	2.86%	0.00%
Other cereals (t)	15.791	-0.108	-0.007	0.001	-0.007	0.005	-0.024	-0.018	-0.083	0.000
% change		-0.68%	-0.05%	0.01%	-0.04%	0.03%	-0.15%	-0.12%	-0.53%	0.00%
Oilseeds (constant €)	1918.762	-68.375	0.000	-1.597	-1.597	0.000	-3.913	-3.913	-62.864	0.000
% change		-3.56%	0.00%	-0.08%	-0.08%	0.00%	-0.20%	-0.20%	-3.28%	0.00%
Large farms (>40 ha)										
Maize (t)	136.873	-1.943	-1.067	0.184	-0.882	0.166	-0.251	-0.085	-0.976	0.000
% change		-1.42%	-0.78%	0.13%	-0.64%	0.12%	-0.18%	-0.06%	-0.71%	0.00%
Durum wheat (t)	59.053	1.565	-0.192	0.797	0.605	0.225	-0.133	0.093	0.867	0.000
% change		2.65%	-0.32%	1.35%	1.02%	0.38%	-0.22%	0.16%	1.47%	0.00%
Other cereals (t)	38.959	-1.457	-0.013	-0.135	-0.148	0.004	-0.022	-0.018	-1.291	0.000
% change		-3.74%	-0.03%	-0.35%	-0.38%	0.01%	-0.06%	-0.05%	-3.31%	0.00%
Oilseeds (constant €)	5251.760	13.657	0.000	-21.736	-21.736	0.000	-2.460	-2.460	37.854	-0.001
% change		0.26%	0.00%	-0.41%	-0.41%	0.00%	-0.05%	-0.05%	0.72%	0.00%

***** We assume a decrease in cereal intervention prices partially compensated by an increase in cereal area payments.

For medium and large farms, most qualitative results are similar for "other cereals". The size of the negative total effect is again determined by the insurance effect, which is, however, much smaller than in the case of maize. Own-price and own-payment effects have the expected behaviour, but the cross-payment effects are stronger, thus reversing the sign of the total payment effect; wealth effect are again negative and very small. Since both crops experience the same proportional variations in the two policy instruments (intervention price and payments), this different behaviour is due to the different responsiveness of the two supply equations to all the exogenous variables, and to the output/land allocation substitution generated by the cross effects.

Referring again to medium and large farms, the results for durum wheat follow the same pattern for both the price/payment effects and the wealth effect: the only difference is that the cross effects are stronger in the case of price response, while they are smaller for the payment response, thus generating a reverse sign for the former and not for the latter. However, the most important difference concerns the insurance effect, whose sign is positive regardless the increase in price variability. This seems somewhat counterintuitive, but in interpreting these results one has to bear in mind that cross effects may be important not just for relative prices/payments, but also for relative price variability. Thus, to reduce risks associated with increased price variability, the farmers may tend to plant more of one crop, according to the sign of price covariances and to the size of the corresponding elasticities.

For these last two crops (other cereals and durum wheat), small farms display the opposite behaviour with respect to medium and large farms. However, these results are based on some parameters that are not statistically significant, and for this reason they should be interpreted with caution. The results for oilseeds are due to the cross effects only, thus the sign of both the relative price and payment effects are opposite with respect to those of the other crops. Once again, the sign and the size of the total effects are determined by the insurance effect, which is positive for small and large farms, and negative for medium farms. These different results are only due to the impact of increased cereal price variability on covariances, since oilseeds price variability does not change in this experiment.

In general, we can certainly assert that the magnitude of all the effects tend to decrease as the size of farms increases, even though there are important exceptions, since, for example, large farms tend to show stronger relative price effects. However, the most interesting element of the whole analysis is that, with a policy change that decreases guaranteed minimum prices and increases direct payments, the size and the direction of the total supply effect is mainly determined by the insurance effect.

Table 3 reports the computed average production ratios for all arable crops in the three samples, where we assumed an equivalent increase in support given in the form of a price increase and, alternatively, in the form of an area payment. Since crop supplies are normally more responsive to prices than to payments, we expect average ratios lower than one, given that under DARA the impact of an increase in guaranteed prices is also reinforced by the decrease in expected price variability. These expectations are confirmed in nine cases out of twelve, but in three cases we get average ratios greater than one. The reason of these apparently counterintuitive results is that, in some cases, the shock applied results in a very strong percentage increase in payments, which generates an output effect stronger than the corresponding price increase. Another remarkable feature of these ratios is their large standard deviations, which basically reflects the strong yield variability that characterises all three samples. In fact, equivalence (in terms of the increase in support applied) tends to generate very strong percentage increase in payments for high yield producers, and a related strong payment impact on output, while for low-yield producers the outcome is the opposite.

Table 3. Computed average production ratios under DARA[a]

	Maize[b]	Durum wheat[b]	Other cereals[b]	Oilseeds[b]
Small farms (<=20 ha)	0.832	0.569	0.454	0.573
	(1.596)	(1.770)	(1.114)	(1.172)
Medium farms (20-40 ha)	1.638	1.144	0.828	0.636
	(1.967)	(1.969)	(1.323)	(1.665)
Large farms (>40 ha)	1.017	0.874	0.960	0.952
	(0.797)	(1.926)	(2.190)	(1.834)

[a] We compute the ratio between the production impacts of the same amount of support given in the form of per hectare payments or in the form of a 1% increase in price support
[b] Standard deviations in parenthesis

5. Concluding remarks

An empirical evaluation of the absolute and relative size of risk-related effects of a farm policy change has been made in this paper, with specific reference to the CAP arable crop regime. The work is based on the theoretical framework developed by Hennessy (1998), who defined three distinct effects that would arise in expected utility maximisation under the hypothesis that farmers are risk averse: the relative price effect, the wealth effect and the insurance effect.

To do this, the model by Moro and Sckokai (1999) has been extended in order to account for the price uncertainty faced by EU arable crop producers, adapting the dual empirical framework proposed by Coyle (1992 and 1999) to their specific decision-making structure. A normalised quadratic system of output supply, input demand and land allocation equations has been estimated on three samples of Italian specialised arable crop farms, distinguished by farm size. Once the relevant elasticities were derived with respect to all the exogenous variables (expected prices, compensatory payments, initial wealth, expected elements of the variance-covariance matrix of output prices, fixed inputs), the impact of an Agenda 2000-type of shock was considered, simulating a decrease in cereal intervention prices and an increase in cereal area payments.

Having rejected the null hypothesis of risk neutral behaviour, the Constant Relative Risk Aversion (CRRA) coefficient has been estimated directly for all the three samples. The results show that farmers are risk averse and that the degree of relative risk aversion tend to decrease with farm size, thus confirming some *a priori* expectations.

The price/payment elasticity estimates tend to confirm most of the results obtained by Moro and Sckokai (1999) under the hypothesis of risk neutrality, where the main policy implication is the “partially decoupled” nature of the CAP arable crop payments, whose supply effect is mainly driven by the land allocation mechanism.

The results concerning the risk-related effects seem to confirm the evidence available in the literature. As in Hennessy (1998) and Mullen *et al.* (2001), estimates here confirm that, under DARA, the size and the direction of the total effect of a policy change that decreases guaranteed minimum prices and increases direct payments, thus generating relative price and payment effects that tend to offset each other, is mainly determined by the insurance effect. Since these results are derived from a more flexible representation of agricultural technology, the parameters are estimated on a large number of individual farm observations and their statistical significance is quite satisfactory, this general result seems quite robust.

This means that, for a partially decoupled policy like the CAP arable crop regime, it is not sufficient to study its effect in a risk neutral framework. The impact of risk related effects can be significant, especially through the insurance effect. On the other hand, the size of the wealth effect, as one might expect, is always very small.

The other important result of this study relates to the impact of cross-crop effects. Results show that cross effects can be important not just for relative price/payments, but also for relative expected output variances/covariances. For example, while all cereals in the sample experience the same proportional reduction of intervention prices and the same increase in area payments, the increased price variability reduces output of maize and "other cereals", but increases durum wheat since, given the pattern of change in the variance-covariance matrix, this crop becomes more attractive for risk averse farmers.

Finally, we have computed total production ratios in order to measure the degree of "coupling" of the CAP payments for arable crops, under the assumption of DARA risk preferences (OECD, 2002). In most, but not all, cases, we obtained ratios lower than one and, in all cases, very strong variability among farms. This is because the same amount of support given via two different PSE forms (price support or area payments), may generate, in some cases, very large percentage increases in payments, especially for high yield producers. Thus, even though, in general, we can certainly conclude that CAP area payments are less "coupled" than market price support, one has to bear in mind that, using this type of indicators at the individual level, there may be very strong deviations from what we assume is the average behaviour of a given policy instrument.

Box 1. Summary of the main results and implications

The variability of risk preferences: the estimated risk aversion coefficient presented in Table 1 show that farmers are risk averse and that the degree of relative risk aversion tends to decrease with farms sizes. This confirms our expectations, since it seems reasonable that, on average, wealthier farmers (large farms) are more willing to take on risk. Morevoer, for a given level of individual wealth, larger farms tend to have a more favourable cost structure, which, on average, make them more willing to take on risk.

The production impact of CAP area payments: The results of the present study confirm empirically the most common interpretation of the nature of the CAP arable crop payments. In the literature, they are often labelled as "partially decoupled" policy tools, since although current production plays no role in determining their level, the fact that they are crop-specific and provided only for some commodities does affect acreage decisions by farmers. This is typically by promoting the allocation of land to those crops that guarantee higher per hectare aids. Results in Tables A1-A3 confirm this claim, since significantly positive payment elasticities both for crop supply and for land allocations have been obtained. This supports the hypothesis that area payments do affect supply through the land allocation mechanism.

The production impact of the whole arable crop regime: The elasticity matrices in tables A1-A3 and A4-A6, which are estimated over the period of application of the MacSharry reform (1993-99), allow a general picture of the impact of the 1992 package to be drawn. As mentioned above, one of the main results is the positive output impact of the area payments, affecting supply through the land allocation mechanism. Though this result could be derived even in a risk neutral framework, the additional contribution of this paper is that the estimation takes into account the impact of farmers' risk aversion. This feature is important for a number of reasons:

a) The response to a change in market prices and/or a change in area payments is calculated more accurately. This is because the analysis includes the risk effects of the increased price volatility introduced by the 1992 reform and the reduced income variability related to the area payments.

b) The elasticities in Tables A4-A6, not calculable in a risk neutral framework, allow farmers' response to changes in price variability to be specifically measured. This variability was clearly increased by the MacSharry package and by the following WTO agreement.

c) Elasticities with respect to initial wealth, shown in the last column in Tables A4-A6, allow farmers' response to changes in their total "wealth" (the sum of farm assets and annual farm income) to be measured. This response affects their willingness to take risk, since we assume that as farmers get richer, they become more willing to take on risk.

The importance of insurance and wealth effects: Results in Table 2 show how the supply impact of policy change that affects farmers risk behaviour can be decomposed into its various components. For example, if one considers results for "maize", it is clear that, the output impact of the policy change is determined by the impact on risk, and, more specifically, by the "insurance effect", the impact of a policy change on price volatility. This is generally true for all crops, where the sign and the magnitude of the output change depends on the insurance effect. Conversely, as one can expect, the "wealth effect", the incentive to produce more because an increase in wealth makes the farmer more willing to take risk, is normally very small. This is because, for most policy changes, the size of the change in annual profits is normally negligible as compared to farmers' wealth.

The importance of cross effects. Another important result of this study concerns the relevance of cross effects. Since estimation is carried out in a multi-output framework, the impact of a policy change can be evaluated taking into account cross-crop relationships. Some of them are well known, and could be estimated even in a risk neutral framework. For example, in Table 2 the total relative price and relative payment effects can be decomposed into their own and cross components. Thus, one can appreciate that, in some cases, cross effects have the same sign as own effects and tend to reinforce them, while in other cases the sign is the opposite and, if the size of cross effects is large enough, they can reverse the sign of the total price/payment effect. The additional contribution of this study relates to the cross effects that arise under risk aversion. For example, results for durum wheat in Table 1 are somewhat counterintuitive, since a positive insurance effect is seen, even though farmers experience an increase in price variability. This is mainly a results of cross effects related to price variability, because, in a multi-output framework, risk averse farmers tend to protect themselves by planting more of the crop with the lower expected relative price variability, such as durum wheat.

The variability of production ratios; The production ratios computed in Table 3, while confirming that CAP arable crop payments tend to be less "coupled" than market price support, since in most cases the ratios are lower than one, show also a very high variability. This is because the same amount of support given in two different ways (price support or area payments), may generate, in some cases, very strong percentage increase in payments, especially for high yield producers, which may generate very strong incentives to increase output.

ANNEX 1.

1. The theoretical model

Farmer's risk preferences can be specified in terms of the following utility function *U(.)* under non-linear mean-variance risk preference (the well known "certainty equivalent" representation of the utility function):

$$(1) \qquad U = \overline{W} - \alpha(\overline{W}, \sigma_W^2)\sigma_W^2 \ / \ 2$$

where $\overline{W}$ is expected final wealth, which is the sum of non random initial wealth W_0 and random profit π, σ^2_W is the variance of wealth and $\alpha(.)$ is the (non constant) Arrow-Pratt coefficient of absolute risk aversion[1].

The utility function in (1) may take many different specifications, depending on which variables are assumed to be stochastic (prices, yields or both) and on the structure of risk preferences. These assumptions are very important, both for the theoretical set-up of the model and its empirical estimation, since they affect the properties of the dual utility function, and may imply different parametric restrictions (see, among others, Pope, 1988; Pope and Just, 1991; Appelbaum and Ullah, 1997; Coyle, 1999).

In this paper, in order to derive the results discussed in the previous sections, consideration will be restricted to *price uncertainty only*, since the policy set-up has nothing to do with yield variability, and *Constant Relative Risk Aversion (CRRA)* preferences, a specific type of DARA preferences. Under CRRA, we can model $\alpha(.)$ simply as:

$$(2) \qquad \alpha = \alpha_R \ / \ \overline{W}$$

where α_R is the constant relative risk aversion coefficient; the specification in (2) clearly shows that, as wealth increase, the degree of risk aversion decreases.

Under the above set of assumptions concerning risk preferences, for any farmer participating in the "professional producer" scheme[2] of the CAP arable crop regime the dual expected utility function can be specified as follows:

1. The Arrow-Pratt coefficient of *absolute* risk aversion is defined as the negative ratio between the second derivative and the first derivative of expected utility with respect to wealth; the corresponding *relative* risk aversion coefficient is the negative elasticity of marginal utility with respect to wealth. If agents are risk averse, both coefficients are positive.

2. The expected utility function for farmers participating in the "small producer" scheme would be simpler, since area payments are not crop-specific.

$$U(p^e, w, V_p, z, s, r, W_0) \equiv$$

(3)
$$\max_{y,x,s_1,\ldots,s_n} \left\{ W_0 + p^e y - wx + \sum_{i=1}^{n_p} r_i s_i - \frac{\alpha_R}{2\left(W_0 + p^e y - wx + \sum_{i=1}^{n_p} r_i s_i\right)} y' V_p y \;\middle|\; \sum_{k=1}^{n} s_k = s \quad (y,x,z,s) \in T \right\}$$

where W_0 is initial wealth, y is the n-dimensional vector of farm outputs and p^e is the corresponding vector of expected output prices, x is the m-dimensional vector of variable inputs and w the corresponding vector of (non-random) prices, s_k*'s* are land allocations to the n crops with s being total farm land, $r_i = b_i + dc/(1-c)$ is the *effective* crop specific per hectare payment for each of the $n_p<n$ crops participating in the regime, including the set-aside compensation, b_i is the basic payment, d is the set-aside payment and c is the fixed set-aside percentage, V_p is the variance-covariance matrix of expected output prices, z the vector of quasi-fixed inputs in the short run and *T(.)* the multi-output short-run technology.

Extending Proposition 2 in Coyle (1999) to the specific CAP arable crop regime decision-making structure represented by (3), the above expected utility function carries the following properties:[3]

(a) under CRRA, the following homogeneity property holds:

(4)
$$U(\lambda W_0, \lambda p^e, \lambda w, \lambda r, \lambda^2 V_p, s, z, c) = \lambda U(W_0, p^e, w, r, V_p, s, z, c) \quad \lambda > 0$$

(b) assuming *U(.)* is differentiable, the following derivative properties hold[4]:

(5)
$$\begin{aligned} y_i(p^e, w, V_p, r, z, s, c, W_0) &= \ (\partial U(.)/\partial p_i^e)/(\partial U(.)/\partial W_0) \quad i = 1,\ldots,n \\ x_j(p^e, w, V_p, r, z, s, c, W_0) &= -(\partial U(.)/\partial w_j)/(\partial U(.)/\partial W_0) \quad j = 1,\ldots,m \\ s_i(p^e, w, V_p, r, z, s, c, W_0) &= \ (\partial U(.)/\partial r_i)/(\partial U(.)/\partial W_0) \quad i = 1,\ldots,n_p \end{aligned}$$

and

(6)
$$\partial U(.)/\partial W_0 = 1 + \frac{\alpha_R}{2(\overline{W})^2} y' V_p y$$

(c) under DARA, *U(.)* is quasiconvex in (p^e, w, r, W_0);

(d) if *U(.)* is weakly separable in the vector $g=(p^e,w,r)$, the standard symmetry and reciprocity properties hold:

3. Proofs of the properties are fairly straightforward and are available from the author.

4. Note that, given the derivative property, this model does not allow to specify land allocation functions for non program crops, except for the special case where we have only one excluded commodity, whose land allocation is defined by the total land constraint.

(7)

$$\partial^2 U(p^e, w, V_p, r, z, s, c, W_0) / \partial g_i \partial g_j \equiv \partial^2 U(p^e, w, V_p, r, z, s, c, W_0) / \partial g_j \partial g_i \qquad i, j = 1, \ldots, n + m + n_p$$

2. The empirical specification

The properties of the utility function outlined in the previous section allow the specification of a parametric form for output supply, input demand and land allocation functions for the crops involved in the new CAP regime. This can be done by choosing any flexible functional form among those suggested by the literature to approximate the dual utility function in (3).

The normalised quadratic function, originally proposed by Lau (1974) and largely applied to agricultural profit function estimation is used here. Among the properties of this functional form, it is valuable to recall that it has a Hessian of constants, such that the curvature properties can hold globally. Moreover, it allows negative realisation of profits, a possibility which cannot be exploited using forms where logarithmic transformations are required.

Choosing w_m as the numeraire, the normalised quadratic dual utility function takes the following general form:

(8) $$\overline{U} = a_0 + a'\overline{q} + \overline{q}' A \overline{q}$$

where $\overline{U} = U / w_m$, $\overline{q} = (p^e / w_m, w / w_m, V_p / w_m^2, r / w_m, z, s, c, W_0 / w_m)$ and the scalar a_0, the vector a and the matrix A are parameters to be estimated.

Using the derivative property in (5), output supply, input demand and land allocation equations can be written as:

(9)
$$y_i = \left(\beta_i + \sum_j \beta_{ij} \overline{q}_j\right) \Big/ \left(\alpha_k + \sum_j \alpha_{kj} \overline{q}_j\right) \quad i = 1, \ldots, n$$
$$x_h = -\left(\gamma_h + \sum_j \gamma_{hj} \overline{q}_j\right) \Big/ \left(\alpha_k + \sum_j \alpha_{kj} \overline{q}_j\right) \quad h = 1, \ldots, m$$
$$s_i = \left(\delta_i + \sum_j \delta_{ij} \overline{q}_j\right) \Big/ \left(\alpha_k + \sum_j \alpha_{kj} \overline{q}_j\right) \quad i = 1, \ldots, n_p$$

where α's, β's, γ's and δ's are appropriate elements of the above a vector and A matrix[5].

The specification of the vector $\overline{q}$ allows the homogeneity property in the form of equation (4) to be maintained, while symmetry and reciprocity can be imposed as $\alpha_{ij} = \alpha_{ji}$, $\beta_{ij} = \beta_{ji}$, $\gamma_{hj} = \gamma_{jh}$, $\delta_{ij} = \delta_{ji}$ only under the maintained hypothesis of weak separability of $U(.)$ in the vector $g=(p^e,w,r)$.

5. Note that, to make the system of equations in (9) empirically tractable, some normalisation is required. The easiest way to do so is to impose α_k=1.

3. Estimation techniques

Given the nature of the available data, before carrying out any estimation, three important problems must be dealt with:

(a) The evaluation of expected output prices and their expected variance-covariance matrix, where clearly a key role is played by the presence of guaranteed minimum prices.

(b) The presence of corner solutions for some outputs, since many farms in the sample do not produce some of the crops considered in our model.

(c) The incomplete panel dimension of our database.

Concerning the first problem, it was necessary to make an assumption on the formation of price expectations. The most common assumptions in this literature are either the adaptive expectation hypothesis (Chavas and Holt, 1990; Pope and Just, 1991), or the rational expectation hypothesis (Oude Lansink, 1999). Following Chavas and Holt (1990), the first alternative was selected, which assumes that, in each period, farmers update their “naive” expectations (prices in the previous period) based on the past history of the observed differences between actual prices and “naive” expected prices:

(10) $$E_{t-1}(p_{it}) = p_{i,t-1} + E_{t-1}(p_{it} - p_{i,t-1})$$

where the second term on the right hand side is approximated by the corresponding sample mean, which is updated in each period.

Clearly, since the panel is incomplete, individual lagged prices cannot be used to construct the series of expected prices. Thus, for each crop, annual average regional prices were calculated and these prices have been used to model the mechanism of price expectations.

Variances of expected output prices have been constructed following Chavas and Holt (1990), thus considering a weighted sum of the squared deviations of past prices from their expected values:

(11) $$Var(p_{it}) = \sum_{j=1}^{3} \omega_j \left[p_{i,t-j} - E_{t-j-1}(p_{i,t-j})\right]^2$$

where weights ω_i are 0.50, 0.33 and 0.17. Covariances have been constructed in a similar manner:

(12) $$Cov(p_{it}, p_{jt}) = \sum_{j=1}^{3} \omega_j \left[p_{i,t-j} - E_{t-j-1}(p_{i,t-j})\right]\left[p_{j,t-j} - E_{t-j-1}(p_{j,t-j})\right]$$

However, one has to consider that both expected cereal prices and the corresponding expected elements of the variance-covariance matrix are influenced by the presence of the intervention price for cereals, which truncates the price distribution at the minimum price level. The resulting truncation will tend to increase the average expected price and to decrease its expected variability. Assuming a multivariate normal distribution for expected output prices, to account for this truncation of expected prices, variances and covariances have been corrected following the procedure laid out in Chavas and Holt (1990).

Concerning the second problem, corner solutions arise because the choice of producing or not producing a given crop does not depend only on relative expected prices and their variability, or relative area payments, but rather on other structural characteristics of the farm such as environmental conditions, rotations, experience of the farmer, traditions, specific capital endowment, etc. These variables are difficult to incorporate in the simple model used here. This problem is quite important for our specific analysis, since the fraction of non-producing farms for the five outputs ranges from 40 to 65% for small and medium farms, and from 40 to 55% for large farms. To deal with corner solutions, the two-step estimation procedure recently proposed by Shonkwiler and Yen (1999) in the context of demand system analysis was used. Thus, for each sample, in the first stage five probit models have been estimated (one for each output equation) of the type:

(13) $$Pr_{it} = h_{it}\eta_i + v_{it} \qquad i = 1,....n$$

where Pr_{it} is the probability of producing crop i and h_{it} is a set of variables which explains this choice. At the second stage, the systems of equations in (9) incorporate the results of the probit models in the following way:

(14) $$k_{it} = \Phi(h_{it}\eta_i^*)\, f(\overline{q}_{it}, a_i) + \rho_i \Theta(h_{it}\eta_i^*)$$

where $k=(y,x,s)$, η_i^* are the estimated probit parameters, $\Phi(.)$ is the univariate standard normal cumulative distribution function estimated over probit results, $\Theta(.)$ is the corresponding estimated density function and ρ_i*'s* are extra parameters to be estimated[6].

For all the three samples, the above probit models were estimated using as explanatory variables the level of some quasi-fixed inputs (capital, family labour and land) and two sets of dummy variables representing geographical location (north, centre and south) and altitude (mountains, hills and plains). In each probit model 8 parameters, including a constant term, are estimated.

Finally, the incomplete panel dimension of the data had to be dealt with. Unfortunately, the non-linear nature of the model does not allow the use of standard panel data techniques like the so-called "fixed effects" (Davidson and MacKinnon, 1993), where farm heterogeneity is accounted by means of a farm-specific intercept. In order to avoid further complications in the model, panel data techniques have not been used. However, first stage probit estimates, which account for geographical location, altitude and farm endowment, satisfactorily approximate this specific aspect.

Equations in (9) define, for this specific application, a system of 11 simultaneous equations: an appropriate estimation method for this system is the maximum likelihood estimator, which guarantees, under the usual stochastic assumptions, consistency, asymptotic normality and asymptotic efficiency (Davidson and MacKinnon, 1993). However, these equations are highly non-linear in parameters and, in all the three samples, convergence of the estimator could not be achieved. Thus, following the suggestion by Coyle (1999), the common denominator of all equations (the parametric form of the marginal utility of initial wealth) was replaced by the result of the derivative property in (6). Unfortunately, this imposes a strong restriction on risk behaviour, since it forces the assumption of a common relative risk aversion coefficient α_R for all farms in each sample, which implies that, inside each sample, individual risk behaviour changes only because of different levels of wealth[7].

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6. In practice, in each equation of the second-step system in (14), each observation is weighted according to the estimated probability of each crop being produced by a specific farm; this allows us to use all the observations to estimate the system, including the *0's* corresponding to the corner solutions (see Shonkwiler and Yen, 1999, for details).

7. The relationships in (6) states that, under CRRA, the marginal utility of wealth can be computed, for each farm, simply as a function of some known variables (wealth, output quantities and output prices) and one

Each of the three systems of equations requires the estimation of 280 parameters. However, since the curvature conditions turned out to be violated for all the three samples, the systems were reestimated by means of the so-called "Cholesky decomposition"[8], which guarantees positive semidefiniteness of the coefficient submatrix that refers to the vector (p^e,w,r,W_0)[9]. The imposition of theory-based constraints is quite common in this type of studies (see for example Oude Lansink, 1999), especially when the estimation results are used for simulation purposes, since it guarantees that own-price supply effects and own-payment land allocation effects have the expected sign.

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parameter, the α_R coefficient. This parameter has to be estimated jointly with the other parameters of the system and, if one does not assume any further functional form for α_R, it turns out to be the same across all farms. This is one of the reason that led us to split the sample in three, in order to explore the differences in the α_R coefficient by size.

8. For a matrix A, a necessary and sufficient condition to be positive semidefinite is that it can be written as $A=T'T$, where $T\equiv[\tau_{ij}]$ is an upper triangular matrix. However, since the estimation of a model with curvature imposed commonly produces convergence problems, a semiflexible version of the model was estimated, adopting the technique proposed by Diewert and Wales (1988) and applied to demand analysis by Moschini (1998). In practice, the semiflexible model can be obtained by restricting the rank of the matrix $T'T$: if we want to restrict such matrix to a rank $K<(maximum\ rank)$, we just need to set to zero all the τ_{ij} elements for $i>K$ (that is to set to zero all the rows of T from $(K+1)$ to $(maximum\ rank)$).

9. It has to be noted that property (c) in paragraph 5 states that the expected utility function is quasiconvex in the vector (p^e,w,r,W_0). Adopting the above "Cholesky decomposition" we are actually imposing convexity, which is a slightly stricter condition.

Annex 2.

TABLES

Table A1. Price and payment elasticities computed at the mean point of the sample (small farms)*

	Prices						*Payments*			
	p_1	p_2	p_3	p_4	w_1	w_2	r_1	r_2	r_3	r_4
Maize (y_1)	0.399	0.333	-0.026	-0.578	0.199	0.186	0.085	0.163	-0.003	-0.294
	(0.093)	(0.046)	(0.041)	(0.079)	(0.026)	(0.037)	(0.022)	(0.030)	(0.011)	(0.048)
Durum wheat (y_2)	1.153	0.963	-0.075	-1.669	0.575	0.539	0.247	0.471	-0.010	-0.849
	(0.161)	(0.174)	(0.119)	(0.164)	(0.077)	(0.086)	(0.041)	(0.109)	(0.032)	(0.098)
Other cereals (y_3)	-0.095	-0.079	0.006	0.138	-0.047	-0.044	-0.020	-0.039	0.001	0.070
	(0.148)	(0.125)	(0.019)	(0.210)	(0.073)	(0.069)	(0.032)	(0.062)	(0.004)	(0.106)
Oilseeds (y_4)	-1.596	-1.333	0.104	2.309	-0.796	-0.745	-0.342	-0.652	0.014	1.175
	(0.218)	(0.131)	(0.159)	(0.222)	(0.108)	(0.133)	(0.056)	(0.099)	(0.043)	(0.129)
Seeds and chemicals (x1)	-0.477	-0.398	0.031	0.690	-0.238	-0.223	-0.102	-0.195	0.004	0.351
	(0.063)	(0.054)	(0.048)	(0.093)	(0.057)	(0.046)	(0.017)	(0.032)	(0.013)	(0.046)
Other inputs (x2)	-0.569	-0.475	0.037	0.823	-0.283	-0.265	-0.122	-0.232	0.005	0.419
	(0.112)	(0.076)	(0.058)	(0.147)	(0.059)	(0.095)	(0.027)	(0.046)	(0.015)	(0.076)
Land to maize (s_1)	0.340	0.284	-0.022	-0.491	0.169	0.159	0.073	0.139	-0.003	-0.250
	(0.086)	(0.047)	(0.035)	(0.081)	(0.029)	(0.035)	(0.022)	(0.028)	(0.009)	(0.048)
Land to durum wheat (s_2)	0.624	0.521	-0.041	-0.903	0.311	0.291	0.134	0.255	-0.005	-0.460
	(0.113)	(0.120)	(0.065)	(0.137)	(0.052)	(0.058)	(0.027)	(0.079)	(0.017)	(0.080)
Land to other cereals (s_3)	-0.045	-0.037	0.003	0.064	-0.022	-0.021	-0.010	-0.018	0.000	0.033
	(0.139)	(0.117)	(0.013)	(0.199)	(0.069)	(0.064)	(0.030)	(0.058)	(0.002)	(0.101)
Land to oilseeds (s_4)	-0.794	-0.663	0.052	1.149	-0.396	-0.371	-0.170	-0.325	0.007	0.585
	(0.130)	(0.076)	(0.079)	(0.126)	(0.052)	(0.067)	(0.033)	(0.057)	(0.021)	(0.089)

* Asymptotic standard errors in parenthesis

Table A2. Price and payment elasticities computed at the mean point of the sample (medium farms)*

	Prices						*Payments*			
	p_1	p_2	p_3	p_4	w_1	w_2	r_1	r_2	r_3	r_4
Maize (y_1)	0.079	-0.170	0.068	0.120	-0.050	0.081	0.031	-0.108	0.017	0.100
	(0.041)	(0.048)	(0.019)	(0.032)	(0.017)	(0.022)	(0.012)	(0.031)	(0.005)	(0.026)
Durum wheat (y_2)	-0.701	1.504	-0.606	-1.067	0.445	-0.717	-0.271	0.953	-0.150	-0.882
	(0.197)	(0.157)	(0.108)	(0.093)	(0.069)	(0.102)	(0.049)	(0.094)	(0.033)	(0.079)
Other cereals (y_3)	0.310	-0.664	0.268	0.471	-0.196	0.317	0.120	-0.421	0.066	0.390
	(0.085)	(0.119)	(0.085)	(0.076)	(0.043)	(0.062)	(0.025)	(0.076)	(0.023)	(0.057)
Oilseeds (y_4)	0.560	-1.201	0.484	0.852	-0.355	0.573	0.216	-0.761	0.120	0.704
	(0.149)	(0.105)	(0.078)	(0.123)	(0.062)	(0.082)	(0.037)	(0.068)	(0.024)	(0.095)
Seeds and chemicals (x1)	0.140	-0.299	0.121	0.212	-0.089	0.143	0.054	-0.190	0.030	0.176
	(0.046)	(0.047)	(0.027)	(0.037)	(0.027)	(0.030)	(0.013)	(0.030)	(0.007)	(0.030)
Other inputs (x2)	-0.291	0.623	-0.251	-0.442	0.184	-0.297	-0.112	0.395	-0.062	-0.366
	(0.079)	(0.088)	(0.049)	(0.063)	(0.039)	(0.079)	(0.021)	(0.055)	(0.015)	(0.054)
Land to maize (s_1)	0.126	-0.270	0.109	0.191	-0.080	0.129	0.049	-0.171	0.027	0.158
	(0.051)	(0.049)	(0.022)	(0.033)	(0.019)	(0.024)	(0.016)	(0.032)	(0.006)	(0.026)
Land to durum wheat (s_2)	-0.504	1.081	-0.435	-0.767	0.320	-0.515	-0.195	0.685	-0.108	-0.634
	(0.145)	(0.106)	(0.079)	(0.069)	(0.050)	(0.072)	(0.037)	(0.079)	(0.024)	(0.060)
Land to other cereals (s_3)	0.243	-0.521	0.210	0.370	-0.154	0.249	0.094	-0.330	0.052	0.306
	(0.073)	(0.116)	(0.074)	(0.074)	(0.038)	(0.059)	(0.022)	(0.075)	(0.021)	(0.056)
Land to oilseeds (s_4)	0.363	-0.778	0.313	0.552	-0.230	0.371	0.140	-0.493	0.078	0.456
	(0.094)	(0.070)	(0.046)	(0.075)	(0.039)	(0.054)	(0.023)	(0.047)	(0.014)	(0.078)

* Asymptotic standard errors in parenthesis

Table A3. Price and payment elasticities computed at the mean point of the sample (large farms)*

	Prices						*Payments*			
	p_1	p_2	p_3	p_4	w_1	w_2	r_1	r_2	r_3	r_4
Maize (y_1)	1.029	-0.807	0.172	0.191	-0.276	-0.171	0.247	-0.442	0.036	0.233
	(0.165)	(0.083)	(0.036)	(0.031)	(0.044)	(0.043)	(0.038)	(0.051)	(0.011)	(0.029)
Durum wheat (y_2)	-1.723	1.352	-0.289	-0.320	0.463	0.287	-0.413	0.740	-0.060	-0.391
	(0.177)	(0.124)	(0.065)	(0.057)	(0.053)	(0.062)	(0.041)	(0.068)	(0.020)	(0.056)
Other cereals (y_3)	0.601	-0.472	0.101	0.112	-0.161	-0.100	0.144	-0.258	0.021	0.136
	(0.125)	(0.107)	(0.044)	(0.028)	(0.038)	(0.032)	(0.030)	(0.060)	(0.011)	(0.032)
Oilseeds (y_4)	0.666	-0.523	0.112	0.124	-0.179	-0.111	0.160	-0.286	0.023	0.151
	(0.106)	(0.093)	(0.028)	(0.041)	(0.037)	(0.032)	(0.025)	(0.053)	(0.008)	(0.043)
Seeds and chemicals (x1)	0.493	-0.387	0.083	0.092	-0.132	-0.082	0.118	-0.212	0.017	0.112
	(0.079)	(0.044)	(0.019)	(0.019)	(0.031)	(0.021)	(0.018)	(0.026)	(0.006)	(0.020)
Other inputs (x2)	0.455	-0.357	0.076	0.084	-0.122	-0.076	0.109	-0.195	0.016	0.103
	(0.113)	(0.077)	(0.024)	(0.025)	(0.032)	(0.033)	(0.027)	(0.045)	(0.006)	(0.028)
Land to maize (s_1)	1.025	-0.805	0.172	0.190	-0.275	-0.171	0.246	-0.441	0.036	0.233
	(0.157)	(0.080)	(0.036)	(0.030)	(0.043)	(0.042)	(0.039)	(0.050)	(0.011)	(0.029)
Land to durum wheat (s_2)	-1.209	0.948	-0.202	-0.224	0.325	0.201	-0.290	0.519	-0.042	-0.274
	(0.139)	(0.088)	(0.047)	(0.041)	(0.040)	(0.046)	(0.033)	(0.062)	(0.014)	(0.042)
Land to other cereals (s_3)	0.395	-0.310	0.066	0.073	-0.106	-0.066	0.095	-0.170	0.014	0.090
	(0.122)	(0.102)	(0.035)	(0.024)	(0.034)	(0.026)	(0.029)	(0.057)	(0.009)	(0.029)
Land to oilseeds (s_4)	0.668	-0.524	0.112	0.124	-0.179	-0.111	0.160	-0.287	0.023	0.151
	(0.084)	(0.075)	(0.027)	(0.035)	(0.032)	(0.030)	(0.020)	(0.044)	(0.007)	(0.042)

* Asymptotic standard errors in parenthesis

Table A4. Variance, covariance and initial wealth elasticities computed at the mean point of the sample (small farms)*

	Variances					*Co-variances*										*Wealth*
	$Var(p_1)$	$Var(p_2)$	$Var(p_3)$	$Var(p_4)$	$Var(p_5)$	$Cov(p_1,p_2)$	$Cov(p_1,p_3)$	$Cov(p_1,p_4)$	$Cov(p_1,p_5)$	$Cov(p_2,p_3)$	$Cov(p_2,p_4)$	$Cov(p_2,p_5)$	$Cov(p_3,p_4)$	$Cov(p_3,p_5)$	$Cov(p_4,p_5)$	W_0
Maize (y_1)	-0.025	-0.320	0.215	-0.173	0.756	-0.016	-0.522	0.120	-0.635	-0.355	0.017	-0.044	-0.045	0.631	0.018	0.012
	(0.080)	(0.060)	(0.067)	(0.055)	(0.181)	(0.006)	(0.104)	(0.049)	(0.095)	(0.083)	(0.013)	(0.020)	(0.021)	(0.136)	(0.100)	(0.004)
Durum wheat (y_2)	0.001	-0.100	-0.160	0.040	-0.409	0.002	-0.033	0.028	0.315	-0.103	0.004	0.010	0.037	-0.321	-0.046	0.048
	(0.065)	(0.074)	(0.061)	(0.060)	(0.161)	(0.008)	(0.077)	(0.038)	(0.092)	(0.074)	(0.013)	(0.015)	(0.015)	(0.100)	(0.079)	(0.005)
Other cereals (y_3)	-0.199	-0.122	-0.074	0.081	-0.305	0.007	0.197	-0.160	0.006	0.408	0.011	-0.034	0.014	0.136	0.113	0.035
	(0.051)	(0.070)	(0.048)	(0.045)	(0.163)	(0.007)	(0.070)	(0.031)	(0.061)	(0.070)	(0.014)	(0.018)	(0.014)	(0.086)	(0.082)	(0.048)
Oilseeds (y_4)	-0.007	0.419	0.025	-0.035	0.089	0.003	0.205	-0.101	-0.110	0.095	0.015	-0.020	-0.011	0.000	-0.037	0.014
	(0.042)	(0.042)	(0.038)	(0.040)	(0.133)	(0.005)	(0.055)	(0.024)	(0.053)	(0.047)	(0.009)	(0.013)	(0.011)	(0.071)	(0.064)	(0.035)
Seeds and chemicals (x1)	-0.054	-0.068	0.022	-0.057	0.398	0.003	-0.059	-0.020	-0.214	-0.041	0.023	-0.017	-0.034	0.136	-0.104	0.057
	(0.025)	(0.025)	(0.026)	(0.021)	(0.066)	(0.003)	(0.031)	(0.014)	(0.028)	(0.032)	(0.006)	(0.007)	(0.006)	(0.037)	(0.039)	(0.022)
Other inputs (x1)	0.004	0.108	-0.021	-0.043	0.055	0.002	0.178	-0.061	0.054	0.041	0.038	0.054	0.002	-0.200	0.062	0.199
	(0.058)	(0.072)	(0.083)	(0.071)	(0.153)	(0.008)	(0.080)	(0.037)	(0.068)	(0.112)	(0.018)	(0.023)	(0.015)	(0.090)	(0.083)	(0.074)
Land to maize (s_1)	0.024	-0.281	0.191	-0.153	0.711	-0.014	-0.468	0.101	-0.596	-0.313	0.016	-0.042	-0.042	0.581	0.003	0.002
	(0.073)	(0.056)	(0.061)	(0.049)	(0.166)	(0.006)	(0.094)	(0.044)	(0.090)	(0.075)	(0.013)	(0.018)	(0.019)	(0.123)	(0.092)	(0.046)
Land to durum wheat (s_2)	0.030	0.079	-0.183	0.112	-0.178	0.001	0.028	0.013	0.359	-0.041	0.005	0.023	0.024	-0.377	-0.086	0.021
	(0.058)	(0.061)	(0.057)	(0.053)	(0.140)	(0.007)	(0.069)	(0.035)	(0.083)	(0.066)	(0.011)	(0.014)	(0.013)	(0.097)	(0.073)	(0.039)
Land to other cereals (s_3)	-0.175	-0.096	-0.125	0.099	-0.276	0.008	0.243	-0.165	0.024	0.412	0.014	-0.018	0.016	0.027	0.100	0.046
	(0.054)	(0.068)	(0.050)	(0.044)	(0.155)	(0.007)	(0.074)	(0.033)	(0.067)	(0.072)	(0.013)	(0.017)	(0.014)	(0.092)	(0.078)	(0.045)
Land to oilseeds (s_4)	-0.009	0.319	0.026	0.035	-0.264	0.009	0.155	-0.066	-0.010	0.039	-0.007	-0.005	-0.009	-0.040	0.005	0.044
	(0.039)	(0.039)	(0.037)	(0.030)	(0.107)	(0.005)	(0.049)	(0.022)	(0.052)	(0.045)	(0.009)	(0.012)	(0.009)	(0.072)	(0.055)	(0.031)

* Asymptotic standard errors in parenthesis

Table A5. Variance, covariance and initial wealth elasticities computed at the mean point of the sample (medium farms)*

	Variances					*Co-variances*										*Wealth*
	Var(p_1)	*Var(p_2)*	*Var(p_3)*	*Var(p_4)*	*Var(p_5)*	*Cov(p_1,p_2)*	*Cov(p_1,p_3)*	*Cov(p_1,p_4)*	*Cov(p_1,p_5)*	*Cov(p_2,p_3)*	*Cov(p_2,p_4)*	*Cov(p_2,p_5)*	*Cov(p_3,p_4)*	*Cov(p_3,p_5)*	*Cov(p_4,p_5)*	*W_0*
Maize (y_1)	-0.003	-0.287	-0.019	0.301	-0.211	0.014	0.042	-0.040	-0.060	0.076	0.002	0.085	-0.269	0.054	-0.164	0.255
	(0.032)	(0.062)	(0.023)	(0.060)	(0.148)	(0.014)	(0.022)	(0.019)	(0.027)	(0.032)	(0.007)	(0.023)	(0.037)	(0.008)	(0.038)	(0.041)
Durum wheat (y_2)	0.187	-0.031	0.105	0.221	0.599	-0.039	0.160	0.031	-0.059	-0.056	0.034	0.004	-0.084	-0.008	0.118	0.002
	(0.039)	(0.072)	(0.037)	(0.087)	(0.183)	(0.016)	(0.031)	(0.025)	(0.036)	(0.042)	(0.007)	(0.026)	(0.049)	(0.011)	(0.059)	(0.041)
Other cereals (y_3)	-0.174	0.184	-0.098	-0.694	-0.039	0.022	-0.105	-0.019	0.127	-0.016	-0.048	-0.088	0.391	-0.030	-0.031	0.030
	(0.033)	(0.065)	(0.032)	(0.083)	(0.193)	(0.014)	(0.025)	(0.024)	(0.028)	(0.044)	(0.008)	(0.026)	(0.041)	(0.009)	(0.054)	(0.051)
Oilseeds (y_4)	-0.251	-0.279	-0.195	-0.061	0.332	-0.066	-0.029	0.107	0.118	-0.072	0.008	0.186	0.095	-0.009	-0.312	0.070
	(0.034)	(0.069)	(0.045)	(0.077)	(0.224)	(0.021)	(0.029)	(0.029)	(0.031)	(0.047)	(0.007)	(0.036)	(0.049)	(0.013)	(0.056)	(0.061)
Seeds and chemicals (x1)	-0.055	-0.036	-0.044	0.026	-0.163	-0.001	-0.027	0.016	0.011	-0.044	-0.014	0.033	0.032	0.005	-0.098	0.110
	(0.014)	(0.029)	(0.018)	(0.031)	(0.078)	(0.007)	(0.012)	(0.010)	(0.014)	(0.018)	(0.003)	(0.010)	(0.019)	(0.004)	(0.020)	(0.021)
Other inputs (x1)	0.093	0.137	0.045	0.028	-0.135	-0.016	0.107	-0.019	-0.052	0.059	0.002	-0.066	-0.091	0.007	0.108	0.177
	(0.033)	(0.055)	(0.047)	(0.076)	(0.177)	(0.011)	(0.026)	(0.018)	(0.029)	(0.061)	(0.010)	(0.026)	(0.057)	(0.009)	(0.046)	(0.060)
Land to maize (s_1)	-0.012	-0.270	-0.024	0.261	-0.194	0.017	0.026	-0.035	-0.057	0.069	-0.001	0.088	-0.244	0.053	-0.159	0.198
	(0.031)	(0.057)	(0.023)	(0.058)	(0.140)	(0.016)	(0.022)	(0.019)	(0.026)	(0.032)	(0.007)	(0.022)	(0.036)	(0.008)	(0.037)	(0.038)
Land to durum wheat (s_2)	0.172	0.009	0.114	0.353	0.319	-0.032	0.107	0.041	-0.073	-0.064	0.030	0.016	-0.163	-0.015	0.216	0.027
	(0.033)	(0.054)	(0.030)	(0.065)	(0.157)	(0.012)	(0.027)	(0.024)	(0.030)	(0.033)	(0.006)	(0.021)	(0.041)	(0.009)	(0.045)	(0.035)
Land to other cereals (s_3)	-0.168	0.241	-0.057	-0.706	0.128	0.038	-0.086	-0.043	0.129	-0.043	-0.041	-0.104	0.386	-0.033	0.018	0.106
	(0.035)	(0.060)	(0.035)	(0.074)	(0.183)	(0.016)	(0.025)	(0.024)	(0.029)	(0.046)	(0.008)	(0.024)	(0.040)	(0.009)	(0.051)	(0.048)
Land to oilseeds (s_4)	-0.149	0.087	-0.106	-0.172	-0.418	-0.051	-0.041	0.036	0.120	-0.009	0.002	0.014	0.134	-0.001	-0.172	0.085
	(0.030)	(0.052)	(0.026)	(0.059)	(0.143)	(0.012)	(0.022)	(0.020)	(0.027)	(0.031)	(0.006)	(0.022)	(0.033)	(0.008)	(0.037)	(0.036)

* Asymptotic standard errors in parenthesis

Table A6. Variance, covariance and initial wealth elasticities computed at the mean point of the sample (large farms)*

	Variances					*Co-variances*										*Wealth*
	$Var(p_1)$	$Var(p_2)$	$Var(p_3)$	$Var(p_4)$	$Var(p_5)$	$Cov(p_1,p_2)$	$Cov(p_1,p_3)$	$Cov(p_1,p_4)$	$Cov(p_1,p_5)$	$Cov(p_2,p_3)$	$Cov(p_2,p_4)$	$Cov(p_2,p_5)$	$Cov(p_3,p_4)$	$Cov(p_3,p_5)$	$Cov(p_4,p_5)$	W_0
Maize (y_1)	-0.079	-0.006	-0.014	-0.041	-0.067	-0.003	0.026	0.024	0.001	-0.012	0.001	-0.059	-0.004	0.005	-0.023	0.168
	(0.014)	(0.044)	(0.029)	(0.030)	(0.060)	(0.002)	(0.020)	(0.021)	(0.001)	(0.018)	(0.009)	(0.012)	(0.002)	(0.007)	(0.035)	(0.045)
Durum wheat (y_2)	0.104	-0.087	0.055	0.073	-0.018	-0.002	-0.013	0.006	-0.005	0.009	-0.002	0.034	0.006	0.005	0.154	0.001
	(0.016)	(0.038)	(0.025)	(0.030)	(0.063)	(0.002)	(0.019)	(0.023)	(0.002)	(0.017)	(0.009)	(0.010)	(0.003)	(0.007)	(0.046)	(0.044)
Other cereals (y_3)	-0.074	-0.111	-0.051	0.035	0.226	-0.003	-0.079	-0.026	0.003	0.046	0.061	0.011	-0.011	-0.037	-0.180	0.018
	(0.015)	(0.034)	(0.024)	(0.025)	(0.069)	(0.002)	(0.025)	(0.023)	(0.001)	(0.018)	(0.009)	(0.012)	(0.003)	(0.008)	(0.036)	(0.043)
Oilseeds (y_4)	-0.123	0.076	-0.076	-0.039	-0.060	-0.003	0.072	0.108	-0.002	-0.007	-0.034	0.006	0.006	0.018	0.024	0.123
	(0.012)	(0.036)	(0.024)	(0.027)	(0.046)	(0.002)	(0.024)	(0.029)	(0.002)	(0.016)	(0.011)	(0.012)	(0.003)	(0.007)	(0.027)	(0.036)
Seeds and chemicals (x1)	-0.027	0.041	-0.039	-0.027	-0.050	0.000	0.004	0.006	0.000	0.012	-0.002	0.015	-0.002	-0.016	-0.080	0.055
	(0.007)	(0.022)	(0.014)	(0.017)	(0.031)	(0.001)	(0.010)	(0.010)	(0.001)	(0.010)	(0.005)	(0.006)	(0.001)	(0.004)	(0.018)	(0.037)
Other inputs (x1)	-0.048	0.077	-0.022	-0.083	0.238	0.005	-0.023	-0.030	-0.001	0.012	0.012	0.025	-0.009	-0.017	-0.144	0.167
	(0.015)	(0.039)	(0.026)	(0.026)	(0.082)	(0.002)	(0.022)	(0.025)	(0.001)	(0.017)	(0.010)	(0.012)	(0.003)	(0.008)	(0.051)	(0.033)
Land to maize (s_1)	-0.079	0.013	-0.023	-0.049	-0.058	-0.002	0.033	0.023	0.001	-0.014	0.003	-0.047	-0.004	0.004	-0.033	0.143
	(0.014)	(0.041)	(0.027)	(0.029)	(0.060)	(0.002)	(0.019)	(0.020)	(0.001)	(0.016)	(0.008)	(0.011)	(0.002)	(0.007)	(0.034)	(0.046)
Land to durum wheat (s_2)	0.125	-0.001	0.035	0.021	-0.043	-0.001	0.021	0.007	-0.004	0.001	-0.016	0.042	0.006	0.018	0.125	0.004
	(0.014)	(0.037)	(0.023)	(0.027)	(0.054)	(0.002)	(0.018)	(0.021)	(0.001)	(0.015)	(0.008)	(0.009)	(0.002)	(0.006)	(0.038)	(0.029)
Land to other cereals (s_3)	-0.045	-0.085	-0.038	0.020	0.219	-0.006	-0.071	-0.008	0.002	0.042	0.044	-0.003	-0.007	-0.028	-0.146	0.033
	(0.016)	(0.033)	(0.023)	(0.025)	(0.062)	(0.002)	(0.023)	(0.023)	(0.002)	(0.018)	(0.008)	(0.011)	(0.003)	(0.007)	(0.037)	(0.057)
Land to oilseeds (s_4)	-0.117	0.036	-0.049	-0.001	-0.045	0.004	-0.014	0.016	0.001	-0.001	-0.002	-0.021	0.001	-0.011	-0.010	0.017
	(0.012)	(0.032)	(0.020)	(0.024)	(0.051)	(0.002)	(0.018)	(0.020)	(0.001)	(0.014)	(0.008)	(0.010)	(0.002)	(0.006)	(0.032)	(0.034)

* Asymptotic standard errors in parenthesis

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