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The impact of pillar I support on farm choices: conceptual and methodological challenges

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Abstract
In the near future the CAP will continue to be structured around two pillars. In the first pillar the main instrument for producers' support is the decoupled Single Farm Payment. In this paper we review the methodological framework for analysing decoupled payments in models of agricultural production. Market and technological uncertainty, credit constraints, farm household choices involving extra-agricultural decisions, policy uncertainty and long-run impact of decoupling on investment and land values are the relevant issues that should be pursued by methodological and empirical analysis. Future research should refine the analysis of decoupled payments, mainly trying to provide results that can be useful for policy simulation, to bridge the gap between analysis at the individual level and sector policy models.

Keywords: decoupled payments, agricultural production models, Common Agricultural Policy.

JEL classification:Q12, Q18.

1. Introduction and motivation

In the Common Agricultural Policy (CAP) jargon, the first pillar represents the set of policy instruments having to do with market support of agricultural products and direct payments to farmers, as opposed to the second pillar, which has to do with Rural Development policies.

What we now identify as the first pillar has always been the cornerstone of the CAP, since its establishment in 1957, when the six founding members of the European Union (EU) decided to start managing agricultural market support at the community level. Although the first Community rural development policies date back to the 1970s, the second pillar has been officially identified in the context of the Agenda 2000 reform, when it was established that the CAP should explicitly pursue additional objectives concerning the sustainable development of rural areas, mainly based on the idea of agricultural multifunctionality (i.e., the ability of the agricultural sector to provide a range of services going beyond the mere production of foodstuffs).

The establishment of the second pillar has had important budgetary consequences for the CAP, since, starting with the 2003 Fishler reform, a gradual transfer of financial resources from the first to the second pillar was implemented, through the so-called "modulation" mechanism, a progressive cuts of direct payments to the largest farms. As a result of this policy, which has been reinforced in the 2008 Health Check reform, the budget allocation between the two pillars has changed, but the first pillar share, according to the 2010 EU agricultural budget, is still around 75% of the total. Thus, the first pillar remains the main source of the CAP spending, and this is clearly the first strong argument for carrying out an accurate evaluation of its impact on farm choices and on the whole agricultural sector of the EU.

As it is well known, since its establishment, the first pillar of the CAP has gone through a number of fundamental changes. When the CAP came into force, in the 1960s, its main tools were explicitly targeted to support the EU prices of agricultural commodities, both with domestic support tools (primarily the intervention buying system at a given minimum price) and with some coherent trade policies (primarily a variable import levy and an export refund). In such a system, the cost of the policy was mainly due to export subsidies and public stocks' management, leaving much of the burden of the support on consumers.

The implementation of the CAP in this form led very quickly to a rapid increase in stocks and in the corresponding management costs, including third country disposal through export subsidies. As a result, some supply control policy tools, like voluntary land set-aside and production quotas for milk and sugar, were introduced. Direct payments to farmers were introduced with the 1992 MacSharry reform, as a compensation for strong cuts in the intervention prices of many agricultural commodities. Although not directly linked to output, the MacSharry direct payments were still considered "partially coupled" to production, since, for example, the area payments for arable crops affected marginal production decisions through the land allocation mechanism (Sckokai and Anton, 2005)[1].

But the true "revolution" of the first pillar was certainly represented by the 2003 Fischler reform, whose main change was the effective "decoupling" of direct payments. In fact, most of the partially coupled payments granted under the various Common Market Organisations were converted into a Single Farm Payment (SFP) based on historical entitlements, with no explicit link to any type of production decisions, although granted on disposal of 'eligible land'. The only further requirement for obtaining the SFP is the so-called "cross-compliance", a provision that links the payments to farmers' fulfilment of a set of criteria concerning issues like environment, public health, animal welfare.

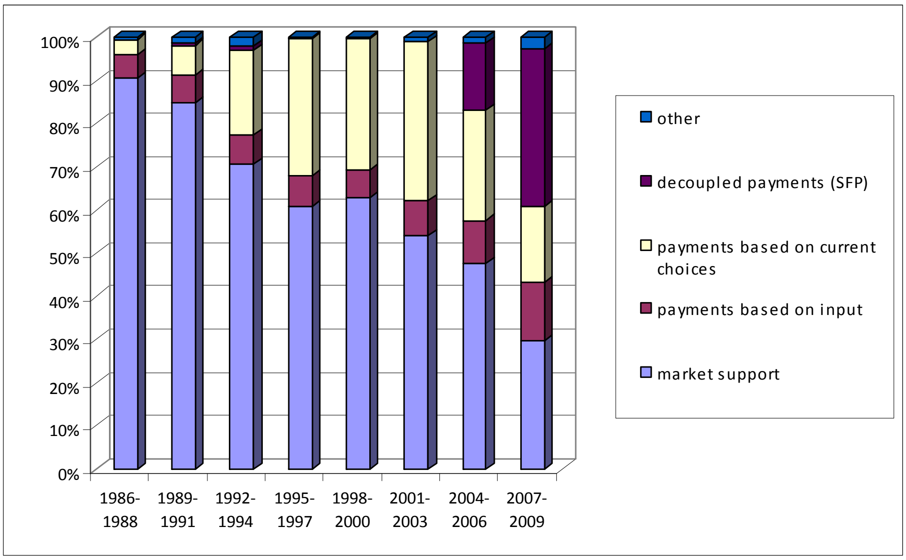
The most recent 2008 Health Check reform confirmed and strengthened this trend towards market orientation of the CAP. In fact, the intervention mechanisms have been strongly limited, all payments still coupled to production have been decoupled and moved into the SFP scheme, with very few exceptions, and one of the most distorting policy tools of the old CAP, milk quotas, will be phased out by 2015.

This wave of reforms has modified the nature of the first pillar and its composition in terms of policy tools. Based on the OECD figures, the Producer Support Equivalent (PSE) of EU farmers has radically changed (Figure 1): while in the 1980's market support measures accounted for around 90% of the PSE, in 2007-09 their share has decreased to around 27%. The

[1] The 1992 reform paved also the way for the 1994 Uruguay Round Agreement on Agriculture in the context of the trade negotiations of the WTO. As a result of that agreement, the first pillar trade policy changed quite substantially, since, for example, variable levies were converted into tariffs and strong limits were introduced on the use of export subsidies.

remaining 73% is all made of direct payments, in which the SFP takes the largest share (almost 40% of the total PSE). In terms of pure budget expenditure, in 2010 the decoupled payments have accounted for around 57% of the total EU agricultural budget.

Figure 1:Three-year average PSE in the European Union – 1986-2009.



Source: our elaboration on OECD data

This trend is likely to continue in the near future. In fact, in November 2010 the Commission presented its proposals for the future of the CAP after 2013, when the new EU budget period will start (European Commission, 2010). While the document remains still open in terms of possible reform strategies (three rather different options are offered to the public debate at the end of the document), some elements are already clear. The CAP after 2013 is likely to maintain the structure around two pillars, the first containing the support paid to all farmers on a yearly basis and the second containing the support tools for rural development, managed by the Member States on a multi-annual programming basis.

In the future first pillar, a central role will again be played by the decoupled direct payments, although their concrete application may be redesigned, based on some criteria mentioned in the document. One of the issue to be discussed is a possible redistribution of the payments across farmers, as well as the introduction of an upper ceiling for large farms. Although a portion of the decoupled payments will continue to be provided conditional on cross-compliance only, the Commission proposes that a significant portion of these payments should be provided on the basis of stronger environmentally oriented agricultural activities. Coupled payments will be maintained only for very limited and justified cases, while a simplified payment scheme for small farmers is likely to be implemented. Market measures will be maintained as a safety-net tool, to be implemented only under specific market conditions, while an increasing attention will be dedicated to the functioning of the food supply chain, since the share of the value added accruing to the agricultural sector is decreasing over time. Although no specific policy tool has been indicated, the Commission emphasises the potential disrupting role of the imbalance of bargaining power along the chain, the level of competition at each stage of the chain, the contractual relations and the transparency of food pricing.

In our opinion, this brief review of the evolution of the first pillar, and of its potential future developments, makes clear the central role of decoupled payments as main policy tool of the present and future CAP. This means that, for the agricultural economics profession, the main area of research concerning the first pillar is certainly to investigate the impact of decoupled payments on farm choices. Thus, the objective of this paper is to review the literature that has already addressed this issue, in order to identify the most relevant research challenges, both in terms of conceptual approaches and in terms of empirical implications. Before getting into the more technical details, in the next section we start reviewing the main general issues that have characterised the scientific and political debate around decoupled payments.

2. RESEARCH QUESTIONS AT STAKE

Since their introduction as concrete agricultural policy tools, with the 1996 FAIR Act in the US and with the 2003 CAP reform in the EU, the central research issue concerning decoupled payments has always been whether or not they have an impact on farm output. This is clearly the most natural research question, since the whole idea of decoupling is the use of support tools that have no market distorting effects, in the sense that they do not affect relative prices of agricultural commodities or of the inputs used to produce them. Moreover, it is also a hot political question, since both the EU and the US policy makers tend to consider their payments as "green-box" payment, which in the current World Trade Organisation (WTO) discipline implies an exemption from any domestic support reduction commitment.

The difficulties in addressing this fundamental issue are clearly shown buy the first wave of studies trying to evaluate the impact of decoupling. Since the announcement of the introduction of the SFP (which became operational in 2005), all large partial and general equilibrium models routinely used for policy analysis have been adapted for simulating the impact of the "decupling" scenario in EU agriculture, as opposed to a counterfactual scenario of continuation of the previous "partially coupled" policies. A review of these studies is available in Balkhausen et al. (2008) and Gohin (2006), where it is clear that simulation results are rather sensitive to the hypotheses made by the modellers on the "degree of decoupling" of the new SFP, and also that these hypotheses are essentially represented by an arbitrary (implicit or explicit) "coupling factor" attached to the SFP. These two review studies show how model assumptions concerning specific aspects of the CAP, like the degree of decoupling of the MacSharry type "partially decoupled" payments and the linkage between livestock and crop/fodder productions, may significantly affect simulation results.

The fact that most simulation models are forced to use an arbitrary coupling factor is clearly a signal of the complexities involved in modelling explicitly the potential output effect of decoupled payments. The conceptual paper written by the OECD (2001) already analyses some of the possible mechanisms that may generate output and trade effects of decoupled payments. Two categories of these mechanisms are analysed in detail in that paper: the risk related effects and the dynamic effects. The first ones occur because, if farmers are risk averse, any measure affecting the absolute level of farmers' income and its variability may affect production decisions, while the second ones occur because investment decisions affect both current and future production, or because farmers develop expectations concerning future policies. However, decoupled payments may affect other key variables concerning the farm decision-making behaviour. For example, if one assumes that the household production and consumption decisions are not separable, any change in income may affect labour/leisure choices, thus affecting on-farm and off-farm labour allocation. Again, if one assumes imperfect credit markets, the availability of a flow of decoupled payments may allow farmers to relax their credit constraints, obtaining, for example, better conditions for their long-term loans or better access to credit for variable input purchasing. Moreover, since the SFP, as well as the corresponding US payments, are still linked to land, the land rental market may be affected by the presence of the payments. Finally, the income support deriving from the decoupled payments may affect a crucial decision like entry and exit from the sector, especially if the provision of the payments is somehow linked to the continuation of some agricultural activity.

These possible linkages between decoupled payments and farm choices have been the subject of a relevant flow of empirical literature in recent years, which is reviewed in detail in the next sections. A common element to most of these papers is that they rely almost exclusively on case studies analysed on farm level data. This is an important signal that researchers are aware that the problems related to the potential impact of decoupled payments has to do with the individual response of farmers to market and policy incentives and that restrictions placed on aggregate model of production choices are very stringent. Of course, the use of individual data poses the problem of aggregating individual response at the sector level, so to provide usable information for policy simulation models.

EU policy and research officials seem also aware of this crucial aspect of the new CAP. If one reviews the calls for proposals launched in recent years by the European Commission in the context of the Framework Programmes (FP) for Research and Technological Development, there are important changes in the topics concerning the analysis of the first pillar of the CAP (European Commission, 2006 and 2011). In FP6 (2002-06) there was a rather strong emphasis on financing modelling efforts for policy analysis concerning either the whole EU agriculture (the AGMEMOD project is certainly the most remarkable effort in this area) or some relevant sectors of the EU agricultural economy (EDIM for dairy and WEMAC for arable crops are examples of this type); to our knowledge, only one call was specifically dedicated to the impact of decoupling, in rather general terms (the IDEMA project). In FP7 (2007-10), the topics related to the impact of the CAP have to do with much more detailed aspects, like the functioning of factor markets as capital, land and labour (the FACTOR MARKETS project) or with the modelling of CAP tools using the Farm Accountancy Data Network (FADN) data (the FACEPA and the FADNTOOL projects). It should also be noted that, in the 2010 call, one topic was specifically addressed to the "transparency" of food pricing and the functioning of the food supply chain (the TRANSFOP project). In our opinion, this change in focus of the FP7 calls, that is likely to be inspired also by the DG-AGRI officials, clearly shows their awareness that the individual farm responses to the CAP tools are the key elements to analyse the impact of decoupled payments on the EU agricultural sector. In addition, EU officials seems aware of the central role of the functioning of the food chain for determining the share of the value added accruing to agriculture.

Another common element of the studies on decoupling is that they often analyse specific details of how such payments are designed. This is another key issue: the same type of decoupled payments may have a totally different impact on farm choices depending on details like eligibility criteria, timing, transferability and so on. Thus, a very important research task is to analyse the effects of such details.

Finally, another common feature of these studies is that most of them (at least those referring to the EU policy) are based on data preceding the introduction of the SFP. Thus, they typically run simulations on the impact of decoupling using data/parameters referring to a totally different policy environment. For this reason, their conclusion should be taken with some caution, and a new wave of studies should be undertaken using also farm data referring to the post-2005 period, which are now becoming available for a reasonable time span.

The following review of the literature follows the development of a stylised behavioural model, taking into account the impact of decoupled payments on farm choices.

3. A STYLISED MODEL OF DECOUPLING

As a general behavioural model for analysing individual decisions in agricultural production, we assume that household utility is obtained by income/consumption expenditure and leisure $U(c,r)$, where leisure r is given by the total amount of allocable time L_T less the time allocated to labour l, that is $r = L_T - l$; for a farm household, income/consumption expenditure c may coincide with farm's profits $\pi = pq - wx + G$, given technology $(q,x,z,l) \in T$, where q are outputs, x are variable inputs, p and w are output and input prices, respectively, z are fixed and/or quasi-fixed inputs, T is the technology and G stands for a generic form of government support, accounting for the CAP first pillar policy instruments. Of course, this model can be extended to account for other sources of income, off-farm labor allocation and also inter-temporal choices (consumption/savings, investment).

This general model may be adapted/simplified to allow for agricultural policy analysis. In this context, can be considered as components of the G term.

3.1 The static model with no uncertainty

We start with the very simple analysis of production choices in a static environment, with production characterized by the existence of some fixed and/or quasi-fixed factors, and output decisions only involving the choice on variable inputs. The short-run time horizon prevents such models from providing an explanation about decisions on farm's investments (land, machinery, building). Choices are modelled in the context of a competitive environment with profit-maximizing price-taker farmers.

Profit maximization has been taken for a long time as the reference framework for analyzing farmer's behaviour and the impact of policy instruments, typically concentrating on choices with no uncertainty. In this case the farmer's problem may be written as:

$$\max_x \pi = pq - wx + G$$
$$s.t. \ (q, x, z, l) \in T$$

Under this simple formulation, with farmer's labor taken as a quasi-fixed factor, a standard result is that agricultural policy instruments may affect farm's output only if their amount is coupled to production choices , that is if $G = G(x)$. Considering for simplicity a single-output technology with production function $q = q(x, z, l)$, then the FOC's for this maximization problem are:

$$\frac{\partial \pi}{\partial x_i} = p\frac{\partial q}{\partial x_i} - w_i + \frac{\partial G}{\partial x_i} = 0$$

and thus coupled agricultural policy support may influence production decisions at the margin[2]. On the contrary, in this context, decoupled instruments do not have any impact on farmer's choices: in fact, lump sum payments exhibit $\partial G / \partial x_i = 0$.

3.2 The static model under risk neutrality

Agricultural production is largely characterized for being a risky business; market risk (i.e. price risk) and technological risk (i.e. output risk) are distinctive features of agricultural production, and production theory and empirical analysis have devoted a large effort to account for uncertainty. In the context of profit maximization, uncertainty is treated in a simplified way. However, if we assume risk neutrality, we may take farmers as maximizing expected profits, and this assumption does not complicate the analysis. For example, consider the simple case of output price risk only, with a given price distribution $p \sim (\overline{p}, \sigma_p^2)$; then the farmer's maximization problem may be re-formulated as:

$$\max_x E(\pi) = E(pq - wx + G) = E(p)q - wx + G$$

and thus choices are conditional on the expected price, and the only additional issue is that of modelling price expectations (naive and adaptive expectations, rational expectations, futures

[2] We first concentrate on the impact of government support on marginal decisions, that is on FOCs for maximizing behaviour. However, government support may intervene also on the decision on whether to produce or not (i.e. to exit the market); we will discuss this issue later.

contracts). Even by adding technological (output) risk, $q \sim \left(\bar{q}, \sigma_q^2\right)$, then the producer's problem is:

$$\max_x E(\pi) = E(pq - wx + G) = E(pq) - wx + E(G) = E(p)E(q) + \text{cov}(p,q) - wx + E(G)$$

that under the common (although not fully reasonable) assumption that $\text{cov}(p,q) = 0$ will just maintain the complexity of the model with no uncertainty. For example, representing the technological risk with the following stochastic technology (Just and Pope, 1978)[3]:

$$q = q(x,z,l) + h(x,z,l)\varepsilon$$

where ε is a stochastic term with zero mean and unit variance, i.e., $\varepsilon \sim (0,1)$, thus giving the following distribution for output, $q \sim \left(q(x,z,l), \left[h(x,z,l)\right]^2\right)$; then the risk neutral producer's problem will reduce to:

$$\max_x E(\pi) = E(p)q(x,z,l) - wx + E(G)$$

that is, to maximize expected profits simply based on the expected price and the expected (planned) output. As we said, the profit maximizing framework under certainty and/or risk neutrality is suitable to analyze the impact of agricultural policy instruments only if they affect decisions at the margin (that is, they impact FOCs, either because $\partial G / \partial x_i \neq 0$ or $\partial E(G) / \partial x_i \neq 0$).

Empirically, we may proceed to obtain a tractable specification by adopting either the primal approach or the dual approach. A system of equations is then derived and estimated using available data (time-series data, cross-section data, panel data, unbalanced panel data, pseudo-panel data), at different possible levels of aggregation (aggregate or individual data, different levels of output and/or input aggregation).

The primal approach requires to specify a functional form for the production function and then to estimate this production function jointly with the FOCs for profit maximization; a possible endogeneity issue for inputs arises in the context of the primal approach, but methods are available to circumvent the problem at the estimation stage[4].

The dual approach has been largely employed in agricultural production modelling. Under this approach, we may start by specifying a profit function for the farm:

$$\pi(p, w, z, l, G) \equiv \max_x \{pq - wx + G\}$$

and then deriving a system of output supply and input demand functions, where exogenous variables are prices, fixed and/or quasi-fixed factors, and policy instruments. Empirically, we need to start by assuming a (flexible) functional form for the profit function and then derive

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[3] This stochastic specification of the production function is largely employed in empirical studies; the stochastic part will allow inputs to be risk-increasing or risk decreasing, according to the sign of $\partial h^2 / \partial x_i$.

[4] Instrumental variable methods, such as 3SLS, or GMM (see Ooms and Peerlings, 2005)

explicit representations for output supply and input demand functions using derivative properties. Applications are widely available in literature.

Under the dual approach, a common practice is also that of analysing production decisions resorting to the 'cost function approach', by which we proceed to estimate an empirical specification of the cost function, defined as:

$$C(q,w,z) \equiv \min_x \{wx : (q,x,z,l) \in T\}$$

from which a system of input demand functions can be derived; note that, in principle, output price risk does not affect the cost function.

Even though, with policy instruments linked to output, the derivation of the cost function is not affected by the amount of the payments, the cost function approach may still be important for the analysis of some specific first pillar tools[5]. However, the definition and the estimation of the cost function under output uncertainty is not a trivial issue. Following Pope and Just (1996) and Chambers and Quiggins (2000) we may represent optimizing behaviour by defining a cost function based on expected output, $C(\overline{q},w,z)$, called the 'ex-ante cost function', whose estimation is challenging because expected (ex-ante) output, which is the result of both technological characteristics and producer's expectations or beliefs, is not observable; what we in fact observe is actual (ex-post) output. Solutions to the problem and further discussion have been proposed by Pope and Just (1996) and Moschini (2001); further developments can be found in Chavas (2008) and in Serra et al. (2010) for an extension to the dynamic context.

With the recent shift from coupled instruments towards decoupled instruments, the above framework appears to be not sufficient. As we have seen, fully decoupled instruments do not influence marginal decision, and therefore they do not enter the FOCs of the primal specification; therefore, also the dual profit function does not account for fully decoupled instruments, if support does not depend on production choices. Of course, moving from fully coupled instruments (like market price support) to partially decoupled instruments will require at least a refinement of the above model specification. For example, take the 1992 MacSharry reform of the Common Agricultural Policy (CAP) for arable crops, where price support was cut and compensated with area payment based on land allocation and consider the (multi-product) above specification:

$$\max_x \pi = pq - wx + G$$
$$s.t.\ (q,x,z,l) \in T$$

The support G can be modelled as $G = \sum_{k=1}^{n} b_k s_k$, for the n products subject to area payments, with s_k being land allocations of the quasi-fixed input land in z. This only partially

[5] For example, policy simulation models for evaluating the impact of the removal of the milk quota system heavily rely on the estimation of marginal costs (see, for example, Moro et al., 2005, Bouamra-Mechemache et al., 2008, and Kempen et al., 2010).

decoupled payment, that may differ among crops, will affect production choices, since the total payment will depend on land allocated between arable crops with area payments and other crops without area payments, and further also on the allocation of land within arable crops receiving different area payments. Then, in order to measure the effect of these payments we need to explicitly modelling the land allocation mechanisms of the quasi-fixed factor land (references and examples can be found in Chambers and Just, 1989; Guyomard et al. , 1996; Oude Lansink and Peerlings, 1996; Moro and Sckokai, 1999; Serra et al., 2005b).

But when instruments are more decoupled, as in the case of the SFP, where an undifferentiated area payment is provided on 'eligible land', normally coinciding with total farmland, then the 'direct' effect of agricultural support cannot be modelled within the above profit maximizing framework. However, economic theory shows that lump-sum payments (decoupled support) may in fact impact on farmer's choices.

A first route to be explored is the role of (decoupled) payments in relaxing farmers' credit constraints that limit the purchasing of variable inputs: this issue may be of great relevance for transition countries in the EU, although credit constraints may affect farms also in developed countries[6]. Consider the profit maximizing farmer with a credit constraint:

$$\max_{x} \pi = pq - wx$$
$$s.t. \; wx \leq C$$

where the presence of the credit constraint C will prevent the farm to produce the unrestricted profit maximizing output; in this context decoupled government payments may relax such constraint, that is $wx \leq C + G$[7]. Empirical evaluation of the impact of government payments on the credit constraint would first require a modelling strategy leading to a model that can be estimated econometrically. Examples of these models are rather scarce in the literature, and further research is certainly needed[8].

3.3. The static model under risk aversion

A second route by which decoupled payments may impact on production is by considering the role of uncertainty in more depth. Following the seminal work by Sandmo (1971) that pointed out how fixed costs have non-neutral effects on firm's production under (price) uncertainty and producer's risk aversion, then a decoupled payment may alter production decisions (for a review of decision-making under uncertainty, see Moschini and Hennessy,

[6] For example, evidence has been found in Blancard et al. (2006) for French farms. Their analysis, based on the definition of an expenditure-constrained profit function and the estimation of a nonparametric production technology, allows to evaluate credit constraints both in the short-run and in the long-run (i.e. on investment decisions).
[7] An important implication is that derived by Ciaian and Swinnen (2009) for land values/rents: with credit constraints, payments based on (eligible) land may increase land rents more than the amount of the payment.
[8] One of the few examples is Kumbhakar and Bokusheva (2009), that have developed a framework for evaluating output losses due to the existence of a credit constraint by applying the indirect production function. Goodwin and Mishra (2005) using a Tobit model to explain the proportion of direct payment that are used on the farm found that their proxy for credit constraint (debt/asset ratio) was significant, concluding that direct payments may in fact affect production decision in credit-constrained farms.

2001). Hennessy (1998) provides a theoretical framework for analyzing the impact of income support policies under uncertainty, basically identifying two specific effects of policy instruments under uncertainty: the *wealth effect* and the *insurance effect*[9].

To generalize the producer's problem, we may think of a (risk-averse) farmer maximizing the expected utility of income (profit) originating from production:

$$\max_x E\left[U\left(\pi\right)\right] = E\left[U\left(pq - wx + G\right)\right]$$

where U is a proper von Neumann-Morgenstern utility function; FOCs are:

$$\frac{\partial E\left[U\left(\pi\right)\right]}{\partial x_i} = E\left[U'\left(\pi\right)\left(p\frac{\partial q}{\partial x_i} - w_i + \frac{\partial G}{\partial x_i}\right)\right] = 0$$

First of all, consider that even when the support payment were fully decoupled from production choices (i.e. $\partial G/\partial x_i = 0$), the level of the payment could impact the FOCs of a non risk-neutral producer, if his expected marginal utility depends on the level of profits. For example, taking a single output farm with only price risk, a well-known result (Sandmo, 1971; Pope and Just, 1991; Hennessy, 1998) is that the *wealth effect* will increase production choices under DARA (Decreasing Absolute Risk Aversion). However, other effects may arise under uncertainty. Hennessy (1998) introduces the notion of an *insurance effect*: if decoupled payments are dependent on the source of randomness/uncertainty, as it is the case for support programs aiming to provide insurance against risk, then a further effect on farmer's choices can be detected. Therefore, a decoupled payment that will provide insurance to farmers (i.e., mitigating risk) will increase production (input use)[10]. However, the actual direction of the total effect of a decoupled payment would be an empirical matter, since it is not always possible to sign it only on a theoretical ground, unless we resort to rather restrictive assumptions.

Again, empirically the issue of uncertainty may be tackled through either a primal or a dual approach[11].

Considering the primal approach, an example may be found in Serra et al. (2006), who extend the model by Leathers and Quiggin (1991). Considering for simplicity only one output, we have:

$$\max_x \; E\left(U\left[W_0 + pq\left(x,z,l\right) + ph(x,z,l)\varepsilon - wx + G\right]\right)$$

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[9] Simulations made in Hennessy (1998) showed that the insurance effect of government programs may provide the largest impact on farmers' decision, even more than the coupling impacts, while wealth effects were in fact very small.

[10] Sckokai and Moro (2006 and 2009) have implicitly considered a further possibility, that the decoupled payment G may modify the distribution stochastic prices, and thus of farm's income. For example, the introduction of the SFP, accompanied by a reduction in guaranteed prices, modified the distribution of the price variable, thus possibly leading to a 'negative' insurance effect. It should be noted that their notion of the insurance effect is not the same as that in Hennessy (1998).

[11] An ad-hoc alternative would be that of introducing risk preferences in empirical models of production choices by means of explanatory proxy variables, as in Sckokai and Anton (2005) and Goodwin and Mishra (2006).

where W_0 is the farmer's initial wealth, with both market and technological uncertainty. By further assuming that production risk and price risk are uncorrelated[12], and assuming that expected utility will depend upon the first two moments of the distribution of wealth (mean and standard deviation), that is:

$$\bar{W} = W_o + \bar{p}q(x,z,l) - wx + G$$

$$\sigma_W^2 = (\sigma_p^2 + \bar{p}^2)\left[(h(x,z,l))^2 + (q(x,z,l))^2\right]$$

we will have the following farmer's optimization problem[13]:

$$\max_x \; E(U[W]) \equiv \max_x V[\bar{W}, \sigma_W]$$

Flexible functional forms can be specified for the expected utility and the production function[14], and then the production function and the FOCs for expected utility maximization can be estimated jointly.

The dual approach under uncertainty has been less exploited in literature. A possible route has been proposed by Coyle (1992; 1999), relying on the specification of an indirect utility function, obtained from the farmer optimizing the (expected) utility of wealth. Such a problem is tackled by specifying a (direct) mean-variance expected utility function:

$$V = \bar{W} - \frac{\alpha(\bar{W}, \sigma_W^2)}{2}\sigma_W^2$$

where $\bar{W}$ and σ_W^2 are respectively the expected wealth and the variance of wealth, and $\alpha(\bar{W}, \sigma_W^2)$ is the coefficient of absolute risk aversion[15]. Also under duality, uncertainty may be related to both output and/or price; taking the simple case of a single output farm, with

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[12] This assumption is of course questionable; market equilibrium will imply that market risk and technological risk are not independent. However, when farm data are used in empirical analysis, as it is common nowadays, this assumption may be considered acceptable (Serra et al., 2006)

[13] Note that according to this specification we are considering only the *wealth effect* of a non-stochastic decoupled payment. However in principle the model can be adapted to accommodate different situations and thus allowing also for evaluating the insurance effect of decoupled payments. For example consider a very simple case for which the payment is taken as a (decreasing) linear function of output price p, thus not depending on producers' choices, that is $G = \bar{G} - gp$, then the problem is:

$$\max_x \; E\left(U\left[W_0 + pq(x) + ph(x)\varepsilon - wx + \bar{G} - gp\right]\right)$$

and therefore $\bar{W} = W_o + \bar{p}q(x) - wx + \bar{G} - g\bar{p}$ and $\sigma_W^2 = (\sigma_p^2 + \bar{p}^2)\left[(h(x))^2 + (q(x))^2 + g^2 - 2gq(x)\right]$.

[14] As an example, Serra et al. (2006) used the flexible utility $V = \bar{W}^\theta - \sigma_W^\beta$ proposed by Saha (1997), where the sign of β will determine risk attitude (aversion, neutrality, loving) and the value of θ the type of risk preferences under risk aversion (constant, decreasing or increasing absolute risk aversion, i.e. CARA, DARA or IARA). For the production function, it is common to refer to a quadratic specification for $q(x,z,l)$ and $[h(x,z,l)]^2$. A slightly different approach can be found in Koundouri et al. (2009).

[15] The coefficient of absolute risk aversion is defined as $\alpha = -U''/U'$. Note that if α were independent from $(\bar{W}, \sigma_W^2)$, then we would have CARA preferences, while DARA preferences would require $\partial\alpha/\partial\bar{W} \le 0$.

uncorrelated price and output risks, then we may have $p \sim \left(\overline{p},\sigma_p^2\right)$ and $q\left(x,z,\varepsilon\right) \sim \left(\overline{q},\sigma_q^2\right)$, where ε may account for weather/environmental variability. Then $\overline{W} = W_o + \overline{pq} - wx + G$ and $\sigma_W^2 = \sigma_p^2 q^2 + \sigma_q^2 p^2$, and therefore we may define the (dual) indirect utility function $\overline{V}$ as (see Coyle, 1999 for properties of this indirect utility function):

$$\overline{V}\left(\overline{p},\overline{\varepsilon},\sigma_p^2,\sigma_\varepsilon^2,W_0,w,G\right) = \max_x V = \max_x \left\{W_o + \overline{pq} - wx + G - \frac{\alpha\left(\overline{W},\sigma_W^2\right)}{2}\left[\sigma_p^2 q^2 + \sigma_q^2 p^2\right]\right\}$$

An application of this procedure to the analysis of the CAP decoupled SFP can be found in Sckokai and Moro (2006); they consider only price risk and rely for the empirical analysis on the normalized quadratic form to approximate the indirect utility $\overline{V}$; Coyle (1999) provides an empirical example on how to use this approach when both price and output risk are considered.

From an empirical point of view, a relevant issue to be considered is related to the modelling of risk perceptions from producers, leading thus to the definition of the form of the distribution of the stochastic variables and the computation of the relevant moments (in the above case, computing the mean and the variance for the two stochastic variables, price and output). This will require to assume some mechanism for the formation of expectations for the two stochastic variables. For example, considering stochastic prices, a very simple way is that of taking the approach by Chavas and Holt (1990) and Pope and Just (1991) that use adaptive expectations for which $\overline{p}_t = p_{t-1} + \left(\overline{p}_{t-1} - \overline{p}_{t-2}\right)$; furthermore, the variance covariance matrix can be computed by resorting again to the method proposed by Chavas and Holt (1990), where variances are computed as a weighted sum of squared deviations of past prices from their expected values (means), that is $\mathrm{var}\left(p_t\right) = \sum_{i=1}^{J} \omega_i \left(p_{t-i} - \overline{p}_{t-j}\right)^2$. A similar route can be followed to compute the mean and the variance of output. A second relevant empirical issue is that of aggregating outputs and prices; theoretical conditions for aggregating outputs and inputs are known (see Just and Pope, 2001 for a review), and also empirically index number theory provides methods to aggregate prices (and output). But when we have risk in either prices or output then the standard approach must be extended to account for risk, in order to define the correct mean and variance for the aggregate index (see Coyle, 2007, and Sckokai and Moro, 2009, for an application).

A common feature of the expected utility maximization approach is that of leading to the estimation (and testing) of farmers' risk preferences: evidence of risk aversion has been found in most of the empirical analysis on decoupled payments. Serra et al (2008) found that Spanish arable crop farmers are risk averse, displaying DARA preferences; the same result was found by Serra et al. (2006) using farm data for Kansas. Risk aversion (under constant relative risk aversion, CRRA, a class of DARA preferences) was found by Sckokai and Moro (2006) for

Italian crop producers, with the degree of risk aversion lowering from small farms to large farms; Koundouri et al. (2009) resorting to a different specification of the primal approach[16] found that in Finland farmers' risk aversion decreased through time, also following the introduction of direct payments, as well as with farm's size[17].

The policy relevance of this type of analyses relates to the empirical measure of the impact of decoupled payment on production decisions. Despite the empirical evidence of risk aversion, the estimated wealth effect implied by risk preferences and decoupled payments is low; thus also the estimated impact on production through the wealth effect is low. Serra et al. (2006) found that input demand elasticities with respect to decoupled payment were not statistically significant; in Sckokai and Moro (2006) estimated 'wealth elasticities' were quite high, but the simulated wealth effect of the introduction of the SFP was small compared to the 'insurance effect' and to the total effect on production and land allocation[18].

The above studies model decoupled support as increasing final wealth in each period, by simply adding (annual) payments to initial wealth; as a results, the actual percentage change in wealth due to decoupled payments is low[19]. Of course, such results can be used also to evaluate the effect of placing limits on payments ('capping the CAP'), as in the case of modulation for the SFP[20]. However, it is important to recognize the role of decoupled payments on land values, since for a landowner land may represent a consistent share of initial wealth[21]; within the context of expected utility maximization (under CRRA), Femenia et al. (2010) show that a decoupled payment will impact on initial wealth through its capitalization in the value of owned land and that the production (wealth effect) is then larger.

Results from such models have important normative implications. As we said, empirical models provide information on the type of risk preferences, also allowing for testing different hypothesis; results from this study may be used to 'improve' actual policy instruments, aiming to augment farmers' welfare. In his 2008 AAEA Presidential Address, Professor Richard Just (Just, 2008) has deeply questioned the relevance of the above empirical approach to study an uncertain world, since the most common specifications would prevent to identify preferences (i.e. attitude towards risk) and perceptions (i.e. agent's subjective probabilities).

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[16] In Koundouri et al. (2009), farmers' risk preferences are not modelled taking an explicit representation of the utility function (as the flexible utility function in Saha, 1997), but a risk preference function is used to model the FOC's term given by $E(U'\varepsilon)/E(U')$. This approach would be flexible enough to accommodate different types of risk aversion preferences. Furthermore, under their specification, risk preferences may vary over time.

[17] A further feature of the analysis in Koundouri et al. (2009) is the identification of the so-called 'downside risk aversion', that measures the attitude towards the skewness in the distribution of profits; findings are that farmers in Finland moved towards more willingness to accept the risk of disastrous effects.

[18] The same evidence was obtained in a multi-period extension of their model (Sckokai and Moro, 2009).

[19] In a recent paper (Just, 2009) it has been questioned that empirical studies aiming at evaluating wealth effects for decoupled payments in production decisions may have some relevance: in fact 'the size of wealth transfer necessary to induce substantial changes in risk aversion … must be extremely large to make a substantial difference' (Just, 2009).

[20] For an example, see the analysis by Goodwin (2009) for the USA.

[21] Usually individual farm data do not allow to have exhaustive information on farm household's wealth, which is then approximated using the value of owned farm assets.

In agricultural production analysis, we may define profits as in the profit function $\pi(x,v)$, where the stochastic variable v represents any source of uncertainty, due to market and/or technological conditions, with density $f(v)$. Given that farmers will base their decision on maximizing the expected value of a proper $U[\pi(x,v)]$, then farmers' behaviour will derive from $\max_x \int U[\pi(x,v)]f(v)dv = \max_x \int \bar{U}(x,v)f(v)dv$. However, the same behaviour (i.e. the same revealed preference data) can be consistent with alternative specifications of risk attitudes and probability density, such as any pair $\tilde{U}(x,v) \equiv \bar{U}(x,v)f(v)/\tilde{f}(v)$ and $\tilde{f}(v)$, so that $\max_x \int \tilde{U}(x,v)\tilde{f}(v)dv$ will lead to the same behaviour (Proposition 1 in Just, 2008; see also Just and Just, 2009). Thus, the empirically estimated behavioural equation systems will not allow for full identification, that is 'the estimation of behavioural equations cannot distinguish curvature in a utility function from a redistribution of … risk' (Just and Just, 2009)[22]. This means that the specification of the utility function U and of the risk perceptions, (i.e. the form of the distribution of random variables), inducing the distribution of profits, is purely arbitrary, and one choice will constrain the other. Further, in the function $\bar{U}(x,v)$ curvature in the utility function U (i.e. risk preferences) and curvature of the profit function π (production technology) may substitute for each other.

The discouraging consequence is that estimation of risk preferences may just be a vain exercise since it will require the identification of both the risk structure and the production structure. Therefore, if risk preferences cannot be identified, then any normative conclusion based on such models may be biased and misleading[23], leaving to such models only a positive value, although still relevant[24]. However such conclusions should not stop researchers to put additional effort in the empirical analysis of uncertainty in production. One proposed solution is that of estimating additional relationships (i.e. technological relationships and relationships identifying price and production risks) together with behavioural (FOC) equations[25]; alternatively, we may supplement observed data with elicitation and/or experimental methods[26]; recent development using the state-contingent approach also allow to analyse at least production risk in models of production decisions without resorting to an expected utility specification (Chavas, 2008).

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[22] As we have seen above, farmers' perceptions are usually modelled in an ad-hoc manner, using simplifying assumption on the way individuals form their (subjective) perception of risk.
[23] A similar conclusion can be found in Lence (2009): using simulated data, he showed that '… allowing for a flexible-utility specification yields risk preference estimates that bear no resemblance to the true parameters' (Lence, 2009).
[24] Further discussion on the appropriateness of the Expected Utility paradigm in applied analysis and proposals of calibration methods to assess the use of such paradigm can be found in Just (2009) and Just and Peterson (2010).
[25] An interesting route may be that of integrating economic analysis with technological principles, as in Zhengfei et al. (2006).
[26] An example of an experiment on production decisions under uncertainty and government payments can be found in McIntosh et al. (2007).

3.4 Further issues in static models

Risk attitudes and market and/or technological uncertainty are not the only way by which decoupled instruments may influence production choices in a static environment. For example, (decoupled) support may impact the decision of exiting the market (see Chau and de Gorter, 2005 and de Gorter et al., 2008): therefore, at the sector level, although marginal decisions are not affected, the infra-marginal decision of staying in the market will produce 'distortion' in the quantity supplied, with a possible relevant impact on trade volumes, and thus on the notion of decoupling in trade negotiations and dispute settlements. The problem is relevant if sector-specific payments are granted for a limited amount of output[27], but it may be important also for the SFP.

To understand this issue, consider the above simple single-output profit maximizing firm that $\max_x \pi = pq - C(q)$; the (short-run) decision on whether the farm will produce, at the optimal level $q^* > 0$, or will not produce and exit the market depends on the relation between output price and average variable costs, that is, $q^* = 0$ if $p < C(q^*)/q^*$. In this simple framework, a decoupled support G does not influence decisions at the margin, but if it is linked to the agricultural activity (as it is the case of the SFP, which is granted to farmers *being active* on eligible land), then we have that the firm will exit the sector if $p < \left[C(q^*)/q^* - G/q^* \right]$. Therefore, even in this simple framework, the (decoupled) support will impact on the farmer's decision to stay in business; the result is output distortion at the sector level and possible inefficiency due to the persistence of infra-marginal firms, affecting the process of sector re-structuring[28]. This of course recognizes the nature of existing decoupled payments in the CAP first pillar that are in fact linked to agricultural activity. One justification for such provision is that policy makers aim to provide income support to actual farmers; another justification is that payments might be taken as rewarding the multifunctional role of agricultural production (although this may overlap with measures that are traditionally included in the second pillar). In such a situation, however, the crucial point is the impact of decoupled payments on land values

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[27] In fact, de Gorter et al. (2008) analyse the issue of cross-subsidization, for which farmers receive a sector-specific support on a limited amount of output. The empirical example refer to the Milk Income Loss Contract in the United States, where milk farmers are granted a support on a limited production eligible for the payment when domestic prices are low.

[28] Key and Roberts (2006) have found a positive significant impact of direct payments on the survival of farm business; thus large farms receiving higher payments may in fact benefit further by decoupling, at the expenses of small farms exiting the sector. Further indirect evidence can be found in Roberts and Key (2008) who evaluated the impact of government payments on land concentration, using zip-code census data; over the time span 1987-1982 they found evidence that government payments did in fact favour land concentration (a proxy for 'exit the sector'), but for the sub-period 1997-2002, when decoupled payment started to be enforced, the rate of land concentration was lower than before.

(which is discussed in detail below); of course, if decoupled payment are capitalised in land values/rent, than support to actual farmers will depend upon the share of land they own[29].

Since the SFP, as well as the US decoupled payments, are linked to land, one of the key policy issues that is often advocated is the potential capitalisation of such payments in land rents/values. The extent to which this capitalisation occurs is relevant for policy in two aspects: for the distribution of payment benefits between landowners and farmers (as it is well known, a relevant share of agricultural land is rented both in the EU and in the US) and as a signal of the extent of the production response to such payments[30]. An excellent review of this literature is available in Latruffe and Le Mouel (2009), who review both the theoretical and the empirical studies. The theory clearly says that the key factors affecting the extent of the capitalisation of both output subsidies and area payments in land rents is the price elasticity of land and non-land inputs as well as the degree of substitutability between these two categories of inputs[31].

A structural model of the impact of government payments on land pricing is provided in the studies by Roberts et al. (2003) and Lence and Mishra (2003). Starting again from the multi-output version of the above profit maximisation model:

$$\max_{x,s} \pi = pq - wx - r\sum_i s_i + G$$
$$s.t.\ \left(q,x,z,l\right) \in T \qquad \sum_i s_i = s$$

where r is land rent, s is total rented land and farmers are supposed to choose land allocation among different crops and the level of non-land inputs, government support G may include (coupled) output subsidies and/or (partially coupled) crop-specific area payments and/or a (decoupled) payment linked to total land. The FOCs of the above representative farmer, in a given geographical area where total agricultural area is fixed at S, yield the equilibrium value of land rent r, whose main determinants are crop revenues and the different categories of government payments. Thus, one can run a simple regression of cash rents against these variables, as well as other variables capturing farm heterogeneity, in order to obtain the degree of capitalisation of government payments However, these regressions normally carry serious identification problems, such that an appropriate estimation technique must be adopted, typically involving instrumental variables.

A common result of these studies, as well as of other studies adopting different approaches[32], is that the degree of capitalisation of (yearly) government payments in (yearly)

[29] Further empirical analysis on the impact of decoupled payments on farmers' exit decisions should be based on the estimation of farms' (marginal) cost; the cost function approach may then be useful.
[30] A high incidence of government payments on land rents may reflect a low production response to support programs, with a larger share of payments accruing to land owners, while a low incidence may imply the opposite, since payments are dissipated in higher output prices and higher non-land input prices, thus accruing to commodity and input producers (Roberts et al., 2003).
[31] See the graphical analysis in Latruffe and Le Mouel (2009) for details.
[32] These approaches are based either on extensions of the traditional Present Value Model, in which researchers try to distinguish between the contribution of crop returns and of government payment returns (Goodwin et al., 2003; Shaik et al., 2005, Latruffe et al., 2008), or on some reduced form regressions that try to link together the

land cash rents is less than 100%, and typically higher for more decoupled payments (from 80 to 90%) than for output-based payments (35-45%). Most authors explain the departure from the theoretical 100% capitalisation rate of decoupled payments with the requirements that farmers have to fulfil for obtaining them (i.e. set-aside, cross-compliance, ...)[33]. However, one of the striking features of this literature is that almost no studies refer to the EU, especially after the introduction of the SFP; notable exceptions are Patton et al. (2008) for Northern Ireland and Latruffe et al. (2008) for Czech Republic, but their data refer to the pre-SFP period. Since national legislations and local conditions are extremely important for land markets, and the issue of capitalisation remains a crucial policy problem, this is certainly an area where further research is needed.

Policy instruments may also impact production decisions if we take as a reference the farm household production model (Sen, 1966), with farm household welfare depending on consumption c and labour allocation, given leisure r. Refining our profit maximizing model by considering the general case of a (unitary) farm-household production model[34]:

$$\max_{l_F} U(c,r)$$
$$c = \pi(l_F) + G$$
$$r = L_T - l_F$$

where l_F is on-farm labor allocation. We may take a simple (additive) formulation for the household utility function, that is $U(c,r) = u(c) + v(r)$, and derive the FOC for optimization, assuming an interior solution:

$$u_c \pi_l - v_r = 0$$

From this result, it is clear that decoupled income support G may impact production decision by substituting for labour allocation, that is $dl_F/dG < 0$[35]; thus, since output is increasing in labour, we have that decoupled payments will reduce production.

If we then consider that the (unitary) farm household may allocate labour either on-farm, l_F, or off-farm, l_O, at the wage w_O, then the above problem becomes:

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contributions of the various theoretical models (Devadoss et al., 2007; Patton et al., 2008), or, more recently, on cointegration techniques, examining the relationship between net farm returns and land prices (Mishra et al., 2008). Lagerkvist (2005) also proposes a dynamic model of farmland investments, which is discussed in the next section.

[33] Other possible explanations are related to the imperfections in the land market, like transaction costs and imperfect competition See for example the analysis by Ciaian and Swinnen (2006) on the new EU member states.

[34] Assuming a unitary farm household is of course a simplification. Note that in this formulation consumption is taken as given by farm's profits, conditional on on-farm labour allocation and decoupled payments. Also, in the discussion we do not account for uncertainty, but of course risk and uncertainty may be introduced in such models.

[35] By totally differentiating the FOC we get that $dl_F/dG = -[u_{cc}\pi_l]/[u_{cc}\pi_l^2 + u_c\pi_{ll} + v_r] < 0$, given the usual assumptions on the curvature of the profit function and the utility function; thus a decoupled payment will reduce the on-farm labour intensity of production.

$$\max_{l_F, l_O} U(c, r)$$
$$c = \pi(l_F) + w_O l_O + G$$
$$r = L - l_F - l_O$$

A standard result from comparative statics is that decoupled payments G will not impact production decisions, since all adjustment is borne by off-farm labour[36]; of course such result will imply the complete functioning of the labour market. In a recent paper (Key and Roberts, 2009) it has been argued that farmers may obtain additional non-pecuniary benefits from on-farm labor: therefore on-farm labor enters directly farmer's utility $U(c, r, l_F) = u(c) + v(r) + b(l_F)$. Two main results are obtained from this simple additive model[37]; first, $dl_F/dG > 0$ and $dl_O/dG < 0$, which means that farmers will substitute on-farm labor for off-farm labor with a decoupled payment; second, in equilibrium $(w_O - \pi_l) > 0$, that is the market wage for off-farm labor is greater than the marginal profit for labour (i.e. its shadow-price). Thus farmers are willing to accept a lower remuneration for their on-farm labour given that non-pecuniary benefits are associated with it. A further striking implication of this result is that the empirical observation that agricultural income is lower than income in other sectors may be explained, at least partially, by this attitude. Thus, payments granted to farmers as a form of compensation for multifunctional activities and for lower average income may not be fully justified[38].

3.5 The dynamic model

As discussed in the introductory sections, a natural extension of the static model is a multi-period dynamic model of farmers' decision making. The relevance of modelling decoupled payments in a dynamic framework is clearly the ability of analysing long term farmers' decisions, like investments in land and/or in other capital goods. The potential linkage between decoupled payments and farm investments has been typically related to imperfect capital markets, which means, for example, gaps between borrowing and lending rates, binding debt constraints, high bankruptcy risk and other financial problems. In these cases, even a fully decoupled payment may stimulate farm investments, thus affecting farm output[39].

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[36] The comparative statics for the problem will give $dl_F/dG = 0$. and $dl_O/dG < 0$. Serra et al. (2005a), Ahearn et al. (2006) and El-Osta et al. (2008) found that government payment has a significant negative effect on off-farm labor participation. Although in the above simple theoretical model uncertainty is not accounted for, decoupled payments may provide an effect on off-farm participation by reducing the risk (i.e. variability) of farm income.

[37] Key and Roberts (2009) stress the fact that such unambiguous results are conditional on additive separability assumption of the farmer's utility function.

[38] In terms of econometric methodology, most of these labour supply models are estimated through discrete choice models and/or sample selection techniques (estimated in one or two stages). A recent example, again referring to the impact of US decoupled payments, can be found in El-Osta et al. (2008).

[39] In a recent theoretical paper, Vercammen (2007) shows that a decoupled payment may relax the risk of bankruptcy and that the consequent investment response by farmers may be stronger for middle-sized farms, the category in which the majority of EU farms is likely to fall.

A dual model of dynamic farm decision making, incorporating also farmers' risk attitude, may take the following form[40]:

$$J\left(\overline{p},\overline{\varepsilon},\sigma_p^2,\sigma_\varepsilon^2,W_0,w,G\right)=\max_I \int_t^\infty e^{-rv}U\left(\overline{p},\overline{\varepsilon},\sigma_p^2,\sigma_\varepsilon^2,W_0,w,G,K(v),I(v),z,l,v\right)dv$$

$$\text{s.t. } \dot{K}=I-\delta K \qquad K(t)=k$$

where v is time, t is the starting time of the planning horizon, K is a vector of quasi-fixed inputs, for which farmers are assumed to make investment decisions, I is a vector of gross investment in quasi-fixed inputs, z is a vector of fixed inputs, for which investment is not possible, and $J(\cdot)$ is the discounted flow of expected utility of wealth. The corresponding indirect expected utility function is similar to the previous one, except that now the technology is time dependent:

$$\overline{V}\left(\overline{p},\overline{\varepsilon},\sigma_p^2,\sigma_\varepsilon^2,W_0,w,G\right)=\max_x V=\max_x \left\{W_o+\overline{pq}-wx+G-\frac{\alpha\left(\overline{W},\sigma_W^2\right)}{2}\left[\sigma_p^2q^2+\sigma_q^2p^2\right]\right\}$$

$$s.t.\ \left(q(t),x(t),K(t),I(t),z,l(t),t\right)\in T$$

The above dynamic maximisation problem can be solved differentiating the Hamilton-Jacobi-Belmann dynamic programming equation corresponding to the function $J(\cdot)$, since this provides a set of output supply, input demand and investment demand equations that can be estimated simultaneously[41]. An example of this approach, considering price uncertainty only, can be found in Sckokai and Moro (2009), where they estimate this model on a sample of Italian arable crop farms and then simulate the potential impact of a change in coupled support tools (the intervention price), partially coupled tools (the MacSharry type area payments) and decoupled tools (the SFP). A reduced form of this same model is estimated by Serra et al. (2009) on a sample of Kansas farms, where the lower complexity of the estimated equations allow the authors to adopt more realistic assumptions in terms of investment farm behaviour, which imply more sophisticated estimation techniques. In fact, Serra et al. (2009) distinguish between three regimes of investment behaviour (investment, disinvestment and no investment) with different adjustment cost functions, while Sckokai and Moro (2009) assume, in line with the previous literature, a strictly convex adjustment cost function, with smooth adjustment of the level of quasi-fixed inputs, which is clearly less realistic[42].

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[40] Continuous time is the standard assumption in these models, since it allows full differentiability when deriving the following dynamic programming equation. However, simpler models may be adopted in a discrete time framework. For example, Feinerman and Peerlings (2005) propose a two-period model of farmland demand under uncertainty in land availability, which is estimated on a sample of Dutch dairy farms. The interest of their model is the evaluation of the "Option Value" of postponing investment when uncertainty is resolved, as predicted by the well known Option Theory (Dixit and Pindyck, 1994). Although they do not explicitly consider the impact of direct payments, their model should be easily extendable to account for them.
[41] See Sckokai and Moro (2009) for details.
[42] An alternative methodology for analysing the investment reluctance phenomenon (i.e. the sub-optimal investment rates observed in many farming systems) is proposed in Hüttel et al. (2010), as an extension of the traditional *q*-

Results concerning the impact of decoupled payments on investment cannot be considered conclusive. Sckokai and Moro (2009), simulating the impact of the SFP, find a rather small impact on investment and, consequently, on arable crop output. On the contrary, in Serra et al. (2009), the ex-post investment demand elasticities with respect to decoupled payments turn out to be rather strong, especially in the disinvestment regime, when their impact can be even stronger then the output price impact. Given these non conclusive evidences, additional research efforts in this area are certainly needed.

A further important problem that can be analysed in a dynamic setting is the issue of uncertainty about future policy, in the sense that farmers may develop expectations about the future evolution of the payments that may affect their current choices. This problem has been analysed by Bhaskar and Beghin (2010) for the US policy, where the level of farm payments depends on individual base acreage and yields that, at least in theory, may be updated in the following Farm Bill period. Their model is a two-period discrete-time dynamic model (the two periods represent two successive Farm Bills) in which their expected utility function is very similar to the one presented above, since they assume a representative risk averse farmer (with CRRA preferences) facing price and yield uncertainty, with price and yield being negatively correlated. They do not estimate the model, but they simply run a simulation after having calibrated their model with some parameters taken from a representative maize farm. Their results show that acreage may increase by as much as 6.25%, when the farmers' subjective probability that base acreage and yields will be updated reaches its maximum.

A parallel analysis for the EU case has been carried out by Lagerkvist (2005), although with a different objective. In this paper, the author analyses the issue of uncertainty about the timing of decoupling of the EU area payments, and he develops a model of optimal farmland investment decisions in order to maximise the land value of a representative farmer. In an infinite horizon risk-neutral dynamic model, farmland value is defined as the capitalised value of the flow of its potential returns, while the decision to invest/disinvest in new farmland depends on the comparison between the returns of land and those of alternative investments, outside the agricultural sector. The model is used to run a simulation in which the farmers' subjective probability about the timing of decupling and the future level of the payments are elicited through a farm survey carried out in Sweden in 2002, when the MacSharry payments were still in place. The main result of this study is that farmers facing this type of policy uncertainty tend to overinvest in farmland, and, once the uncertainty is resolved, the final value of their land turns out to be lower than the optimum.

In this specific area of dynamic analysis of policies, the available results have only been obtained through numerical simulations. However, since the future level of the post-2013 CAP

model. Their objective function $J(\cdot)$ is similar to the one presented here, except that they do not consider risk attitudes. Although they do not specifically analyse the impact of decoupled payments, their model should be easily extendable to account for them.

payments is one of the key source of uncertainty for EU farmers, it is certainly valuable to develop more research efforts.

4. EMPIRICAL ISSUES

The empirical analysis of the issue of decoupling is rather complex and the literature proposes a number of different approaches. However, as it is clear from the previous section, the most widespread approach relies on case studies based on the econometric analysis of farm-level data. This clearly raises a number of issues concerning both the quality of the available farm-level databases and the econometric methods that are most suitable for this kind of analyses.

4.1 Farm data and the FADN

The use of farm data for analysing the impact of decoupling on the agricultural sector seems coherent with the general idea that such impact is mainly due to the individual farm response to decoupled payments, like the SFP. We think this is also the most suitable starting point for deriving results at the aggregate level, or for deriving parameters to be used as input for large models that are routinely used for policy analysis, although generalising individual results may not always be straightforward.

As it is well known, the FADN is by far the most widely used farm-level database in the EU, since it provides very detailed data on many aspects of the farm business (production activities, costs of production, labour use, capital and livestock endowment, land allocation, subsidies and CAP payments...) and data are homogeneously collected in all EU member states. Moreover, the FADN sample is representative both at the regional and at the sector level (i.e. cereals, dairy, beef, fruits and vegetables…) and each farm carries a specific weight corresponding to the number of agricultural holdings it represents. This rather unique feature of the FADN database is very important, since it allows to design rigorous procedures for generalising the sample results to the population level[43].

Nonetheless, since the FADN database structure is regularly revised by the European Commission, a natural question is whether it can be improved in order to better analyse a crucial issue for the CAP like the impact of decoupling. In this respect, we think that at least five aspects deserve some careful consideration.

First, since many studies try to answer questions concerning the impact of the SFP on input use, data concerning the quantities of variable inputs used on farm would be extremely helpful, especially if they have to do with the environmental impact of agriculture. Right now,

[43] An example of this type of generalisation can be found in Moro et al (2005) and Kempen et al (2010), where milk marginal costs are estimated at the regional or sub-regional level, considering explicitly the farm-specific weights in the estimation procedure. Moreover, results are generalised at the national level properly using the corresponding FADN weights.

input use is detailed only for labour, while for most categories of variable inputs (fertilisers, pesticides, water, energy, feed...) only total costs are provided, such that researchers are forced to derive indirectly input quantities making use of some aggregate input price indices, typically taken from national/regional statistics. While for inputs like water and energy quantities should be easily recorded, we are aware of the difficulties in measuring quantities for inputs like fertilisers, feed or pesticides. However, the technical literature provides some aggregate indicators that may be useful in providing a common base for aggregating quantities of different commercial products used on farm (i.e. the nutrient content of fertilisers, the energy content of feed, …..).

Second, as long as the SFP is supposed to affect both production and consumption choices of the farm household, the availability of more data on household characteristics would be also very helpful. For example, some socio-demographic information (i.e., age and education of the farm manager, number of household members...), as well as data concerning the household off-farm labour and off-farm sources of income/wealth (including savings and share holdings), would help in better interpreting the farmers' choices, especially in models taking explicitly into account farmers' risk aversion.

Third, since the investment impact is considered a crucial issue for studying the role of the SFP, more detailed information on stocks and investments in capital goods would greatly help research in this area. For example, it would be helpful to know the type of capital goods for which the farmer makes its investments (i.e. a new milking machinery, a new barn, a new tomato harvesting machinery, new production or emission rights,…) in order to link more precisely investments and farm activities.

Fourth, as long as the impact of the SFP has to be estimated using dynamic models, in which the time dimension becomes relevant, it would also be helpful if farms stay in the FADN sample for a longer time period. This would help the identification of unobserved heterogeneity among farms, using appropriate panel data models, and would also allow to better analyse a crucial policy issue like farm entry and exit.

Finally, if the results of farm business, and the choices concerning the SFP, are increasingly dependent on what happens in the downstream supply chain, some information on the relationship between the farm and the downstream firm/markets would be very helpful (i.e. if the farm delivers its product to a private processor, to a cooperative or to an intermediate agent; which type of processed products are made from the agricultural raw material…)

To be honest, similar recommendations on possible improvements of the FADN database have already been raised in the past (see for example Gardebroek and Oude Lansink, 2008). This means that it is also necessary to find an appropriate communication channel between researchers and FADN managers, in order to make at least some of these changes operational.

4.2 Econometric issues

The structure of most individual farm databases, including the FADN, is that of an unbalanced rotating panel, where farms stay in the sample for a (variable) number of years. An exception may be represented by some ad hoc farm surveys, carried out in the context of specific research projects: in these cases, the structure of the databases is that of a pure cross-section.

Most of the papers reviewed in the previous sections use classical econometric techniques to analyse such data. Possible alternatives could be the use of Bayesian estimation as well as of Maximum Entropy estimation, since both approaches carry the well known advantage of using prior information in the estimation of the parameters of the model (i.e. natural bounds concerning supply/demand elasticities, investment rates, risk aversion coefficients...) as well as the possibility of deriving individual specific parameters[44]. Although they have been often invoked as superior alternatives to classical econometrics methods, very few agricultural policy studies published in peer reviewed journals have recently used either Bayesian estimation or Maximum Entropy estimation[45], and none of them have dealt with the issue of decoupling.

In the econometric analysis of unbalanced panels of farm-level data, most of the papers reviewed in the previous sections have relied on some simplified approach, even though most of them required the estimation of complex systems of equations, in which the issue of censoring is also extremely relevant (i.e. in most cases, the dependent variable of these equations displays many "zeros", since it is very common that, for example, not every farm produces each crop every year).

The analysis of unbalanced panel datasets is an area of econometrics that has developed dramatically in recent years, such that most of these methods have not yet been incorporated as automatic commands in the common commercial softwares. In general, econometric panel-data techniques relies on the so-called Error Component Model (ECM), of which the well known fixed effect and random effect models are the most standard applications. However, when the panel is incomplete, standard estimation methods cannot be applied and the ECM must be generalized to the unbalanced case (see, e.g., Wansbeek and Kapteyn, 1989; Baltagi et al., 2001; Davis, 2002). Furthermore, since the farm-level data-sets often span over several years, the most appropriate regression technique is a two-way ECM, in which both time and individual (i.e. farm-specific) effects are taken into account (see, e.g., Boumahdi et al., 2004, for a recent application). Finally, if one has to estimate a system of equations, these panel data estimation techniques must be generalized to the simultaneous estimation of a set of regressions. This clearly implies a high level of complexity, since the structure of the error term of the estimated equations is heavily affected by the panel structure of the data and by the censoring problem.

In terms of estimating systems of equations on unbalanced panel data, in a recent paper, Platoni et al. (2010) have extended the one-way Seemingly Unrelated Regression (SUR) technique proposed by Biørn (2004) to the two-way case. The same authors (2011) have

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[44] See Green (2007, chapter 18) for an introduction to Bayesian methods and Lancaster (2004) as a textbook in this area. See Golan et al (1996) for a comprehensive discussion of Maximum Entropy.
[45] Notable exceptions are Gardebroek (2006) for Bayesian estimation and Bailey et al. (2004), Gardebroek and Oude Lansink (2004) and Tonini and Jongeneel (2008) for Maximum Entropy.

analysed how arable crop supply and acreage response to policy parameters, estimated on FADN data, change as a result of the application of different panel data techniques. Their results clearly show that the adoption of different estimation methods implies obtaining quite different results, both in terms of absolute value of the estimated parameters and in terms of their statistical significance; moreover, the two-way system of equation techniques seem to guarantee the most reliable results[46].

The issue of censoring in systems of equations has also been the subject of relevant developments in recent years, especially in the area of demand analysis. Three main approaches have been developed. The most rigorous approach implies the evaluation of multiple probability integrals (see, among others, Yen et al, 2003, Yen, 2005, and Yen and Lin, 2006) that are likely to be unmanageable in many concrete applications with large databases. In these cases, a two-step approach (see, for example, Shonkwiler and Yen, 1999), although statistically less efficient, is likely to be the most viable alternative, since it avoids the computational complexity of the previous method. More recently, a new approach based on copulas has been proposed (Yen and Lin, 2008), which seems rather promising, since it does not require the normality assumption for the error terms and it also avoids the computational difficulties of the multiple probability integrals[47].

To our knowledge, the combined impact of both censoring and unbalanced panel data structure on the estimation of large systems of equations has not been fully explored.

This very brief review of the literature on panel data and censoring clarifies how the results obtained in many studies evaluating the impact of decoupling may be sensitive to the econometric technique used. A further effort is certainly required by agricultural economists to adopt the most appropriate techniques, in order to obtain more robust estimations of the key policy parameters.

5. CONCLUDING REMARKS FOR A RESEARCH AGENDA

In this paper, we have reviewed the literature concerning the impact of the CAP first pillar policy instruments on farm choices, focusing on decoupled payments and econometric models. In fact, based on the current structure of the first pillar, where the SFP account for 57% of the total EU agricultural budget, and on the perspectives of the post-2013 CAP, sketched in the November 2010 Communication of the European Commission, it is clear that decoupled payments are going to be the main policy tool of the present and future CAP.

In general, this literature shows that there are different channels through which decoupled payments, like the SFP, may impact farm choices. These channels have been explored through a

[46] An alternative solution to this issue could be that adopted in Whitaker (2009); starting from U.S. data of the Agricultural Resource Management Survey (ARMS), a pseudo-panel was created taking means of cohorts of observations within each period.
[47] In a recent paper (Tiffin and Arnault, 2010), a new method of addressing the censoring problem has been proposed in the context of Bayesian estimation, which avoids the computational complexities of the standard approaches.

number of theoretical and empirical studies, that, in terms of methodology, typically rely on case studies based on the econometric analysis of farm level data. This seems coherent with the general idea that the impact of decoupled payments is better analysed starting from individual farm responses to the (possible) economic incentives created by such payments, since aggregate models place too strong restrictions Despite the relevant research efforts of many agricultural economists, results of these studies cannot be considered conclusive, especially those related to the EU. In fact, while the US has a longer history of implementation of decoupled payments, and the corresponding studies are typically based on farm data referring to the period where such payments were already in place, most of the empirical studies concerning the EU are simulations carried out using parameters estimated on data preceding the 2003 reform. Since now new post-2005 farm data are becoming available for a reasonable time span, further research efforts are certainly needed in all the topics reviewed in this paper, as well as in areas that are virtually unexplored at this stage.

For example, studies concerning the relationship between decoupled payments and risk have already reached some important results: the so-called "wealth effect" is likely to be small, while the "insurance effect" may be larger, as long as payments affect farm income volatility. Nonetheless, some recent papers have claimed, with rather strong arguments, that the normative value of these studies may be rather low, because of their inability to distinguish between farmers' risk preference and perceptions. Thus, a new wave of studies should be carried out, following these last indications of the literature and refining the empirical approach.

Most of the studies concerning the impact of decoupled payments on issues like credit constraints, entry/exit decisions, off farm labour allocation and capitalisation in land values refer to the US situation, with very few exceptions. Since behind these research questions there are some crucial policy issues like farm structural change, farm employment and the true beneficiaries of the payments, European agricultural economists should devote some additional effort to the empirical analysis of these problems. Moreover, for many of these issues the local situations of the different EU member states may generate rather different farm responses to decoupled payments, such that obtaining a global picture may imply carrying out a relevant number of detailed national studies.

Finally, studies concerning the dynamic impact of decoupled payments, typically related to farm investment behaviour, have reached rather diverging results, such that the size of this impact is uncertain. Moreover, a crucial issue like the impact of farmers' expectations on future policies has been addressed only through some simplified numerical simulations. Thus, in the whole area of dynamic modelling, further research efforts are certainly needed

Although the above agenda is already full of topics to be addressed, there are also a number of issues that are virtually unexplored at this stage.

For example, the fact that payments are linked to both land use as well as to other input uses (i.e. cross-compliance) should stimulate studies in this area, that have to do also with the environmental impact of agriculture. While the possible distortions linked to the capitalisation of payments in land values are well known, since payment benefits may accrue to land-owners only, those linked to other key inputs like water or chemicals may be also very important.

Another important issue, often invoked in the EU documents, is the distribution of EU payments across farms. Since one of the key issue of the post-2013 CAP is a possible redistribution of the SFP, this is clearly an area of research that should be considered, perhaps linked with the issues that have been identified as potential channels through which decoupled payments affect farm choices (i.e. risk, entry/exit, labour use, land values, investment decisions).

Finally, a further crucial area of research, which is strongly emphasised in the recent communication of the EU Commission on the post-2013 CCAP, is the impact of policies on the functioning of the food supply chain and on the distribution of the valued added along the chain. This is a rather neglected area of research by agricultural economist, but it is likely to be crucial for the long term prospects of agriculture. In this area, a crucial problem is the imperfectly competitive structure of the chain, both at the processing and at the retail level, while most modelling efforts concerning agricultural policies assume a perfectly competitive environment. The few available evidences in this area indicate that the bias due to this assumption may be rather relevant (Soregaroli et al, 2010).

In addressing such a ponderous research agenda, economists should be aware of two general issues. The first relates to the generalisation of results obtained from samples of individual farm data to the aggregate sector level. The FADN weighting mechanism provides a useful tool for carrying out a rigorous procedure of this type. Thus, this should provide a starting point to obtain plausible parameters in aggregate relations for revising the large partial and general equilibrium models routinely used for policy analysis, where the impact of decoupled payments is typically analysed by means of arbitrary "coupling" factors. The second refers to the adoption of the most appropriate estimation techniques. Recent developments in the area of the econometric treatment of unbalanced panel data and in the area of censoring should be carefully considered, since results are likely to be sensitive to these methodological details.

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