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**Modelling dynamic beef supply response using a microeconomic approach: an application to the French cattle sector**

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Abstract.

The European Union beef market regulation is largely influenced by the Common Agricultural Policy (CAP). With the 1992 CAP reform, there was a partial shift by the EU from product price support to a more direct form of income support by way of direct payments. For beef there was a move to direct payments on intermediate products which was essentially a direct payment for the possession of various categories of animals and these were linked to a land resource base. The Agenda 2000 reform consists in a further price decrease associated with an increase in direct payments.

This contribution focuses on the dynamics of beef supply response in the French beef sector. The objective of this paper is to provide a model of beef supply response within a dynamic microeconomic framework. The aim of this model is the understanding of cattleman decisions and to assess how the behaviour of beef producers is sensitive to changes in production prices and to changes in premiums. In particular, the paper studies how the beef supply response is modified when various exogenous variables like prices or policy instruments are changed.

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where  $FC_t = \lambda_F K_t$  and  $MC_t = \lambda_M K_t$  represent females and males calves, respectively.

Assume that there is no calf mortality. The simplification does not change the final results, since the mortality rate is very small and can be neglected in the maximisation of the profit function.

The following constraints summarise the stock-flow relations implied by above assumptions on cattle inventory management. The first constraint describes the evolution of the capital stock. Cows may be kept in the reproductive herd or sold for slaughter. The variation of the actual stock of suckling cows derives from the addition of newly bred heifers  $\delta_t$  (gross investment) and from the sale of cows for slaughter  $VK_t$  (disinvestment).

$$K_{t+1} - K_t = \delta_t - VK_t \quad (2)$$

The second equation depicts the evolution of the stock of heifers  $H_t$ . In each period, the initial stock of heifers and the age distribution of this stock are given from the producer's point of view. Hence, the optimal decision about heifers concerns sale of heifers for slaughter, or selection of heifers for the stock of capital (reproductive herd) and breeding heifers. Breeding increases the stock of cows, since once bred, heifers are cows by definition. Thus, the variation of the actual stock of heifers derives from the addition of newly female calves  $FC_t$ , which have reached the age of twelve months, from the selection of heifers to reproductive purpose  $\delta_t$ , and from the sale of heifers for slaughter  $VH_t$ .

$$H_{t+1} - H_t = FC_t - \delta_t - VH_t \quad (3)$$

Similar decisions must be taken with respect to the stock of male animals. However, the decision concerning male cattle clearly does not affect future production of calves.

For male cattle, the cattleman has only two possibilities: sale for slaughter or placement on feed to be sold in the future. Thus, the variation of the actual stock of old male cattle derives from the addition in the stock of male calves  $\eta_t$ , which have reached the age of twelve months, and from the sale of some of them for slaughter  $VB_t$ .

$$B_{t+1} - B_t = \eta_t - VB_t \quad (4)$$

The cattleman can sale male calf now for slaughter or it can enter the male cattle herd. Thus, the allocation of the production of male calves ( $MC_t$ ) derives from the selection of young male cattle for the replacement of the male cattle herd  $\eta_t$ , and from the sale of some of them for slaughter  $VMC_t$ .

$$MC_t = \eta_t + VMC_t \quad (5)$$

## 2.2. Modelling representative cattleman behaviour

The cattleman is assumed to maximise profits, not only for this period, but over his entire production horizon. Thus, the producer tries to maximise the expected net present value of his enterprise.

First, a profit function is constructed using years as the unit observation period. This profit function is quadratic in its arguments, a fact that guarantees a unique maximum and that satisfies the condition for the existence of

certainty equivalents. The function is maximised by dynamic programming methods to obtain the relevant behavioural relations, which determine the econometric specification.

The cattleman's revenue comes from selling animals for slaughter, at any point in time, the premiums granted according to the number of animals<sup>1</sup>, while his costs consists of various production and investment costs (maintenance and ageing costs of the cattle stock kept on farm, cost of breeding/producing calves, feeding costs). Assume that the cattleman maximises his profits not only for this period, but for the whole period for which he is in business. Assume further that we know that the cattleman will be in business  $T$  periods and then retire. In each period, he must make decisions based on actual facts and on facts that he does not yet know for the future periods.

The features of cattle herd management described above translate into the different choice options for each decision variable. Male are animals that, from the decision-making point of view, can either be sold now or in the future. Heifers can also be sold now, or can be bred and thereby be transformed into cows (added to the capital stock), and in turn used to produce new calves. The reproductive capacity of heifers makes them different, and this difference is expressed in the profit function.

Keeping an animal one more period entails a cost and yields the benefit of being able to sell it in the future. If the cattleman acts rationally, he will decide how many cattle to keep in such a way as to equate marginal expected cost and marginal expected benefit, both discounted to the present period. Given constant unit costs, the function to be maximised by the cattleman may be approximated by the following quadratic expression:

$$\begin{aligned}
& \pi(VK_t, VH_t, \delta_t, VMC_t, VB_t, \eta_t / K_t, H_t, B_t, t) \\
& = \text{Max}(p_{Kt}VK_t + p_{Ht}VH_t + p_{Mt}VMC_t + p_{Bt}VB_t \\
& + s_{Kt}K_t + s_{Mt}\eta_t + s_{Bt}\eta_{t-1} \\
& - \frac{1}{2}b_1(K_t - VK_t + \delta_t)^2 - \frac{1}{2}b_2(K_t - VK_t)^2 \\
& - \frac{1}{2}b_3(C_t)^2 \\
& - \frac{1}{2}b_4(H_t - VH_t - \delta_t + FC_t)^2 - \frac{1}{2}b_5(H_t - VH_t - \delta_t)^2 \\
& - \frac{1}{2}b_6(B_t - VB_t + \eta_t)^2 - \frac{1}{2}b_7(B_t - VB_t)^2 \\
& + rE_t\{\pi(VK_{t+1}, VH_{t+1}, \delta_{t+1}, VMC_{t+1}, VB_{t+1}, \eta_{t+1} / K_{t+1}, H_{t+1}, B_{t+1}, t+1)\})
\end{aligned} \tag{6}$$

subject to the constraints (1) to (5).

Where the subscript  $t$  refers to the current period, and where  $\pi(VK_t, VH_t, \delta_t, VMC_t, VB_t, \eta_t / K_t, H_t, B_t, t)$  is the expected present value of profits. The slaughter prices are  $p_{Kt}$  for suckling cows,  $p_{Ht}$  for heifers,  $p_{Mt}$  for male calves,  $p_{Bt}$  for male cattle and the headage premiums are respectively for the suckler cows  $s_{Kt}$ , and for the male cattle  $s_{Mt}$ , and  $s_{Bt}$ .

The terms of  $\pi$  may be interpreted as follows:

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<sup>1</sup> See the annex 1 for more details on the premiums granted under the Common Agricultural Policy.

♦  $p_{K_t}VK_t + p_{H_t}VH_t + p_{M_t}VMC_t + p_{B_t}VB_t$  is the total revenue from selling various cattle categories: suckler cows, heifers, male calves, male cattle.

♦  $s_{K_t}K_t + s_{M_t}\eta_t + s_{B_t}\eta_{t-1}$  is the revenue from premiums. The former premium is granted per cows each year while the latter is granted only twice in the male cattle life. In our model, we assume that a male calf which enter in the cattle herd is grown until the age of two years and that the special beef premium is obtained when a male enters in the cattle herd at the age of twelve month and when he reaches the age of two years, i.e., after one year in the cattle herd<sup>2</sup>.

♦  $-\frac{1}{2}b_1(K_t - VK_t + \delta_t)^2$  is the maintenance cost of the capital stock.

♦  $-\frac{1}{2}b_4(H_t - VH_t - \delta_t + FC_t)^2$  and  $-\frac{1}{2}b_6(B_t - VB_t + \eta_t)^2$  is the feeding cost of respectively, heifers and male cattle. Feeding costs for heifers are assumed to differ from those for male cattle for the following reasons: first, if heifers are kept in part for possible future breeding, there is no need to feed them as much as male cattle; second, the capacity of heifers for transforming feed into weight is less than the capacity of male cattle.

♦  $-\frac{1}{2}b_3(C_t)^2$  is the production and maintenance cost of calves.

♦  $-\frac{1}{2}b_2(K_t - VK_t)^2$ ,  $-\frac{1}{2}b_5(H_t - VH_t - \delta_t)^2$  and  $-\frac{1}{2}b_7(B_t - VB_t)^2$  is the cost of holding respectively the capital stock, the heifers and the male cattle due to ageing. The ageing costs are also assumed to be different for cows, heifers, and male cattle. It is the additional cost involved in keeping the animal one more period, resulting from the need for more feed and the higher probability of death, etc., as the animal becomes older. The principal element of the aging cost, however, is the loss in value at sale. Animals sold for slaughter are classified by weight, sex, and age. Older animals are generally worth less, *ceteris paribus*. The productivity and the expected benefits and costs differ according to age.

♦  $r$  is the one period discount rate,

♦  $E$  is the expectation operator,

♦ and  $\pi(VK_{t+1}, VH_{t+1}, \delta_{t+1}, VMC_{t+1}, VB_{t+1}, \eta_{t+1} / K_{t+1}, H_{t+1}, B_{t+1}, t+1)$  the profit function for the next period  $t+1$ .

The main notations used in the framework are summarised in the table 1.

(Insert Table 1)

### 3. Empirical Implementation: the maximising solution

The method used is dynamic programming, which is a recursive maximisation procedure starting from the last period  $T$ , i.e., the period after which the cattleman will retire. In the usual fashion, having obtained the solution

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<sup>2</sup> In fact, during the studying period, the special premium was obtained between 10 and 22 months and after 23 months.

for this period, we then solve for the next to last period; and so on, as many times as necessary for determination of the general solution until period  $t$ , for any  $t$  (Howard, 1966, 317-320).

The model represented by equations (2) and (3) is equivalent to maximising

$$\begin{aligned} \pi(VK_t, VH_t, \delta_t, VMC_t, VB_t, \eta_t / K_t, H_t, B_t, t) \\ = \sum r^{T-t} [\pi_t - \beta_{1,t}(K_t - K_{t-1} + VK_{t-1} - \delta_{t-1}) \\ - \beta_{2,t}(H_t - H_{t-1} + VH_{t-1} + \delta_{t-1} - FC_{t-1}) \\ - \beta_{3,t}(B_t - B_{t-1} + VB_{t-1} - \eta_{t-1})] \end{aligned} \quad (7)$$

where the Lagrange multipliers  $\beta_{1,t}$ ,  $\beta_{2,t}$  and  $\beta_{3,t}$  are the shadow prices of an animal in stock for cows, heifers and male cattle. Expression (7) is maximised with respect to  $VK_t$ ,  $VH_t$ ,  $\delta_t$ ,  $VMC_t$ ,  $VB_t$  and  $\eta_t$ . The first-order conditions with respect to  $VK_t$ ,  $VH_t$ ,  $\delta_t$ ,  $VMC_t$ ,  $VB_t$  and  $\eta_t$  are as follows:

$$\frac{\partial \pi}{\partial VK_t} = p_{Kt} + b_1(K_t - VK_t + \delta_t) + b_2(K_t - VK_t) - r\beta_{1,t+1} = 0$$

$$\frac{\partial \pi}{\partial VH_t} = p_{Ht} + b_4(H_t - VH_t - \delta_t + FC_t) + b_5(H_t - VH_t - \delta_t) - r\beta_{2,t+1} = 0$$

$$\frac{\partial \pi}{\partial VB_t} = p_{Bt} + b_6(B_t - VB_t + \eta_t) + b_7(B_t - VB_t) - r\beta_{3,t+1} = 0$$

$$\frac{\partial \pi}{\partial \delta_t} = -b_1(K_t - VK_t + \delta_t) + b_4(H_t - VH_t - \delta_t + FC_t) + b_5(H_t - VH_t - \delta_t) + r\beta_{1,t+1} - r\beta_{2,t+1} = 0$$

$$\frac{\partial \pi}{\partial \eta_t} = -p_{Mt} + s_{Mt} + rs_{Bt+1} - b_6(B_t - VB_t + \eta_t) + r\beta_{3,t+1} = 0$$

Solving for  $VK_t$ ,  $VH_t$ ,  $VMC_t$ ,  $VB_t$ ,  $\delta_t$  and  $\eta_t$  we find<sup>3</sup>:

$$VK_t = K_t + \frac{1}{b_2} p_{Kt} - \frac{1}{b_2} p_{Ht} \quad (8)$$

$$VH_t = H_t - \delta_t + \frac{1}{b_4 + b_5} p_{Ht} - \frac{r}{b_4 + b_5} \beta_{2,t+1} + \frac{b_4}{b_4 + b_5} FC_t \quad (9)$$

$$VB_t = B_t + \frac{1}{b_7} p_{Bt} - \frac{1}{b_7} p_{Mt} + \frac{1}{b_7} s_{Mt} + \frac{1}{b_7} s_{Bt+1} \quad (10)$$

$$\delta_t = \frac{1}{b_2} p_{Kt} - \left(\frac{1}{b_1} + \frac{1}{b_2}\right) p_{Ht} + \frac{r}{b_1} \beta_{1,t+1} \quad (11)$$

$$\eta_t = \frac{1}{b_7} p_{Bt} - \left(\frac{1}{b_6} + \frac{1}{b_7}\right) p_{Mt} + \frac{r}{b_6} \beta_{3,t+1} + \left(\frac{1}{b_6} + \frac{1}{b_7}\right) s_{Mt} + \left(\frac{1}{b_6} + \frac{1}{b_7}\right) s_{Bt+1} \quad (12)$$

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<sup>3</sup> Details of calculations are available from the authors.

$$VMC_t = MC_t - \frac{1}{b_7} p_{Bt} - \left(\frac{1}{b_6} + \frac{1}{b_7}\right) p_{Mt} + \frac{r}{b_6} \beta_{3,t+1} + \left(\frac{1}{b_6} + \frac{1}{b_7}\right) s_{Mt} + \left(\frac{1}{b_6} + \frac{1}{b_7}\right) s_{Bt+1} \quad (13)$$

Substituting these equations into the three constraints controlling the evolution of the stock variables,  $K_t$ ,  $H_t$ , and  $B_t$  are given by:

$$K_t = -\frac{1}{b_1} p_{Ht-1} + \frac{r}{b_1} \beta_{1,t} \quad (14)$$

$$H_t = -\frac{1}{b_4 + b_5} p_{Ht-1} + \frac{r}{b_4 + b_5} \beta_{2,t} + \frac{b_5}{b_4 + b_5} FC_{t-1} \quad (15)$$

$$B_t = -\frac{1}{b_6} p_{Mt-1} + \frac{r}{b_6} \beta_{3,t} + \frac{1}{b_6} s_{Mt-1} + \frac{r}{b_6} s_{Bt} \quad (16)$$

The first-order conditions for the stock variables  $K_t$ ,  $H_t$  and  $B_t$  are:

$$\begin{aligned} \frac{\partial \pi}{\partial K_t} &= p_{Mt} \lambda_M + s_{Kt} - b_1(K_t - VK_t + \delta_t) - b_2(K_t - VK_t) - b_3 \lambda^2 K_t - b_4 \lambda_F (H_t - VH_t - \delta_t + \lambda_F K_t) \\ &\quad - \beta_{1,t} + r \beta_{1,t+1} + r \lambda_F \beta_{2,t+1} = 0 \end{aligned}$$

since  $C_t = \lambda K_t$ ,  $MC_t = \lambda_M K_t = VMC_t - \eta_t$  and  $FC_t = \lambda_F K_t$

$$\frac{\partial \pi}{\partial H_t} = -b_4(H_t - VH_t - \delta_t + FC_t) - b_5(H_t - VH_t - \delta_t) - \beta_{2,t} + r \beta_{2,t+1} = 0$$

$$\frac{\partial \pi}{\partial B_t} = -b_6(B_t - VB_t + \eta_t) - b_7(B_t - VB_t) - \beta_{3,t} + r \beta_{3,t+1} = 0$$

Thus, the shadow prices are given by:

$$\beta_{1,t} = \gamma_1(s_{Kt} + p_{Kt}) + \gamma_2 p_{Ht-1} + \gamma_3 p_{Ht} + \gamma_4 p_{Ht+1} + \gamma_5 p_{Mt}$$

$$\beta_{2,t} = p_{Ht}$$

$$\beta_{3,t} = p_{Bt}$$

$$\text{where } \gamma_0 = b_3 \lambda^2 + \frac{b_4 b_5}{b_4 + b_5} \lambda_F^2, \quad \gamma = 1 + \frac{r}{b_1} \gamma_0, \quad \gamma_1 = \frac{1}{\gamma}, \quad \gamma_2 = \frac{\gamma_0}{\gamma b_1}, \quad \gamma_3 = \frac{b_4 \lambda_F}{\gamma(b_4 + b_5)}, \quad \gamma_4 = \frac{r b_5 \lambda_F}{\gamma(b_4 + b_5)} \quad \text{and}$$

$$\gamma_5 = \frac{\lambda_M}{\gamma}$$

At the optimum, the Lagrange multipliers associated with the stock-flow constraints for heifers and male cattle are equal to the corresponding slaughter prices. The expression of the shadow price for cows is more complicated, owing to the reproductive capacity of these animals: the shadow price of cows is a linear combination of their slaughter value  $p_{Kt}$  and their capital value in production, which in turn depends on expected future prices of heifers.

The first conditions derives above can be solved for each endogenous variable in terms of past, current and future price levels, and lagged values of the capital stock. Following Nerlove and Fornari (1998), we obtain the

*Expectationally Conditional Reduced Form (ECRF)* of the dynamic maximisation model, that expresses endogenous variables in terms of exogenous and predetermined ones, conditional on expectations of future levels of exogenous variables.

Omitting the expectations operator for simplicity, the ECRF for the optimal decision variables ( $VK_t$ ,  $VH_t$ ,  $\delta_t$ ,  $VMC_t$ ,  $VB_t$ ,  $\eta_t$ ) and for the stock variables ( $K_t$ ,  $H_t$ ,  $B_t$ ) are the equations:

$$K_t = \frac{r\gamma_1}{b_1}(p_{Kt} + s_{Kt}) + (-\frac{1}{b_1} + \frac{r\gamma_2}{b_1})p_{Ht-1} + \frac{r\gamma_3}{b_1}p_{Ht} + \frac{r\gamma_4}{b_1}p_{Ht+1} + \frac{r\gamma_5}{b_1}p_{Mt} \quad (17)$$

$$VK_t = \frac{r\gamma_1}{b_1}s_{Kt} + (\frac{r\gamma_1}{b_1} + \frac{1}{b_2})p_{Kt} + (\frac{r\gamma_2}{b_1} - \frac{1}{b_1})p_{Ht-1} + (\frac{r\gamma_3}{b_1} - \frac{1}{b_2})p_{Ht} + \frac{r\gamma_4}{b_1}p_{Ht+1} + \frac{r\gamma_5}{b_1}p_{Mt} \quad (18)$$

$$H_t = \frac{b_5}{b_1(b_4 + b_5)}(r\gamma_2 - 1)p_{Ht-2} + \frac{1}{b_4 + b_5}(\frac{b_5r\lambda_F\gamma_3}{b_1} - 1)p_{Ht-1} + \frac{r}{b_4 + b_5}(1 + \frac{b_5r\lambda_F\gamma_4}{b_1})p_{Ht} + \frac{b_5\lambda_Fr\gamma_1}{b_1(b_4 + b_5)}(p_{Kt-1} + s_{Kt-1}) + \frac{b_5\lambda_Fr\gamma_5}{b_1(b_4 + b_5)}p_{Mt-1} \quad (19)$$

$$VH_t = \frac{b_5\lambda_F}{b_1(b_4 + b_5)}(r\gamma_2 - 1)p_{Ht-2} + \frac{1}{b_4 + b_5}[\frac{b_5\lambda_Fr\gamma_3}{b_1} - 1 + \frac{b_4\lambda_F}{b_1}(r\gamma_2 - 1)]p_{Ht-1} + [\frac{r}{b_4 + b_5}(1 + \frac{b_5\lambda_F\gamma_4}{b_1}) + \frac{1}{b_1} + \frac{1}{b_2} - \frac{r\gamma_2}{b_1} + \frac{1}{b_4 + b_5}(1 + \frac{b_4\lambda_Fr\gamma_4}{b_1})]p_{Ht} + (\frac{b_4\lambda_Fr\gamma_4}{b_1(b_4 + b_5)} - \frac{r}{b_4 + b_5} - \frac{r\gamma_3}{b_1})p_{Ht+1} - \frac{r\gamma_4}{b_1}p_{Ht+2} + \frac{rb_5\lambda_F\gamma_1}{b_1(b_4 + b_5)}(p_{Kt-1} + s_{Kt-1}) + [-\frac{1}{b_2} + \frac{b_4\lambda_Fr\gamma_1}{b_1(b_4 + b_5)}]p_{Kt} - \frac{b_4\lambda_Fr\gamma_1}{b_1(b_4 + b_5)}s_{Kt} - \frac{r\gamma_1}{b_1}(p_{Kt+1} + s_{Kt+1}) - \frac{rb_5\lambda_F\gamma_5}{b_1(b_4 + b_5)}p_{Mt-1} + \frac{rb_4\lambda_F\gamma_5}{b_1(b_4 + b_5)}p_{Mt} - \frac{r\gamma_5}{b_1}p_{Mt+1} \quad (20)$$

$$\delta_t = \frac{1}{b_2}p_{Kt} + \frac{r\gamma_1}{b_1}(p_{Kt+1} + s_{Kt+1}) + [-\frac{1}{b_1} + \frac{1}{b_2} + \frac{r\gamma_2}{b_1}]p_{Ht} + \frac{r\gamma_3}{b_1}p_{Ht+1} + \frac{r\gamma_4}{b_1}p_{Ht+2} + \frac{r\gamma_5}{b_1}p_{Mt+1} \quad (21)$$

$$B_t = -\frac{1}{b_6}p_{Mt-1} + \frac{r}{b_6}p_{Bt} + \frac{1}{b_6}(s_{Mt-1} + rs_{Bt}) \quad (22)$$

$$VB_t = (\frac{r}{b_6} + \frac{1}{b_7})p_{Bt} - \frac{1}{b_6}p_{Mt-1} - \frac{1}{b_7}p_{Mt} + \frac{1}{b_6}s_{Mt-1} + \frac{1}{b_7}s_{Mt} + \frac{r}{b_6}s_{Bt} + \frac{r}{b_7}s_{Bt+1} \quad (23)$$

$$\eta_t = \frac{1}{b_7}p_{Bt} - (\frac{1}{b_6} + \frac{1}{b_7})p_{Mt} + \frac{r}{b_6}p_{Bt+1} + (\frac{1}{b_6} + \frac{1}{b_7})(s_{Mt} + rs_{Bt+1}) \quad (24)$$

$$VMC_t = (\frac{r\lambda_M\gamma_5}{b_1} + \frac{1}{b_6} + \frac{1}{b_7})p_{Mt} - \frac{1}{b_7}p_{Bt} - \frac{r}{b_6}p_{Bt+1} - (\frac{1}{b_6} + \frac{1}{b_7})(s_{Mt} + rs_{Bt+1}) + \frac{r\lambda_M\gamma_1}{b_1}(p_{Kt} + s_{Kt}) + \frac{\lambda_M}{b_1}(r\gamma_2 - 1)p_{Ht-1} + \frac{r\lambda_M\gamma_3}{b_1}p_{Ht} + \frac{r\lambda_M\gamma_4}{b_1}p_{Ht+1} \quad (25)$$

The expected effects of the exogenous variables (observed and anticipated prices, levels of current and anticipated premiums) on the endogenous variables (numbers of animals and levels of slaughtering) derived from the model are summarised in Tables 2.

(Insert Table 2a)

(Insert Table 2b)

(Insert Table 2c)

The only unambiguous effect concerns the impact of headage premiums. The suckler cow premiums should have always a positive effect on the sales and the number of animals. The effect of anticipated prices cannot be predicted in general, while the impact of observed prices is in general indeterminate, depending on the value of the estimated shadow costs.

#### 4. Econometric analysis

In the following section we describe the econometric estimation techniques, the data used in the econometric analysis, and lastly discuss the results from the estimation.

##### *Price and premium expectation formulation*

For each anticipated price, we use the following formulation

$$p^*_{t+1} = \alpha_1 p_{t-2} + \alpha_2 p_{t-1} + \alpha_3 p_t$$

where  $p^*_{t+1}$  is the anticipated price that each producer makes in  $t$  for the following time period  $t+1$ ,  $p_{t-i}$  is the current price in  $t-i$ , and  $\alpha_1, \alpha_2, \alpha_3$  are the coefficients to be estimated.

For each anticipated premium, we use naive expectations since each producer knows the value of premiums for each year:

$$s^*_{t+1} = s_t$$

##### *The data*

The data for France are drawn from the national Farm Business Survey for the 1995-1997 years. These is annual national survey collected by agencies of the government. The sample of farms are chosen so as to be representative of national agriculture in the country. In general, each survey farm remains in the survey for 5 or 6 years. Hence, a balanced panel of 343 farms can be constructed for the period.

##### *The results for suckler cows*

Equations (17) to (25) have been estimated by OLS. Although the ECRF expressions determine the optimal supply functions and gross investment behaviour of the producer, in terms of his anticipations of future price levels and predetermined variables, their evident complexity and the presence of many cross- and within



equations restrictions present formidable obstacles to empirical investigation. The large number of leads and lags in the price and stock variables, the appearance of the same parameters in different equations, the large number and non-linear nature of cross-equation restrictions on parameters, create difficulties in direct estimation. Hence, in a first step we estimate the unrestricted model.

(insert Table 3)

For the number of the cow, all the coefficients in the regression which are statically significant have the predicted sign. We can note the negative effect of the price of heifers showing the substitution between cows and heifers. The suckler cow premium has an important positive effect. For the equation explaining the sales of cows as expected from the model, the price of the cows and the suckler cow premium have a positive and significant effect.

The last table provides a comparison between the effect of a decrease in the current price level and an increase in the current premium for the suckler cows.

Tableau 4. Elasticities of suckler cow variables relative to slaughter price and premium.

Variables	Slaughter price for cows	Suckler cow premium
Number of cows	-0,00026	0,959
Sales of cows	0,313	1,007
Heifers added to the herd	0,029	0,925

Elasticities are evaluated for the average point of the sample

For each variable, there exists a positive effect of the premium which is larger than the effect of slaughter price.

## 5. Concluding remarks

This paper has provided a dynamic optimisation model to describe the behaviour of a representative cattleman maximising his expected profits over an infinite time horizon. It allows us to derive a reduced form which defines each endogenous variables (sales of different animal categories and investment in the herd) by current, past and future exogenous variables as slaughter prices or headage premiums. The model is estimated on a balanced panel data set of 353 farms for the French cattle sector for the period 1995-1997.

Results from the estimation show a positive effect of the premium which is larger than the effect of slaughter price concerning the choices of the number of cows maintained in the herd and the sales of cows during the current period.

The disaggregation by animal categories is helpful in assessing supply response to changes in market conditions or in agricultural policy. This work can be extended in two directions. Firstly, the various equations of the reduced form can be estimated simultaneously. Secondly, it is possible to simulate different reforms of the Common Agricultural Policy.

## References

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Table 1. Notations and definitions

<b>Number of animals (stock variables)</b>	
$K_t$	Reproductive herd at the beginning of the period t
$H_t$	Stock of heifers at the beginning of the period t
$B_t$	Male cattle at the beginning of the period
$C_t$	Total calves born at period t
$FC_t$	Females calves born at period t
$MC_t$	Males calves born at period t
<b>Slaughter variables (disinvestment)</b>	
$VK_t$	Sales of cows for slaughter
$VH_t$	ales Heifers for slaughter
$VB_t$	Sales of male cattle for slaughter
$VMC_t$	Males calves sales for slaughter
<b>Investment</b>	
$\eta_t$	Selection of young male cattle for replacement of the male
$\delta_t$	Heifers added to the reproductive herd
<b>Slaughtering prices</b>	
$p_{Kt}$	Slaughter cows price
$p_{Ht}$	Slaughter heifers price
$p_{Mt}$	Slaughter males calves price
$p_{Bt}$	Slaughter males calves price
<b>Premiums</b>	
$s_{Kt}$	Suckler cow premium
$s_{Mt}$	First special beef premium
$s_{Bt}$	Second special beef premium

Table 2a. Expected effects of observed past and current prices

Slaughter prices	Calves		Heifers		Cows		Male cattle
	$P_{Mt-1}$	$P_{Mt}$	$P_{Ht-1}$	$P_{Ht}$	$P_{Kt-1}$	$P_{Kt}$	$P_{Bt}$
Reproductive herd $K_t$	ni	-	?	?	ni	+	ni
Stock of heifers $H_t$	ni	-	?	+	ni	+	ni
Male cattle $B_t$	-	ni	ni	ni	ni	+	+
Cows sales $VK_t$	ni	-	?	?	ni	+	ni
Sales of heifers $VH_t$	+	+	?	?	+	?	ni
Sales of male cattle $VB_t$	-	-	ni	ni	ni	ni	+
Sales of males calves $VMC_t$	ni	+	?	+	ni	+	-
Selection of young male cattle $\eta_t$	ni	-	ni	ni	ni	ni	+
Heifers added to the reproductive herd $\delta_t$	ni	ni	ni	?	ni	+	ni

ni means that the variable is not included in the specification. The lagged beef price does not appear in any equation.

Table 2b. Expected effects of the anticipated variables

Slaughter prices	Calves	Heifers		Cows	Male cattle	Premiums	
	$P_{Mt+1}$	$P_{Ht+1}$	$P_{Ht+2}$	$P_{Kt+1}$	$P_{Bt+1}$	$S_{Kt+1}$	$S_{Bt+1}$
Reproductive herd $K_t$	ni	+	ni	ni	ni	ni	ni
Sales of cows $VK_t$	ni	+	ni	ni	ni		
Sales of heifers $VH_t$	-	?	-	-	ni	-	ni
Sales of male cattle $VB_t$	ni	ni	ni	ni	ni	ni	+
Sales of males calves $VMC_t$	ni	+	ni	ni	-	ni	-
Selection of young male cattle $\eta_t$	ni	ni	ni	ni	+	ni	+
Heifers added to the reproductive herd $\delta_t$	+	+	+	+	ni	+	ni

For the stock of heifers ( $H_t$ ) and the number of male cattle ( $B_t$ ), there are no anticipated variables in the equations.

Table 2c. Expected effects of the premiums

Premiums	Suckler cows		Male cattle (first)		Male cattle (second)
	$S_{Kt-1}$	$S_{Kt}$	$S_{Mt-1}$	$S_{Mt}$	$S_{Bt}$
Reproductive herd $K_t$	ni	+	ni	ni	ni
Stock of heifers $H_t$	+	ni	ni	ni	ni
Male cattle $B_t$	ni	ni	+	ni	+
Sales of cows $VK_t$	ni	+	ni	ni	ni
Sales of heifers $VH_t$	+	+	ni	ni	ni
Sales of male cattle $VB_t$	ni	ni	+	+	+
Sales of males calves $VMC_t$	+	ni	ni	-	ni
Selection of young male cattle $\eta_t$	ni	ni	ni	+	ni

For the heifers added to the reproductive herd ( $\delta_t$ ), there are only an effects of the expected Suckler cow premium.

Table 3. Estimates for the number of cows, the sales of cow sand the number of heifers added to the herd

	Dependent variables		
	Number of cows $K_t$	Cows sales $VK_t$	Heifers added to the herd
Intercept	5.141 (2.54)	-3.518 (1.63)	-4.037 (-2.11)
$p_{Kt}$	$0.238*10^{-3}$ (-0.10)	$0.550*10^{-3}$ (2.55)	$0.543*10^{-4}$ (0.19)
$p_{Kt-1}$	—	—	$0.594*10^{-3}$ (2.06)
$p_{Kt-2}$	—	—	$0.221*10^{-3}$ (0.81)
$p_{Ht}$	$-0.346*10^{-4}$ (-1.86)	$-0.137*10^{-4}$ (-0.09)	$-0.103*10^{-3}$ (0.66)
$p_{Ht-1}$	$-0.176*10^{-4}$ (-0.09)	$0.715*10^{-4}$ (0.47)	$0.112*10^{-3}$ (0.71)
$p_{Ht-2}$	$0.224*10^{-4}$ (-1.86)	$0.307*10^{-3}$ (1.99)	$0.186*10^{-2}$ (1.18)
$p_{Mt}$	$-0.647*10^{-3}$ (-2.06)	$-0.442*10^{-3}$ (-1.75)	$0.181*10^{-4}$ (0.05)
$p_{Mt-1}$	—	—	$0.186*10^{-2}$ (1.18)
$p_{Mt-2}$	—	—	$-0.750*10^{-4}$ (0.25)
$s_{Kt}$	$0.760*10^{-3}$ (44.87)	$0.152*10^{-3}$ (11.16)	$0.145*10^{-3}$ (10.23)
$R^2$	0.87	0.36	0.34
DW	1.83	1.89	1.96

The t ratios are reported in brackets under the coefficients.

## **Annex 1 Definition and Construction of Variables**

The model used requires a desegregation of the livestock into four categories of animals: calves, heifers, cows and the number of male cattle. In the data set, we have available information for each category of animals on the stock of animals on the farm at the beginning of the period.

Furthermore we have information on levels slaughtering for each category of animals measured in value and in number of animals. Hence we can calculate the slaughter price.

For the premiums, we have available information on the total of amount of premiums for each category of animals. Under the Common Agricultural Policy, the premiums are granted accordingly to the number of animals (each year for suckler cows, once or twice in the life for male bovine animals), but they are submitted to a maximum of heads on each holding (for male premium) and a maximum stocking density, that is, live units per hectare (for both male and suckler premiums). From a technical point of view, a special beef premium is granted twice in the cattle life within ceilings set at regional level on up to 90 male animals per age bracket, per calendar year and per holding. The first special premium is obtained when male cattle age is between 10 and 22 months and the second one after 23 months. For holding suckler cows, a premium is granted each year. This entitlement is restricted by an individual ceiling set by reference to a base year (1992 in France). Eligibility of animals for the special premium or for the suckler cow premium is limited by the application of a density factor of (for 1997) 2.0 livestock units (LU) per hectare of forage for the animals which a premium application has been made. An additional extensification premium is payable per head of eligible suckler cows and male cattle if the stocking density is less than 1.4 or 1.0 LU/ha.

By using the total amount of premiums in the estimations, we take into account the ceilings

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INTERNATIONAL TRADE IN LIVESTOCK PRODUCTS  
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# AGENDA

Thursday, 18 January 2001

## SESSION ONE - THE LIVESTOCK REVOLUTION

8.15 - 10.15 am

Chair and Discussion Opener: Walter Armbruster, Farm Foundation

- Delgado, C. M Rosegrant, and S Meijer, IFPRI, USA, "Livestock to 2020: The Revolution Continues".
- Liapis, P.S., OECD, Paris, "Medium Term Projections and Selected Issues for Meat Markets".
- Narrod, C. USDA, and C. Pray, Rutgers University, USA, "Technology, Policies, and the Role of the Private Sector in the Global Poultry Revolution".

## SESSION TWO - LIVESTOCK TRADE REFORM AND THE WTO

10.30 – 12.30 pm

Chair and Discussion Opener: Timothy Josling, Stanford University

- Andrews, N., ABARE, Australia, "Livestock Products Trade: Prospects for Liberalisation".
- Rae, A.N., Massey University, Palmerston North, NZ, "Trade in Livestock Products and the WTO Millenium Round: Projections to 2005 and Problems with TRQs".
- Buckingham, D.E., University of Ottawa, Canada, S. Tangermann, University of Goettingen, Germany, and P. Farnese, University of Saskatchewan, Canada, "Through the Looking Glass: An examination of governance issues in the WTO through the mirror of WTO institutions and jurisprudence affecting trade in livestock products".

## SESSION THREE - 3.1 CHINA: LIVESTOCK PRODUCTION

1.45 - 3.15 pm

Chair and Discussion Opener: Richard Wallace, NZ Ministry of Agriculture and Forestry

- Tuan, F.C., ERS/USDA, USA, and Peng Tingjun, CIAT/CAAS, "Structural Changes in China's Livestock and Feed Production: Trade Implications".
- Simpson, J.R. Ryukoku University, Kyoto, Japan, and Ou Li,



China Agricultural University, Beijing, China, "Long-Term Projections of China's Supply and Demand of Animal Feedstuffs."

- Gilbert, J., and T. Wahl, Washington State University, USA, "China's Accession to the WTO and Impacts on Livestock Trade and Production Patterns".

### 3.2 DEMAND ANALYSIS: A

Chair and Discussion Opener: Tony Zwart, Lincoln University

- Miljkovic, D., Missouri State University, USA, J. Marsh and G. Brester, Montana State University, USA, "Japanese Import Demand for US Beef and Pork: Effects on US Red Meat Exports and Livestock Prices."
- Washington, A.A. Southern University at Baton Rouge, Louisiana, USA, and R.L. Kilmer, University of Florida, Gainesville, Florida, USA, "The Derived Demand for Imported Cheese into Japan by Country".
- Umberger, W.J., D.M. Feuz, C.R. Calkins and K.M. Killinger, University of Nebraska-Lincoln, USA, "US Consumer Preference for Domestic Corn-fed versus International Grass-fed Beef".

### SESSION FOUR - DEMAND ANALYSIS: B

3.45 - 5.15 pm

Chair and Discussion Opener: Phillip Bishop, NZ Institute of Economic Research

- Lee, C. and G. Schluter, Economic Research Service, USDA, "Consolidation, Economies of Scale, and the Heckscher-Ohlin Theory of Trade – An Empirical Analysis of US Meat Processing Industry."
- Kim, R.B. University of Manitoba, USA, and M. Veeman, University of Alberta, Canada, "Korean Beef Import Preferences: Implications for Trade Patterns In the Twenty First Century."

**Friday, 19 January 2001**

### SESSION FIVE - DAIRY TRADE

8.30 - 10.00 am

Chair and Discussion Opener: Allan Rae, Massey University

- Dobson, W.D. University of Wisconsin-Madison, USA, "Policy and Management Lessons for Dairy Exporters and Investors in Foreign Dairy-Food Businesses – What did we learn in the Past Decade".
- Swinnen, J.F.M., L. Dries and H.R. Gow, Katholieke Universiteit Leuven, Belgium, "Dairy Markets, Policies, and Trade in Eastern Europe and the former Soviet Union".

- Mitchell, N., NZ Dairy Board, “New Challenges in International Dairy Trade”.

## SESSION SIX - 6.1 LIVESTOCK AND THE ENVIRONMENT

10.30 – 12.00 pm

Chair and Discussion Opener: Rod Forbes, NZ Ministry of Agriculture and Forestry

- Gray, R., University of Saskatchewan, Canada, D. Harper, Agriculture and Agri-food Canada, and T. Highmoore, University of Saskatchewan, Canada, “Greenhouse Gas Policies and the International Competitiveness of the Hog Industry”.
- Saunders, C., Lincoln University, NZ, A. Moxey, University of Newcastle Upon Tyne, UK and V. Roningen, Washington DC, USA, “Trade and the Environment. Linking a partial equilibrium trade model with production systems and their environmental consequences”.

The following speaker could not attend but the paper is available:

- Metcalfe, M.R. University of California, Berkeley, USA, “Environmental Regulation and Implications for Competitiveness in International Pork Trade”.

## 6.2 LIVESTOCK TRADE AND NAFTA

Chair and Discussion Opener: Lars Brink, Agricultural and Agri-Food Canada

- Furtan, H., R. Gray, University of Saskatchewan, Canada, and A. Schmitz, University of Florida, USA, “The RCALF Case: Upstream STE’s, Livestock Trade and US Trade Law”.
- Annand, M., University of Saskatchewan, Canada, “Regionalisation of Trade in Livestock and Livestock Products”.

## SESSION SEVEN - 7.1 A LIVESTOCK COCKTAIL

1.00 - 3.00 pm

Chair and Discussion Opener: Pam Cooper, Agriculture Canada

- Benjamin, C. and I. Piot-Lepetit, INRA-ESR, France, “Modelling dynamic beef supply response using a microeconomic approach: an application to the French cattle sector”.
- Sudaryanto, T., I.W. Rusastra, and T.D. Seodjana, Ministry of Agriculture, Indonesia; “The Impact of Economic Crisis on Livestock Industry in Indonesia”.
- Reed, M. and A. Iswariyadi, University of Kentucky, USA, “Competitive Forces in the Japanese Beef Market”.

## 7.2 ANIMAL HEALTH, BIOTECHNOLOGY AND TRADE

Chair and Discussion Opener: Robin Johnson, Wellington, NZ

- Josling, T. Stanford University, California, USA, D. Orden and D. Roberts, "Technical Barriers in the Global Poultry Market: A Search for 'Missing Trade'".
- Seitzinger, A.H. and K.N. Forde, USDA, Fort Colling, "Prioritisation of the Sanitary Issues Limiting Exports of US Live Animals and Germplasm".
- Haghiri, M. and P.W.B. Phillips, University of Saskatchewan, Canada, "Trade in the Market of Biotechnological Livestock Products and the Theory of the Intermediary Firms".

## SESSION EIGHT - SOME OPTIONS FOR LIVESTOCK TRADE REFORM

3.15 - 5.00 pm

Chair and Discussion Opener: Thomas Wahl, Washington State University

- Joerin, R., Swiss Federal Institute of Technology, Zurich, "The Impact of Tariff-Rate Quotas and Imperfect Competition on Market Access".
- Bredahl, M.E., University of Missouri, USA, and M.A. Normile, USDA/ERS, and "Trade Impacts of Voluntary Quality Standards for Livestock Products".
- Johnson, R., Wellington, NZ, J. Hillman, University of Arizona, Tucson, USA, and A. Petrey, Wellington, NZ, "Food Safety Issues, Protection and Trade (with respect to Animal Products)".

The following speakers could not attend but the paper is available:

- Meilke, K., University of Guelph, Canada, Hayes, D., Iowa State University, USA, Y. Surry, Economie Rurale, INRA, France, J. Fabiosa and F. Fuller, Iowa State University, USA, "Trade Liberalization in the International Pork Sector: Analysis of Zero-for-Zero Option.