Effects of policy instruments on farm investments and production decisions in the Spanish cop sector

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Abstract Our paper asses the impacts of the partially decoupled (PD) scheme, implemented during the 1990s and first half of the 2000s in the framework of the Common Agricultural Policy (CAP), on on-farm investment as well as on other production decisions. The Spanish COP sector was taken as a case study due to its economic and political relevance. The empirical analysis is applied on farm-level data from the Farm Accountancy Data Network (FADN), observed from 2000 to 2004, based on. We use a reduced-form application of the dual model of investment under uncertainty and a system of censored and non censored equations is estimated. PD payments are found to increase short-run production and to generate a statically significant increase in the investment in farm assets. Results also show the importance of assessing the effects of PD payments in a dynamic framework as the one applied in this paper.

Keywords: farm investments, Common Agricultural Policy, decoupling, production.

1. Introduction and Objectives

Farm household assets can be classified into two main different types; off-farm and on-farm investments. The former are not directly related to farming activities and are based on non-farming assets such as financial assets. These investments are generally used by farmers to effectively stabilize the financial performance of their farm income and to reduce risk in their economic results. On the other hand, on-farm investments are directed toward farming activities to improve or support agricultural practices and to ensure a regular flow of goods and services. In this regard, on-farm investments involve assets such as farm machinery, farm buildings, land improvements and other farming assets.

Farmer behaviour towards investment and production decisions has been the focus of numerous studies. While Mishra and Morehart (2001), Gustafson and Chama (1994) and Serra *et al*. (2004), among others, have assessed non-farm investment decisions, on-farm investments have received even more attention in the literature. Oude Lansink *et al*. (2001) analyse the factors that determine farmer investment in energy-saving systems. Carey and Zilberman (2002) analyze investments in modern irrigation systems and technologies. Baer and Brown (2006) assess the investments in internet technology to improve farming business results. Wabi *et al*. (2006) analyze the investment in integrated pest management systems. Knowler and Bradshaw (2007) carry out a literature review to identify the variables that are significant in explaining farmers' adoption of innovations and investment.

Findings from previous research allow us to classify variables that usually influence farmers' investment decisions into non-economic and economic factors. The former factors are represented by a) *Farmer characteristics*, such as age, gender, education, social status, farming experience or knowledge; b) *Farmer attitudes and opinions* like risk aversion, membership in organizations, political opinion, source of information or environmental preferences; and c) *Agronomic characteristics,* such as soil fertility and degree of erosion, or animal welfare. The economic factors include a) *farm management issues* including input use intensity, family and hired labour, farm size, production costs, crop diversity, gross farm income, off-farm activities, debt level, access to credit, extension and technical assistance, farm productivity and efficiency; and b) *Exogenous factors* like the market size, policy support, input and output prices, interest rate and price variation.

Among the economic factors, agricultural policy support has been shown to play a relevant role in investment decisions (Sckokai, 2005; Coyle, 2005 and Cahill, 2005). This is particularly relevant in the cereal, oilseed and protein (COP) crops sector, which has received considerable attention within the EU agricultural policy. Over the last years, the Common Agricultural Policy (CAP) applied to the COP sector has undergone an important reform process characterized by a reduction in price supports. Direct income supports were introduced to compensate farmers for their reduced income due to reduced prices. These supports were defined as area payments on the basis of historical average yields and arable crops area. Several authors (see, e.g., Moro and Sckokai, 1999; Oude Lansink and Peerlings, 1996 and Serra *et al*., 2005a) have concluded that these payments are only partially decoupled (PD) since they contain some elements of support still tied to farmers' production decisions. The CAP reform process culminated with the 2003 reform that introduced the single farm payment, defined as a fully decoupled measure (FD) since payments were not theoretically related to production decisions.

This paper focuses on analysing the impact of agricultural policy support on on-farm investment decisions in the Spanish COP sector. Farm-level data observed from 2000 to 2004, based on the Farm Accountancy Data Network (FADN) are used in the empirical application. The statistical data to analyze the effects of FD payments are not yet available, since these payments were first applied in the 2006-2007 marketing year, we thus will focus on the PD payments. Previous research assessing the impacts of CAP PD payments has mainly focused on variable input use and land allocation (Balkhausen *et al*., 2008; Hennessy and Rehman, 2008; Serra *et al*., 2005b; Ridier and Jacquet, 2002; Moro and Sckokai, 1999; Guyomard *et al*., 1996; or Oude Lansink and Peerlings, 1996). Although, to date, only a few unpublished studies have analysed the impacts of the PD support scheme on investment decisions in the EU context (Sckokai, 2005), this is the first attempt to analyse this issue specifically for Spain.

The remainder of this paper is organized as follows. Section 2 provides more details on the COP sector and the CAP support received by this sector. The next two sections introduce the econometric framework and the empirical implementation. In Section 5 the results are discussed. Finally, some conclusions are outlined.

2. The COP sector and the CAP Reforms

The EU-27 is the third world's largest producer of cereals with 12.12% of global production, behind the USA (15.60%) and China (20.05%), and is the first worldwide producer of barley (40.5%) and wheat (20.8%) (FAOSTAT, 2007). The EU-27 COP sector represents 76.5% of total utilized agricultural area (UAA) and 37.2% of total crop production (FAOSTAT, 2007). In 2006, the most important cereal producers within the EU-27 were France and Germany, representing 23.27% and 14.76% of total EU production, respectively, followed by Italy, Poland, Spain and the United Kingdom. The Spanish COP sector occupies 59.0% of the Spanish UAA and represents 30.2% of the Spanish total crop production. As can be seen in Table 1, during the period of analysis (2000-2004) cereals represent the most important crop within the Spanish COP sector, followed by protein and oilseed crops. Moreover, the Spanish COP sector represents 10.1% of the total European (EU-27) COP UAA and 6.83% of the total European COP production.

Table 1: The COP area and production in Spain within the period study

	Cereals		**Oilseeds**		**Protein crops**		**Total COP**	
	1,000 ha (%)[a]	1,000 t (%)[b]	1,000 ha (%)	1,000 t (%)	1,000 ha (%)	1,000 t (%)	1,000 ha (%)	1,000 t (%)
2000	6,802.49 (78.3)	24,555.67 (80.9)	894.06 (10.3)	992.47 (3.3)	996.61 (11.5)	4,811.40 (15.8)	8,693.16 (100)	30,359.54 (100)
2004	6,597.28 (76.5)	24,808.86 (78.5)	763.99 (8.9)	837.35 (2.6)	1,266.92 (14.7)	5970.80 (18.9)	8,628.19 (100)	31,617.00 (100)

FAOSTAT, 2007
[a] Percentage over total COP area
[b] Percentage over total COP production

As mentioned in the introduction, the COP sector has received a lot of political attention in Europe, being one of the most relevant sectors within the CAP. Of the European Agricultural Guidance and Guarantee

Fund (EAGGF) expenditure, 25.1% is devoted to COP. (MAPA, 2006). Furthermore, it was one of the axes of the CAP reform process (Serra *et al*., 2005a). The 1992 reform was mainly focused on the COP sector and was characterized by a substantial reduction in guaranteed prices. Oilseed and protein crop guaranteed prices were abolished, while cereal prices were reduced by one third. In order to compensate farmers' income decline, an area payment defined on the basis of historical regional average yields and arable crop areas was introduced. Moreover, professional producers were required to set aside a percentage of their cultivated area in exchange for set aside premium.

The so called Agenda 2000 continued to further decouple support received by farmers. The guaranteed price for cereals was reduced by 15% and the direct payment increased by the same proportion (Table 2). Direct payments to oilseed crops were reduced to the cereals' payment level. Direct payments to protein crops were also reduced but kept above the cereal and oilseed payments, to ensure the relative profitability of protein crops. It is worth mentioning that the novelty of this reform is defined by the support for the rural economy as a whole and the overall contribution of farmers to society, rather than supporting them for what they produce. In 2003, another substantial reform (Mid Term Review) was approved aiming at increasing farmers' efficiency, reducing the negative environmental externalities of agriculture, and maintaining farm income without distorting farm production decisions. The single farm payment was introduced as a key element in the new farm support system. This latter reform started to operate in the 2006-2007 season. Due to the lack of data to analyse the latter reform, our study focuses on the consequences of the Agenda 2000 on on-farm investments. Results provide guidance regarding the expected consequences of the latter reform.

Table 2: Expenditure and change in the support to the COP sector after Agenda 2000 Reform

		1999	**2000**	**2001**	**2004**
Cereals	Intervention price (€/t)	119.19	110.25	101.31	101.31
	Direct Payment (€/t)	54.34	58.67	63.00	63.00
Oilseeds	Direct payment (€/t/cereal equivalent)	94.24	81.74	72.37	63.00
Protein crops	Direct payment (€/t/cereal equivalent)	78.49	72.50	72.50	72.50
Set aside	Direct payment in (€/t)	68.83	58.67	63.00	63.00

Expenditure in COP crops	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
millions €	1.866,167	1829.98	1.825,70	1.827,82	1.824,60	1.571,58
(%)*	(32.0)	(30.0)	(28.0)	(28.4)	(27.1)	(25.1)

MAPA (2006)
*% of the Total Common Organization of the Market (C.O.M.) expenses by the European Agricultural Guarantee Fund transferred to the COP sector.

3. The theoretical and econometric frameworks

Our empirical analysis is based on a reduced-form application of the dual model of investment under uncertainty developed by Sckokai (2005). The conceptual foundations of this model rely on the duality theory results from McLaren and Cooper (1980) and Epstein (1981). Under the assumptions that farmers produce a single output, are not risk neutral and take their decisions to maximize discounted utility over an infinite horizon, the value of the firm can be represented as (Sckokai, 2005):

$$J(.) = \max \int_0^{\infty} e^{-rt} u(A, \sigma_A^2)$$

s.t. $\dot{k} = (1 - \eta k)$ (1)

where function u is the expected utility of wealth which is assumed to depend on the expected farm's wealth (A); the variance of wealth (σ_A^2), which can originate from uncertainties in production and/or market prices. $\dot{k}$ is the time derivative of the capital path, η represents the capital depreciation rate and k are the units of capital. The expected farm's wealth is given by: $A = A_0 + \bar{p}y - wx - ck + S + S_r$, where A_0 is a farm's initial wealth; $\bar{p}$ is the expected market output price; y is the farm output production function; w is the known variable input price; x is the quantity used of a variable input; c is the capital rental price, also assumed to be known; S includes the CAP direct payments to COP crops; and S_r is the rural development subsidies. The farm's single output production function is represented as $y = f(x, k, I; b) + e$, where I is the gross investment in capital and b is labor which is considered a fixed input

The Hamilton-Jacobi-Bellman dynamic programming equation corresponding to the optimization problem is: $rJ = \max_{I,x,y} \{u + J_k (I - \eta K)\}$ where the subscript denotes a derivative and r is the interest rate. The first derivatives of this expression with respect to output and input prices yield the optimal output and input demand equations:

$$\begin{cases} \dot{k}(r, A_0, \overline{P}, w, c, b, S, S_r, \sigma_A^2, k) \\ y(r, A_0, \overline{P}, w, c, b, S, S_r, \sigma_A^2, k) \\ x(r, A_0, \overline{P}, w, c, b, S, S_r, \sigma_A^2, k) \end{cases} \quad (2)$$

Since not every farm invests in every asset nor produces each crop considered, a censoring issue underlies the empirical model. To handle this issue, we use the Shonkwiler and Yen (1999) estimation procedure that is described below. Let $F_i, i = 1, ..., n$, represent a censored decision variable, $H_j, j = n+1, ..., m$ a non-censored one, and $\mathbf{X} = (r, A_0, \overline{P}, w, c, b, S, S_r, \sigma_A^2, k)$ the vector of explanatory variables. Equation (2) can alternatively be expressed as:

$$\begin{cases} \mathbf{F}_t = f(\mathbf{X}_t, \boldsymbol{\beta}) \\ \mathbf{H}_t = f(\mathbf{X}_t, \boldsymbol{\gamma}) \end{cases} \quad (3)$$

where $\mathbf{F}$ and $\mathbf{H}$ are vectors containing the censored and non-censored variables respectively, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are vectors of parameters and *t* denotes each observation. In order to estimate (3) we follow the two-step procedure outlined by Shonkwiler and Yen (1999).

In the first step, the discrete variable indicating a non-censored observation of $\mathbf{F}_t = d(\mathbf{F}_t > 0)$ is evaluated through a probit model of the form:

$$\mathbf{d}_t = g(\mathbf{Z}_t, \boldsymbol{\alpha}) \quad (4)$$

where $\mathbf{Z}_t$ represents a vector of exogenous variables that can or cannot coincide with $\mathbf{X}_t$ and $\boldsymbol{\alpha}$ is a vector of parameters. In the second step, the normal cumulative distribution function $\Phi(\mathbf{Z}_t, \boldsymbol{\alpha})$ and the normal probability density function $\phi(\mathbf{Z}_t, \boldsymbol{\alpha})$ derived from the probit model are used to construct correction terms in the censored equations in system (3). Thus, the resulting system can be rewritten as:

$$\begin{cases} \mathbf{F}_t = \Phi(\mathbf{Z}_t, \boldsymbol{\alpha}) f(\mathbf{X}_t, \boldsymbol{\beta}) + \boldsymbol{\delta}\phi(\mathbf{Z}_t, \boldsymbol{\alpha}) + \boldsymbol{\xi}_t^{\mathrm{F}} \\ \mathbf{H}_t = f(\mathbf{X}_t, \boldsymbol{\gamma}) + \boldsymbol{\xi}_t^{\mathrm{H}} \end{cases} \tag{5}$$

where $\boldsymbol{\delta}$ is a vector of coefficients and $\boldsymbol{\xi}_t^{\mathrm{F}}$ and $\boldsymbol{\xi}_t^{\mathrm{H}}$ are vectors of error terms. Assuming a linear system of censored and non-censored equations, the system in (5) can be expressed as:

$$\begin{cases} \mathbf{F}_t = \Phi(\mathbf{Z}'_t \boldsymbol{\alpha}) \mathbf{X}'_t \boldsymbol{\beta} + \boldsymbol{\delta}\phi(\mathbf{Z}'_t \boldsymbol{\alpha}) + \boldsymbol{\xi}_t^{\mathrm{F}} \\ \mathbf{H}_t = (\mathbf{X}'_t \boldsymbol{\gamma}) + \boldsymbol{\xi}_t^{\mathrm{H}} \end{cases} \tag{6}$$

which is estimated by the Seemingly Unrelated Regression (SUR) Procedure.

Following Su and Yen (2000), it should be noted that parameter estimates derived from the Shonkwiler and Yen two-step method might disguise the actual effects of the explanatory variables. This would be especially true when a common explanatory variable is used in the first and second stages of the estimation process. This common variable affects the dependent variable through the index $\mathbf{X}'_t \boldsymbol{\beta}$, as well as through the normal cumulative distribution function $\Phi(\mathbf{Z}'_t \boldsymbol{\alpha})$ and the normal probability density function $\phi(\mathbf{Z}'_t \boldsymbol{\alpha})$ derived from the probit model. In order to solve this problem, we compute the marginal effects and rely on them for the interpretation of results. Marginal effects are derived using the Su and Yen (2000) formulation and evaluated at data means:

$$\frac{\partial E\left[\mathbf{F}_t / \mathbf{X}_t, \mathbf{Z}_t\right]}{\partial X_{zt}} = \Phi(\mathbf{Z}'_t \boldsymbol{\alpha})\beta_z + \mathbf{X}'_t \boldsymbol{\beta}\phi(\mathbf{Z}'_t \boldsymbol{\alpha})\alpha_z - \delta_z(\mathbf{Z}'_t \boldsymbol{\alpha})\phi(\mathbf{Z}'_t \boldsymbol{\alpha})\alpha_z \tag{7}$$

where subindex *z* represents the explanatory variable whose marginal effect is being computed.

As Shonkwiler and Yen (1999) note, the error term derived from the second step of the method is heteroscedastic. In light of this problem, we use Monte Carlo bootstrapping procedures to derive consistent variance-covariance estimates for the parameters of the model[1].

4. Empirical implementation

Farm-level data for a sample of Spanish farms specialized in the production of COP crops are utilized. Data are taken from the Farm Accounting Data Network (FADN) for the period 2000-2004, a period during which the Agenda 2000 reforms were effective. The FADN data set is a harmonized source of information for European production that includes technical, financial and economic data on farming. Though our analysis is based on farm-level data, aggregate statistics are also used to define some variables not included in FADN. Country-level nominal market inflation rates and interest rates have been taken from the official statistics published by EUROSTAT (2007) and OECD (2007), respectively.

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[1] 1,000 pseudo-samples of the same size as the actual sample, drawn with replacement, to provide a sample of parameter estimates from which we estimate the parameter covariance matrix. For each pseudo-sample of data, Shonkwiler and Yen's two-step method is applied to estimate the parameters of the model. The covariance matrices are derived from the distribution of the replicated estimates generated in the bootstrap process. The standard errors of the marginal effects are also derived using the replicated marginal effect estimates from the bootstrapped samples.

In our empirical application, the model presented in (2) is generalized to consider a multi-output firm, as well as the investment in different types of assets. We distinguish between two output types: 1) cereals and 2) oilseeds and protein crops. As explained, the regulation of these crops is very similar. However, while cereals continue to have an intervention price, oilseed and protein crops do not. Additionally, cereals represent the main crop for the farms in our sample (see Table 3). The two-output specification is also motivated by this fact: we observe cereals as one single entity instead of aggregating them into a wider group in light of their importance.

Five dependent variables are defined. First, we define two quasi-fixed inputs (k_1 and k_2). While k_1 represents the gross farm investment in machinery and equipment, k_2 aggregates the gross investment in farm buildings and land improvements[2]. Assuming constant returns to scale, output can be approximated by land. Thus, the third and fourth decision variables represent land allocated to cereals (y_1) and to oilseed and protein crops (y_2), respectively[3]. The last decision variable represents variable input costs (x). This variable includes crop-specific variable inputs such as seeds and seedlings, fertilizers, crop protection products and other specific crop costs[4].

Following the theoretical framework presented above, a set of explanatory variables is defined. The holding's lagged agricultural area is used as an indicator of a farms' wealth (A_0). Expected output prices ($\overline{p}$) are defined for cereals ($\overline{p}_1$) and oilseed and protein crops ($\overline{p}_2$) and computed at the farm-level as the ratio of farm sales in currency units to farm output in physical units. Variable input prices (w) are approximated through the lagged price index for plant protection products and pesticides (w_1) and fertilizers and soil improvers (w_2). The rental price for capital (c) is defined for both types of investment considered: for machinery and equipment (c_1) and for farm building and land improvement (c_2). For each group, the capital rental price is calculated as $c_i = (r + \eta_i) z_i$, $i = 1,2$, where r is the annual market interest rate, η_i is the capital depreciation rate which is computed at the data means and at the farm level, and z_i is the capital price index. To avoid multicolinearity issues, the interest rate is not included again as a single explanatory variable. Total labor of the holding (b) is expressed in annual working units and includes both family and rented labor. Variable S includes CAP subsidies received by COP producers, while rural development subsidies, i.e., the environmental and less favoured area payments, are included in S_r. A farm's wealth variability σ_A^2 is approximated by the coefficient of variation of lagged COP sales on a per hectare basis. This measure was calculated at the farm level for the five years considered in this study. To avoid endogeneity issues, k is approximated by the lagged value of machinery and equipment ($k_{1,-1}$) and of building and land improvement ($k_{2,-1}$).

Other explanatory variables not included in the theoretical framework, but shown by previous research to be relevant when explaining production decisions are also considered. These variables include the age of the manager (g) of the holding and the proportion of rented land over total land (PR). Since farmers tend to be risk averse (Chavas and Pope, 1985, Hansen and Singleton 1983 and Serra *et al*., 2004), producers' risk preferences may play an important role in their decisions. Farmers' risk attitudes can be captured using a dummy variable (D_{ins}) that takes the value 1 if the farm insures its crops and zero, otherwise (Serra, *et al*., 2004 and, Goodwin and Mishra, 2006). Moreover, thirteen dummy variables, which represent the Spanish Autonomous Communities (m_j), are included in the empirical specification

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[2] Almost 90% of our farms do not invest in machinery and equipment, while more than 95% have zero investment in farm buildings and land improvements. As a result, both variables are considered as censored.
[3] Almost 64% of the farms did not plant oilseed or protein crops. Therefore this variable was considered as censored. Conversely, less than 1% of the farms did not plant cereals and thus the variable was not considered a censored one.
[4] This variable was treated as non-censored since only a 0.04% of observations are null.

to account for differences between different Spanish regions. Summary statistics of the explanatory variables are shown in Table 3.

Table 3: Variable summary statistics

	Variable name	Measurement Unit*	Mean	Std. deviation
A_0	Total Agricultural Area of holding (UAA).	ha	101.503	133.88
k_1	Gross investment of machinery and equipment.	€ 100	0.172	0.875
k_2	Gross investment of farm building and Land improvement.	€ 100	0.064	0.665
y_1	Cultivated area of cereals crops.	ha	69.557	96.041
y_2	Cultivated area of protein and oilseeds crops.	ha	6.128	20.546
x	Total specific cost.	€ 100	121.240	171.347
$\bar{p}_1$	Expected oilseed and protein crop price.	€	110.547	29.218
$\bar{p}_2$	Expected cereal price.	€	119.411	21.430
w_1	Lagged input price index for plant protection products and pesticides.	-	1.031	0.022
w_2	Lagged input price index for fertilizers and soil improvers.	-	1.019	0.065
c_1	Rental price of Machinery and equipment	-	6.979	2.632
c_2	Rental price of Building and land improvement.	-	5.597	0.509
b	Total labor input of holding.	number	1.206	1.071
S	Area payments and set aside premiums.	€	16,113.290	20,827.59
S_r	Subsidies for environmental and rural development.	€	425.266	1,560.85
σ_A^2	Coefficient of variation of lagged sales by hectares.	-	49.161	432.834
$k_{1,-1}$	Lagged machinery and equipment capital.	€	17,685.72	27,312.72
$k_{2,-1}$	Lagged Building and land improvement capital.	€	17,230.45	25,648.55
g	Regular unpaid holding manger age.	year	50.727	12.21
PR	Proportion of rented UAA from the total UAA.	-	0.361	0.428
D_{ins}	Dummy variable: 1 for insurance cost, 0 otherwise.	-	0.9024	0.2967

* All the monetary values were expressed in constant currency units.

5. Results

Parameter estimates of the SUR model and the marginal effects are presented in Table 4. As mentioned, in those cases where the decision variables are censored (machinery, building and land improvement investments, and oilseeds and protein crops area), we rely on marginal effects for the interpretation of our results, because parameter estimates derived from Shonkwiler and Yen two-step method might be masking the actual effects of the explanatory variables.

As shown by previous research (Sckokai, 2005), government payments can impact production decisions through different mechanisms. First, they can influence production decisions by altering relative market prices. Second, they can also alter farmers' risk preferences by altering price or revenue uncertainty and exogenous income. As has been shown by previous research (Sandmo, 1971; Chavas and Pope 1985; Hennesy, 1998 and Serra, *et al.*, 2006), a change in risk preferences are likely to have an effect on production decisions. Finally, government payments can have dynamic effects on production by stimulating changes in investment demand (Sckokai, 2005 and Coyle, 2005).

Subsidy parameter estimates suggest that an increase in PD payments (S) increases the investment in building and land improvement (k_1). In addition, both PD payments and rural development subsidies (S_r), have a positive impact on machinery and equipment investment (k_2). Since farm output is a function of different inputs including the level of capital, which depends on past decisions on investments, the impact of CAP subsidies on investment demand will have long-lasting (dynamic) impacts on production.

PD payments further stimulate production by motivating an increase in the use of variable inputs. These results are consistent with those obtained by Serra *et al.* (2005a) who found area payments in the COP sector to motivate an increase in the use of crop protection products, thus suggesting that they are not fully decoupled. Finally PD payments are found to influence land allocation by stimulating an increase in the area devoted to cereals, the predominant crop within the Spanish COP sector.

The initial wealth coefficient estimate demonstrate that an increase in farm's wealth causes an increase in the area devoted to cereal crops as well as an increase in variable input use. The relevance of wealth in explaining production decisions is compatible with the relevance of risk attitudes in explaining production behavior. It is widely accepted that an economic agent's degree of risk aversion decreases with wealth (Sandmo, 1971; Hennessy, 1998). Hence, wealthier farmers, in being less risk averse, are likely to be more prone to expand their business size. These results together with the subsidy parameter estimates suggest that agricultural subsidies can have relevant wealth effects. Because government payments contribute to enhanced wealth, they lead to increasing output supply and input demand.

Serra *et al*. (2005b), suggested that direct costs of land rentals may create stronger incentives to work the land more intensively, relative to the opportunity costs borne by owned fields. Compatible with this hypothesis, our results show that those farms with a higher proportion of rented area (PR) are more prone to invest in machinery and use more variable inputs. They are also more likely to devote more land to grow cereals to the detriment of land allocated to oilseed and protein crops.

Farmer's age is an indicator of farmer's experience. Results demonstrate that an increase in the age (g) of the holding manager leads to an increase in investment demand. These results suggest that the more experienced the farmers are, the more likely they are to invest. It is also true that older farmers are less likely to be credit constrained relative to their younger counterparts, which facilitates investment.

Farmers who have signed up for an insurance contract (D_{ins}) tend to invest more and use more variable inputs than farmers who do not insure. To the extent that farmers are not risk neutral, insurance will reduce their aversion to risk and stimulate production. Compatible with these results, the parameter estimate representing risk (i.e., the coefficient of variation of lagged sales per hectare- σ_A^2) suggests that an increase in risk levels is accompanied by a decrease in both types of investments. Moreover, farmers also try to minimize variable input use when uncertainty increases.

While rental prices for machinery (c_1) and building and land improvements (c_2) are not significant in explaining investment decisions, other market prices such as oilseed and protein crop prices ($\overline{p}_1$) and the input index for plant protection products and pesticides (w_1) are statistically significant. An increase in w_1 yields a decrease in both investment and the demand for variable inputs. An increase in $\overline{p}_1$ is found to motivate investment in buildings and land improvements.

As expected, results suggest that a decrease in the expected price of protein and oilseed crops ($\overline{p}_1$) yields a decrease in their cultivated area in favor of cereals. Conversely, a decrease in the expected price of cereal ($\overline{p}_2$) is found to increase the area allocated to cereals. Since cereals are the main crop within the sector, a price decline causes a substantial reduction in the farmer's income. To compensate for this decline, farmers increase the quantity produced of this crop to maintain income. It is worthwhile to note that average cereal prices are higher than the alternative crop prices (Table 4). As a result, to the extent that the cereal price decline is weak, the shift to the alternative crop may not be attractive enough.

The coefficients representing the lagged stock of capital take values between -1 and 0, implying that capital adjusts to its long-run equilibrium (Boetel, *et al*., 2007). Parameter estimates of the dummy variables represent different Spanish Autonomous Communities (m_j) and are not included here to preserve space, though results are available upon request.

Table 4: SUR model and Marginal effects results

	Parameter Estimates and summary statistics (p_value between brackets)					*Marginal Effects and summary statistics for censored equations (t-value between brackets)*		
Variables	*Machinery*	*Building and land improvement*	*Oilseeds and Protein*	*Cereals*	*Variable inputs*	*Machinery*	*Building and land improvement*	*Oilseeds and Protein*
Intercept	1507.03 (0.17)	10009.81 (0.00)	-29.15 (0.50)	11.84 (0.67)	132.53 (0.19)	241.94 (0.55)	360.02 (0.83)	-27.43 (-1.23)
A_0	0.22 (0.21)	-1.46 (0.00)	0.09 (0.00)	0.45 (0.00)	0.17 (0.00)	-1.00E-3 (-0.01)	-0.03 (-0.44)	0.03 (0.81)
$\bar{p}_1$	0.21 (0.55)	4.24 (0.00)	0.11 (0.00)	-0.09 (0.00)	-0.05 (0.24)	0.02 (0.21)	0.13 (2.17)	0.07 (6.51)
$\bar{p}_2$	0.74 (0.08)	-5.00 (0.02)	5.00E-3 (0.798)	-0.03 (0.03)	-0.07 (0.16)	0.06 (0.91)	-0.13 (-1.62)	-2.00E-3 (-0.22)
w_1	746.90 (0.22)	-7849.08 (0.00)	12.09 (0.64)	2.27 (0.89)	-162.83 (0.01)	-116.56 (-0.873)	-262.84 (-1.78)	11.57 (0.76)
w_2	-1019.89 (0.01)	-2490.73 (0.00)	12.54 (0.27)	-15.08 (0.06)	42.78 (0.14)	-155.18 (-0.74)	-84.53 (-0.71)	9.41 (1.20)
c_1	-29.30 (0.00)	55.54 (0.00)	0.06 (0.77)	-0.03 (0.77)	-0.36 (0.42)	-3.09 (-0.27)	1.95 (1.01)	0.01 (0.06)
c_2	-73.43 (0.19)	-751.32 (0.00)	-2.08 (0.10)	0.88 (0.45)	-1.51 (0.72)	-12.32 (-0.33)	-25.00 (-1.23)	-0.64 (-0.72)
b	-12.86 (0.61)	-141.63 (0.12)	4.84 (0.00)	3.67 (0.00)	47.71 (0.00)	-4.32 (-1.20)	-3.70 (-0.93)	1.41 (1.70)
S	2.00E-3 (0.11)	0.02 (0.00)	2.00E-4 (0.00)	1.00E-3 (0.00)	4.00E-3 (0.00)	4.00E-4 (2.88)	4.00E-4 (2.919)	9.00E-5 (0.99)
S_r	0.02 (0.00)	7.00E-3 (0.54)	3.00E-4 (0.13)	-1.00E-3 (0.00)	-1.00E-3 (0.04)	2.00E-3 (5.22)	7.00E-5 (0.185)	2.00E-4 (1.38)
σ_A^2	-1.05 (0.08)	-5.64 (0.08)	0.02 (0.45)	0.01 (0.31)	-0.22 (0.00)	-0.16 (-1.82)	-0.148 (-2.403)	6.00E-3 (0.375)
$k_{2,-1}$	-8.00E-4 (0.06)	4.00E-3 (0.125)	-1.00E-4 (0.00)	2.00E-4 (0.00)	8.00E-5 (0.14)	-1.00E-5 (-0.28)	8.00E-5 (1.45)	-3.00E-5 (-2.63)
$k_{1,-1}$	3.00E-4 (0.503)	-2.00E-3 (0.12)	-1.00E-4 (0.00)	7.00E-5 (0.00)	2.00E-4 (0.00)	1.00E-5 (0.19)	-4.00E-4 (-0.58)	-3.00E-5 (-2.57)
g	5.44 (0.00)	12.83 (0.05)	5.00E-3 (0.87)	-0.08 (0.00)	-0.06 (0.52)	0.76 (4.86)	0.33 (3.35)	3.00e-3 (0.09)
PR	147.66 (0.00)	-64.06 (0.34)	-9.38 (0.00)	1.68 (0.05)	16.46 (0.00)	21.35 (5.43)	-2.49 (-0.63)	-2.51 (-3.59)
D_{ins}	85.80 (0.06)	272.95 (0.10)	-5.52 (0.00)	0.41 (0.70)	14.12 (0.00)	12.45 (2.38)	7.22 (2.02)	-1.67 (-1.31)
PDF	372.03 (0.00)	2008.73 (0.01)	0.71 (0.86)	-	-			
R^2	0.114	0.032	0.570	0.948	0.796			
Objective value	4.9591		Nº observation		5023			

6. Concluding remarks

Our paper focuses on assessing the impacts of PD payments on investment as well as on other production decisions. Since this is fundamentally an empirical question, we carry out an empirical analysis based upon a reduced-form application of the dual model of investment under uncertainty developed by Sckokai (2005). The model is estimated using farm-level data from a sample of Spanish farms specialized in COP production and observed during the period 2000-2004.

Our model decision variables include investment demand, variable input use and land allocation. Since some of the dependent variables are censored, a system of censored and non censored equations is estimated using the two-step procedure proposed by Shonkwiler and Yen (1999). PD payments are found to increase short-run production by increasing variable input use. An increase in PD area payments is also found to generate a statically significant increase in the investment in farm assets. In this context, the results demonstrate that this support scheme is found to increase long-run production. Results also show the importance of assessing the effects of PD payments in a dynamic framework as the one applied in this paper.

Apart from PD payments, other variables are found to influence investment decisions. These include crop insurance contracting, tenure regime of land, farmers' age, input and output prices, as well as risk. Moreover, PD payments are shown, in some cases, to be more relevant than market prices in influencing investment demand. This is a major contribution of our paper as previous literature using a static framework, arrived at different conclusions. Specifically, prices were found to be more relevant than payments in stimulating production decisions (Moro and Sckokai, 1999; Oude Lansink and Peerlings, 1996; Serra, *et al*., 2005a and Serra *et al*., 2006).

As expected, an increase in risk has a negative impact on farm investment. Compatible with these results, crop insurance contracts reduce risk and thus increase investment demand. Also, increases in output prices tend to increase investments, while increases in input prices reduce investment demand.

Results demonstrate that farmers' land allocation decisions mainly depend on market prices for both inputs and outputs. Also subsidies, labor input use and farmer age are shown to be important variables in explaining production decisions. In the same context, farm wealth and rented land are revealed to be relevant factors in influencing farmer's decisions.

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