Farm household production under CAP reform: the impact of borrowing restrictions

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Production des ménages agricoles et réforme de la PAC: l'impact des contraintes de crédit

Résumé – Classiquement, dans le ménage agricole, les fonds propres de l'entreprise ont deux fonctions: fournir à la fois le capital de l'exploitation et le patrimoine du ménage. Ainsi, une interdépendance potentielle existe entre les décisions de production et celles de consommation dans le ménage qui peut influer sur l'impact des réformes de la politique agricole, comme la reforme MacSharry, sur la production.

Cet article examine l'importance virtuelle d'une telle interdépendance quand des contraintes financières limitent la dette totale du ménage. De manière théorique, ce type de contrainte s'explique par l'existence d'asymétrie d'information dans le marché du capital où les banques et autres intermédiaires financiers ne peuvent pas être certains que leurs prêts seront remboursés. Ils utilisent différents mécanismes pour réguler leurs prêts, y compris des limites quantitatives.

En France, l'évidence empirique montre que les jeunes agriculteurs sont souvent sous des contraintes financières. Dans cet article est construit un modèle de cycle de vie intégrant les contraintes financières adaptées à la situation du ménage agricole, et où le ménage choisit les valeurs de production, consommation, investissement et dette afin de maximiser son bien-être. On démontre que la présence des contraintes financières implique que les décisions de production et consommation soient simultanées. Ensuite, le modèle, calibré pour présenter une exploitation céréalière spécialisée française, est utilisé pour simuler les impacts sur la production de trois aspects de la réforme MacSharry: la baisse du prix de céréales, le gel des terres et les paiments compensatoires.

Pour montrer les effets des contraintes financières sur la production de l'exploitation, les simulations de ce modèle «simultané» sont contrastées avec celles d'un modèle dont les contraintes financières sont absentes. Ce dernier modèle est simplifié et les décisions de production deviennent indépendantes de celles de consommation. Dans ce modèle «recursif», le comportement productif du ménage est donc équivalent à une exploitation qui maximise tout simplement le profit d'entreprise. Les résultats indiquent que les impacts négatifs des réformes MacSharry sur la production sont toujours inférieurs dans le modèle simultané par rapport au modèle recursif. D'ailleurs, parce que les réformes réduisent souvent l'impact des contraintes financières, pour plusieurs simulations, les effets sur la production à longue écheance sont positifs dans le modèle simultané.

Bien qu'il ne s'agisse que de modèles calibrés (économétriquement non estimés), les résultats se trouvent consolidés pour des spécifications différentes. Ainsi, ces résultats montrent pourquoi les impacts négatifs de la réforme MacSharry sur la production de céréales pourraient être inférieurs à ceux prévus par des modèles basés sur le principe de maximisation de profit.

Mots-clés:
cycle de vie, simulation, MacSharry, production

Farm household production under CAP reform: the impact of borrowing restrictions

Summary – This paper examines the potential impact of borrowing constraints on the production responses of farm households to certain aspects of the MacSharry reforms. A life cycle model of the farm household is calibrated for specialized cereal producers in France and used to simulate the output effects of cereal price reductions, set-aside and compensation payments.

The responses of this model are contrasted with a recursive model where production is independent of consumption. The results show that the output effects resulting from the policy changes are always less negative in the farm household model than in the recursive model and may, in many cases, be positive.

Key-words:
life cycle, simulation, MacSharry, output

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THE combination of ownership and control typically observed in the farm household may have important behavioural implications as farm capital represents both a source of finance for the farm business and also a store of wealth for the household. Hence, there exists a potential trade-off between current farm consumption and farm investment. In terms of agricultural policy the existence of such interactions has implications in terms of the household's responses to changes in policy such as in the recent MacSharry reforms to the CAP. In this paper, the potential importance of such interactions is examined using a life cycle model of the farm household with restrictions on borrowing. The model is calibrated to replicate average data for specialized cereal producers in France. It is then used to simulate the output responses of the farm household to certain aspects of the MacSharry reforms, namely cereal price reductions, set-aside and compensation payments.

For EU agriculture as a whole little econometric evidence exists on the number of farms affected by the use of quantitative restrictions on borrowing by banks (Miller *et al.,* 1993; LEI/Rabobank, 1990). However, in France, Lifran (1994) has estimated that, at least amongst young farmers, the proportion of farms constrained by restrictions on debt was as high as two thirds. Further, the evidence on the number of farms considered to be financially fragile (and hence by implication likely to be affected by credit restrictions) suggests that a significant proportion of all farms in EU agriculture may be affected (Blogowski *et al.*, 1992).

Theoretically, quantitative restrictions on borrowing arise from the presence of imperfect information in the credit market (Stiglitz and Weiss, 1983) and imply the potential existence of non-standard production responses (Phimister, 1995), *e.g.* output increases in response to output price decreases. Depending upon the actual number of farm households affected, such responses may reduce the actual aggregate cereal output reductions caused by the MacSharry reforms relative to those predicted by models based around the assumption of profit maximizing farmers (Guyomard *et al.*, 1993).

The main purpose of this paper* is to show, using simulations representing cereal farms, that distinct production responses to the MacSharry reforms are likely at the farm level. In contrast to the recent empirical evidence on the lack of labour supply-production interactions in Dutch agriculture (Elhorst, 1994), these results reinforce the need to consider farm household effects in EU agriculture.

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The plan of the paper is as follows. In the next two sections the life cycle model is introduced and analyzed. Following this, the model initialization is explained and simulation results presented.

MODEL DESCRIPTION

Basic model structure

While the oritinal life cycle model was formulated at the individual level (Modigliani and Blumbert, 1955), here it is applied to the household. The full empirical model is formulated below:

$$\max_{\substack{C_t, Y_t, K_t, B \\ d_t A_t IA_t I_t}} \sum_{t=1}^{T} \frac{N_t}{(1+\rho)^t} U\left(\frac{C_t}{N_t}\right) + Q(B) \tag{1}$$

subject to

$$C_t = (1-\pi)(P_t(1-\alpha)Y_t - 0_t) - rd_t + (d_{t+1} - d_t) - p_{kt}I_t - h(IA_t) + \Omega_t A_t \tag{2}$$

$$(1-\alpha)\, Y_t = F(K_t, \beta A_t, \bar{L}_t, t) \tag{3}$$

$$K_{t+1} = (1-\delta)\, K_t + I_t \tag{4}$$

$$A_{t+1} = A_t + IA_t \tag{5}$$

$$d_t \leq d_t^* \tag{6}$$

$$C_t \geq \gamma N_t \tag{7}$$

$$A_t \geq TA_1 \tag{8}$$

$$B \leq p_{aT+1}(A_{T+1} - TA_1) + p_{kT+1} K_{T+1} - d_{T+1} \tag{9}$$

$$K_{T+1} \geq 0 \tag{10}$$

$$d_1 = \bar{d}_1;\ K_1 = K_1;\ A_1 = OA_1 + TA_1 \tag{11}$$

The definitions of the variables are given below, split according to whether they are exogenous or endogenous to the model.

Exogenous variables

P_t - output price, r - interest rate, p_{kt} - capital goods price, p_{at} - land price, α - share of current inputs in gross output, δ - depreciation rate, ρ - rate of time preference, π - rate of income tax, β - proportion of land in production, T - length of the planning horizon, N_t - number of adult equivalents in household, TA_1 - area of tenanted land, L_t - quantity of effective labour available, OA_1 - initial area owned land, d_1 - initial debt, k_t - initial capital stock, O_t - total other payments, Ω_t - compensation payment per hectare.

Endogenous variables

C_t - consumption expenditure, Y_t - gross output, K_t - capital stock, A_t - land, I_t - investment, IA_t - land investment, d_t - debt owed, B - bequest.

Consistent with the non-stochastic version of the life cycle model (Keyzer, 1988) the household wishes to maximize utility, here obtained from consumption and the bequest to the post-planning period, where the household's life is the period in which the current generation controls the farm business. The household's decisions are constrained by a series of equalities and inequalities. The first set of these (2) defines consumption in each period as after-tax income, minus interest payments, plus new borrowings, minus net investment in capital goods, minus costs associated with investment in land, plus compensation for set aside and price reductions[1]. Given that the empirical analysis considers the case of specialized cereal producers under the MacSharry reforms, it is assumed that the base area on which compensation payments are based is equal to the total owned and tenanted by the farm household, A_t. The exact composition of the compensation payment per unit of land is discussed below.

Gross value added in each period is generated from the production of an aggregate cereal product, gross value added being a function of the inputs of capital, land and labour (3). Due to set-aside, only βA_t of the total area owned and rented by the farm enters the production function. Capital stock and the utilized land area are defined for each period by constraints (4) and (5) respectively. Although the area of land employed, A_t, is endogenous, due to set-aside, only β of each extra unit purchased is used in production. Further, any investment in the total land area is assumed to be subject to adjustment costs. To capture the general increase in productivity that will occur over the planning period, technical change is introduced by exogenously augmenting the value added function at a constant rate, i.e. $F(K_t, A_t, L_t, t) = \exp(\lambda_t) f(K_t, A_t, L_t)$ where F(.) exhibits constant returns to scale. While in practice additions to the land employed can occur from a number of sources, e.g. purchase, gifts or rented area, in order to keep the modelling as simple as possible, it is necessary to assume that only one of these adjustment processes is possible. The empirical evidence for France suggests a complex system of adjustment through the farm household's life cycle with expansion occurring mainly through a combination of gifts and purchase (SCEES,

[1] It is therefore assumed that the farm household has opted in to the set-aside scheme and is therefore entitled to any compensation payments available.

1994). The nature of the gifting process is beyond the scope of this paper and therefore it has been assumed that that adjustments in the land area occur through purchase only. Hence, the tenanted land area is fixed at its initial level with total area of land used constrained to be at least this level (8).

Finally, on the production side the assumed exogeneity of labour input must be examined. Although the existence of potential labour supply-production interactions is well documented (Singh *et al.*, 1986; de Janvry *et al.*, 1991), the empirical evidence of its relevance in the developed country context is mixed (Benjamin, 1993; Elhorst, 1994). Nevertheless, a model which allowed for both capital and labour market imperfections would be the ideal. However, the extra level of model complexity required for the inclusion of farm household labour supply decisions did not prove possible to implement empirically. Given that the primary focus in this paper is on the savings and investment interactions occurring in the farm household the assumption of labour input exogeneity is viewed as operationally justifiable.

The demographic structure of the farm household will play an important role in determining household consumption patterns. The model incorporates this by weighting household utility by the number of equivalent adults in the household and by specifying minimum consumption levels (7).

The borrowing restrictions on debt set by the lending institution are represented by the constraints (6). In the case considered here, the lending institution sets a simple exogenous limit on the farm's total debt in each period, d_t^*. While the connection between these limits and the use of collateral or profitability requirements by lending institutions can be made explicit (Phimister, 1993), the simpler case employed here can be justified if one argues that farm households do not consider (or do not have the information to determine) the effect of their behaviour on their credit worthiness. The final constraints define the value of the bequest (9), ensure that terminal capital stock is non-negative (10), and restrict the starting values for debt, capital stock and utilized land area (11).

MODEL PROPERTIES

For solution purposes the model can be simplified through the substitution of Y_t and I_t in (2) using the constraints (3) and (4) respectively. In the modified model, dual variables for a number of the remaining constraints must be introduced. Define mt as the dual variable for the equations (2), ψ_t the dual variable, normalized by μ_t associated with the land constraints (5) and finally ν_t as the dual variable for the minimum consumption constraints (7). Using these definitions, it can be shown that the optimal solution must satisfy the following equations[2]:

$$P_t\,(1-\pi)\,\frac{\partial F(K_t,\ \beta A_t,\ \bar{L}_t,\ t)}{\partial K_t} = r_t\,p_{kt-1} + (p_{kt-1} - p_{kt}) + \delta p_{kt} \tag{12}$$

$$\beta P_t\,(1-\pi)\,\frac{\partial F(K_t,\ bA_t\ \bar{L}_t,\ t)}{\partial A_t} + \Omega_t = \bar{r}_t\,\psi_{t-1} + (\psi_{t-1} - \psi_t) \tag{13}$$

$$\frac{\mu_{t-1}}{\mu_t} = 1 + \bar{r}_t \tag{14}$$

$$\frac{\partial h\,(IA_t)}{\partial IA_t} = \psi_t \tag{15}$$

$$\frac{N_t}{(1+\rho)^t}\,\frac{\partial U\,(C_t\,/\,N_t)}{\partial C_t} = \mu_t - v_t \tag{16}$$

$$d_t \le d^*_t,\quad \bar{r}_t \ge r,\ [d^*_t - d_t]\,[\bar{r}_t - r] = 0 \tag{17}$$

$$C_t \ge \gamma N_t\quad v_t \ge 0\quad [C_t - \gamma N_t]\,v_t = 0 \tag{18}$$

Equations (12), (13) and (14) are defined for periods $t = 2, ..., T$ and are derived from the first-order conditions for capital input, land input and debt respectively. The relations (15) and (16) hold for $t = 1, ..., T$ and are derived from the first-order conditions for land investment and consumption. Finally, the complementary slackness conditions (17) and (18) hold for $t = 1, ..., T$ and are derived from the first order conditions associated with the inequality constraints on debt and minimum consumption.

The distinctive nature of the farm household model arises from (14) and (17). These two conditions link the production and consumption sides of the model such that when the farm household is borrowing constrained, i.e. $d_t = d^*_t$ for some t, then the value of r_t is determined endogenously. Analogously, if the farm household is never borrowing constrained, i.e. $d_t < d^*_t$ all t, then $r_t = r$ and the model becomes recursive with the production decisions equivalent to those obtainable from an appropriately defined profit maximization problem (Phimister, 1993).

The impact of the tying of compensation payments to the area farmed can be seen from the marginal condition for land (13). The right hand side of this equation represents the effective marginal cost of an extra unit of land being composed of the internal discount cost, $r_t\,\psi_{t-1}$ of land investment plus the effective economic depreciation, $(\psi_{t-1} - \psi_t)$ Likewise, the left hand side of the equation is the effective value product

[2] For exposition, it is assumed that the minimum land constraints (8) are never binding.

for the marginal unit of land employed comprising of the value of output from the portion of the unit in production, $\beta P_t (1 - \pi) \partial F/\partial A$, plus the value of the compensation associated with this unit of land, Ω_t. It follows that, whether the household is borrowing constrained or unconstrained, set-aside and compensation payments tied to land will have production effects. However, in the former case the endogeneity of r_t means that there will also be effects on the marginal costs of land and capital. Further, as r_t enters these equations asymmetrically, any changes induced in r_t will also affect the optimal relative values of capital and land. The presence of this extra effect, combined with the endogeneity of the marginal cost of land investment ψ_{t-1} makes it difficult to determine analytically the exact qualitative response of the model to price cuts, set-aside and compensation payments, i.e. changes in P_t β and Ω_t.

HOUSEHOLD SIMULATIONS

Model initialisation

In order to gauge the effects on production responses of the borrowing constraints, two distinct simulation models will be used. In the first, to be known as the recursive model, the borrowing constraints (6) are excluded. This case represents the unconstrained household with the model's production behaviour reducing to that of an approp :tely defined profit maximizing problem. In the second, to be known as the debt constrained model, the borrowing constraints (6) are included. In this case the household is (potentially) affected by the restrictions on borrowing and hence the household's production and consumption decisions are simultaneous.

To simulate the models, functional forms and parameter values for the various functions, the initial values and the planning horizon must be specified. CES functions are used for the sub-utility, bequest and production functions, while the land investment adjustment function is a quadratic.

Due to the costs associated with farm take-over not unexpectedly the existing econometric evidence (Lifran, 1994) suggests that young farmers are most likely to be affected by restrictions on debt. In France, the majority of young farmers succeed to the business before the age of 36 (SCEES, 1994). Therefore, assuming a retirement age of 65, the base planning horizon for the models was chosen to be 30 years[3].

(3) Although computational problems prevented experiment with planning horizons of more than 30 year, sensitivity analysis with horizons of 20 and 25 years indicate that the results are insensitive to this assumption.

For the production parameters required a calibration procedure has been used which may be summarized as follows (the details and parameter values are given in the appendix) Firstly, it is assumed that the pre-MacSharry policies are continued, i.e. no set-aside, no price cut, and no compensation. Then, using the recursive model, the production parameter values are adjusted such that the initial optimal production values replicate the average values of output, capital, land and labour input for specialized French cereal farms (40 to 100 economic size units) in 1990 from the RICA (SCEES, 1992). In addition, in the short run, i.e. fixed labour and land inputs, the own price output elasticity is equal to that obtained econometrically for specialized French cereal farms of this size (Dronne *et al.*, 1989). For the long run, under the assumption that all prices remain the same, the land investment cost and technical change parameters are adjusted so production increases at a rate of around 3 per cent a year (with yield increasing at around 2 per cent per a year), while the area farmed increases by around 30 per cent over the 30 year period. These increases in production and yield are consistent with those used elsewhere (Guyomard *et al.*, 1991), while the increase in land area employed is well within the average 70 per cent increase reported for farms which have existed since 1960 (SCEES, 1994).

Due to the lack of appropriate data on French farm consumption, the utility and bequest parameters used were obtained from a study using a similar farm household model which was calibrated against individual data on Dutch farm households (Phimister, 1993). While not ideal this at least ensured that the simulated consumption profiles in models were 'plausible'.

As it is assumed that those farms which are financially fragile are more likely to be borrowing constrained, the initial rate of debt for the simulation farm is set to be 75 per cent of total assets. This corresponds to one of the criteria used by Blogowski et al.(1992) as a defining characteristic of what constitutes a financially fragile farm in France[(4)]. Finally, the minimum consumption level per adult equivalent value is set equal to 30,000 French francs. This is a (inflation adjusted) poverty consumption level estimated for France (EC Commission, 1990).

The calibrated version of the recursive model also serves a second purpose, namely, it provides a base simulation from which one can calculate the relative responses of this model under policy changes. To construct the analogous base simulation for the debt constrained model the value of d_t^* must also be specified. For this case it is assumed that household is initially debt constrained and hence the value of d_I^* is equal to 75 per cent of the initial asset value. It further assumed that the maximum value of debt in the other periods is not adjusted, i.e. $d_t^* = d_I^*$.

(4) The authors estimate that in 1988 around 14 per cent of all French farms are financially fragile.

For specialized cereal farms the compensation payments per hectare associated with the MacSharry reforms arise from two sources; the compensation for the cut in cereal support prices, and for setting aside part of the cereals area. The portion attributable to price cuts can be written as $(P_t^o - P_t^m)y\beta$ while that for set-aside can be written as $sy(1 - \beta)$ where P_t^o, P_t^m represent the pre and post-MacSharry prices, y the reference yield, and s the set-aside payment per hectare (Froud and Roberts, 1993). In the simulations, as in the original implementation of the policy itself (Home Grown Cereals Authority, 1992), the rate of set-aside compensation is fixed (at the level equal to the final price compensation), while the rate of price compensation varies with the three year phasing in of the price cuts. In practice the reference yield is calculated using average regional yields. As a result, the extent to which actual losses in revenue are compensated will vary considerably from farm to farm. For French specialized cereal farms it has been estimated that only 75 per cent of their revenue losses will be covered by the compensation payments (Blogowski and Boyer, 1993).

In the model simulations this information is used as follows. The initial yield estimate is obtained from the base simulation, i.e. the simulated yield for the first year under the no policy change option. The reference yield used is then set to 75 per cent of this value. By implication the farms considered are therefore under-compensated for their losses in revenue. In simulating the change in policy one problem concerns the length of time for which compensation payments are to be paid. Although the status of the payments beyond 1996 is uncertain, in the past many 'temporary' policies have become semi-permanent in nature, e.g. milk quotas. Hence, it has been assumed that the payments continue indefinitely although their real value is taken to diminish, via the impact of inflation, at a rate i each year (set equal to 0.03).

RESULTS

Base simulations

The recursive and the debt constrained models have been simulated (using GAMS (Brooke *et al.*, 1988)) under three different scenarios. The first considers the effect of a 30 per cent price cut with compensation, the second the impact of a 15 per cent set-aside policy with compensation, while the third scenario considers the combined effect of the price cut combined with set-aside. In this section, each scenario is simulated with, the effect on each model calculated by comparing the outcomes to the relevant base simulation values. In the next, the sensitivity of these results will be investigated by considering the effects of changing various parameters in the models.

Table 1. Effects of Policy Changes

Recursive Model

Output	Price cut	Set-aside	Combined
5 years	-0.277	-0.088	-0.344
10 years	-0.238	-0.083	-0.310
20 years	-0.199	-0.079	-0.277
30 years	-0.180	-0.081	-0.263
Equivalent Variation (000 francs)	993	143	901
Debt constrained model			
5 years	-0.255	-0.040	-0.290
10 years	-0.145	-0.028	-0.225
20 years	-0.007	+0.016	-0.103
30 years	-0.075	-0.020	-0.167
Equivalent Variation (000 francs)	993	143	901

In table 1 the effects on the production levels for each model relative to the relevant base simulation levels are presented for various points in the households planning horizon. Hence, in the recursive model the price cut reduces output after 5 years by 27.7 per cent, by 23.8 per cent after 10 years, by 19.9 per cent after 20 years, and finally by 18.0 per cent after 30 years. In comparison the effect of set-aside is considerably less, with the overall reduction in output after 30 years only 8.01 per cent. In this model the sum of the individual effects of the price cut and set-aside are approximately equal to the effect of the combined policy. Hence, one can conclude in this model that the main source of output reduction in the combined scenario arises from the effect of the price cut, although the effect of set-aside becomes more important over time.

Despite the fact that the farm household is under-compensated for its loss in revenue, all the policy changes increase household welfare. This can be seen from results of the equivalent variation calculations which are given in the table. These values are the amounts by which initial farm household debt would have to be reduced in order for the utility level in the base simulation to be equal to the values under the policy change scenarios. These positive welfare effects can be explained as follows. In all scenarios, the effect of the policy changes is to reduce farm investment and hence the level of debt relative to the base scenario values and thus interest payments. With the addition of compensation payments, the net effect is to increase household income in each period and therefore household welfare.

For the debt constrained model, the policy changes also decreases the demand for debt. In this case, given that debt is constrained, this reduces the overall impact of the borrowing constraints so that, while in the base scenario for this model the household is constrained for 28 periods, this reduces to zero for the price cut and combined scenarios, and to 23 periods for set-aside alone. In the base scenario the effect of the borrowing constraints is to reduce output relative to the recursive model. Hence, the fact that the policy scenarios reduce the impact of these constraints leads to a reduction in the negative output effects associated with the policy changes. In fact, for both the price cut and the set-aside scenarios the level of output is actually above the base simulation level for some years (in the former case this occurs at 21 and 22 years). This borrowing constraint effect explains the overall differences between the results of the two models. However, the explanation of the relative effects of set-aside and the price cuts is more complicated as the endogeneity of r makes the responses of the debt constrained model more non-linear than the recursive model. Hence, for the debt constrained model the sum of the individual price cut and set-aside output effects is not reflected by the effect observed in the combined scenario. For example, while after 30 years the price cut effect is negative 7.5 per cent and the set-aside affect is negative 2 per cent, the effect in the combined scenario is negative 16.7 per cent. Thus, in the combined scenario there is a significant interaction effect between the two policies and it not possible to attribute the output effect seen into the part due to the price cut and that due to set-aside.

Finally, the apparent equality between the values of equivalent variation across the two models should be noted. In fact, while this equality is exact for the price cut and combined scenarios, there are minor differences for the set-aside scenario. The reason for the identical results for the former cases arises from the impact of the borrowing constraints. For these two scenarios, the decreases in initial debt associated with the equivalent variation calculation mean that the household never faces a binding borrowing constraint. Therefore, because the debt constrained model is equivalent to the recursive model if it has no binding borrowing constraints, the calculated values for the two models must necessarily be identical.

From these results a number of tentative conclusions can be drawn. Firstly, they show that, for 'realistic' parameter values, debt constrained farm households will react differently to the policy changes relative to those farms unaffected by such constraints. However, the differences are likely to vary over time, being more significant in the medium to long term than in the short run. Further, the impact on output of set-aside relative to price cuts is difficult to determine for debt constrained farms, but appears to be different than that for unconstrained farms. This latter aspect implies that any further policy changes are likely to affect output levels on debt constrained farms in an unpredictable way.

Sensitivity analysis

One obvious problem with a calibration/simulation approach is the non-generality of the results obtained. Sensitivity analysis partially alleviates this problem. Hence, in table 2 the sensitivity of the results are considered with respect to a number of selected parameters. The first part of the table reports the effects of changing the minimum consumption levels. Although the production levels in the recursive model are independent of this parameter the results for this model are also included here. In contrast, the responses in the debt constrained model are clearly sensitive to this assumption, with a reduction of the minimum consumption level to 25,000 francs per adult equivalent increasing the overall response towards that of the recursive model. Alternatively, increasing the minimum consumption value to 32,500 per adult equivalent dramatically alters the overall responses in the debt constrained model, with a positive response to the price cut and set-aside scenarios and a negligible negative overall fall for the combined case.

In the second part of the table the effect of changes in the rate of compensation are considered, i.e. the relationship between the reference yield, y, and the actual model yield before the change in policy. Reducing the rate of compensation does reduce the extent to which the models respond differently as this reduces the positive net household welfare effects of the policy changes[5].

Table 2. Overall Effects of Policy Changes on Output: Sensitivity Analysis

Minimum consumption level (francs)		Price cut	Set-aside	Combined
Recursive model	2,500	-0.180	-0.081	-0.263
	32,500	-0.180	-0.081	-0.263
Debt constrained model	25,000	-0.136	-0.056	-0.223
	32,500	+0.054	+0.067	-0.052
Rate of Revenue Compensation				
Recursive model	0.5	-0.252	-0.095	-0.329
	0.625	-0.216	-0.088	-0.296
Debt constrained model	0.5	-0.155	-0.064	-0.242
	0.625	-0.114	-0.041	-0.204
Rate of Value Added Function Augmentation (λ)				
Recursive model	0.008	-0.173	-0.074	-0.254
	0.016	-0.190	-0.087	-0.274
Debt constrained model	0.008	+0.111	+0.137	+0.003
	0.016	-0.092	-0.046	-0.181

[5] In fact, in the debt constrained model the net welfare gain is negligible when the compensation rate is 0.5, i.e. 'perfect' compensation occurs around this rate.

Finally, the effects of changing the rate of augmentation of the value added function, λ are considered. In the previous table this value was set to 0.012 leading, as mentioned above, to an average growth rate in the base simulation of the recursive model of around 3 per cent per year. The reduction in the value of l to 0.008 reduces the average growth rate in the base simulation (for the recursive model) to around 2 per cent per year, while the increase to 0.016 implies an average growth rate of around 4 per cent per year. Perhaps surprisingly, the differences in the responses between the two models increase as the growth rate falls with, for λ to 0.008, the overall responses in the debt constrained model positive for all scenarios. These results are attributable to the fact that, in the base simulation for the debt constrained model, the impact of the borrowing constraints is more severe for the lower value of λ and, because the policy changes substantially reduce the impact of these constraints, the relative output response is larger.

SUMMARY AND CONCLUSIONS

In this paper, the potential interactions between farm consumption and farm investment have been examined using a life-cycle simulation model of a farm household with restrictions on debt. The model was calibrated to replicate average data for specialized cereal producers in France and then used to simulate the output responses of an example farm household to certain aspects of the MacSharry reforms, namely cereal price reductions, set-aside and compensation payments. The analysis contrasted the results from two distinct models. In the first, known as the recursive model, the household is assumed to be unaffected by the borrowing restrictions with, as a consequence, the farm's production behaviour reducing to that of a profit maximizing farmer. In the second, known as the debt constrained model, the household is affected by the restrictions on borrowing and the household's production and consumption decisions become simultaneous.

Overall, these results show that the reduction of output on debt constrained farms in response to cereal price cuts and set-aside is likely to considerably less than that observed for unconstrained farms. In fact it was found, for a number of parameter values, that debt constrained farms actually often increased output in the long run in response to the price cuts and set aside. In contrast, the output effects caused the policy changes were always negative for the model representing unconstrained farms. Although the models are not econometrically estimated, the sensitivity analysis undertaken indicates that the general results are robust to a range of parameter values. Further, while the models used excluded the labour supply-production interactions which have traditionally been the main focus of the analysis of farm household behaviour, the incorporation of such effects seems likely to increase the potential for the non-standard production responses illustrated. Clearly, the simultaneous modelling of labour supply, investment and savings in the farm household is one possible area for future development.

In terms of agricultural policy the importance of the differences in production responses depends on the number (and size) of the farm households which are borrowing constrained. Nevertheless, given the evidence that, at least for French farms, these type of constraints affect a significant number of farms, the simulation results provide one reason why the overall impact of the MacSharry reforms on French cereal production may be less than that predicted by models based on profit maximizing farmers. The exact quantitative effect of these constraints at the aggregate level is, however, a question for future research.

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APPENDIX

Functional Forms

The exact forms of the various functions are as follows:

(1) Gross value added, adjustment cost function

$$F(K_t, A_t, \bar{L}_t, t) = exp\,(\lambda_t) b_0 \left[b_1 \left(\frac{A_t}{\bar{L}_t} \right)^{\theta} + (1 - b_1) \left(\frac{K_t}{\bar{L}_t} \right)^{\theta} \right]^{\frac{\sigma}{\theta}} \bar{L}_t \qquad (19)$$

$$h(IA_t) = pa_t\, IA_t + \Phi IA_t^2 \qquad (20)$$

(2) Sub-utility function, bequest function

$$U\left(\frac{C_t}{N_t}\right) = \frac{1}{1 - 1/\eta} \left(\frac{C_t}{N_t}\right)^{1-\frac{1}{\eta}}, \; Q(B) = \frac{\Gamma}{1 - 1/\eta} B^{1-\frac{1}{\eta}} \qquad (21)$$

Calibrated values: production

The initial year of the recursive model replicates the average values for specialized French cereal farms (40 to 100 economic size units) given in Table 3.

Table 3. Base year production values

Quantity	Initial Value
Capital	588,465 Francs (1990 prices)
Land	99.3 ha
Net value added	229,209 Francs (1990 prices)
Total labour	135 annual work units (UTA)

Source: SCEES (1992)

The model was calibrated to these values as follows. Firstly, for fixed land and labour input, it is possible to derive, from the standard profit maximising first order conditions, relationships between the short run output price elasticity e_{py} and (1) the elasticity of capital with respect to output price e_{pk}, and (2) the parameter b_1, *i.e.*

$$1 + \left(1 - \frac{\theta}{\sigma}\right) e_{py} + (\theta - 1)\, e_{pk} = 0 \qquad (22)$$

$$(1 - b_1) = \frac{(1-\theta)e_{py}}{1 + (1 - \theta/\sigma)\, e_{py}} \frac{1}{\sigma} \left(\frac{Y_1}{\bar{L}_1}\right)^{\frac{\theta}{\sigma}} \left(\frac{K_1}{\bar{L}_1}\right)^{-\theta} \tag{23}$$

Given the fixed values of land and labour from Table 3, plus e_{py} from Dronne *et al.* (1991), the parameters σ and e_{pk} [(6)] were then adjusted in order to ensure that the initial values of capital and net value added were optimal given the land and labour values. As stated in the text the long run properties of the simulation model were controlled by the adjustment of the land investment cost parameter Φ and technical change parameters λ such that production increased at a rate of around 3 per cent a year (with yield increasing at around 2 per cent per a year), while the area farmed increased by around 30 per cent over the 30 year period. The following table summarizes the values of the production parameters used.

Table 4. Production parameters

Parameter	Value	Description
e_{py}	0.450	output elasticity with respect to output price
e_{pk}	1.200	capital elasticity with respect to output price
θ	-0.388	capital-land substitution
σ	0.810	returns to scale in capital and land
b_0	0.437	base production efficiency
b_1	0.357	land share
λ	0.012	rate of increase of production efficiency
Φ	25.0	cost of adjustment in land investment
α	0.417	share of current inputs in gross output

Calibrated values: consumption

Table 5 presents the values of the parameters used in the sub-utility and bequest functions derived from Phimister (1993).

Table 5. Consumption parameters

Parameter	Value	Description
η	0.8	elasticity of substitution in consumption
Γ	11	bequest weight
ρ	0.2	rate of time preference
N_t	2.6 t = 1,...,10 3.5 t = 11,...,18 4.25 t = 19,...,22 4 t = 23,...,30	number of equivalent adults (2 adults, 3 children)

(6) The starting value for this parameter 0.92 was also taken from this source