The Decoupling of Farm Programs: Revisiting the Wealth Effect

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Recent reforms of agricultural policies in developed countries have introduced direct payments as replacements for traditional production-enhancing instruments. Whereas these new instruments can, in principle, influence production through several channels, current empirical studies show no significant impact on production; direct payments mainly increase land values. In this article, we revisit the evaluation of the coupling effects passing through the wealth of agricultural households. The initial wealth of these agents, while mainly being in the form of land asset holding, is always assumed to be fixed. To the contrary, we show theoretically and through an empirical simulation exercise that once the impact of farm programs on initial wealth is properly accounted for, the measure of the coupling effects is not as negligible as found in previous studies.

Key words: agricultural policy, decoupling, wealth effect.

JEL codes: D81, Q18.

The agricultural policies of the European Union and the United States have been reformed considerably over the last 20 years with the introduction of direct payments independent of production volumes as replacements for traditional production-enhancing instruments. The so-called decoupling process started in 1985 in the United States with the introduction of deficiency payments on arable crops based on historical yields. In the European Union, the McSharry reform of 1992 also introduced direct subsidies independent of current yields to offset the decrease in the total amount of price support. This process is still used in the recent Common Agricultural Policy (CAP) reforms, and has been motivated by internal efficiency considerations (better economic efficiency in agricultural income support), as well as by external pressures in the World Trade Organization (WTO) format (less distortionary effects on trade).

Reforms of farm policies in developed countries have generated a huge economic literature seeking to evaluate their effects. Many methodological frameworks have been developed to identify the effects of these direct payments on production, i.e., their coupling effects. In theory, several microeconomic mechanisms establish a link between direct payments and farm production. Direct payments modify: (i) agricultural labor decisions by altering the labor/leisure arbitrage of farm households (Benjamin 1992); (ii) the capital invested in agriculture by relaxing the potential constraints on credit markets (Phimister 1995); (iii) the number of farms by covering their fixed costs (Chau and de Gorter 2005); (iv) the wealth of farmers and thus the incentive to produce for risk-averse farmers (Hennessy 1998); (v) the real wages and the employment level in different sectors through a general equilibrium effect linked to the public funding of these payments (Chambers 1995). Moreover, some eligibility criteria necessarily go with the definition of these direct payments (base area in the United States, number of single farm payments and cross-compliance conditions in the European Union, land use restrictions in both regions). These eligibility criteria may

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also create a link between payments and production (see Bhaskar and Beghin 2007a for base area in the United States, Courleux *et al.* 2007 for the number of European single farm payments). Finally, direct payments can theoretically affect agricultural production through a technical efficiency channel. This occurs when efficiency depends on input levels and also when one of the above mechanisms applies. For instance Serra, Zilberman, and Gil (2007) consider the case where direct payments have a wealth effect on risk-averse producers leading them to increase their input use, which in turn has an impact on their technical efficiency.

From an empirical point of view, the current literature tends to show that the effects on production from direct payments are low. Their main effect is to increase the value of land for purchase/sale or rent (Bhaskar and Beghin 2007b). However, this synthesis is based upon a limited number of empirical studies. The largest literature concerns the effects of direct payments through the wealth effect.[1] The wealth effect is expected to increase production under the assumption that farmers' attitudes toward risk are characterized by downside risk aversion. Downside risk aversion is often considered a reasonable assumption (see, e.g., [Lffont 1989]bib28; Gollier 2001). All these studies show that direct payments have a low effect on production. They generally report that direct payments have a small impact on the final wealth of farmers. Since they do not move wealth levels to points of the utility function characterized by significantly lower risk aversion, these limited changes in wealth have in turn a very limited impact on farmers' risk-taking behavior.

The main idea advanced in this article is that these studies underestimate the effect of direct payments on the wealth of those farmers who own the factors (land) on which payments are based.[2] In fact, the observed wealth of a farm household depends on the benefits that are expected from farming. The future direct payments are part of these expected benefits. So it must be taken into account that the wealth of a farm household depends on the expectations of different actors concerning the durability of direct payments. This implies that initial wealth should not be considered as fixed, as is currently done in econometric analysis and in simulation models. One must also modify the initial wealth of a risk-averse farm household when identifying the effect of decoupling of farm programs in general, and of direct payments in particular. This new effect depends on the structure of farm households' wealth. In particular the effect is zero if the farm household owns no land. In such cases, all of the benefits of farm programs are passed to the landowners. However, if the farm household partly owns farmland, then it will capture part of the benefits of farm programs. In that case, the farm household will be better off and will become less risk averse if its risk aversion decreases with wealth. This may then cause it to increase production.

By explaining the initial wealth of a farm household, we simultaneously pay attention to the final beneficiary of direct payments. Available analyses with risk-averse producers generally focus on the production impacts of direct payments without measuring their impacts on land values and farm household welfare. In these analyses, direct payments are represented as lump sump payments, and thus they do not translate into increased land values. This is readily apparent in the analysis of Mullen *et al.* (2001), where the impacts on land values are reported. Their simulations show that American landowner welfare increases much more with the coupled loan deficiency payments than with the more costly United States direct payments. In this article, to the contrary, we identify the landowner rather than the farm producer as the final beneficiary of direct payments. Our analysis is thus consistent with the well-known fact that farm programs finally end up in increased land values (Bhaskar and Beghin 2007b).

In this article we first demonstrate theoretically the impact of considering farm household wealth when analyzing farm programs. We consider two farm programs: a traditional price subsidy, which increases the average output price, and a direct payment defined over historical yield and acreage. Then we develop a simulation model applied to a representative American corn farm to measure how this empirically modifies the impacts of these instruments.

[1] Chronologically, econometric analysis includes Sckokai and Anton (2005), Sckokai and Moro (2006), Serra *et al.* (2006), Goodwin and Mishra (2006), Lin and Dismukes (2007), McIntosh, Shogren, and Dohlman (2007), and Serra, Zilberman, and Gil (2007). Simulation modeling analyses include Young and Westcott (2000), Burfisher, Robinson, and Thierfelder (2000), Mullen *et al.* (2001), Anton and Le Mouel (2002), OECD (2004), Anton and Le Mouël (2004), Anton and Giner (2005), and Just (2006).

[2] Goodwin and Mishra (2006) acknowledge in a footnote that this effect on wealth may be pertinent, but their subsequent analysis does not capture it.

The Standard Starting Point with Fixed Initial Wealth and Lump Sum Direct Payments

We consider a simple framework of a farm household using its fixed human capital (L) and two variable inputs: land (T) and an aggregate including the other inputs (X) to produce one good (Y). The two variable inputs are combined in the production technology with a Constant Elasticity of Substitution (CES) function and decreasing returns to scale (due to fixed human capital). The farm household receives a direct payment (D) independent of its current activity. It faces just one source of risk: the price of production ($\tilde{p}$), of which the expectation is $\bar{p}$ and standard deviation is σ. The other input price is fixed and denoted by w. We also assume that this farm household is risk averse and that its preferences are represented by a power utility function. This utility function exhibits constant relative risk aversion and, as a result, decreasing absolute risk aversion. It is widely used for empirical and simulation purposes (Bontems and Thomas 2000; Holt and Laury 2002; Andersen *et al.* 2008). This form of utility function will allow us to use levels of relative risk aversion immediately available from previous studies in our empirical simulations. Finally we assume in this section that the initial wealth of the household (W_0) is fixed.

We thus make the usual assumption that the agricultural household maximizes its expected utility. Many alternative models have been proposed in the literature to explain behavior under risk (like the safety-first approach, the generalized expected utility models, the state contingent approach). In the expected utility literature, many arguments about how the utility function should be defined have been proposed (based, for example, on final wealth, profit, consumption, or net wealth gains). This creates a source of confusion from study to study, but there are no general arguments in favor of one particular approach (Meyer 2002). Accordingly we rely on the expected utility model defined over final wealth as it provides the basis for most of the research on the economics of risk. Furthermore, Chavas (2004) underlines that this expected utility model provides a good approximation to risk preferences for small changes in the probability distribution. In this article we do not investigate the effects of changes in the probability distribution of output prices, but look only at the effect of alternative initial wealth computations. This is also the reason why we simplify the analysis by relying on a polynomial approximation of the risk premium.

All the assumptions discussed so far pertain to the individual farm household and will define the optimal production and input demands given the market price of inputs and output. To this framework we add a land supply function, so that we will be able to identify the impacts on land rental rates. Like Mullen *et al.* (2001), we adopt a simple constant price elasticity form. In order to lighten the comparative statics, we assume that the price of other variable inputs is fixed. This assumption will be relaxed in the simulation section.

Optimal Supply and Demand Functions

Formally the farm household's decision problem is defined as follows:

$$\text{(1)}\quad \begin{aligned} &Max_{(T,X)} E[(1-\rho)^{-1}(W_0+\tilde{\pi}(T,X))^{1-\rho}] \\ &s.t.\ \tilde{\pi}(T,X) = \tilde{p}Y - wX - rT + D \\ &Y = \alpha_0(\alpha_1 X^{(g-1)/g} \\ &\quad + (1-\alpha_1)T^{(g-1)/g})^{\theta g/(1-g)} \end{aligned}$$

where $\tilde{\pi}(T,X)$ denotes the current profit, ρ is the relative risk aversion coefficient (assumed different from 1), and r is the rental price of land (assuming here that the farmer rents the land he uses). Parameters α_0, α_I, and g are the CES function parameters, and $\theta < 1$ is the returns to scale coefficient. Maximizing expected utility is equivalent to maximizing the certainty equivalent (CE) of final wealth defined as the expectation of final wealth less the risk premium (RP):

$$\text{(2)}\quad \begin{aligned} CE[W_0+\tilde{\pi}(T,X)] &\equiv E[W_0+\tilde{\pi}(T,X)] \\ &\quad - RP[W_0+\tilde{\pi}(T,X)]. \end{aligned}$$

According to our assumptions on the source of risk and utility functional form, the Arrow and Pratt (1964) approximation of the risk premium is provided by:

$$\text{(3)}\quad \begin{aligned} &RP[W_0+\tilde{\pi}(T,X)] \\ &\simeq -\frac{1}{2}\frac{U_{WW}(W_0+E[\tilde{\pi}(T,X)])}{U_W(W_0+E[\tilde{\pi}(T,X)])} \\ &\quad \times V[W_0+\tilde{\pi}(T,X)] \\ &= 1/2\rho(W_0+\bar{\pi}(T,X))^{-1}\sigma^2 Y^2 \end{aligned}$$

where $\bar{\pi}(T,X) \equiv E[\tilde{\pi}(T,X)]$. A subscript denotes the first derivative of a function with respect to the variable.

The farmer's (approximate) decision problem is finally written as:

$$(4) \quad Max_{(T,X)}[\bar{\pi}(T,X) - 1/2\rho \times (W_0 + \bar{\pi}(T,X))^{-1}\sigma^2 Y^2]$$
$$s.t.\ \bar{\pi}(T,X) = \bar{p}Y - wX - rT + D$$
$$Y = \alpha_0(\alpha_1 X^{(g-1)/g} + (1-\alpha_1)T^{(g-1)/g})^{\theta g/(1-g)}.$$

It is not possible to obtain an analytical solution for these optimal demands or for the product supply. However, it will be easier to analyze the effects of farm programs by decomposing this program into two steps. The first step consists of minimizing the production costs for a given production quantity. The second step consists of maximizing the CE given the production costs. The first step is thus defined as:

$$(5) \quad Min_{(T,X)}\ (wX + rT)$$
$$s.t.\ Y = \alpha_0(\alpha_1 X^{(g-1)/g} + (1-\alpha_1) \times T^{(g-1)/g})^{\theta g/(1-g)}$$

and leads to the following restricted cost and conditional input demand functions:

$$(6) \quad C(Y;r) \equiv Y^{1/\theta}\alpha_0^{-1/\theta}(\alpha_1^g w^{1-g} + (1-\alpha_1)^g r^{1-g})^{1/(1-g)}$$
$$X^*(Y;r) \equiv Y^{1/\theta}\alpha_0^{-1/\theta} w^{-g}\alpha_1^g(\alpha_1^g w^{1-g} + (1-\alpha_1)^g r^{1-g})^{g/(1-g)}$$
$$T^*(Y;r) \equiv Y^{1/\theta}\alpha_0^{-1/\theta} r^{-g}(1-\alpha_1)^g(\alpha_1^g w^{1-g} + (1-\alpha_1)^g r^{1-g})^{g/(1-g)}.$$

The equations in (6) show mainly that the ratio of variable inputs does not depend on the direct payment. The impact passes strictly through the production quantity effect. This quantity is the solution of the second-step decision problem:

$$(7) \quad Max_Y[\pi(Y;\bar{p},r,D) - RP(Y;\pi(Y;\bar{p},r,D) + W_0)]$$

where $\pi(Y;\bar{p},r,D) \equiv \bar{p}Y - C(Y;r) + D$, and $RP(Y;W) \equiv 1/2\rho W^{-1}\sigma^2 Y^2$. The optimal production quantity Y^* is thus implicitly determined by the first-order condition:[3]

$$(8) \quad \pi_Y(Y^*;\bar{p},r,D) \times [1 - RP_W(Y^*;W(Y^*;\bar{p},r,D,W_0))] - RP_Y(Y^*;W(Y^*;\bar{p},r,D,W_0)) = 0$$

with $W(Y^*;\bar{p},r,D,W_0) \equiv \pi(Y^*;\bar{p},r,D) + W_0$, *i.e.*, by:

$$(9) \quad (\bar{p} - C_Y(Y^*;r)) \times \left[1 + \frac{1}{2}\rho\left(\frac{Y^*\sigma}{W(Y^*;\bar{p},r,D,W_0)}\right)^2\right] - \rho\frac{Y^*\sigma^2}{W(Y^*;\bar{p},r,D,W_0)} = 0.$$

Comparative Statics

Equations (6) and (9) define the behavior of the farm household. We complete the system with the specification of the land supply function with ε_T, the own price elasticity:

$$(10) \quad T = \beta_T r^{\varepsilon_T}$$

where ε_T is the own price elasticity. First differentiation of these equations allows us to identify the impacts on production and land rental rates of direct payments, and of a price subsidy, which is equivalent in this framework to an increase in the expected price:

$$(11) \quad \frac{\partial Y^*}{\partial D} = \frac{1}{H}\rho Y^*\left(\frac{\sigma}{W_f^*}\right)^2 \times \left[1 - Y^*\frac{\bar{p} - C_Y(Y^*;r^*)}{W_f^*}\right]$$

$$(12) \quad \frac{\partial Y^*}{\partial \bar{p}} = \frac{1}{H}\left[1 + \rho\left(\frac{Y^*\sigma}{W_f^*}\right)^2 \times \left(\frac{3}{2} - Y^*\frac{\bar{p} - C_Y(Y^*;r^*)}{W_f^*}\right)\right]$$

$$(13) \quad \frac{\partial r^*}{\partial Y} = \frac{r^*}{\theta Y^*}\frac{1}{\varepsilon^T + gs_X^*}$$

[3] Second-order conditions of the maximization program are automatically satisfied.

where:

$$(14)\quad H = \left(C_{YY}(Y^*; r^*) + C_{Yr}(Y^*; r^*) \frac{r^*}{\theta Y^*} \times \frac{1}{\varepsilon^T + g s_I^*} \right) \left[1 + \frac{1}{2} \rho \left(\frac{Y^* \sigma}{W_f^*} \right)^2 \right] + \rho \frac{\sigma^2}{W_f^*} \left(1 - Y^* \frac{\bar{p} - C_Y(Y^*; r^*)}{W_f^*} \right) \times \left[1 - Y^* \frac{\bar{p} - C_Y(Y^*; r^*)}{W_f^*} + \frac{T^* r^*}{\theta} \frac{1}{\varepsilon^T + g s_I^*} \right].$$

The term r^* denotes the equilibrium rental rate of land and $W_f^* \equiv W(Y^*; \bar{p}, r^*, D, W_0)$ denotes the final (expected) wealth. The term $s_X^* \equiv wX^*(r^* T^* + wX^*)^{-1}$ is the share of the other variable inputs in total variable expenditures, with $X^* \equiv X^*(Y^*; r^*)$ and $T^* \equiv T^*(Y^*; r^*)$. From the assumption of decreasing returns to scale, we have $W_f^* > Y^*(\bar{p} - C_Y(Y^*; r^*))$, and the denominator H is always positive. Consequently an increase in direct payment increases production (equation 11). As expected, it appears that there is no effect when the relative risk-aversion coefficient is zero. On the contrary, the impact of a price subsidy on production is always positive even if the relative risk-aversion coefficient is zero (equation 12). Finally, both farm programs increase the land rental rate (equation 13). It is more interesting to compare the effects of these two instruments for a given public expenditure ($\partial D = Y^* \partial \bar{p}$), and starting from a no-support situation. The relative impact on production is thus given by:

$$(15)\quad \frac{\partial Y^*}{Y^* \partial \mu_{P_Y}} - \frac{\partial Y^*}{\partial D} = \frac{1}{H} \left[\frac{1}{Y^*} + \frac{1}{2} \rho Y^* \left(\frac{\sigma}{W_f^*} \right)^2 \right].$$

This demonstrates the standard result that for a given public expenditure, a price subsidy has a higher production impact than a direct payment. But this first framework also implies (equation 13) that the price subsidy has a higher impact on land rental rates than a direct payment. This is so because the latter is assumed to be kept by the farm producer for the remuneration of the fixed human capital. Landowners thus do not benefit from direct payments, a result which is in contradiction with many empirical studies (Bhaskar and Beghin 2007b).

Explaining Farm Wealth and Identifying the Final Beneficiary of Direct Payments

In all studies on the decoupling of agricultural farm programs, the initial wealth of farm households is assumed to be fixed. According to the United States Department of Agriculture (Mishra *et al.* 2002), this wealth is constituted mainly in the value of the agricultural land that they own. Moreover, agricultural land is mainly owned by farm households. Therefore it is important to clearly understand the formation of land values. In this respect, much theoretical and empirical work has tried to explain the land price, both rental and selling. All have shown that agricultural profits and farm programs positively influence this price. They also have shown that agricultural land is a specific asset, in the sense that it yields expected returns lower than do other assets and its returns are simultaneously riskier (Erickson, Moss, and Mishra 2004). This suggests that asset markets are segmented. Chavas and Thomas (1999) showed that this segmentation can be explained by the importance of transaction costs in the buying/selling of agricultural land, the nature of intertemporal preferences of investors, and their attitude toward risk. In other words, the agricultural land asset is not directly substitutable for other assets, and farm households are thus more affected by a modification in the value of this asset. Regarding the sharing of direct payment between farmers and landowners, both American and European farmers receive direct payments only if they meet certain conditions. In particular they must have some eligible land (base acreage in the United States, reference acreage in the European Union). These direct payments are in fact defined as the product of a fixed amount per acre/hectare unit (d) and a historical acreage (T_H). Accordingly, these producers must farm this acreage to get the direct payments. If the producer rents all his land, then he may not receive benefits from direct payments due to increased rental rates. The distribution of payments between renters and landowners depends on the farm land regulations. In the United States case that we will refer to in the simulation section, renters cannot acquire base and thus always pay the full costs of program benefits to the landowner

(Duffy *et al.* 1994). In sum, the wealth of a farm household is composed mainly of the land asset, and farm programs have a significant impact on land values. So it seems appropriate to introduce these two characteristics into the conceptual framework.

Our Conceptual Framework

In order to include these two characteristics, it is useful to distinguish the farm producer, the farm household, and the landowner. Suppose first the extreme case of a producer renting all his land and whose wealth is in terms of nonagricultural asset (denoted by W_{NF}). His landowner knows that he needs the land to get the direct payments, and can thus increase the rent in order to collect the benefits of subsidies (Duffy *et al.* 1994). This is in fact one of the most important criticisms of the direct payments system (see, for instance, Goodwin, Mishra, and Ortalo-Magné 2005). The wealth effect of direct payments is zero for such a producer because d disappears from his agricultural income and, as a result, from his wealth. In this case, the farmer's wealth is given by:

$$(16) \quad W_{NF}+\tilde{p}Y-wX-(T-T_H)r-T_H(r+d) + T_H d = W_{NF}+\tilde{p}Y-wX-Tr.$$

It should also be clear that there are two rental prices of land: the level r on the acreages not eligible for direct payments, and $r+d$ on the others. This is a consequence of our assumption that the direct payments are captured by the landowner. Even if the producer does not change his behavior due to direct payments, these payments lead to an increase in average land rental price.

Turn now to the more realistic case of a farm household that partially owns its land. The owned farmland, denoted by T_P, is furthermore supposed to be less than the total land eligible for direct payments, *i.e.*, $T_P < T_H$. The household's initial wealth is then determined by:

$$(17) \quad W_0(W_{NF}, d) = W_{NF} + (r\tau_r^{-1} + d\tau_d^{-1})T_P$$

where τ_r and τ_d are the discount rates applied respectively to the land rental price and the direct payment. Note that this definition excludes the current direct payments. These payments are included in the current profit function. The wealth of the farm household thus depends on the nonagricultural assets (assumed fixed in this analysis) and the total value of land in property. Like Lamb and Henderson (2000), we assume that the land value depends on its rental price and on the unitary direct payment. The expression of wealth is obviously simplified because it does not explicitly include any risky components for nonagricultural assets or for land. These components are, however, implicit in the different discount rates of the three components of wealth.

In fact, we assume here that this farm household does not sell (or buy) farmland, and hence the composition of its portfolio does not change, and for two main reasons. First, American agricultural land tenure has proven to be very stable despite large changes in land values in the past (Johnson 2002). In addition to a very low rate of land ownership turnover, farmland transactions involve mostly nonfarm operators such as brokers. The main explanation provided in the literature for this unique feature of the land market is the huge transaction costs associated with farmland buying (see, for instance, de Fontnouvelle and Lence 2002). Second, modeling simultaneously the optimal decisions of the farm household as producer (optimal level of production, input use, land use) and as asset owner (optimal portfolio composition) considerably complicates the analytical framework, since this would require a dynamic optimization framework. In particular, this requires that the farm household as asset owner makes expectations regarding the distribution (at least the mean and the standard deviations) of land values. This distribution depends partly on the behavior of the farm household as producer because this determines its land-derived demand. The approximate framework developed in this article is designed to be tractable in a partial equilibrium framework.

It should be clear that the absence of land transactions (buying or selling) by our farm household does not prevent the evolution of farm land values with respect to direct payments. In fact, given the low turnover of farmland ownership, many American states assess farmland for property tax purposes, using an income capitalization approach similar to equation (17) above (Johnson 2002).

We assume a perfect land market, implying that the considered farm household has the possibility of renting out its land, which is eligible for direct payments. In this case, the net cost of the farmland input is defined as:

$$(18) \quad r(T^*(Y;r)-T_H)+(r+d)(T_H-T_P) + (r+d)T_P - dT_H = rT^*(Y;r).$$

This implies that the direct payments no longer appear in expected profit. As a result, the decision problem of the farm household is similar to the decision problems considered so far. It can simply be defined as:

$$(19)\quad Max_Y[\pi(Y;\bar{p},r) - RP(Y;\pi(Y;\bar{p},r) + W_0(W_{NF},d))]$$

where $\pi(Y;\bar{p},r) \equiv \bar{p}Y - C(Y;r)$. The direct payment enters the maximization program only through its effect on initial wealth.

First-order conditions of the new program for an interior solution are very similar to the standard ones (equations 6 and 9). The implicit equation defining the optimal supply has the same structure. Only the expression of final expected wealth is modified:

$$(20)\quad (\bar{p} - C_Y(Y^*;r)) \times \left[1 + \frac{1}{2}\rho\left(\frac{Y^*\sigma}{W(Y^*;\bar{p},r,d,W_{NF})}\right)^2\right] - \frac{\rho Y^*\sigma^2}{W(Y^*;\bar{p},r,d,W_{NF})} = 0$$

with:

$$(21)\quad W(Y^*;\bar{p},r,d,W_{NF}) \equiv W_0(W_{NF},d) + \pi(Y;\bar{p},r).$$

Comparative Statics

In order to analyze the effects of a price subsidy and of a direct payment, we assume that the latter occurs through a change in the unitary direct payment (this will ease comparison for an equal budgetary cost). Total differentiation of equations (6), (10), and (20) leads to:

$$(22)\quad \frac{\partial Y^*}{\partial d} = \frac{1}{G}\rho Y^*\left(\frac{\sigma}{W_f^*}\right)^2 \times \left[1 - Y^*\frac{\bar{p} - C_Y(Y^*;r^*)}{W_f^*}\right] \times \tau_d^{-1}T_P$$

$$(23)\quad \frac{\partial Y}{\partial \bar{p}} = \frac{1}{G}\left[1 + \rho\left(\frac{Y^*\sigma}{W_f^*}\right)^2 \times \left(\frac{3}{2} - Y^*\frac{\bar{p} - C_Y(Y^*;r^*)}{W_f^*}\right)\right]$$

with:

$$(24)\quad G = \left(C_{YY}(Y^*;r^*) + C_{Yr}(Y^*;r^*)\frac{r^*}{\theta Y^*} \times \frac{1}{\varepsilon^T + gs_I^*}\right)\left[1 + \frac{1}{2}\rho\left(\frac{Y^*\sigma}{W_f^*}\right)^2\right] + \rho\frac{\sigma^2}{W_f^*}\left(1 - Y^*\frac{\bar{p} - C_Y(Y^*;r^*)}{W_f^*}\right) \times \left(1 - Y^*\frac{\bar{p} - C_Y(Y^*;r^*)}{W_f^*} + \frac{r^*}{\theta}\frac{T^* - \tau_d^{-1}T_p}{\varepsilon^T + gs_I^*}\right)$$

and where $W_f^* \equiv W(Y^*;\bar{p},r^*,d,W_{NF})$. The impact on the rental price of land is still given by equation (13). The sign of the new denominator G cannot be determined without ambiguity. If negative, this implies that the optimal supply of the farm household increases with the land rental price. This possibility cannot be ruled out in theory, and the economic interpretation is as follows. On the one hand, an increase in the rental price of land increases the production cost of the farm producer, and thus reduces the production incentive. On the other hand, an increase in the rental price of land increases the wealth of the farm household, which in turn stimulates the production of a risk-averse agent. With standard values of behavioral parameters (elasticity of land supply, substitution elasticities, and values of final wealth), this possibility does not appear empirically. Disregarding this case, the impacts of a price subsidy and a direct payment on production and land rental rates remain positive. The comparison with former impacts (equations 11 and 12) is not immediate because the denominators are not strictly the same, and because the levels of the involved endogenous variables vary. We can nevertheless remark that the production impact of direct payments may be greater than previously recognized, especially if the discount rate of direct payment is low. We can also remark that the two denominators are the same if the land supply elasticity is infinite. In this case, it is readily apparent that the direct payment now has a larger impact on production by an amount equal to the inverse of the discount rate. On the other hand, the production impact of price subsidies remains the same.

For the same budgetary cost and starting from a situation without farm programs, the relative impact of these two farm programs on production is given by:

$$(25)\quad \frac{\partial Y^*}{Y^*\partial\bar{p}} - \frac{\partial Y^*}{T_H\partial d} = \frac{1}{G^*Y^*}\left(1+\frac{1}{2}\rho\left(\frac{\sigma Y^*}{W_f^*}\right)^2 \times\left[1+\left(1-Y^*\frac{\bar{p}-C_Y(Y^*;r^*)}{W_f^*}\right)\times\left(1-T_P T_H^{-1}\tau_d^{-1}\right)\right]\right).$$

Assuming that the denominator is always positive, this last expression shows that it is still impossible to determine the relative production impact of direct payments and price subsidies. Again, if the discount rate of direct payments is low, it cannot be ruled out that direct payments have a greater production impact than equal cost price subsidies. By extension, their impact on the rental price of land not eligible for direct payments may be greater. Finally, their impact on the average rental price of land may be greater too.

In sum, the effect of payments on the wealth of farm households can, theoretically, increase the coupling effects of different agricultural policy instruments. Even if it is not possible to compare these increased coupling effects in all cases, we show in a simple example that this is more likely for direct payments than for price subsidies. Simultaneously we identify in our conceptual framework the ultimate beneficiary of direct payments. Contrary to current analyses, we thus acknowledge the capitalization of farm support in land values. How these modifications impact the different results is an empirical matter, to which we now turn.

Calibration of an Empirical Model

The conceptual framework described here is simplified compared with the reality of farm households that realize several types of production (rather than just one), using several inputs (not just three), and facing several sources of risk (not just price risk). However, our main objective in this article is to identify the influence of wealth discounting in the estimation of the decoupling degree of farm programs. As an illustrative example, we apply the framework to a representative American farm producing only corn. The model parameters are first obtained from a United States Department of Agriculture publication on the characteristics and production costs of corn-specialized farms in 2001 (Foreman 2006, tables 1 and 3). We use the average production costs given in these tables. We thus assume the existence of a domestic farm of 670 acres cultivating only corn. The representative farm household owns 60% of its initial area. It produces 146 bushels per acre, which are valued at $2 per bushel (6% of which comes from the loan deficiency payment program). The operational costs are $172 per acre and the opportunity cost of land is $86 per acre. The household's profit (remunerating its human capital and the risk premium) is thus $34 per acre excluding direct payments. According to the Organisation for Economic Co-operation and Development (OECD) (ESP [Spain] database), direct payments for corn in 2001 amounted to $3,802 million, and 75 million acres were allocated to corn. Accordingly the direct payments represented $50 per cultivated acre. The base area is, however, at the most equal to 85% of the cultivated area, and we thus assume that this direct support is paid on only 85% of the area. This makes the support equal to $58.8 per eligible acre.

Concerning the initial wealth of the household, the initial net value of the farm is equal to $783,000. At the macroeconomic level, land value represents 80% of agricultural assets. This farm owns 60% of its land, so its agricultural land is valued at $1,560 per acre. This value is lower than the agricultural land value of the states in the Corn Belt (where the value reaches $2,000 per acre in Iowa and Illinois, for instance), but higher than the agricultural land value at the national level ($1,100 per acre). We thus adopt this value in the calibration of the model.

We also have to calibrate the nonagricultural assets owned by the household. According to Mishra *et al.* (2002), 69% of the net wealth

Table 1. Computation of Price Elasticities, Percentage Impacts of a 1% Expected Price Decrease

	Production	Land use	Land rental price	Other inputs
Risk neutrality	−0.40	−0.17	−1.65	−0.59
Risk aversion	−0.44	−0.17	−1.73	−0.62

of farm households is made up of agricultural assets. Yet this proportion reaches 90% for the farms making positive profits (which are the farms realizing most agricultural productions). As the farm we model initially makes profit, we assume that only 10% of initial net wealth includes nonagricultural assets. The value of nonagricultural assets is then \$87,000, and the total net wealth is \$870,000.

To determine the value of elasticities, we use the summary of Abler (2001). The substitution elasticity between land and variable inputs is fixed at 0.4, the land supply elasticity at 0.1, and the other input aggregate (capital and intermediate consumption) supply elasticity at 1.0 (as in Mullen *et al.* 2001, we introduce a constant price elasticity supply function for this input aggregate). We use the econometric estimates of Mullen *et al.* (2001) and Moledina, Roe, and Shane (2004) to calibrate the coefficient of variation of corn price at 0.2 (that is, a variance of 0.16). Similarly to other authors such as Lamb and Henderson (2000), we assume the same discount rate in the initial wealth formula (7.4%). The underlying assumption is that the uncertainty concerning the durability of direct payments is discounted in the same manner by the farm household as is the uncertainty of market returns.

One parameter remains for the model to be completely calibrated. We can fix either the initial level of relative risk aversion or the level of returns to scale. Indeed, these two parameters are linked in equation (9), which implicitly defines the production level. Here we fix the relative risk aversion coefficient at 5.0 (see Hennessy 1998). This implies a level of returns to scale of 0.92. In other words, 8% of the production value is used to pay the fixed factor, and the risk premium is initially \$4,132, i.e., 2.1% of the production value.

In table 1 we report the effects of a 1% expected price decrease, so as to compute the price elasticity of supply and further legitimate our calibration choices. It is well known that in a deterministic framework the price elasticity of supply depends on the price elasticities of factor supply, and on the substitution between these factors (see, for instance, Hertel 1989). When risk aversion of producers is introduced, the price elasticity of supply also depends on the repartition of profit between the risk premium (which is sensitive to price) and the (residual) income of the fixed factor. Consequently the price elasticity of supply is more important when the risk aversion of farmers is taken into account. The estimated elasticities are 0.40 without risk aversion and 0.44 with risk aversion. These values are consistent with the elasticities estimated by the United States Department of Agriculture (Lin *et al.* 2000), which confirm our choices for the different parameters.

Illustrative Simulations

We first simulate the impact of removing direct payments according to the two conceptual frameworks. We also simulate the removal of a hypothetical price subsidy leading to the same static effect on farm revenue. Practically we reduce the expected price by 17%. Results are reported in table 2.

With the standard modeling of risk-averse farmers (first section of table 2), the suppression of direct payments leads to a negligible decrease in production (0.07%). The main effects are a reduction in the farm household's profit (59%) and a slight decrease in its final wealth (3.58%). The wealth elasticity of production is thus very low (0.03), which is common in econometric estimations (Serra *et al.* 2006). Still under the same assumption, the removal of the hypothetical price subsidy (leading to the same static effect on the farm total revenue) leads to an 8% decrease in production (*ex post* elasticity of 0.47). The production impact is thus much larger by a factor of 119. This ratio is not unrealistic; the OECD (2004), for instance, estimated the effect of a marginal price subsidy of one dollar 66 times higher than the effect of a marginal direct payment of one dollar. Our estimation is thus higher in spite of a higher relative risk aversion coefficient (5 instead of 2). The difference in production ratio can be explained by the fact that the OECD's analysis assumes that the household's wealth includes the off-farm revenues only. In other words, the initial wealth is relatively low compared with the farm household's profit. We can reproduce this ratio (66) with a relative risk aversion coefficient of 2 by assuming that the initial wealth of our representative farmer is 57% lower. This result reinforces our main idea that the initial wealth of farm households needs to be measured correctly. This idea is reinforced again by the analysis of the consequences of these two instruments on the rental price of land. The production subsidy instrument has a noted effect on this price (28% decrease), whereas the direct payment effect is very small (0.27%). This contradicts the great majority of economic

Table 2. Impacts of the Suppression of Direct Payments and of Price Subsidies (in % Related to the Initial Situation)

	Production	Land use	Land rental price[a]	Other inputs	Profit	Initial wealth	Final wealth
Standard modeling with fixed initial wealth and lump sum direct payments							
Initial value	97,820 bushels	670 acres	86$/acre	115,240 (index)	56,280$	870,000$	926,280$
Suppression of direct payment	−0.07	−0.03	−0.27	−0.10	−59.06	0	−3.58
Suppression of price subsidy	−7.98	−3.23	−27.95	−11.05	−8.38	0	−0.51
Production ratio	119						
Proposed modeling with discounted initial wealth and capitalization of direct payments in land values							
Initial value	97,820 bushels	670 acres	86$/acre	115,240 (index)	22,780$	870,000$	892,780$
Suppression of direct payment	−1.11	−0.44	−4.35	−1.58	18.36	−38.88	−37.42
Suppression of price subsidy	−8.37	−3.38	−29.09	−11.55	−15.88	−15.55	−15.55
Production ratio	7.5						

[a]Noneligible land in the direct payment case.

studies, which conclude that this support is strongly capitalized in land.

When we use our conceptual framework (second section of table 2), the production effect of direct payments is no longer negligible, though it remains modest (1.11%). This can be explained by the fact that the (initial or final) wealth of the farm household is now seriously decreased (more than 37%). The wealth elasticity of production is still low (0.03) and consistent with econometric estimates. The estimated effects of the support program removal illustrate two main points. First, the income support payments account for 60% of the considered farmer's profit. As farmland value depends on the present value of the future expected profit flows, the removal of the income support program seriously decreases the farmer's wealth, which is due mostly to farmland ownership. Thinking of the long history of agricultural income support policies, the considered scenario is rather extreme. Second, the effect of wealth on production appears limited because this effect involves only changes in the risk premium, which itself has a moderate impact on production levels. Production level changes are due only to changes in the concavity of the utility function within the considered wealth level regions. The effect of a reduction in the price expectation on production is also greater in our framework, with a reduction of 8.37% compared with 7.98% previously, because here again initial (and final) wealth decreases more. The strongest result concerns the production effects ratio: it is now 7.5 instead of 119.

Conclusion

Recent agricultural policy reforms in developed countries introduced direct payments as replacements for traditional instruments enhancing production. Several channels through which these new instruments can affect production have been identified. In particular, direct payments increase farm households' wealth, which reduces the risk premium of risk-averse households. However, available studies estimate that this effect is negligible. In this article, we have revisited the measurement of the coupling effect through wealth for risk-averse farm households. Our main point is that the capitalization of agricultural income support programs in farm land prices generates large wealth effects when farmland accounts for a large part of farmers' asset holdings. These large wealth effects are a consequence of the importance of income support in farming profits, and generate modest changes in production levels. As a result, ignoring capitalization of income support program benefits tends to understate the coupling effects of these programs through farmers' attitudes toward risk when farmers exhibit downside risk aversion.

From a political point of view, these results imply that the support instruments classified in the green box can have a real impact on production. It would be useful to consider integrating this work into some more global analyses of agricultural policies. It would be useful to understand why agricultural land is mainly owned by farm households and why, at the same time, their wealth is mainly held in agricultural land assets. Is it simply the consequence of the farmers' preferences? Or does it result from land regulation or tax policies that are in favor of farmers? If this is the case, our results suggest that it is important to consider simultaneously direct and indirect agricultural income support policies.

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