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Production Effects of Direct Payments to Active Farmers: a Microeconomic Dynamic and Stochastic Analysis

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Abstract

For the 2014-2020 phase of the Common Agricultural Policy, the European Commission has the opportunity to reduce the leakage of public support to landowners and to better target it towards active farmers. Our purpose is to assess whether shifting the basis of direct payments from land towards active farmers will significantly alter agricultural production decisions. In a dynamic and stochastic microeconomic framework, we identify the impact of this shift on the farm household's production and consumption decisions. In the dynamic setting the production impacts of direct payments are much higher than previously quantified, because the "long run" absolute risk aversion (associated with the value function) is lower than the "short run" one (associated with direct utility). In our dynamic setting, the impact profiles are opposed for initially poor and initially wealthy farmers, due to their different precautionary motives. Leakage to land owners is lower with an active-farmer than with a land subsidy, so that the production impact is higher.

1 Introduction

We study the relative impacts of a subsidy on land and a subsidy to presently active farmers on farm production in a dynamic framework that accounts for the farm household's consumption decisions. Such a shift of direct payments from land towards active producers has been discussed in relation to recent proposals for the 2014–2020 phase of the Common Agricultural Policy (CAP) (*e.g.*, European Commission 2011, Conseil Économique, Social et Environnemental 2011). The redirection shall reduce the leakage of direct payments from farmers to landowners. Indeed, many papers conclude that direct payments mainly increase land rents or values and only modestly modify the incentives to produce private or public goods (Bhaskar and Beghin 2009). Channels for such production effects that have been studied include farmer wealth (Hennessy 1998, Féménia et al. 2010), credit constraints (Phimister 1995, Vercammen 2007, Ciaian and Swinnen 2009), the on-farm/off-farm labor decision (Benjamin 1992, Ahearn et al. 2006, Key and Roberts 2009), entry/exit decisions (Chau and Gorter 2005), and expectations regarding future payments (Lagerkvist

2005, Bhaskar and Beghin 2010). In extreme cases farmers who completely rent land do not benefit at all from these direct payments.

While a large economic literature has analyzed effects of direct payments in the EU and the U.S., previous analytical frameworks have paid little attention to farmer consumption choices. However, a recent empirical study for the U.S. finds that direct payments have, on the margin, a greater effect on farm household consumption than on farm profits (Whitaker 2009). Farmers may use direct payments in part to finance household expenditures. This part may significantly differ between small and large, young and old, and poor and wealthy farms. We account for a farmer's final demand behavior in addition to production behavior. This leads us to adopt a dynamic framework where farmers maximize the discounted expected utility of their consumption stream. We find that the production impacts of direct payments are much higher in the dynamic setting than in a static framework. The impact profiles over time may differ between initially poor and wealthy farmers because of their different precautionary motives. With an active-farmer subsidy, leakage to land owners is indeed lower and production impact are higher than with a land subsidy. In the dynamic setting, the level of risk aversion is not only important for the quantitative results but influences also the relative shapes of risk aversion associated with direct and indirect utility.

The justification of interventions in the agricultural sector on a welfare-economics basis is not without difficulty (*e.g.*, Tangermann 2011). A major argument derives from a structural policy that aims to sustain rural regions as viable living areas. Recent debates stress, moreover, protecting the environment and nature as an important function of agriculture. We do not further enter this discussion. We rather investigate whether the shift from a land towards an active-farmer subsidy will significantly modify production decisions and, hence, the market equilibrium. Land subsidies, as payments to a fixed economic factor, became a major part of support policies in order to decouple payments from output. By logically trying to prevent the leakage of direct payments to landowners active-farmer payments may reintroduce distortions on agricultural markets by changing the incentives for farm labor and production.

Section 2 describes our analytical framework and shows that the production impact of direct payments may be theoretically ambiguous in a dynamic setting. Section 3 provides a numerical analysis to assess the importance of the introduction of consumption decisions in the analysis of direct payments. We start in a two-period context, and then expand the simulations to a multi-period setting to study the dynamic impacts of direct payments. Section 4 concludes. A proof and all tables are gathered in an online appendix (Carpentier et al. 2012).

2 Farmer Problem and Comparative Statics

Consider a presently active farmer who disposes in every period over a time endowment that we normalize to unity. In every period t he chooses his composite consumption good c_t, variable input aggregate x_t, and rented land l_t such as to maximize the discounted expected utility of consumption over his remaining lifetime.[1] During his productive life, the farmer only faces risk on the price p_t of his output y_t which we assume non-hedgeable. The output arises according to the production function

$$y_t = f(x_t, l_t, N) \tag{1}$$

where $N > 0$ represents the farmer's human capital which we take, for simplicity, as constant over the considered part of his work life. We assume $f(.)$ to be increasing and concave in all of its arguments. The price of the composite consumption good is exogenous and fixed to unity. For the current period, the farmer knows with certainy the price of the composite inputs $p_{x,t}$, and the land rent $p_{l,t}$. For simplicity, we assume that the farmer is not credit constrained and can freely participate (by saving/borrowing) in the credit market facing the exogenous certain interest rate r. He does not own farm assets, such as machinery, farm buildings, or land, so that liquid (financial) wealth constitutes the only link between periods. Liquid wealth is thus the only state variable. The latter assumptions allow us to avoid the critical issue of valuing these farm assets and to concentrate on the impact of dynamics and consumption decisions.[2] We consider two extreme policy instruments: a land subsidy $s_{l,t}$ given per hectare to the landowner, and a subsidy S_t given to the individual active farmer. For every period active in agricultural production, $t = 0, \ldots, T-1$, the farmer's intertemporal budget contraint is thus:

$$w_{t+1} = \tilde{p}_t y_t + (1+r)\left(w_t - c_t - p_{x,t} x_t - (p_{l,t} - s_{l,t})\, l_t + S_t\right) \tag{2}$$

After retirement in T, the farmer faces no risk anymore. Until the end of his life in T' he lives out of the liquid wealth accumulated during work life.[3] The farmer's problem reads:

$$\max_{c_t, x_t, l_t} E_0 \sum_{t=0}^{T'} \beta^t u(c_t) \tag{3}$$

[1] The model is an adaption of the classic multi-period model of consumption-investment behavior under risk (*e.g.*, Neave 1971).

[2] Because the land price depends on a variety of factors, including the farmers' demand, it is endogenous to the decision variables we want to analyze. By excluding the land asset from the initial wealth, we can analyze our individual farmer's decisions without modelling the land (purchase/selling) price. (A similar reasoning applies for other farm assets.) We will consider the impact of a land constraint $l_t \leq \bar{l}$, making endogenous the land rental price, in the numerical analysis below.

[3] Instead of immediate retirement, the farmer could also move to different production sector. We do not consider this case and also exclude a later return to agricultural production.

subject to the budget constraint (2), and for production as defined in equation (1), and $x_t = l_t = N_t = S_t = 0$ for $t = T, \dots, T'$, where β is the utility discount factor, and u is the instantaneous felicity function which we assume to exhibit DARA

Our dynamic framework with finite time horizon can be solved backwards, leading to the definition of value functions. The program of the last periods where the farmer is no longer active, nor faces risk is very simple. The program leads to a value function with the same properties as the instantaneous utility function (independent of the terminal condition for the last period wealth).

$$V_T(w_T) = \max_{c_t} \; E_T \sum_{t=T}^{T'} \beta^t u(c_t) \quad \text{s.t.} \quad w_{t+1} = (1+r)(w_t - c_t) \;\; \text{for} \;\; t = T, \dots, T' \; .$$

For the periods with production $t = 0, \dots, T-1$, the farmer program is recursively defined by:

$$V_t(w_t) = \max_{c_t, y_t} \; u(c_t) + \beta E_t V_{t+1}(\tilde{p}_t y_t + (1+r)\left(w_t - c_t - C\left(y_t, p_{x,t}, p_{l,t}, s_{l,t}\right) + S_t\right)) \qquad (4)$$

where $C(.) \equiv \min_{x_t, l_t}\{p_{x,t}x_t + (p_{l,t} - s_{l,t})l_t \; : \; y_t = f(x_t, l_t, N)\}$ is the associated cost function.The following first-order conditions derive:

$$u'(c_t) - \beta(1+r)E_t V'_{t+1}(\tilde{w}_{t+1}) = 0 \qquad (5a)$$

$$E_t\left[V'_{t+1}(\tilde{w}_{t+1})(\tilde{p}_t - C'(y_t))\right] = 0 \qquad (5b)$$

Conditions (5) have some similary with the condition determining the level of production in the corresponding static problem,

$$\max_{x,l} \; Eu\left(w + \tilde{p}y - p_x x - (p_l - s_l)\, l + S\right) \quad \text{s.t.} \quad y = f(x, l, N)$$

whose first-order condition is: $E\left[u'(\tilde{w})(\tilde{p} - C'(y))\right] = 0$. In our solution to the dynamic problem, two aspects complicate the analysis. First, conditions (5) also involve the derivative of the value function, instead of only marginal direct utility. Second, the argument of the value function, final wealth, now depends on endogenous consumption, the level of which is implicitly determined by condition (5a). The second-order conditions depend on the second derivative of the value function (*cf.* the Online Appendix). The properties of the value function have been extensively analyzed in the context of the consumption theory (*e.g.*, Carroll and Kimball 1996, Meyer and Meyer 2005). Because the value function is an envelope, resulting from maximisation, it is less concave and exhibits thus less risk aversion than the instantaneous utility function. Unfortunately, it is impossible to establish all properties of the value function in particular in a context with production (Cao et al. 2011). For example, while it is in a two-period framework still concave with respect to wealth, it does not necessarily exhibit decreasing absolute risk aversion (DARA) even if the instantaneous utility function satisfies DARA. The intuition is that in a context with endogenous production and consumption, it is impossible to globally establish that the positive marginal impact of wealth on consumption is decreasing.

Let us now examine the impact of a marginal increase of the subsidy to active farmers on production and consumption choices. We concentrate on the active-farmer subsidy in this comparative-statics exercise because the mechanism associated with a marginal increase of the land subsidy is comparable, whereas its encompassing analysis requires to also control for the level of the land rent $p_{l,t}$. Total differentiation of first-order conditions (5) yields:[4]

$$\begin{bmatrix} u'' + E_t V''_{t+1} & -E_t\left[V''_{t+1}(\tilde{p}_t - C')\right] \\ -E_t\left[V''_{t+1}(\tilde{p}_t - C')\right] & E_t\left[V''_{t+1}(\tilde{p}_t - C')^2 - V'_{t+1}C''\right] \end{bmatrix} \begin{bmatrix} dc_t \\ dy_t \end{bmatrix} = \begin{bmatrix} E_t V''_{t+1} \\ -E_t V''_{t+1} \end{bmatrix} \cdot dS_t \tag{6}$$

Using Cramer's rule, this system can be solved to obtain the production and consumption impact of the active-farmer subsidy:

$$\begin{aligned} \frac{dc_t}{dS_t} &= \frac{1}{D}\left[E_t V''_{t+1} E_t\left[V''_{t+1}(\tilde{p}_t - C')^2\right] - E_t\left[V''_{t+1}(\tilde{p}_t - C')\right]^2 - E_t V''_{t+1} E_t V'_{t+1} C''\right] \\ \frac{dy_t}{dS_t} &= \frac{1}{D}\left[-u'' \cdot E_t V''_{t+1}(\tilde{p}_t - C')\right] , \end{aligned}$$

where the determinant of the matrix in system (6) $D > 0$ (see Online Appendix). Both multipliers involve the second derivative of the value function. Despite the, in general, theoretically not fully known properties of the value function, we can still determine that the impact of the active-farmer subsidy on consumption is positive and lower than one (using again the Cauchy-Schwarz inequality as in the Online Appendix). On the other hand, the production impact is theoretically ambiguous as it depends on the DARA properties of the value function (this can be shown using the decomposition approach of Orminston (1992), as already performed by Hennessy (1998) in the static context). More precisely, we are only sure that the production impact of the active-farmer subsidy is positive if the value function is DARA. It can be positive or negative otherwise.

To go one step further in the analysis of the production impact of active-farmer subsidy, consider the last production period where the properties of the next-period value function are known, they are equal to the properties of the instantaneous utility function. In that period, this impact is positive but, due to the impact of consumption, still different from

[4] We simplify the expression by omitting the arguments of the utility, value, and cost functions. Without loss of generality, we assume, moreover, that utility discount rate and the interest rate are equal, *i.e.*, $\beta(1 + r) \equiv 1$.

the one obtained from the static program:

$$0 \leq \frac{dy}{dS_t} = \left.\frac{dy}{dS_t}\right|_{c_t=\bar{c}} + \left.\frac{dy}{dc}\right|_{c_t=\bar{c}} \frac{dc}{dS_t} = \left.\frac{dy}{dS_t}\right|_{c_t=\bar{c}} \left(1 - \frac{dc}{dS_t}\right) \leq \left.\frac{dy}{dS_t}\right|_{c_t=\bar{c}}$$

As expected, the production impact of the active-farmer subsidy in the last production period is lower when the consumption decision is taken into account. The intuition is that the individual farmer already consumes at the beginning of the last production period part of the subsidy. Hence, his final wealth is lower, his expressed risk aversion is greater, and production is lower.

3 Numerical Analysis

To quantitatively illustrate a series of aspects related to our theoretical reasoning, we turn to a numerical analysis. After specification of our numerical model and parameters in Subsection 3.1, we analyze in Subsection 3.2 the specific consequences of the land and active-farmer subsidies in the static and a two-period framework, and thus without and with considering consumption. In Subsection 3.3, we introduce an additional land constraint. Subsection 3.4 extends the analysis to the multi-period framework. Subsection 3.5 considers the sensitivity of main results to the risk-aversion parameter. Because the effects of subsidies may significantly differ depending on farm characteristics such as initial wealth, we conduct the analysis in this section throughout for a farmer who is poor and one who is wealthy at the moment of policy implementation.

3.1 Numerical Model and Parameter Assumptions

Main elements we need to specify for our simulations include the production function (3), the instantaneous utility function in problem (1), and the prices. In order to obtain most sensible results, we use rather flexible forms for the production functions and utility. Regarding the production function, we adopt a constant elasticity of substitution (CES) specification:

$$y = \alpha \left(\delta_x x^{\frac{\sigma-1}{\sigma}} + \delta_l l^{\frac{\sigma-1}{\sigma}} + \delta_N N^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

We assume that the substitution elasticity σ is 0.2. All other parameters of the CES function are calibrated using initial shares. We assume that, without price risks and subsidies, the farmer would optimally produce in a period 700t of an agricultural product y, say wheat, at the price of €150/t using 100ha of land l remunerated at €200/ha. He would also use 600 units of variable inputs x bought for €100/unit. Working 2000 hours a year for €12.5/hour, the farmer's profit would thus amount €25,000. With these assumptions, the price elasticity of supply under certainty is 0.63.

Regarding instantaneous utility, we use the expo-power function, as proposed by Saha (1993):

$$u(c) = u_0 - \exp(-u_1 c^{u_2})$$

The associated Arrow-Pratt coefficient of absolute risk aversion is given by:

$$A_u(c) = \frac{1 - u_2 + u_2 u_1 c^{u_2}}{c} \ .$$

This function exhibits DARA if the parameter u_2 is lower than 1. In our main analysis, we assume this parameter to equal 0.5. Parameter u_1 is chosen such that the coefficient of absolute risk aversion is equal to 0.5 when consumption is equal to the profit under certainty of €25,000.

As in the theoretical analysis, all prices are exogenous to the decisions of the farmer, and input prices are fixed. To capture the typical asymmetric distribution, we specify a lognormal law for the output price with mean 150 and a standard error of 30, $\ln \tilde{p}_y \sim \mathcal{N}(150, 30)$. Solving the farmer program involves determining an expectation over future output prices. We assume that the farmer considers 20 equi-probable realizations of output prices from the lognormal law in each period. Finally, we assume (like Kimball 1990) that the discount factor β is equal to unity, and the interest rate r is zero.

The last parameter we need to determine is the farmer's initial liquid wealth w_0. We will consider two cases: first a poor farmer with liquid wealth of €5,000, second a wealthy farmer with €30,000 (thus, just greater than the expected profit). These levels are chosen in order to obtain non-marginal effects in our policy experiments.

To test the viability of our parameter assumptions, we consider the static model under risk as a benchmark. Starting from the no-policy case, we simulate a 1% increase of the output price, as potentially induced by a classic output subsidy, and the impact of an increase of initial wealth, potentially due to an active-farmer subsidy implying the same level of public expenditures as the output subsidy. We distinguish the cases of a poor and a wealthy farmer. Table 1 reports the results of these calibration tests.

As compared to the case without price risk (700t), risk aversion leads the wealthy farmer in the present no-policy benchmark to produce less (665.4t), a reduction by 4.9%. The price that induces the farmer to produce this level is 6.7% lower than the mean price. In other words, this farmer is indifferent between the risky output price with mean €150/t and a certain price equal to €140/t. For the initially poor farmer, this certain price is obviously lower (€132/t).

The production impact of an output subsidy of €1.5/t is greater for the poor farmer (1.7%) compared to the wealthy farmer (0.9%). However, public expenditures of this policy are greater for the wealthy farmer (€1,007 compared to €963), because the poor farmer initially produces less. The production impact of the active-farmer subsidy is in this static framework much lower than the impact of an output-price increase. For the wealthy farmer, the former amounts to less than 0.1% and thus to only 8% of the price-subsidy effect. This production ratio is in line with available estimates (Féménia et al. 2010). For the poor farmer, the production impact of the active-farmer subsidy is greater (0.7%), representing 42% of the price-subsidy effect.

3.2 Impacts of a Land Subsidy and an Active-Farmer Subsidy with and without Endogenous Consumption

We compare now the production impacts of a land subsidy of €100 per hectare and an active-farmer subsidy of €10,000 per year (corresponding to €5 per hour), chosen such that the public expenditures for both interventions are *ex ante* comparable. We assess the impacts of these policies in the static framework with risk, and our dynamic framework restricted to two periods (hence, only one period of production). We first abstract from land constraints. Results are reported in Table 2.

In the static framework, results are quite usual: both subsidies favor production and land use. The effects are larger in the case of the initially poor farmer. The active-farmer subsidy, as a payment on a fixed factor, is less production-distorting than the land subsidy, based on a variable input (land), because in the case of the former in addition to the wealth effect relative price effects occur (according to the OECD (2001) terminology). In the dynamic framework with two consumption periods and one production period, we observe that production increases in the two policy experiments, as predicted in our theoretical analysis. However, compared to the static framework the production impacts are much greater. For instance, the active-farmer subsidy leads to a production increase of 14.5% for the initially poor farmer and of 1.5% for the initially wealthy farmer, compared to 3.7% and 0.6%, respectively, in the static case under risk. Moreover, in the dynamic framework production levels are much lower both in the no-policy environment and with policies. For instance, for the initially poor farmer under the active-farmer subsidy the level of production reaches 603t compared to 655t with the standard framework.

The more pronounced effects in the dynamic setting are related to the farmers' risk aversion and prudence. The two risk attitudes are implied by the DARA assumption for instantaneous utility. Risk aversion leads farmers to reduce their exposure to future price risk by reducing their production level. In other words, a reduction in the production level provides self-insurance to risk averse farmers as it reduces the losses when the future prices are low (even if it also reduces the benefits when the future prices are high). Prudence makes the farmer reduce production in order to save some production costs and increase precautionary savings. In our setting, prudence leads the farmer also to reduce first-period consumption in favor of savings. Hence, without subsidy a prudent farmer produces, and consumes, less in the first period in order to be better prepared for the consequences of the price risks in the second period. For instance, the initially poor farmer produces 527t without subsidy, compared to 631t in the static framework with risk. The active-farmer subsidy makes him exhibit less risk aversion and prudence because his stochastic second-period consumption will in part be financed by the subsidy. Accordingly, he is ready to incur more production costs at the beginning of the production period and decides to produce more.

Interestingly, the initially poor farmer consumes in the first period a more important part of the active-farmer subsidy than the initially wealthy farmer (€8,276 vs. €5,721 of the €10,000). This result may seem counterintuitive. However, the initially poor farmer exhibits relatively high prudence and does not consume a lot such as to increase future consumption. We underline that the farmer is, by assumption, not credit-constrained and could have borrowed money to increase first-period consumption. So, his marginal utility of income is initially very high. The initially wealthy farmer has without policy a lower marginal utility of income, he basically splits the subsidy between the two periods.

Our dynamic framework with endogenous consumption thus provides a new assessment of the impact of farm subsidy policies. We find greater production impacts compared to those obtained in the static framework under risk. An interesting question is whether it is possible to obtain similar results to the static case by constraining the level of first-period consumption. To answer this question, we simulate our dynamic framework assuming that first-period consumption is constrained to its no-policy level. The results are reported at the bottom of Table 2. In line with our theoretical results, we find that production impacts are greater in percentage terms. For instance, the production impact of the active-farmer subsidy for the initially poor farmer now amounts to 23.1% (compared to 14.5% when the consumption is endogenous). Indeed, fixing first-period consumption corresponds to simulating a static model with a much greater wealth effect because initial wealth is diminished by this consumption level. The results correspond to the static case under risk only when we assume that first-period consumption is equal to zero. This reminds of the fundamental question whose risk preferences become operative in agricultural production decisions, for example, those of the farm manager or those of the farm household. In this paper, we focus on the economic behavior of a farm household engaged with its human capital in farming and bearing the consequences of risk in monetary (and ultimately consumption) terms.

3.3 Introducing Land Constraints

In our dynamic framework with endogenous consumption the land subsidy still appears more production-distorting than the active-farmer subsidy. For the results we have thus far assumed that land is available to the farmer without restriction at a constant rental price. This assumption is rather unrealistic at the aggregate level. We now impose that land supply is constrained at a level of 100 ha for each farmer, and that landowners have no alternative uses of their land at a positive rental rate. The results for the no-policy benchmark and our two policy scenarios are reported in Table 3. In this table, we report the equilibrium land rental price instead of land use as in this setting land use is, in equilibrium, always equal to the exogenous land supply.

The land subsidy has no production impact anymore, in both the static and the dynamic setting it is fully captured by the landowner. By contrast, the active-farmer subsidy is only partly capitalized in land values. For instance, in the static framework it increases the land rental price by 6.2% if given to the initially poor farmer. In other words, the landowner can reap €1,000 of the €10,000 received by this initially poor farmer, because the farmer's production is increased (by 0.8%) due to the standard wealth effect. In the dynamic framework, the production impact of this subsidy is again greater, amounting to 2.1% for the initially poor farmer, because farmers also adjust their optimal consumption level and exhibit, due to the subsidy, less risk aversion and prudence. In the dynamic framework, we have simultaneously a higher impact on production and on the land rental price. The landowner is able to capture €2,000 of the €10,000 granted to the initially poor farmer (only €500 from the initially wealthy farmer). One reason for the difference to the static case is that without policy the initial land rental price is much lower (€117/ha for the initially poor farmer).

These results are obtained without considering a clearing mechanism for the market for rental land. Indeed, the land rental prices farmers should pay in the absence of policies differ much: €117/ha for the initially poor, €152/ha for the initially wealthy. This is hardly possible in a steady-state solution. (Obviously, landowners would then prefer to allocate their land to initially wealthy farmers.) Therefore, we perform a further simulation assuming a perfect land rental market: each farmer pays initially the same land rental price to landowners. Results for the no-policy benchmark and the active-farmer subsidy are shown in Table 4.

The no-policy benchmark is slightly different from the previous ones, because the initially poor farmer now pays a higher price for land (and conversely for the initially wealthy farmer). When the active-farmer subsidy is granted to both farmers, the production impact is positive for the initially poor one but negative for the initially wealthy one. This result is obtained in both frameworks. The reason is that the wealth effect dominates in the case of the initially poor farmer, while the induced negative effect on the land rental price dominates in the case of the initially wealthy farmer. Still, we observe larger effects in our dynamic framework. For example, aggregate production increases by 1.4% compared to 0.5% in the static framework.

3.4 Extension to Many Periods of Production

The numerical results described thus far follow immediately from theory because, when considering one production period (and two consumption periods), we work with the known direct utility function. When considering multiple production periods with stochastic future prices, the analysis involves value functions whose properties can be ambiguous (*cf.* Section 2). For example, even if the instantaneous utility function exhibits DARA, it is possible for the value function to show CARA or IARA. In this case, also the impacts of a wealth increase (as induced, for example, by an active-farmer subsidy) are ambiguous. Because of this theoretical ambiguity, we simulate our dynamic framework with many periods. As our results are qualitatively similar for three to five (consumption) periods, we report below only the results when there are two periods of production. We assume for simplicity that the stochastic output prices between two periods are not correlated (for instance due to sufficient storage). We only examine the active-farmer subsidy policy, and assume it is granted in both production periods, so that farmers receive €10,000 each period. Because the market for financial capital is assumed perfect, this corresponds to an initial wealth increase of €20,000 for each farmer.

We solve the farmer's program for period one where he determines his first-period consumption and production levels (including variable inputs and land use) with uncertain future prices. He also chooses the second-period consumption and production levels as a function of the possible first-period output price. The true second-period consumption and production levels are obtained once the first-period output price is known. Thus, we consider the program:

$$V_1(w_1) = \max_{y_1, y_{2|p_1}, c_1, c_{2|p_1}} u(c_1) + E_1 \Big[u(c_{2|p_1}) + E_2 u \big(w_1 + 2S + \tilde{p}_1 y_1 + c_1 + C(y_1) \qquad (7)$$
$$+ \tilde{p}_{2|p_1} y_{2|p_1} + c_{2|p_1} + C(y_{2|p_1}) \big) \Big]$$

The first-order conditions of this program do not show a clear impact of a wealth increase on first-period production, because the impacts on consumptions and second-period production need to be determined simultaneously. Hence, we rely on simulation. Program (7) can be written recursively as:

$$V_1(w_1) = \max_{y_1, c_1} u(c_1) + E_1 V_2(\tilde{w}_2) \quad \text{with} \quad \tilde{w}_2 = w_1 + 2S + \tilde{p}_1 y_1 - c_1 - C(y_1)$$
$$V_2(w_2) = \max_{y_{2|p_1}, c_{2|p_1}} u(c_{2|p_1}) + E_2 u \left(\tilde{w}_2 + \tilde{p}_{2|p_1} y_{2|p_1} - c_{2|p_1} - C(y_{2|p_1}) \right)$$

As explained in the theoretical section, we are sure that a wealth increase has a positive production impact if the value function exhibits DARA. But, in general, we are not sure about the shape of the value function. Accordingly, we solve program (7). We are then able to estimate the second-period value function (using the 20 different first-period prices the farmer considers) and check whether it is of the DARA form. We postulate a flexible expo-power form for this value function:

$$V_2(w_2) = v_0 - \exp(-v_1 w_2^{v_2}) \ .$$

Using the results simulated for the initially poor farmer, we find that the value function has a DARA shape: $v_2 = 0.71$. As explained by Meyer and Meyer (2005), the value function is less concave than the the instantaneous utility function. So we are assured that the production impact of the active-farmer subsidy is positive in this setting. Table 5 reports our simulation results when no land constraint is imposed.

The production impact of the active-farmer subsidy is quite important for the initially poor farmer, his first-period production now increases by 18.5% instead of 14.5% obtained previously. Interestingly, the expected production impact is much lower in the second period for the initially poor farmer (5.4%). Without subsidy, the initially poor farmer produces little in period one (550t) and expects to produce more in period two (602t) as the prudence and risk aversion he exhibits decrease. With the subsidy, he produces more in the first period as he exhibits much less prudence and risk aversion, and the reduction of exhibited prudence and risk aversion is lower in the second period due to the lower no-policy prudence and risk aversion in that period.

Surprisingly, we find opposite dynamic results for the initially wealthy farmer. In the first year, the production impact of the active-farmer subsidy is modest (1.9%), and in the second period higher (in expectation) (2.6%). The reason relates again to the no-policy benchmark. Without subsidy, the initially wealthy farmer produces in period one more than the expected period-two production. Indeed, this initially wealthy farmer may become poor at the beginning of period two if the realized output price in period one is low. Obviously, he can become wealthier if this price is high. But the expected production starting with a low second-period wealth is much lower than the one starting with a high second-period wealth, leading to this lower expected second-period production. For instance, if the first-period price amounts to €108/t, he makes a production loss of €2,906, and his second-period wealth is then equal to €6,832 (his first-period consumption amounts to €20,262). If the first-period price amounts to €225/t, his benefit reaches €74,080, and his second-period wealth amounts to €83,818. In other words, the initially wealthy farmer exhibits less prudence and risk aversion in the first period compared to the second one. Accordingly, the active-farmer subsidy has a lower production impact in the first period than in the second (again in expectation).

3.5 Sensitivity Analysis

Our simulations depend on various assumptions on functional forms and parameters. A critical parameter is the farmers' risk aversion coefficient. Thus far, we assumed $u_2 = 0.5$. We increase this parameter now to $u_2 = 0.8$, so that instantaneous utility still exhibits DARA. Hence, a static analysis still automatically yields a positive production impact of a direct payment. What about the dynamic analysis with endogenous consumption levels? We simulate the model with two production periods and estimate the resulting value function. The value function is now of the IARA type, with $v_2 = 1.2$. We are thus in the case of theoretical ambiguity. Table 6 reports our simulated results for this case.

While production impacts remain positive, they have a lower level than derived above (*cf.* Table 5). A first message is that the static analysis with a synthetic value function can be misleading. One may estimate IARA value functions and wrongly conclude that decoupled payments do not distort production (in the positive direction). Our results make clear that the deep parameters of the utility function should be used in the analysis of the decoupling of agricultural policy instruments. A second message is that the dynamic estimates are less sensitive to these deep parameters. For instance, the production impact for the initially poor farmer shrinks from 3.7% to 1.4% in the static framework, but from 18.5% to 14.3% in our dynamic framework. The difference is explained by the envelope theorem.

4 Conclusion

For the 2014-2020 phase of the Common Agricultural Policy, the European Commission may favor a redirection of direct payments from land towards active producers in order to reduce the leakage of direct payments from farmers to landowners. We study whether shifting the basis of direct payments from land towards active farmers will significantly alter agricultural production decisions. Our dynamic and stochastic analysis of the impacts of this shift accounts for both the farm household's production decisions and its consumption choices. In the dynamic setting, the production impacts of direct payments are much higher than previously quantified in static frameworks. An important reason is that in the dynamic framework decisions depend on an individual's value (or indirect utility) function which exhibits lower absolute risk aversion than the direct utility function. The higher absolute risk aversion associated with the value function follows from the endogeneity of consumption and the envelope theorem. In our dynamic setting, the development of production impacts over time is opposed between our initially poor and our initially wealthy farmer. Production impacts decrease over time for the initially poor but are time increasing for the initially wealthy due to the higher or lower precautionary motive, respectively. Leakage to land owners is, of course, much lower, and hence the production impact is higher, with an active-farmer subsidy than with a land subsidy. The strength of risk aversion plays an important role not only for the quantitative results but also for whether differing risk-aversion shapes associated with direct and indirect utility occur or not.

We do not provide normative conclusions on agricultural policy. We just note that an active-farmer subsidy has generally a higher impact on farmer production than a land subsidy, and is less attractive for landowners. Obviously, the combination of subsidy policies with an environmental regulation that is production-neutral and still farmer-beneficial can be analyzed. Our analysis is subject to a number of limiting assumptions. For example, we assume that farmers are not credit-constrained and do not own the capital goods they use such as land, buildings, or machinery. We focus on just one source of risk, associated with the output price, and do not consider background risk or risk correlations, nor diversification devices such as future markets or insurances. Still, our analysis underlines the importance of relying on dynamic frameworks and including endogenous consumption.

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