An econometric analysis of the hog cycle in France in a simultaneaous cobweb framework and welfare implications

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An econometric analysis of the hog cycle
in France in a simultaneous cobweb framework
and welfare implications

Louis-Pascal MAHE [(1)]

- May 1976 -

Dissertation submitted for the Ph.D. degree at the University of Minnesota

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... "You know, these diagrams on which variations over time of prices, interest rates etc... are represented by upwards and downwards zig-zag lines. While I was analysing the crises, I tried several times to calculate these peaks and troughs by fitting irregular curves, and I believe that the essential laws of crises could be mathematically determined on the basis of such curves. I still think this is possible given sufficient data" ...

K. MARX
(letter to Engels 1873)

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I N T R O D U C T I O N

So much has been written about livestock cycle theory that it seems bold to try again bringing some new light on the subject. This was however the first intention of my dissertation. Two points appeared to me as deserving more attention. First no economic model of livestock supply has ever included a demographical part expressed by a dynamic complete model in the line of human populations. Since I had studied the properties of such a model I intented to analyse hog supply in these terms, by plugging in control variables related to supply behavior of hog producers. This turned out to be unfeasible for lack of detailed data on inventories of hogs on farm in France, which were necessary to set up the model in a demographic framework. The only data available over a long enough period of time, concern slaughtered hogs. I had therefore to give up this approach, which would have led also to some particular estimation problems.

The second point I wanted to study in a systematic manner, was the implications of the relationship between inventories and slaughtered hogs at each point in time, a relationship which comes up naturally when the demographic approach is used. Contrarily to my first impression I found out that this was not really a new idea. Some authors and particularly Fox [11] and Reutlinger [39], have already analysed some aspects of this problem in the context of a formalized model.

Given this situation, the contribution I hoped to make on a more general and moderately theoretical nature was very slim, and an alternative focus of my thesis was to analyse the pecularities of the hog cycle in France and to put the stress on the estimation of the underlying relationships, a work which had never been done in an econometric framework before in this country.

The final output of my research is half-way between these two objectives. In the first chapter I discuss the two well known theories of livestock cycles namely the cobweb and the harmonic motion model, along with the published formulation of the inventory-supply interaction. In chapter two, I attempt to clarify the relationships between the various types of supply specifications used in hog models, in particular between recursive and simultaneous specifications and between models explaining first inventories on farms and those explaining directly liveweight marketed by lagged price. This analysis throws some new light, I believe, on the economic interpretation of the parameters estimated and essentially the supply elasticity. The next step is to formulate explicitely the consequences of the inventory-supply interaction on the dynamics of the cobweb and the stability conditions. The third aspect of this addition to the cobweb theory is the analysis of its implications on estimation procedures, and an analytical discussion of the biases which may arise in both supply and demand when recursiveness is unproperly assumed.

Chapter three gives an account of the empirical results of estimation on the basis of French hog industry. Although a complete market model was estimated, including demand, margins, piglet market, and imports, emphasis has been put on the supply and the other equations have not received so much attention. Some particular features of the French hog industry and economic behavior are discussed in the light of these empirical results.

Chapter four deals with an attempt to analyse the welfare aspects of cyclical fluctuations. The approach is based on surpluses and follows the line of welfare analyses of random fluctuations of agricultural prices. An empirical illustration is presented on the basis of the estimated model of chapter three. It allows to give an order of magnitude of the efficiency loss due to the fluctuations along with the resulting distribution effects both in the short run and in the long run. This last chapter is one of the possible applications of the estimated model which makes use of the theoretical discussion of specification problems. Since the welfare analysis is carried in the cobweb framework, and since the concept of surplus used must be consistent with micro-economic foundations, it is necessary to discuss the nature of the supply we are dealing with before using it for welfare analysis.

*

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Chap. 1 - A SHORT REVIEW OF LIVESTOCK CYCLES THEORY

Basically two chemes have been proposed to explain livestock cycles : the cobweb and the harmonic motion. The cobweb theorem has received considerable attention from agricultural economists, both from a theoretical and an empirical point of view. Following Lorie [31], Larson [28] has recently argued that "The cobweb model seems to be so intriguing, and so persuasive, that it is uncritically accepted on meager grounds". Then he goes on "there is a basically different model, wich I have termed harmonic motion that provides a more likely explanation of the hog cycle and many other agricultural production cycles".

In a review article on both theories Mc Clements [32] criticises Larson's assertion that the superiority of this model is based on two main issues : the periodicity of the cycle and the reversibility of the supply functions. I shall review the discussion of these problems and follow with the estimation procedure difficulties. But first let us present briefly the two models.

Cobweb vs. harmonic motion

In his classical article on the cobweb theorem, Ezekiel [9, p. 272] states three conditions for the theory to be relevant to a commodity (1) where production is completely determined by the producers'response to price, under conditions of pure competition (where producer bases plans for future production on the assumption present prices will continue, and that his own production plans will not affect the market) ; (2) where production cannot be changed,once plans are made ; and (3) where the price is set by the supply available.

These features may be expressed in the following simple model :

COBWEB MODEL

(1.1)	demand	$p_t = a + b\, Q_t^d$	, $b < 0$
(1.2)	supply	$Q_t^s = c + d\, P_{t-w}$	, $d > 0$
(1.3)	equilibrium	$Q_t^s = Q_t^d$	

where w is the time duration of the production process. As is well known, this model yields a cycle with period 2 w, and which is convergent or divergent according to the relative slopes of the supply and the demand. Ezekiel was aware of the limitations of such a model to explain agricultural cycles. He discussed briefly the possibility of a non zero short-run elasticity of supply and mentionned lag of farmers' response to prices which could increase w in the above specification.

Harmonic motion differs from the cobweb in the behavioral assumption with regard to producers : "Reference to a supply curve might well be supplanted by a decision rube which is higly conservative, in the sense of involving little explicit prediction of future events. Producers do not in fact decide to produce a given level of output in response to an expected price, but rather decide to change the current rate of production in response to current prices, or current level of profits" [29, p. 169].

HARMONIC MOTION

(1.4)	demand	$P_t = a - b\, Q_t^d$
(1.5)	producers'behavior	$\frac{d\, B_t}{dt} = c\, (P_t - \bar{P})$
(1.6)	production lag	$Q_{t+w}^s = m\, B_t$

(1.7) clearing $Q_t^s = Q_t^d$

where B_t is the breeding stock and $\bar{P}$ is the equilibrium price. This model generates a cycles of production and prices of 4 w.

1 - Periodicity

"The chief difficulty in accepting tre cobweb as the explanation of the Hog cycle has been that the hog cycle is usually about four years long (slightly less in some countries), whereas, in view of the 12 months production period for market weight hogs, the cycle should according to the cobweb theorem be two years long" [29, p. 172]. It is a fact that known hog cycles have a period of more than two years, although one year is the average production lag (1). The period is about 4 years in the United States, but it varies from 36 to 40 months in most European countries ans is 52 months in the Netherlands [20, p. 144]. This evidence gives support to Larson's assertion that his model is consistent with the facts, and he considers that the arguments advanced to reconcile the cobweb with observed periodicity are not very convincing ; they are based mostly on a lag between prices and production response [15, p. 32].

McClements suggested mistakenly that Nerlove's partial adjustment hypothesis is one way to alter the period. "Depending on the speed of adjustment this model can imply cycles of more than twice the production lag" [32, p. 145]. It is clear however in Nerlove's article [36, p.232], that neither adaptive expectations nor partial adjustment hypothesis alters the periodicity since the difference equation of prices and quantities is still of order one. Only the stability domain is enlarged due to the fact that the producers' short run reaction is less than the long run supply elasticity would imply.

---

(1) Technical progress has reduced the production lag, and it is now approaching 10 months.

We cannot therefore do away with the assumption of a response lag longer than the production lag if the cobweb is to be the framework used to explain the hog cycle.

Is there however a great difference between the economics involved in this hypothesis and the one underlying the mathematical formulation of Larson ? There should be an intuitive explanation, based on economic analysis or technology, of the fact that the phase angle between price and production is twice the production lag. Larson does not give such an explanation, he says only, "First there is a shift of 90 degrees (i.e. one fourth of the period) cause by price being equal to the rate of change of planned output, and then there is a further shift of 90 degrees caused by the fixed production lag" [28, p. 379]. The solution of the differential equation derived from model (1.4) to (1.7) given by Larson [15,p.378] is (assuming bcm = 1),

(1.8) $$p_t = \cos\left(\frac{\pi t}{2w} + e_p\right)$$

(1.9) $$q_t = \cos\left(\frac{\pi t}{2w} + e_q\right)$$

"Where, if e_p and e_q differ by π radians, the solutions are consistent and the system is in resonance".

But equations (1.8) and (1.9) solved explicitely with respect to time, have built in an implicite relationship between q_t and p_{t-2w}. Taking $e_p = 0$ and $e_q = \pi$, as raquired by Larson for resonnance we get (1)

(i) $$q_t = \cos\left(\frac{\pi t}{2w} + \pi\right)$$

(ii) $$p_t = \cos\frac{\pi t}{2w}$$

(1) There is a lot of oddness in the assumptions on the coefficients which lead to this equality between lagged prices quantities deviations.

From (ii) $$p_{t-2w} = \cos \frac{\pi}{2w} (t - 2w)$$

$$p_{t-2w} = \cos \left(\frac{\pi t}{2w} - \pi \right)$$

compared to (i) it implies (1) : $q_t = p_{t-2w}$. This relationships comes from the reduced form of (1.4) and (1.5), but the lag connot originate in the demand where adjustment is instantaneous. It must therefore be built in the "supply" equation, which supposes, quite similarly to what cobweb users do, that there is a lag between price changes and response to them. Moreover the constraint making response lag equal to the production lag is quite strong. The main objection to Larson's model is that the underlying economic theory is unclear. His model may well represent reality, but it does not explain why the periodicity is 4 times production lag. The superiority of harmonic motion over the cobweb is open to question, at least on the periodicity point of view, to which Larson gives great weight.

2 - Reversibility and the nature of the supply function

Ezekiel's exposition of the cobweb theorem has been criticized, mainly on the basis of the reversibility of the supply curve involved [1, 6]. It is clear that the domain of application of the cobweb is in the explanation of short run fluctuations. However the reversibility implied in the treatment of the theory is a long-run characteristic.

From this observation, Ackerman suggests that producers'behavior is better expressed by shifts of the short run normal supply curves. "Between the sharply rising market supply curve and the very slowly rising long term supply curve, there exists, accordingly, for some time following cultivation year a moderately rising short term normal supply curve" [1, p. 154]. This would lead to a cobweb converging more easily than assumed in the traditionnal interpretation.

This point is certainly valid, for it is always a delicate task to interpret supply elasticity estimates in the light of static supply theory and consequently for policy purposes. The partial adjustment argument and Johnson'sfixed asset theory [24] go along with this line of interpretation. But this is more a problem in supply theory than in cobweb theory. And what it changes in the latter is mainly the stability conditions.

In any case, while the supply curve has an economic basis related to the equilibrium of the firm and of the industry, it is not so for Larson's equation (1.5). The economic interpretation of the coefficient c in (1.5) for example is not clear. Furthermore, an estimation procedure has not been developed for the structural equations of the model (1.4) to (1.7). Empirical verifications put forth by Larson [28], French and Bressler (1) or others [Hartman,16] are based only on the periodicity argument using spectral analysis or similar techniques. This is a rather roundabout method of empirical verification.

In the specification of equation (1.5) there is an interesting point made by Larson, especially for the livestock cycles he actually had in mind. It is the assumption that breeding decisions are made continuously over time. But there exists a constraint on decisions at any point in time which is not taken into account. Altering the breeding stock B_t cannot be achieved without influencing the sales of females for slaughter at time t because the stock of animals in the whole herd at t is fixed by past decisions. Therefore sales Q at t do not depend only on the breeding stock at t - w like in equation (1.6) but also on the change in B at the same time t. If this has little relevance to crops for which seeds count for a very small fraction of the output, it is a genuine part of livestock production and its consequences should therefore be explored. We shall do this within the cobweb theory where it is simpler as far as interpretation and estimation are concerned. We will see that if this biological

(1) Considered by Larson "most dramatic verification of the model". The lemon cycle, JFE, nov. 1962.

constraint is accounted for, modification of the supply equation is required with an interpretation of supply parameters going along with it. A negatively sloping short run supply response follows, which changes the dynamics of the cobweb and the stability conditions. A practical consequence of this point of view is that the model loses its recursiveness and simultaneous equations are then required throughout.

3 - The relationships between breeding stock and supply

Supply theory deals with the relation between output prices and quantities (1) produced. However some students of hog supply use farrowings as dependent variable [15] while others use quantities marketed measured through slaughter [7, 26]. As data on farrowings and inventories are not available in many countries including France, we may raise the question of the relationships between the two specifications. To be more specific, one may wonder if the supply elasticity derived from the two specifications has the same meaning. This can be done by trying to find out the analytical correspondence between the supply specified as a lagged prices marketed quantities relationship on the one hand, and supply specified as a lagged prices - inventories (or farrowings) relationship, on the other hand.

The second point to explore is the rationale and the consequences of the relationships between changes in supplies and in the breeding stock. Conceptually this is not a new idea. Ezekiel has already mentionned possible short run adjustment of the supply, and Breimyer [5, p. 2] gave an explicit justification of the necessity to study breeding stock and supply changes jointly : "When prices of cattle are high, producers hold back stock for

(1) And more generally, of course, with factor prices and even prices of output substitutes.

breeding. The supply of cattle for slaughter is reduced and prices are pushed still higher. Inventory of cattle build up. As progeny of increased numbers of breeding stock reach slaughter age annual slaughter starts upward. Eventuelly it increases a lot, and it reduces prices to a point that discourages further expansion of production and, later, results in liquidation of inventories".

A new step was made by Reutlinger [39] who gave the first formulation of the ideas expressed by Breimyer. He introduced the notion of demand for cow inventories which is mostly influenced by output prices, and showed that prices lagged one year have a negative effect on cow slaughter. But he did not carry the argument far enough to formulate the implications on stability, specifications bias and estimation. This may be the reason why Hayenga and Hacklander [17, p. 543] were unable to use this line of analysis to explain their hog supply findings which exhibited a negative short-run price elasticity : "This rather stong negative supply response is quite intriguing, since it differs from the response by cattle feeders". Even more intriguing is the positive short run response for cattle, in the light of later results.

Tryfos [44] is the first to have translated Reutlinger's model into the simultaneous equations framework in a systematic manner (1). He found evidence supporting the influence of inventory variations on the supplies of beef, veal, mutton and pork. The model may be summarized as follow.

A biological dynamic relationship,

(1.10) $$A_t = a_0 + a_1 \quad I_{t-1}$$

(1) Dean and Heady [8] and Fox [11] had found a small instantaneous price effect on the supply. But they did not separate the two components of short-run supply ; change in numbers, and change in average weight. Morever, they found opposite signs for the current price effect. It is also quite surprising that neither Reutlinger nor Tryfos refer to Hildreth and Jarret's book where a formulation of the inventory supply interaction is explicitely given and in a form very close to equation (1.13) below [19, p. 23].

where :

A_t is the quantity of livestock available at t
I_{t-1} is the inventory at the beginning of the period.

Desired livestock inventory,

(1.11) $$I_t^* = b_0 + b_1 P_t + b_2 C_t$$

with :

P_t current price of meat, $b_1 > 0$
C_t current price of feed, $b_2 < 0$

Partial adjustment hypothesis,

(1.12) $$I_t - I_{t-1} = c\ (I_t^* - I_{t-1})\ ,\ 0 < c < 1$$

Total supply equation,

(1.13) $$S_t = A_t - d\ (I_t - I_{t-1})$$

where d is expected to be close to one.

"Thus the model calls for the simultaneous estimation of the following system of equations :"

(1.14) $$I_t = c\ b_0 + c\ b_1\ P_t + c\ b_2\ C_t + (1 - c)\ I_{t-1}$$

(1.15) $$S_t = a_0 + (a_1 + d)\ I_{t-1} - d\ I_t$$

Empirical results confirmed the expected signs of the functions i.e. positive effect of price on current inventory and negative effect of current inventories on current supply. Tryfos'model is quite similar to

Reutlinger's specification ; the simultaneity in Tryfos'case comes from making desired inventory depend on current price instead of price lagged by one period as in Reutlinger's model.

While the idea of inventory changes has been clearly expressed and correctly estimated in the previous models, the interpretation of the functions involved, the meaning of parameters with reference to the supply part of the cobweb, the consequences of the specification error made in using a recursive model, and the implications on the dynamics of the cobweb have not been clearly stated. This is what I would like to show and illustrate on the basis of the hog industry in France.

*

*   *

Chap. 2 - INVENTORY-SUPPLY INTERACTION AND ITS CONSEQUENCES ON THE SUPPLY FUNCTION

In this chapter I will develop a model of hog supply along the line of Reutlinger and Tryfos, but I will set it in the cobweb framework, so that the interpretation of the various specifications used becomes easier. I will also show that this model, where supply depends on current price and price lagged by w units of time (w = production lag), takes a simple autoregressive form when partial adjustment or adaptive expectations are assumed. The long run supply elasticity may then be derived in a simple way as in other Nerlove's type models. This specification is particularly useful when little aggregation is made over time e.g. when quarterly data are used.

The current price affects both numbers and weights of animals slaughtered at each point in time. The relation between specification in numbers and live weight is also discussed.

Then, I analyse in a formalized way the consequences of the current price effect on the dynamics of the cobweb and the estimation problems.

1 - A supply function based on inventory-sales interaction

Both Reutlinger and Tryfos specified a model with a high level of aggregation over time by using annual data. I use a model where the production lag is defined more accurately. At one point in time, we may define the state of the herd by a vector X_t whose components are the numbers of individuals in each properly defined age and physiological classes. Then there is a dynamic relationship between the state vectors at successive points in time, namely,

(2.1) $$X_t = M_t \cdot X_{t-1}$$

Where the matrix M_t includes both demographic parameters (fertility, survival rates, ...) and control variables corresponding to farmers decisions.

Now if we can't use this detailed framework because of incomplete data, we may still consider the dynamical relationship between some components of the state vector. Consider the age group of individuals which may be either bred or sold for slaughter at time t, its number depends on the number of females bred w units of time before. Then we may write (1),

(2.2) $$H_t = m\ B_{t-w}$$

Where, H_t is total number of individuals (herd) ready to be bred or slaughtered at t. This corresponds to the "available supply" of Reutlinger.

B_{t-w} is the number of females bred at time t-w. It corresponds approximately to the inventory demand of Reutlinger (Breeding stock).

m is a technical coefficient characteristic of the species, for hogs it lies between 5 and 10 (saved piglets per litter).

---

(1) I do not use Reutlinger-Tryfos notations since, partly due to the smaller time unit, the definition of variables relates to narrower groups of animals in the specification I use.

But at each unit of time we do have a technical identity constraint relating current supply and current breeding stock (inventory demand).

(2.3) $$H_t \equiv B_t + S_t$$

where, S_t is the marketed supply, i.e. the sales or the slaughtered animals (1).

This constraint has been stated by Reutlinger with $B_t - B_{t-1}$ instead of the level of B_t but forgotten about by several authors subsequently (2). Tryfos relaxed this constraint in (1.14), which seems justified only by the high level of aggregation over time (annual data) and over types of animals.

Equations (2.3) and (2.2) show that available supply in predetermined at time t, by previous decisions made on B_{t-w}. However marketed supply is not fixed, since decisions made at t on B_t will also affect marketed supply. Let us assume for the moment immediate adjustment to current price, and formulate farmers'decisions.

(2.4) $$B_t = \alpha_0 + \alpha P_t$$

where P_t is basically output price, but may be generalised as a vector of output price, factor prices, substitutesprices. Equations (2.4) means that when producers think that their operation becomes more profitable they are ready to increase their ouptut, and for doing so they increase their production capacity B_t. (2.4) may then be thought of as a factor demand equa-

---

(1) When there are various types of animals sold for meat in a species like beef, a vector identity would simplify Reutlinger's formulation.

(2) In particular, it is susprising that Larson, whose model has some simularities to Reutlinger's one, and should include naturally the constraint (2.3), did not discuss this question in his 1967 article.

tion where output price plays the major role (1).

Combining (2.4) and (2.2) we get what should be considered in my opinion as the true supply equation in livestock models.

(2.5) $$H_t = m\alpha_0 + m\alpha P_{t-w}$$

This is the relationship between the available supply at t and the lagged price which has actually induced this livel of supply, or more rigorously this level of production. As the concept of supply elasticity refers to the relative variation of output induced by price variation, whether this output is sold or stocked by the firms, the relevant parameter to evaluate supply elasticity should be m α. Becuase of the linear form the supply elasticity should be estimated at mean values by :

(2.6) $$\sigma = m\alpha \frac{\bar{P}}{\bar{H}}$$

This is the procedure used by Harlow [15, p. 39], whose model explained the farrowings by lagged price. Available supply is just m times the farrowings and both models yield the same elasticity as far as specification is concerned (practical problems may lead to differences). However, several workers used marketed supply S_t as the dependent variable, because it is the only available data [Kettunen, 26]. Combining (2.3), (2.4) and (2.5) we get the marketed supply equation :

$$S_t = H_t - B_t$$

$$S_t = m\,\alpha_0 + m\alpha P_{t-w} - \alpha_0 - \alpha P_t$$

---

(1) Since B_t may be both sold and invested, output price influencing factor demand is actually expected price P_t^*, opportunity cost is actually P_t which should affect B_t negatively. Sorting out the two effects is a rather frustrating task as shown by Myers et al. in a slightly different context, dealing with average weight [34, 35].

(2.7) $S_t = \alpha_0 (m-1) + m\alpha P_{t-w} - \alpha P_t$, which we may write,

(2.8) $S_t = a_0 + \eta_1 P_{t-w} + \eta_0 P_t$, $\eta_1 > 0$, $\eta_0 < 0$

Then one can see that while it is correct to assume recursiveness in Harlow's specification (2.5), it is no longer the case when the explained variable is the number of hogs marketed. This has obviously estimation consequences which will be taken up later on But suppose also that (2.8) were correctly estimated with respect to η_1, i.e. that plim $\hat{\eta}_1$ = $m\ \alpha$. One would calculate the supply elasticity by,

(2.9) $\sigma_1 = m\alpha\frac{\bar{P}}{\bar{S}}$

Internal consistency of the model implies $\bar{H} > \bar{S}$, and therefore the supply elasticity is overvalued by $\sigma_1 > \sigma$. This is actually what some of the results of Kettunen show when he used successively available supply and marketed supply as the dependent variable |26, p. 48|. The price elasticity of marketed supply was 0,25, while the result with the "quantity of pork produced" as dependent variable was 0,20. The difference (1) is not big, but Kettunen quotes results of an author who found 0,40 for marketed supply elasticity. There may be other pecularities which also contribute to explain the difference. I do not know of any American study which would allow to verify this comparison between σ_1 and σ. The above evidence does not appear as a dramatic verification of the analysis. However, we can see on a priori basis that the approximation of σ by σ_1 is not really far away. The relationships on mean values may help to evaluate the discrepancy.

$$\bar{H} = \bar{B} + \bar{S}$$

$$\bar{H} \simeq m\ \bar{B}$$

$$\bar{B} \simeq \bar{S}/m - 1$$

$$\bar{H} \simeq \frac{m}{m-1}\bar{S}$$

(1) The difference seems even smaller in view of the use of a recursive model, which implies further overestimation, as will be seem later.

which implies the relation between σ_1 and σ.

$$\frac{\sigma 1}{\sigma} = \frac{\bar{H}}{\bar{S}} = \frac{m}{m - 1}$$

Therefore if m is close to 5 for hogs, the error is 25 %, which is non inconsistent with Kettunen results (1).

Of course if data on inventories are available, which is a great estimation advantage as will be seem later, one can explain the marketed sypply by current price and lagged breeding stock, as done by some authors. Combining (2.2), (2.3) and (2.4) gives

(2.10) $$S_t = m\ B_{t-w} - \alpha_0 - \alpha\ P_t$$

In Tryfos'notations, assuming full adjustment (c = 1, and d = 1), the single equation on marketed supply is written as

(2.11) $$S_t = a_0 + (a_1 + 1)\ I_{t-1} - b_0 - b_1 P_t - b_2 C_t$$

These equations (2.10) and (2.11) make clear why current price effect should be negative when marketed supply is explained by lagged inventories and current price. Failing to take the inventory-supply interaction has led some workers to find their results surprising as already noted [26, p. 50 ; 17 ; 27 ; 35]. Now, how to derive the supply elasticity from (2.10) and (2.11) ? One could get the marketed-supply elasticity σ_1 defined by (2.9) by estimating (2.10). (2.10) has the disadvantage of adding a non linearity to get the product $m\alpha$. But as will be seen later (2.8) leads to estimation difficulties due to the correlation between P_{t-w} and P_t.

Apparently Tryfos did not see the a priori relationship between the coefficient of lagged inventory a_1 and the current price ef-

---

(1) If one defines $\sigma_0 = -\alpha\frac{\bar{P}}{\bar{S}}$, an approximation of the true supply elasticity is given by $\sigma_1 + \sigma_0$ since $m\ \alpha\frac{\bar{P}}{\bar{S}} - \alpha\frac{\bar{P}}{\bar{S}} = \frac{\bar{P}}{\bar{S}}\ (m - 1) = m\,\alpha\frac{\bar{P}}{\bar{H}} = \sigma$

fect b_1(1). I think this has led him to give improper definitions to the elasticities derived from the two simultaneous equations (1.15) and (1.16) which becomes when d = c = 1,

(1.15') $$I_t = b_0 + b_1P_t + b_2C_t$$

(1.16') $$S_t = a_0 + (a_1 + 1)\ I_{t-1} - I_t$$

He called inventory elasticity the parameter derived from (1.15'), while this is the true supply elasticity, in the usual definition of supply. (1.15') is the equivalent of (2.4) which would give the elasticity expressed as,

$$\sigma'' = \alpha \frac{\bar{P}}{\bar{B}}$$

For, if we assume again $\bar{H} \simeq m\bar{B}$ from (2.2), then (2.6) becomes :

$$\sigma = m\,\alpha \frac{\bar{P}}{\bar{H}} \simeq m\,\alpha \frac{\bar{P}}{m\bar{B}} = \alpha\,\frac{\bar{P}}{\bar{B}} = \sigma''$$

On the other hand he called supply elasticity the negative short run effect derived from both the equations, presumably the expression $db_1 \frac{\bar{P}}{\bar{S}}$. But, althrough it affects current supply, this parameter is in fact related to inventory demand and should be interpreted as such and certainly not as something like short run supply.

What I consider to be a misleading interpretation of the parameters of the estimated equations on a supply point of view, may be seen again in the Reutlinger - Tryfos'models. Although they both introduced a partial adjustment hypothesis in their model they did not try to derive long run elasticity of supply from their results, which they really were

(1) Probably because of the way he specified in (1.14) the marketed supply as the difference between available supply A_t and change in inventories instead of the level of breeding stock as in our specification.

in a position to do. But, assimilating current price effect to short run supply response prevented them to think of the inventory equations (2.4), (2.5) or (1.15) as true supply functions, with both short and long run aspects when the introduction of partial adjustment or adaptive expectations give them an autoregressive form.

2 - Partial adjustment and adaptive expectations

Since decisions are basically made on breeding stock it is natural to define the "slow adjustment" at this level. The behavioral equation (2.4) becomes now,

(2.12) $$B^*_t = \alpha_0 + \alpha P^*_t$$

partial adjustment hypothesis means,

(2.13) $$B_t - B_{t-1} = \varphi (B^*_t - B_{t-1}) \quad , 0 \leqslant \varphi \leqslant 1$$

adaptive expectations imply,

(2.14) $$(P^*_t - P^*_{t-1}) = \psi (P_t - P^*_{t-1}) \quad , 0 < \psi \leqslant 1$$

As well known when either one of the two assumptions is introduced alone (e.g. $\varphi \neq 1$, $\psi = 1$) the estimable equation takes the same form. If both are introduced, then one cannot identify φ and ψ. Assuming $\psi = 1$, we get the equation expressed in observable variables,

(2.15) $$B_t = \varphi\alpha_0 + (1 - \varphi) B_{t-1} + \varphi\alpha P_t$$

Again, in Tryfos'case the coefficient of P_t (in 1.15 as in 2.15) is what is usually called short run elasticity when multiplied by $\bar{P}/\bar{B}$. The long run elasticity is obtained by dividing by φ. The equation (2.15) may easily be expressed in terms of available supply or production,

$H_t = mB_{t-w}$ gives

(2.16) $$H_t = m\varphi\alpha_0 + m\ (1 - \varphi)\ B_{t-w-1} + m\varphi\alpha P_{t-w}$$

This is an unpractical equation to estimate, but the marketed supply equation is much nicer to both estimate and interpret. By using (2.15) and (2.16)

$$S_t = H_t - B_t$$

$$S_t = \varphi\alpha_0\ (m - 1) + (1 - \varphi)\ (mB_{t-w-1} - B_{t-1}) + m\varphi\alpha P_{t-w} - \varphi\alpha P_t$$

Using the relation between H_{t-1} and B_{t-w-1} we get the simple autoregressive marketed supply equation,

(2.17) $$S_t = \varphi\alpha_0\ (m - 1) + (1 - \varphi)\ S_{t-1} + m\varphi\alpha P_{t-w} - \varphi\alpha P_t$$

This equation includes both partial adjustment and inventory-supply interaction in a form close to the cobweb. In this equation $m\varphi\alpha$ will serve to calculate short run supply elasticity, $m\alpha$ long run supply elasticity, $\varphi\alpha$ the inventory demand effect. But it should be noted that using $\bar{S}$ instead of $\bar{H}$ means, as said before, that this procedure overstates supply elasticities and yields the marketed supply elasticities (SR and LR).

Equation (2.17) takes an interesting form, since, although it involves price lagged by w units of time, the introduction of a partial adjustment assumption is made by using the dependent variable lagged by just one unit of time. This would not be abvious if one specifies supply behavior directly on a marketed supply equation of the form $S_t^* = f\ (P_{t-w})$ in the recursive case. It is then tempting to specify partial adjustment with the production lag w as a unit of thime as,

$$S_t - S_{t-w} = \varphi'\ (S_t^* - S_{t-w})$$

which would lead to an estimable equation

$$S_t = f' (S_{t-w}, P_{t-w})$$

where the coefficienf of S_{t-w} would be interpreted as one minus the adjustment coefficient φ'. At one time I made such an attempt, without any success. Kettunen had also done the same [26, p. 51], but the coefficient was very small (0,08) and not significant. The simple form given to the marketed supply equation with slow adjustment by the breeding stock-supply interaction seems to add a nice coherence to the averall supply behavior implied by the model. The results turn out to be acceptable for the lagged marketed supply, as we shall see later on.

3 - Supply in numbers, supply in weights

All the previous models have been specified in numbers. But the relevant variable on market equilibrium is the live weight marketed. Current prices have a positive effect on average carcass weights, as well known, e.g. Harlow [15, p. 40]. More recently, Myers, Havliceck and Henderson [34 , 35] have provided us with a more sophisticated model of short run (1) supply behavior. Basically, they consider the problem of the profitability of delaying the sales of fattened animals when prices are changing. They expect total live weight at time t to depend positively on current price and negatively on the price expected for the next unit of time, where the available animals at t will still be in the suitable weight range for slaughter. The difficulty is that expected prices depend heavily on current prices, as the authors were avare of, making impossible to separate the two effects. It seems to me that they could have introduced in their model one more function based on the relationship between hogs'age and their average weight ; they could have then sorted out the

(1) Compared to the previous short run elasticity this a "very short run problem".

two components of supply : numbers and weight per head. What they really tended to show is that when price go up, farmers anticipate further increase and delay the sales. This is the same as saying that average weight increases with price, at least this seems to be the only way to verify their hypothesis. Using total liveweight as they did leads to a misleading interpretation of their results. They found a negative current price effect in a model very close to (2.10) with liveweight instead of numbers as dependent variable, which may be stated with some simplification as,

(2.18) $Q_t = gH_t - \alpha_0 - \alpha P_t$, Q_t = total liveweight

But one may also explain the negative sign by the inventory-demand effect, which plays a negative role on the number component of the total liveweight supply.

When it comes to explain the supply in weight on the market, many authors specify a function like (2.18), where in some cases the number supplied S_t takes the place of H_t, the available supply [44, 8, 11]. In the context of Tryfos'model where he discussed the current price effect, I considers this specification as little adequate to evaluate the overall current price effect. This is in fact an aggregation problem between the behavioral equations on numbers on one hand and average weight on the other, which both depend, although with opposite signs, on the current price. To make the presentation nicer, let us approximate (2.17) by the corresponding equation linear on the logarithms,

(2.19) $\text{Log } S_t = \varphi s' + (1-\varphi) \text{ Log } S_{t-1} + \varphi\sigma_1 \text{ Log } P_{t-w} + \varphi\sigma_0' \text{ Log } P_t$

If we formulate similarly a constant elasticity model on average weight, with also partial adjustment,

(2.20) $\text{Log } W_t = \varphi' s'' + (1-\varphi') \text{ Log } W_{t-1} + \varphi'\sigma_0'' \text{ Log } P_t$

We have a simple formulation for the aggregate liveweight marketed (assuming $\varphi = \varphi'$ for simplicity, with no real justification),

$$\text{Log } Q_t = \text{Log } S_t \cdot W_t$$

(2.21) $$\text{Log } Q_t = \varphi(s'+s'') + (1-\varphi) \text{ Log } Q_{t-1} + \varphi\sigma_1 \text{ Log } P_{t-w} + \varphi(\sigma_0'+\sigma_0'') \text{ Log } P_t$$

The only parameters which deserves the name of (very) short run elasticity is σ_0'' in the average weight equation. This is the only way producers may affect supply in the short run when numbers are fixed (by a different production and decision process). The parameter σ_0' (in 2.19) refers to future production by the inventory demand, and therefore to another kind of production process. This is why $\sigma_0'' > 0$ is consistent with the usual sign of a supply elasticity, while $\sigma_0' < 0$ is not.

Equation (2.21) is suitable to discuss the consequences on the dynamics and the stability of the cobweb, with the inventory-demand effect and the (very) short run supply elasticity on weights tend to offset one another.

4 - Dynamics and stability conditions

As already noted, the relevant variable on the supply side for market equilibrium and stability is total liveweight marketed, even though for economic analysis other specifications may be more suitable.

As I want to illustrate the consequences of the inventory-supply interaction on the dynamics of the cobweb, I drop the partial adjustment which is known to have a stabilizing effect. Then, denoting by σ_0 the algebraic sum of σ_0' and σ_0'' we have the liveweight marketed supply equation, in the constant elasticity case,

(2.22) $$q_t = s + \sigma_1 \, p_{t-w} + \sigma_0 \, p_t$$, "marketed supply" where lower case letters stand for the logarithms of corresponding variables.

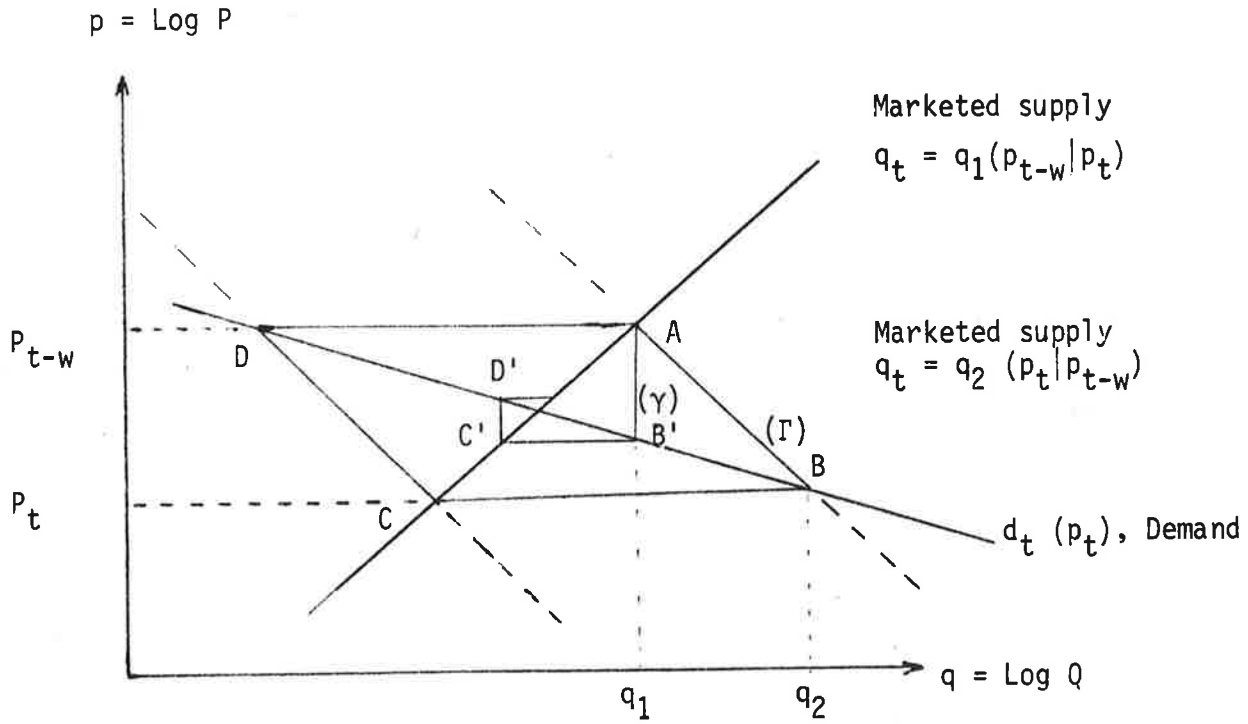
Assuming, a constant elasticity on demand for simplicity,

(2.23) $d_t = \theta + \theta_0 \, p_t$, demand

(2.24) $q_t = d_t$, clearing equation

A few authors have already noted the destabilizing role of the inventory-supply interaction [5, 39, 44]. Figure 2.1 gives an illustration of this effect on the shape of the cobweb, which takes now a skewed face, since supply at time t is no longer predetermined, but depends also on current prices. Figure 2.1 assumes that inventory-demand effect on numbers ($\sigma_0' < 0$) dominates (very) short run price elasti-

Figure 2.1 - Cobweb with current price effect



city of average weights ($\sigma_0'' > 0$). Under these circumstances prices and quantities will trace the ABCD parallelogram (in the case of a stationary skewed cobweb). Without the negative current price effect the cycle would be more stable i.e. converge by the path AB'C'D'. This approach seems to fit rather well the sort of cumulative movement of prices observed in the peaks and troughs of the hog cycle.

The stabilizing role of average weight is also clear from the above equation ; and whether the two opposite effects of current price on liveweight supplied cancel is an empirical question. Some results suggest that the overall effect is negative [17, 11, 35] . Putting together Harlow's results on average weight ($\sigma_0'' = 0.05$) and Tryfos'results on numbers ($\sigma_0' = .13$) tend do confirm this evidence. But their work do not cover the same sample, and may not be comparable.

Dean and Heady [8, p. 856] estimated a supply equation for hogs with a current price effect,

$$\hat{Q} = - 0.11 + 0.08 \ P + 1.0 \ Z$$

where, Q is total liveweight of hogs slaughtered

Z is an "estimate of a based on predetermined variables.

The positive sign of the coefficient of P contradicts the above results (1), but is consistent with the authors'expectations, since they assumed it reflected the short run supply response on average wieghts. The standard deviations of estimates are not given in this article and the exact nature of Z is rather ambiguous. These contradictory results illustrate in my opinion the possible misinterpretation of various specifications of the supply function.

The dynamics of the cycle may be derived analytically along with slightly different stability conditions from the usual cobweb ones.

Using (2.22) and (2.23) and denoting by p_t' the deviation of p_t from equilibrium $\bar{p}$, we get the difference equation :

$$p_t' = \frac{\sigma_1}{\theta - \sigma_0} \ p_{t-w}' \qquad (2.25)$$

(1) Particularly Fox'results reproduced p. 29.

Of course, the two parameters of the marketed supply equation matter for the stability condition which require :

$$(2.26) \qquad -1 < \frac{\sigma_1}{\theta - \sigma_0} < 0$$

Since $\sigma_1 > 0$, negativeness is obtained when $\theta - \sigma_0 < 0$ i.e. $\theta < \sigma_0$: the elasticity of demand should have a larger magnitude than the current price elasticity (1).

The condition for stability is then :

$$(2.27) \qquad \sigma_1 < \sigma_0 - \theta$$

The elasticity of supply may therefore be quite smaller in magnitude than the demand elasticity and we would still have a continuing cycle.

The implication is that even with a relatively less elastic supply than demand, continuation of the cycle remains possible. Further complexities are certainly required however, to give a complete explanation of the persistence of the cycle. Some nonlinearities probably exist along the lines mentioned by Waugh [46] ; they prevent the cycle from exploding. In a sense,the current price effect considered here is the kind equilibrium destabilizer whose existence was pointed out by Waugh.

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(1) On fig. 2.1, the slope of AB should be larger in absolute value than the slopeof the demand so that intersection occurs on the right of the equilibrium point, so that oscillations are obtained.

5 - Simultaneous or recursive cobweb ? Biases resulting from unappropriate estimation procedure

Quite a few workers have used simultaneous equations methods in livestock and hog supply research. Some were looking for an estimate of "short run supply" elasticity which they expected to be positive [8, 35]. Others justifying this approach by the inventory-supply interaction [44, 11]. Hildreth and Jarret were probably the first to interpret correctly the negative sign they obtained on the current price parameter. Fox [11, p. 73] was interested in the possible bias on demand elasticity resulting from the wrong assumption that supply is pre-determined, i.e. assuming recursiveness instead of simultaneity. His results are of interest and are presented below since they illustrate the analytical discussion of the biases given in this section.

Fox compared the results obtained by ordinary least squares (OLS) and by indirect least squares (ILS) on a just identified model which includes a supply specified as in (2.18) and a demand with price and income.

OLS	Demand	(2.28)	$p = - \underset{(.07)}{1.16}\, q + \underset{(.06)}{.90}\, y$
	"Supply"	(2.29)	$q = \underset{(.06)}{.84}\, h$
ILS	Demand	(2.30)	$p = - 1.14\, q + .89\, y$
	"Supply"	(2.31)	$q = - .06\, p + .77\, h$

where, y and h are respectively, income and "an estimate of production basedon predetermined variables". Numbers in parentheses are standard deviations of estimates. Variables are expressed in logarithms.

The current price effect on supply is actually negative, but it is not significantly different from zero, as seen on the reduced form equation (not quoted here). The differences on the estimates derived from the two methods are quite small as pointed out by Fox. Assuming recursivity does not appear as a damaging simplification on the basis of this evidence.

It is intersting however to analyse in a systematic manner what is the direction and the magnitude of the bias incurred by using unproperly a recusive model. I shall do this in the context of a simple cobweb-like model with lagged price as explanatory variable in the marketed supply equation. It is in such a specification that supply elasticity is more likely to be biased (1). As said before, when farrowings are used as dependent variable as in Harlow [15], supply elasticity is correctly estimated by assuming recursiveness. On the other hand, when marketed supply is explained by inventories (or production) like in (2.18) and (2.31), the coefficient of inventories is not used in most cases to estimate supply elasticity. In such models supply elasticity should be drawn from the inventory or production equation (2.5) as already said. The following discussion is not relevant to such models. If however, one derives supply elasticity by tracing out the lagged price effect through available supply h, as in [33] in the following way,

$$(2.32) \qquad \frac{\partial q}{\partial p_{t-w}} = \frac{\partial q}{\partial h} \cdot \frac{\partial h}{\partial p_{t-w}}$$

Then the bias would still exist, since the first derivation above would be biased as we shall see below, and as illustrated by Fox' results (i.e. .84 instead of .77).

Let us rewrite our simple model of price and quantities simultaneous determination. We specify the relations as linear on the logarithms.

---

(1) This is the case for Kettunen's model written as $Q_t = f\ (P_{t-5})$. He found a negative current price effect, but rejected it "since it only reflects the dependency of current price on the quantity supplied [26, p. 50].

(2.33) $s_t = s' + \sigma_1 p_{t-w} + \sigma_0' p_t$ marketed supply in heads

(2.34) $w_t = s'' + \sigma_0'' p_t$ average weight (1)

(2.35) $d_t = \theta_0 + \theta p_t$ demand

(2.36) $s_t + w_t = d_t = q_t$ clearing

This model is particularly suitable to identify the parameters we have termed, marketed supply elasticity σ_1, (very) short run supply elasticity σ_0'', and true supply elasticity $\sigma \simeq \sigma_1 + \sigma_0'$. Of course there is a need of at least one shifter in the demand equation for the supply to be identified. Average weight equations like (2.34) have not received the favor of workers. They usually lead to poor fit (ex. Harlow [15, p. 40], $R^2 = .32$), and as this variable acts in a multiplicative way on the liveweight marketed supply, it may be wiser to aggregate (2.33) and (2.34) for prediction purposes for example. By doing so, we get a simple simultaneous cobweb with liveweight marketed as the dependent variable on the supply side.

(2.37) $q_t = s + \sigma_1 p_{t-w} + \sigma_0 p_t + \varepsilon_t$ supply

(2.38) $p_t = \delta_0 + \delta q_t + u_t$ demand

Since we are interested mostly in σ_1 and δ, we want to know what is the bias and inconsistency of OLS estimates from the classical cobweb (2) below

(2.39) $q_t = s + \sigma_1 p_{t-w} + \varepsilon_{1t}$ supply

(2.40) $p_t = \delta_0 + \delta q_t + u_{1t}$ demand

(1) w_t = Log W_t should not be confused with w without subscript which is the production lag.

(2) Recursiveness requires also cov $(\varepsilon_{1t}, u_{1t}) = 0$ which may have been accepted without much justification especially in the context of a bloc recursive model [Tryfos, p. 112], since the decision process on weights is not independant of the decision on numbers (e.g. sows slaughtered).

where δ is the price flexibility assimilated for simplicity to the inverse of price elasticity of demand. OLS estimate of σ_1 from (2.39) gives,

$$(2.41) \qquad \hat{\sigma}_1 = \frac{\Sigma p'_{t-w}\, q'_t}{\Sigma p'^2_{t-w}}$$

where the variables with prime denote the deviations from the mean values. Now, since the observed time series are assumed generated by model (2.37) (2.38) we solve these equations for p'_t, q'_t.

$$(2.42) \qquad q'_t = \lambda\ (\sigma_1\ p'_{t-w} + \sigma_0\ u'_t + \varepsilon'_t)$$

$$(2.43) \qquad p'_t = \lambda\ (\delta\sigma_1\ p'_{t-w} + u'_t + \delta\varepsilon'_t)$$

with $\lambda = 1/(1 - \delta\sigma_0)$. These equations naturally show that unless supply is perfectly inelastic to current price ($\sigma_0 = 0$) or demand perfectly elastic ($\delta = 0$)(together with cov $(\varepsilon_t, u_t) = 0$) neither of these variables is uncorrelated with error terms in OLS estimation. Replacing q'_t in (2.41) yields,

$$\hat{\sigma}_1 = \frac{\lambda}{\Sigma p'^2_{t-w}} \{\sigma_1 \Sigma p'^2_{t-w} + \Sigma p'_{t-w}\ \varepsilon'_t + \sigma_0\ \Sigma p'_{t-w}\ u'_t\}$$

Using the probability limit operator, with the assumption that ε_t and u_t are independent of p_{t-w} (i.e. no serial correlation of the errors), we get :

$$(2.44) \qquad p \lim \hat{\sigma}_1 = \lambda\sigma_1 = \frac{\sigma_1}{1 - \delta\sigma_0}$$

Unless $\sigma_0 = 0$ or $\delta = 0$ the estimate of σ_1 will be inconsistent. Moreover given the assumed signs $\sigma_0 < 0$, $\delta < 0$, the marketed supply elasticity will be overestimated even when sample size goes to infinity.

(2.45) $\text{p lim } \hat{\sigma}_1 > \sigma_1$

Now, if the dependent variable is marketed supply in heads we can be sure that the overestimation exists since $\sigma_0' < 0$ on the basis of the breeding stock-supply relationship (1). Then if one accepts the approximation of the "true supply elasticity" by the algebraic sum $\sigma \simeq \sigma_1 + \sigma_0'$, then not only the supply elasticity is overstated by using marketed supply instead of available supply (production) but it is furthermore overestimated by using a recursive model :

(2.46) $\text{p lim } \hat{\sigma}_1 > \sigma_1 > \sigma$

Is this inconsistency really important ? As Fox's results suggest, it is not really big. If we assume $\sigma_0 \simeq - 0.05$ $\delta \simeq - 1.2$ then $1/(1 - \delta\sigma_0) \simeq 1.06$ and the overestimation is about 6 %, which may not be negligible (2).

The bias on the supply side is illustrated on fig. 2.2. When the cobweb is supposed recursive, we fit a biased supply $\hat{q}\ (p_{t-w})$ by assuming that the points (p_{t-w}, q_t) and (p_t, q_{t+w}) belong to the supply curve, while only A and B are the relevant points. When variables are expressed in logarithms, elasticities are the slopes in the (q, p) plane. The less elastic true supply curve $h\ (p_{t-w})$ is represented on fig. 2.2 by the steeper straight line.

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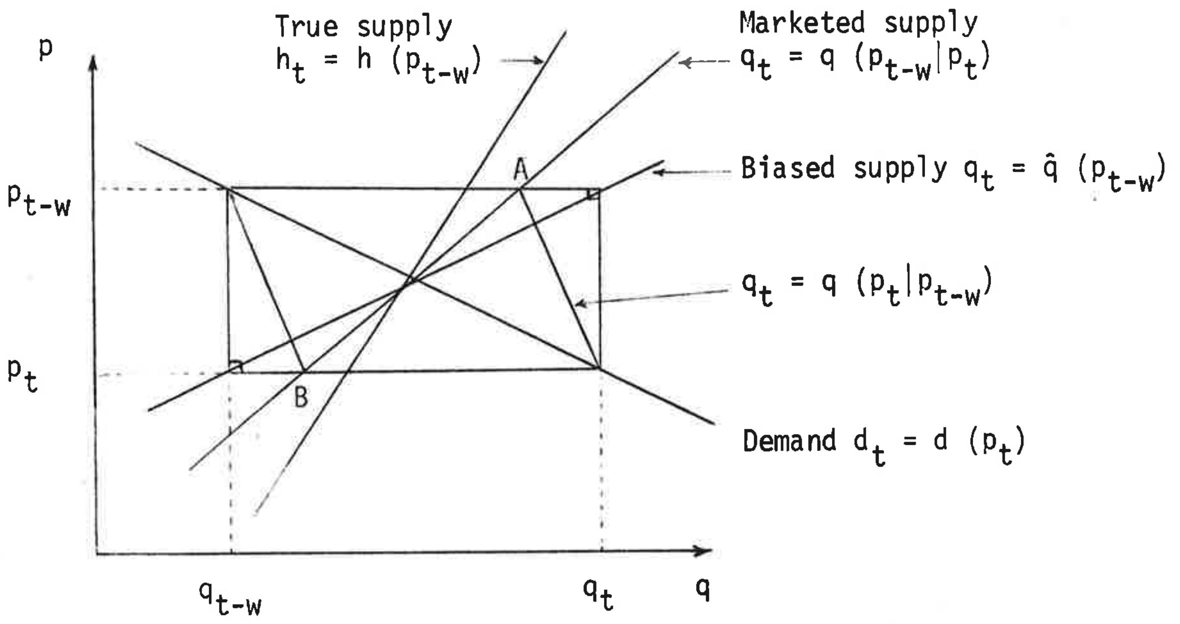
(1) This statement follows more easily from the omitted variable approach to the bias taken below.

(2) If we add the two sources of error on we get $\text{p lim } \frac{\hat{\sigma}_1}{\sigma} = \frac{m}{m-1} \frac{1}{1-\delta\sigma_0} = 1.16$ with m = 10, such an inconsistency cannot be neglected.

Figure 2.2 - Specification bias from assuming mistakenly a recursive cobweb



While the bias on the supply results from the exclusion of a variable namely p_t, there is also a bias on the demand which comes from assuming away simultaneity. The recursive model (2.40) gives the OLS estimate of the price flexibility δ.

(2.47) $$\hat{\delta} = \frac{\Sigma p'_t\, q'_t}{\Sigma q'^2_t}$$

$$\Sigma p'_t\, q'_t = \lambda^2\{\delta\sigma_1{}^2\ \Sigma p'^2_{t-w} + \delta\Sigma\varepsilon'^2_t + \sigma_0\Sigma u'^2_t + 2\delta\sigma_1\ \Sigma p'_{t-w}\varepsilon'_t + \sigma_1(1+\delta\sigma_0)\ \Sigma p'_{t-w}\, u'_t$$

$$+ (1+\delta\sigma_0)\ \Sigma u'_t\varepsilon'_t\}$$

Assuming again ε_t, u_t serially uncorrelated and therefore uncorrelated with p_{t-w} in the limit, we get (denoting $\frac{1}{N}\ \Sigma p'^2_{t-w}$ by π),

$$p\lim \frac{1}{N} \Sigma p'q'_t = \lambda^2 (\delta\sigma_1^2\pi + \lambda\sigma_\varepsilon^2 + \sigma_0\sigma_u^2 + (1+\delta\sigma_0)\ \sigma_{u\varepsilon}$$

where : $\sigma_\varepsilon^2 = \text{var}\ (\varepsilon_t)$

$\sigma_u^2 = \text{var}\ (u_t)$

$\sigma_{u\varepsilon} = \text{cov}\ (u_t, \varepsilon_t)$

By a similar way we derive the denominator of (2.47),

$$p\lim \frac{1}{N} \Sigma q_t'^2 = \lambda^2\ (\sigma_1^2\ \pi + \sigma_0^2\sigma_u^2 + \sigma_\varepsilon^2 + \sigma_0^2\sigma_{u\varepsilon})$$

and the probability limit of $\hat{\delta}$,

$$p\lim\ \hat{\delta} = \frac{\delta\sigma_1^2\ \pi + \delta\sigma_\varepsilon^2 + \sigma_0\sigma_u^2 + (1+\delta\sigma_0)\ \sigma_{u\varepsilon}}{\sigma_1^2\ \pi + \sigma_\varepsilon^2 + \sigma_0^2\sigma_u^2 + \sigma_0^2\sigma_{u\varepsilon}}$$

If we assume that random shifters in the supply (ε_t) and in the demand (u_t) are independent, which may not be a too bad simplification, since factors of a different nature affect the two sides of the market, we may write,

(2.48) $$p\lim\ \hat{\delta} = \delta\ \frac{1 + \frac{1}{\sigma_1{}^2\ \pi}(\sigma_\varepsilon^2 + \frac{\sigma 0}{\delta}\ \sigma_u^2)}{1 + \frac{1}{\sigma_1{}^2\ \pi}(\sigma_\varepsilon^2 + \sigma_0\sigma_u^2)}$$

Equation (2.48) shows that except for special cases ($\sigma_u^2 = 0$, $\sigma_0 = 0$), the demand flexibility will be overestimated in magnitude, and therefore the absolute value of price elasticity of demand under estimated by OLS.

(2.49) $$p\lim\ |\delta| > |\delta|$$

This result is consistent with Fox'results who found respectively - 1.16 for $\hat{\delta}$ by OLS and - 1.14 by ILS. Again the difference is quite small especially when σ_0 is small (1) relatively to σ_1^2, and σ_u^2 relatively to $\frac{1}{N}\Sigma p'^2_{t-w}$, which one expect to be the case in general.

While the nature of the bias on the demand side is a simultaneous bias, it is not strictly so on the supply side. We may still have a bias on the supply elasticity estimated on times series highly disaggregated over time, for example with weekly or monthly data. In such a case the model could still be recursive since most of the inventory-sales interaction would work on weeks or months preceding t. But failing to introduce this interaction into the model would still entail a specification bias resulting from the exclusion of variables, namely P_{t-1}, P_{t-2}, ... which should be included in the equation. As an example, Reutlinger used prices lagged by one unit of time to verify the inventory-supply interaction, although he was dealing with annual data.

This discussion looks rather trivial, I shall present it with some detail however, since it throws some light on further difficulties encountered in estimating the supply equation including both price at t and t-w.

Let us suppose first that the production lag is perfectly known so that we are sure that it is P_{t-w} which must be included into the model ant not $P_{t-w'}$, with w' close to w. (We can guess right now that this problem will be at the heart of the estimation difficulties).

I shall use the following notations to simplify the presentation. Let,

(1) Again since $\sigma_1 = - m\sigma_0'$, we have an upper bound for $\left|\frac{\sigma_0'}{\sigma_1^2}\right|$ i.e. $|1/m^2\sigma_0'| =$ .20 with m = 10, $\sigma_0' = 0.05$.

$Y_t = S_t$

$X_{1t} = \hat{P}_t$ or P_{t-w_0} , where w_0 is small relatively to w

$X_{2t} = P_{t-w}$

$X_{3t} = P_{t-w'}$, where w' is close to w

$\hat{P}_t$ is an instrument for P_t, uncorrelated with u_t.

If we suppose that w is known without error, this means that the true model (in deviation form) is,

$$y_t = \beta_1 x_{1t} + \beta_2 x_{2t} + u_t \tag{2.50}$$

Then if we leave out x_{1t} which represents the inventory supply interaction we estimate β_2 from the model,

$$y_t = \beta_2 x_{2t} + v_t \tag{2.51}$$

As well known $\hat{\beta}_2$ will be biased if X_1 and X_2 are correlated, which is necessarily the case in any rather regular cycle,

$$E(\hat{\beta}_2) = \frac{1}{\Sigma x_2^2} \Sigma x_2 (\beta_1 x_1 + \beta_2 x_2)$$

$$E(\hat{\beta}_2) = \beta_2 + \beta_1 \hat{\gamma}_{21} \quad , \hat{\gamma}_{21} = \frac{\Sigma x_2 x_1}{\Sigma x_2^2}$$

A priori information includes $\beta_2 > 0$, $\beta_1 < 0$, $\hat{\gamma}_{21} < 0$ by the cyclical pattern of prices. Then $E\hat{\beta}_2 > \beta_2$, the supply elasticity is over estimated as already shown in the simultaneous context.

Now, one may raise the question as done by Kettunen (1), could

(1) See footnote p. 30.

it happen that $|\beta_1|$ is overestimated by (2.50) as a result of the negative empirical correlation between current price and marketed supply, i.e. by the so called demand effect. This is the same as saying, including mistalenly X_1 could give a significant parameter due to spurious correlation. Estimating (2.50) while the true model is (2.51) gives an estimate of $\hat{\beta}_1$,

$$(2.52) \qquad \hat{\beta}_1 = \frac{\Sigma x_2^2 \; \Sigma x_1 y - \Sigma x_1 x_2 \; \Sigma x_2 y}{\Sigma x_1^2 \; \Sigma x_2^2 - (\Sigma x_1 x_2)^2}$$

of course, $\hat{\beta}_1$ is unbiased since $E(\hat{\beta}_1)$, is identically zero,

$$(2.53) \qquad E(\hat{\beta}_1) = \frac{1}{D} \beta_2 \; (\Sigma x_2^2 \; \Sigma x_1 x_2 - \Sigma x_1 x_2 \; \Sigma x_2^2) \equiv 0$$

However, it is not unlikely that for some samples we get a point estimate $\hat{\beta}_1$ different from zero, especially if there is a strong empirical correlation between Y and X_1, relatively (2) to the correlation between Y and X_2. Therefore Kettunen's argument, i.e. the demand effect, used to explain the negative current price effect, may be used also to explain why we tend to find a short run effect over estimated in absolute value, as we shall see in the next chapter.

The situation is even worse on a priori basis, if we are not quite sure what is exactly the relevant lag w. But this is always the case, since the appropriate lag on price which reflects causal effect is usually different from the production lag because of a possible reaction lag added to the former. Besides, decisions at time t can be made on females at different stages with corresponding different lags as to the effect on supply. It seems appropriate to think of P_{t-w} as a constrained lag function which should include also $P_{t-w'}$ for example and may be some others lagged prices. Again because of collinearity it is almost hopeless to try drawing from

(1) Since $X_1 = P_t$, $X_2 = P_{t-w}$ we expect $|\Sigma x_1 x_2| < \Sigma x_2^2$

the data both the lagged structure free from any constraint and estimates of the parameters.

"We may be asking too much of our data. We want them to test our theories, provide us with estimates of important parameters, and disclose to us the exact form of the interrelationships between the various variables" [Griliches, 14 , p. 18].

This can be illustrated in the present case. Suppose P_{t-w}, (represented by X_3) should appear in the true model as well as P_t. Then the true model is,

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + u_t \tag{2.54}$$

While we estimate (2.50) i.e. the model including only x_1 and x_2. Then we get again a biased estimate of $\hat{\beta}_1$ given by (2.52). Substituting y from (2.54) in (2.52), taking expection,

$$E\ (\hat{\beta}_1) = \beta_1 + \beta_3\ \hat{\psi}_{13} \tag{2.55}$$

where $\hat{\psi}_{13}$ is the least square estimate of ψ_{13} from $x_3 = \psi_{13}x_1 + \psi_{23}x_2$. A priori information about the pattern of the cycle in price gives the following signs, $\beta_1 < 0$, $\beta_3 > 0$, $\hat{\psi}_{13} < 0$. Therefore β_1 will be overestimated in magnitude, when the structure of lagged prices is specified unproperly.

This simple analysis of possible biases, presented on a a priori basis, has been done in fact after a lot of estimation work. Although it is mainly meant to explain my results, I have included it in this chapter to make it more self contained.

I have emphasized the possible error made by forgetting about the breeding stock-supply interaction. My results and the above discussion suggest that on a practical point of view, particularly because of collinearity problems and the writer's limitations, there is a possibility that putting without caution current price into the model may lead to even greater evils. This is actually what some of my results show.

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Chap. 3 - AN ECONOMETRIC MODEL OF THE HOG SUBSECTOR IN FRANCE

Before giving an account of the economic relationships estimated on the French pork subsector, I will describe briefly the main features of the hog industry in this country. Then I will discuss the available data and the limitations they impose on the specification of the model as well as on the results gotten. Last, I will present the results with their implications on the economic behavior of the various groups of agents involved in the market equilibrium. Although in its present form, the model does not include all the policy variables it could, some possible uses for policy purposes will also be analysed. Chapter four will be devoted entirely to one of the policy aspects, namely the welfare analysis of hog prices fluctuations.

1 - General setting of the French hog industry

11 - Production

Hog production ranks fourth in gross value at farm level, among single products in the French agriculture. On a total gross agricultural output of 109 billions francs (bF) in 1974, milk accounted for 18 bF, beef for 13,6 bF, wheat for 9,2 bF and hogs for 7,6 bF. Over years, hog production share amounts to about 8 % of total output and 13 to 14 % of all animal products. It is the second most important meat after beef as in most countries (table 3.1).

Table 3.1 - Importance of hog production in the gross farm output

	1971	1972	1973	1974
	Unit : billions Francs (bF)			
Milk	13,8	16,3	17,0	18,3
Beef	9,3	10,4	11,2	13,6
Hogs	5,8	6,5	8,3	7,6
Animal Products	43,7	49,7	55,5	59,7
Total farm output	77,0	87,4	104,2	109,0

Source I.N.S.E.E. Comptes de l'Agriculture 1974 (C39)

Detailed information about hog enterprises was not available before 1966. The common agricultural Policy (CAP) includes hog production since 1967. One of its effects was to standardize statistical data by a survey on december 1st of each year. Structural changes in this industry may therefore be described starting from 1966. Tables 3.2, 3.3 and 3.4 summarize the evolution of numbers of operations and number of hogs, along with specialization in feeder pigs, slauthter hogs, and mixed enterprises. In 1971 about 600 000 farms raised hogs, which is more than a third of all French farm operations. But if one leaves out the farms with less than 5 slaughter hogs, mainly concerned with self consumption, only 275 000 units remain which work for commercial production.

Average size of hog raising units is still quite small in 1971, 6.2 sows for feeder pig producers (FPP) and 6.5 hogs for slaughter hog producers (SHP). For commercial SHP the average number of slaughter hogs on farm (over 50 kilograms) is about thirty. With respect to the size criterion French production structures lag behind most those of EEC members. From 1966 to 1972 concentration has increased quite drasticly however. More than a 100 heads facilities went from 2,300 to 9,800, picking up a large share of the whole production (25 % in 1968 to 51 % in 1972). Structural changes have occured also among FPP. Over 20 sows - units were 2,500

Table 3.2 - Size distribution and concentration of feeder pigs units (1966-1972) (sow herd)

	size class (nb of sows)	1-4	5-9	10-19	≥ 20	total
april 66	nb of operations (1 000)	239.3	51.5	14.8	2.5	308.1
	% of total operations	77.7	16.7	4.8	0.8	
	cumulated %	77.7	94.4	99.2	100	
	nb of sows (1 000)	498.0	320.4	185.8	86.6	1 090.8
	% of total sows	45.7	29.4	17.0	7.9	
	cumulated %	45.7	75.1	92.1	100	
dec.68	nb of operations (1 000)	188.5	46.5	15.3	5.6	256.0
	% of total operations	73	18	6	2	
	cumulated %	73	91	97	99	
	nb of sows (1 000)	389.9	299.2	198.0	188.9	1 076.0
	% of total sows	36.2	27.8	18.4	17.5	
	cumulated %	36.2	64.0	82.4	99.9	
dec.69	nb of operations (1 000)	172.9	48.3	20.9	8.5	250.6
	% of total operations	69.0	19.2	8.3	3.4	
	cumulated %	69.0	88.2	96.5	99.9	
	nb of sows (1 000)	378.4	306.8	272.4	291.3	1 248.9
	% of total sows	30.2	24.5	22.0	23.3	
	cumulated %	30.2	54.8	76.6	100	
dec.70	nb of operations (1 000)	154.4	51.2	19.6	14.2	239.4
	% of total operations	64.4	21.4	8.2	6.0	
	cumulated %	64.4	85.9	94.0	100	
	nb of sows (1 000)	333.1	326.2	252.9	469.9	1 382.1
	% of total sows	24.1	23.6	18.3	34.0	
	cumulated %	24.1	47.7	65.9	100	
dec.71	nb of operations (1 000)	139.5	41.1	19.9	14.5	215.0
	% of total operations	64.9	19.1	9.2	6.8	
	cumulated %	64.9	84.0	93.2	100	
	nb of sows (1 000)	296.3	269.2	260.7	521.2	1 347.4
	% of total sows	22.0	20.0	19.4	38.6	
	cumulated %	22.0	42.0	61.4	100	
dec.72	nb of operations (1 000)	121.3	35.7	18.0	15.4	190.6
	% ot total operations	63.8	18.7	9.4	8.1	
	cumulated %	63.8	82.5	91.9	100	
	nb of sows (1 000)	247.4	232.6	242.8	572.4	1 295.2
	% of total sows	19.1	18.0	18.8	44.0	
	cumulated %	19.1	37.1	55.9	100	

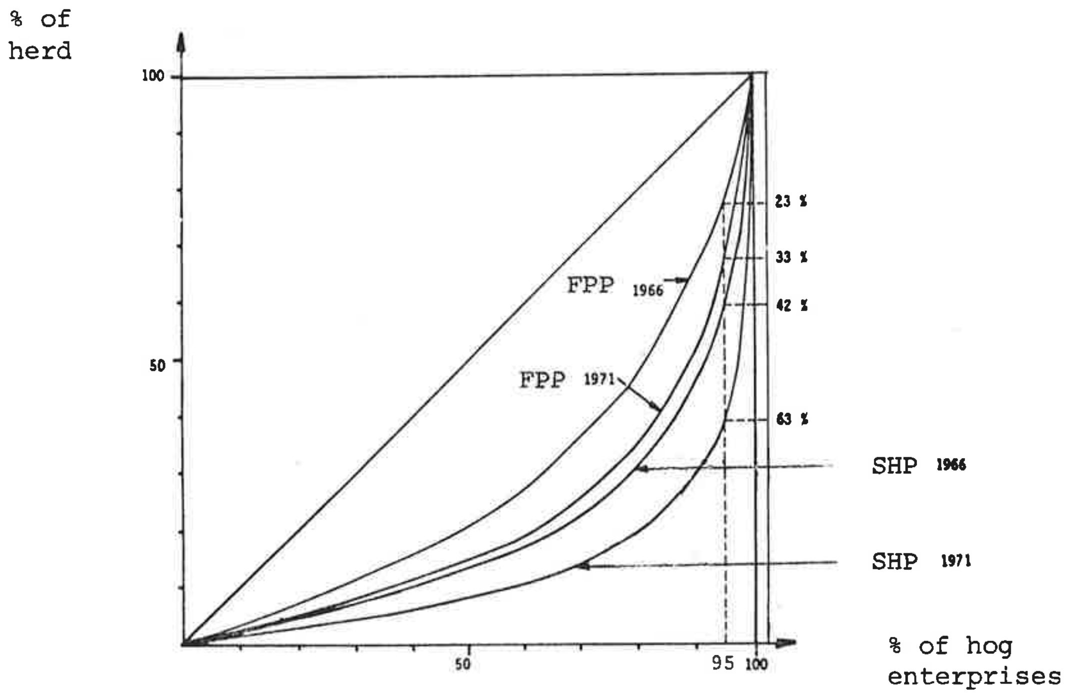
Source : S.C.E.E.S.

Table 3.3 - Size distribution and concentration of slaughter hogs units (1966-1972) (slaughter hogs over 50 kg weight)

	size class (nb of slaughter hogs)	1-4	5-19	20-49	50-99	≥100	total
april 66	nb of operation (1 000)	273.6	115.5	18.8	3.2	2.3	413.4
	% of total operations	*66.2*	*27.9*	*45*	*0.8*	*0.6*	
	cumulated %		94.1	98.6	99.4	100	
	nb of slaughter hogs (1 000)	577.1	998.8	540.3	215.1	488.6	2 820.9
	% of total hogs	*20.5*	*35.5*	*19.1*	*7.6*	*17.3*	
	cumulated %		56	75.1	82.7	100	
dec.68	nb of operations (1 000)	517.0	95.0	18.6	6.4	4.4	641.4
	% of total operations	*80.6*	*14.8*	*2.9*	*0.91*	*0.7*	
	cumulated %	80.6	95.4	98.3	99.3	100	
	nb of slaughter hogs (1 000)	930.3	818.7	539.4	432.9	937.2	3 658.5
	% of total hogs	*25.4*	*22.3*	*14.7*	*11.8*	*25.6*	
	cumulated %		47.8	62.5	74.4	100	
dec.69	nb of operations (1 000)	454.7	83.8	19.4	6.8	5.4	570.1
	% of total operations	*79.7*	*14.7*	*3.4*	*1.2*	*0.9*	
	cumulated %		94.4	97.8	99	100	
	nb of slaughter hogs (1 000)	803.2	732.1	572.2	464.9	1172	3 744
	% of total hogs	*21.4*	*19.5*	*15.3*	*12.4*	*31.3*	
	cumulated %		41.0	56.3	68.7	100	
dec.70	nb of operations (1 000)	411.6	79.7	18.8	5.4	7.1	522.6
	% of total operations	78.7	*15.2*	*3.6*	*1.0*	*1.3*	
	cumulated %		94.0	97.6	98.6	100	
	nb of slaughter hogs (1 000)	765.4	696.9	548.4	365.6	1341.9	3 808
	% of total hogs	*20.0*	*18.3*	*14.4*	*9.6*	*37.6*	
	cumulated %		38.3	52.8	62.4	100	
dec.71	nb of operations (1 000)	420.7	74.1	16.7	7.1	7.4	526
	% of total operations	*79.9*	*14.1*	*3.2*	*1.4*	*1.4*	
	cumulated %		94.0	97.2	98.6	100	
	nb of slaughter hogs (1 000)	776.8	631.8	501.3	492.5	1652.4	4 055
	% of total hogs	*18.9*	*15.6*	*12.4*	*12.2*	*40.8*	
	cumulated %		34.7	97.1	59.2	100	
dec.72	nb of operations (1 000)	399.2	67.0	12.9	6.8	9.8	
	% of total operations	*80.5*	*13.5*	*2.6*	*1.4*	*2.0*	
	cumulated %		94	96.6	98.0	100	
	nb of slaughter hogs (1 000)	720.8	565.0	387.0	483.1	2153.5	4 309.5
	% of total hogs	*16.7*	*13.1*	*8.0*	*11.2*	*51.0*	
	cumulated %		29.8	37.8	49.0	100	

Source : S.C.E.E.S.

Figure 3.1 - Concentration of hog farming enterprises
1 - FPP (piglet producers, sows)
2 - SHP (slaughter, fattenned hogs > 50 kg)



in 1966 and 15,400 in 1972 taking a share of the sow-herd of respectively 8 % and 44 %. Fig. 3.1 shows the importance of the concentration for both activities in 1966 and 1971. The concentration is higher for SHP than for FPP, and the concentration in the SHP group (1) has been going faster.

Table 3.4 - Evolution of the share of production according to specialized hog operation

		1966 april	1968 april	1968 dec.	1969 dec.	1970 dec.	1971 dec.	1972 dec.
Feeder Pigs Producers	nb operations (1 000)	154	119	79	83	75	70	-
	% of sow herd	*49,0*	*36,5*	*28,7*	*33*	*31*	*32,1*	*30*
Mixed hog-farms	nb operations (1 000)	154,5	175,6	176,5	167,2	164,1	145,3	-
	% of sow herd	*51,0*	*63,5*	*71,3*	*67*	*68*	*68*	*70*
	% slaughter hogs herd (1)	*43*	*43*	*37,5*	*37*	*39*	*38,6*	*38*
		2,2	2,2	1,8	1,7	1,5	1,7	-
Slaughter hogs Producers	nb operations (1 000)	259	286	465	403	358	381	-
	% slaughter hogs herd (1)	*57*	*57*	*62,5*	*63*	*61*	*61,4*	*62*

(1) Slaughter hogs (over 50 kg weight)

Source Statistique Agricole SCEES

An important point must be made about the share of total production marketed by the three groups of specialization. Table 3.4 shows that the SHP group produces 62 % of marketed slaughter hogs in 1972. This share has not changed really from 1968 to 1972, in spite of the favor of

(1) Concentration change is over estimated for SHP since the survey of 1966 was not made in december but in april when the hogs raized for self consumption are already turned into cold cuts

of extension advisers for the mixed type operation, which among other advantages, would better escape the price fluctuations of feeder pigs which are about twice as large as those of slaughter hogs. This situation creates some difficulty to choose the appropriate output price for an aggregate supply model. For FPP the appropriate price is the one of feeder pigs, for SHP it is slaughter hog price, and for mixed type of operation the decision to market or to feed the piglets probably depends on the ratio between expected SH price and current FP price.

Other important changes have occured with size increase and concentration, as well as under the influcence of agricultural policy which I shall discuss briefly later on. Hog production used to be a side product of milk when it was still transformed into butter on the farms. Potatoes and other roots were the complementary source of feed, little protein and barley was used in the 1950's. By that time self consumption of pork amounted to about a third of total production, and a half of nationally inspected slaughter. Milk processing in large facilities, along with farm labor shortage have broken down the old factor mix of hog production. A lot of capital has flowed into the subsector, particularly in the last decade when new facilities had to be created to increase labor efficiency and to adopt the new feeding practices based on the protein-cereal mixture and more recently, automatic feeding. There are no complete data on invested capital into hog production, but on the basis of subsidies granted to new constructions one may evaluate the total capital invested from 1966 to 1973, to an amount close to 8.5 billions Francs, which is about the cash farm receipts for hogs in 1973. Another way to measure the investment effort in this decade is to compare the new logding capacities with actual herd growth. New constructions for sows are 50 % higher than the actual increase of sow numbers. They are 60 % higher for slaughter hogs. Considerable replacement of facilities has therefore occured along with creation of new large hog operations.

Feeding practices have changed a lot during the same period. Increasing opportunity cost of farm labor has shifted feed rations toward

Figure 3.3 - Location of hog production in France (1974)

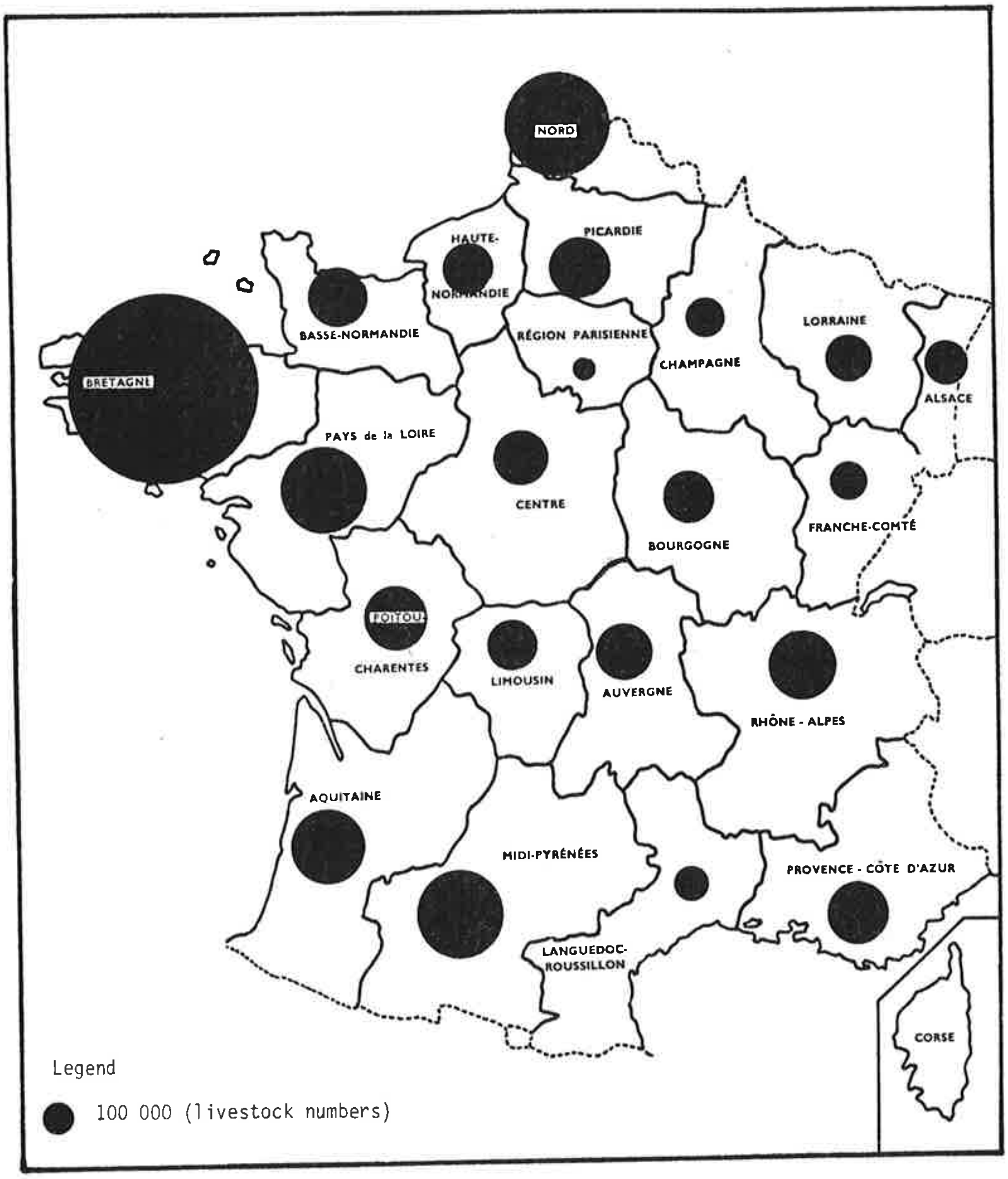
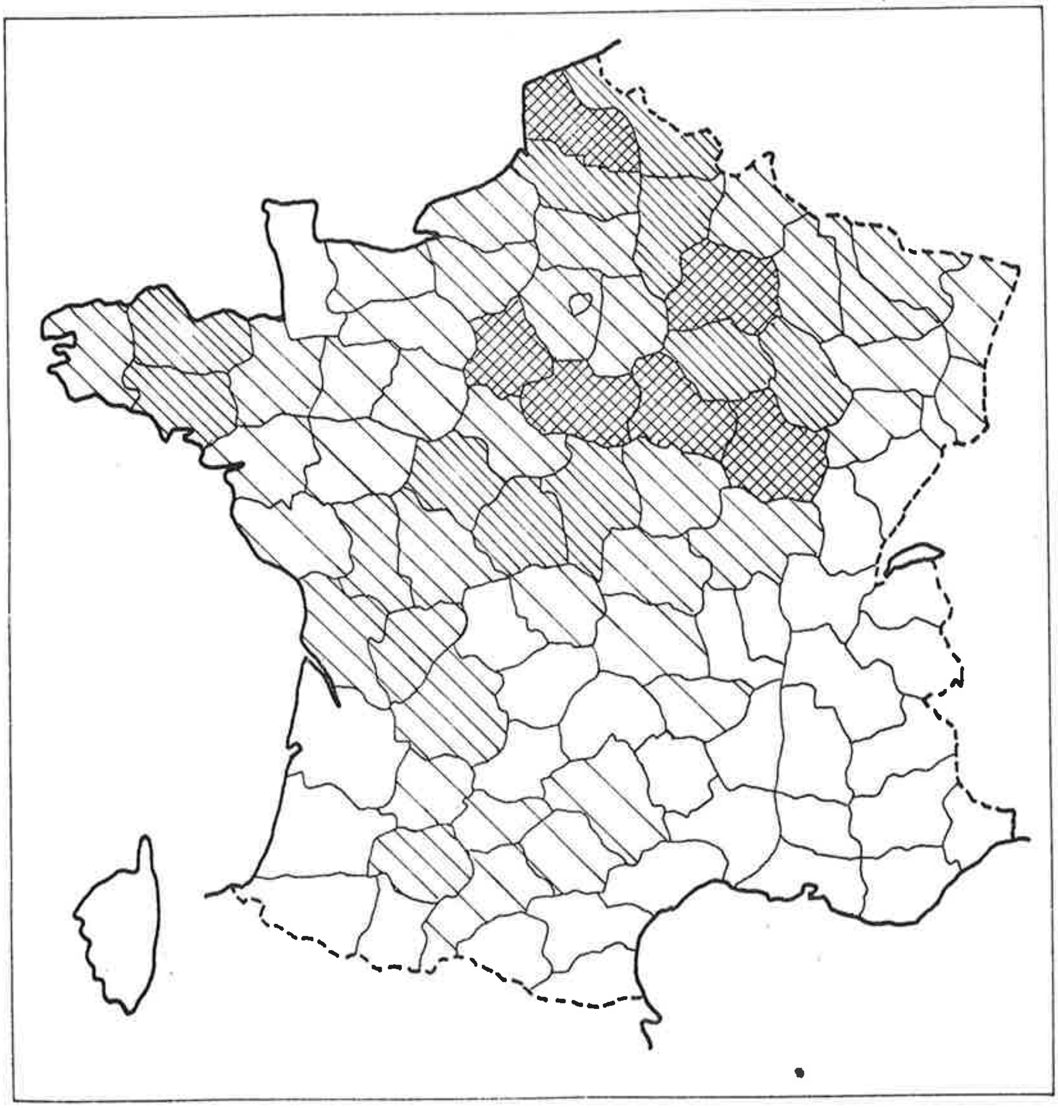


Figure 3.2 - Map of feed grains production in 1974

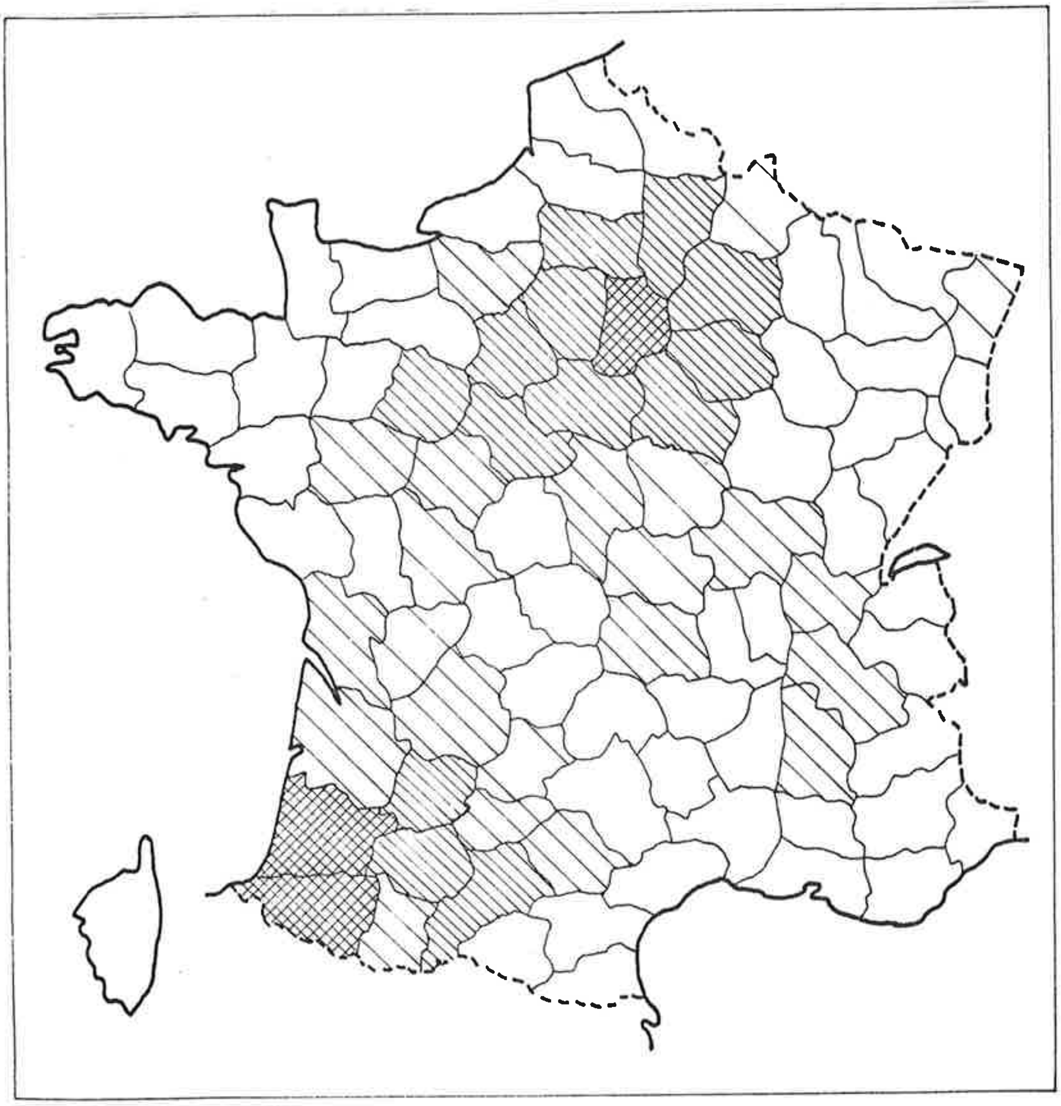
a) BARLEY



(tons) | - 50 000 | 50 000 à 100 000 | 100000 à 200 000 | 200 000 à 300 000 | + 300 000

Source : O. N. I. C.

Figure 3.3 - Map of feed grains production in 1974
b) CORN



(1 000 tons) -50 | 50–100 | 100–200 | 200–500 | +500

Source : O. N. I. C.

feed grains and concentrated protein sources (oilakes), much easier to feed to hogs raised in confinement. An important feature of French hog industry is its location away from the main feed grain producing areas (fig. 3.2 and 3.3). Therefore hog operation has become more and more independent of the available land on the farm. Consequently a larger share of feed is now bought out of the farm where hogs are raised. As early as 1965 72 % of source of energy was provided by feed grains. But purchased feed (mostly protein ans minerals complements) accounted for only 30 % of the ration fed to hogs. By that time 60 % of the energy nutrients was produced on the hog farming operation itself. In 1971, the situation has changed a lot under the influence of the feed-mix industry, which as grown tremendously during these five years. It provides 65 % of the ration in 1971.

Some economists have used the term of industrialization to define the structural changes in hog farming. This concept, vague whatsoever, is certainly an exageration. But there is no doubt that hog farming has become specialized and more involved in commercial channels for both input supply and output destination. Quite a few policy advisers were thinking in the early 70's that these structural changes, concentration, specialization, invested capital, would determine a drastic shift of supply behavior in the direction of increased stability. I shall deal with this issue with more detail when examining the empirical results of estimation.

12 - Consumption, prices

France ranks fifth in the world for meat consumed per head (table 3.5) French consumers eat more meat than any other EEC member. For pork however Germany comes first in the EEC with 48 kg/head while France is fourth with 32,7 kg/head. Pork consumption has increased more than any other meat from 1950 to 1970 (table 3.6). It is now the second source of meat and accounts for 11 % of the consumer expenditure on food.

Table 3.5 - Meat consumption in OCDE countries (1972)
(in kilogram/hea) (1)

Belg.	Den-mark	France	Germa-ny	Ire-land	Italy	Nether-lands	U K	Austra-lia	Canada	Japan	New-Zeland	Spain	Swe-den	Swit-zerland	USA
24.5	12.4	22.0	21.5	19.6	22.3	17.5	22.3	)40.5	41.5	3.7	42.2	0.1	14.8	19.9	52.6
2.4	3.8	6.5	1.9	-	3.1	0.4	0.2	)	1.6	-	3.4	1.4	1.0	6.3	1.0
35.6	34.0	32.7	48.8	30.9	15.3	28.8	28.0	14.5	26.4	8.6	13.5	15.4	27.5	35.5	30.5
0.9	0.4	3.3	0.3	11.6	1.1	0.2	9.5	30.7	2.1	1.4	38.8	3.9	0.5	1.1	1.5
3.5	0.2	1.7	0.1	-	1.0	2.6	-	-	-	0.5	-	0.5	0.7	0.6	-
9.4	5.4	15.1	8.9	11.6	13.4	6.4	12.5	12.2	20.6	6.2	7.1	9.8	3.8	7.0	23.6
1.4	0.6	(2.0)	0.9	-	2.5	-	0.7	-	-	1.2	-	0.8	-	1.2	1.1
6.0	6.6	8.8	4.5	12.3	3.1	4.9	4.4	5.7 (a)2.0	1.8 (a)3.5	1.7	5.1	1.9	2.5	4.9	4.8
83.6	63.5	92.1	86.9	86.0	61.8	60,9	77.6	105.6	97.5	23.3	110.1	43.7	50.8	76.7	115.2

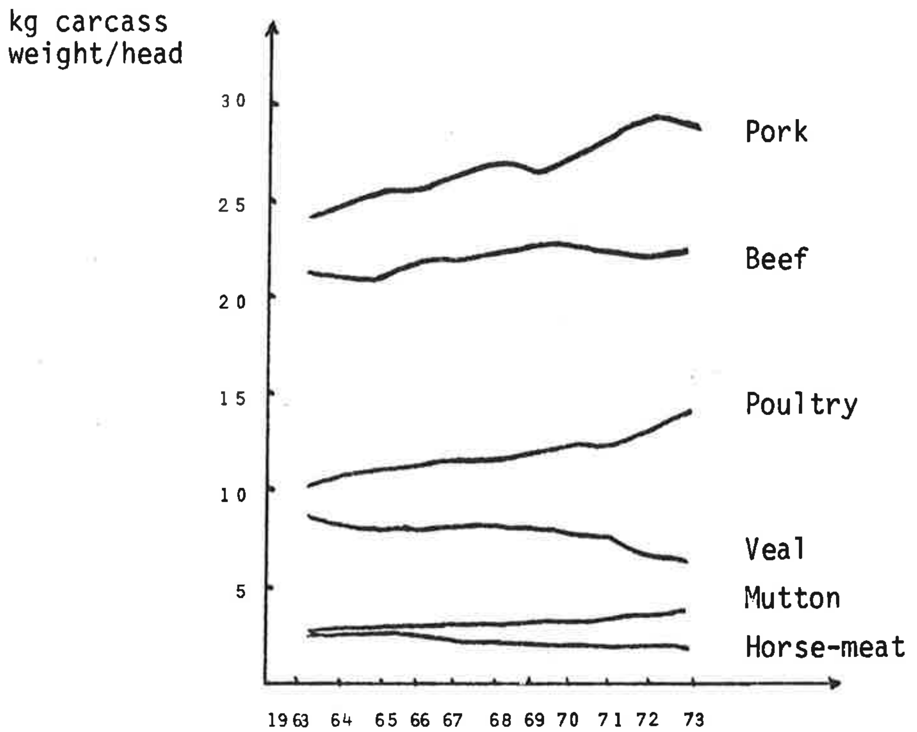
Source : "Les bilans de la viande pour les pays de l'OCDE 1974
(1) carcass weight without blood, head, bellies and dressing fat.

Table 3.6 - Relative share of various meat products in the consumer food budget (% of food expenditure in francs)

	1950	1960	1965	1970
Beef, veal, mutton, horse	10.5	13.0	13.7	13.3
Pork	7.8	10.2	10.9	11.1
Poultry, eggs	9.6	7.9	7.4	7.3
Fish and canned meat	2.8	3.4	3.6	4.1
Total, fish and meat	30.7	34.5	35.6	35.8

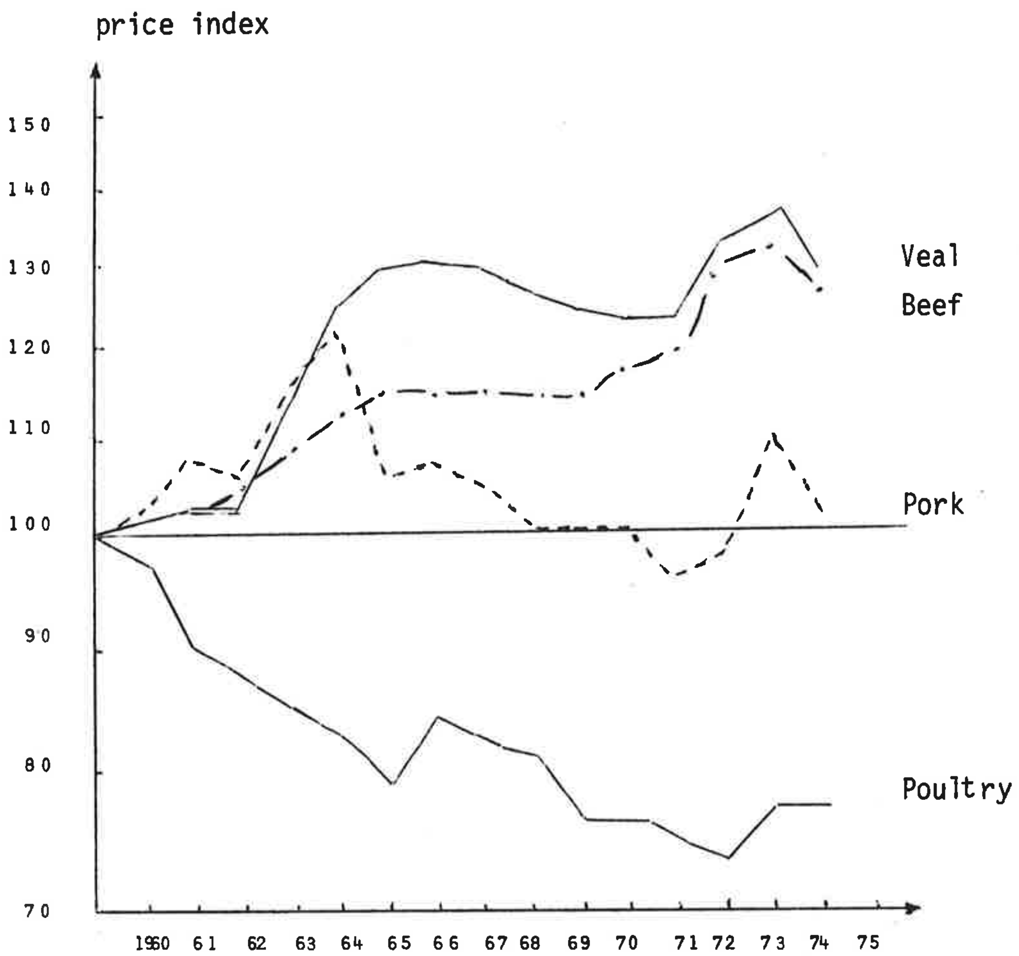
Source : INSEE, VIIè Plan

Figure 3.4 - Variation of consumption per head for various kinds of meat (1963-1973) .



Consumption increase of pork meat, as well as poultry meat, is mainly due to the steady decreasing trend of prices in real terms of these two kinds of meat. At the retail level their relative price has considerably improved their competitive position with respect to beef and veal (fig. 3.5). As in all countries, technical progress in feed-conversion ratios and "labor efficiency" has lowered the production costs to a considerable extent.

Fig. 3.5 - Retail meat price index for main meats (1960-1974)



Source : INSEE (BAC 74/4)

Around the trend, prices have been fluctuating with a rather regular cyclical pattern of period three years in the average. Prices fluctuate much more at farm level than a retail, as usual for agricultural products. Feeder pigs price fluctuations are about twice as large as hog price fluctuations, which may be roughly explained by the intermediate product nature of piglets whose derived demand follows final output price (fig 3.6)

As for all cyclical productions, price fluctuations originate mostly in supply, which exhibits also a cyclical pattern (fig 3.7). During the sample period 1955-1973, consumption has increased rather steadily at a rate running from 2 to 3 percent each year. Another dominant feature of French hog industry during that period is the shift from a net exporting position to a net deficit, which as culminated in 1969 and stays at a rather constant level since. The slower growth of production relatively to consumption goes back before EEC trade bar iers removal for pork which occurred in 1967 along with cereals.

Figure 3.6 - Price of pork at retail, of hogs at farm level and feeder pigs price

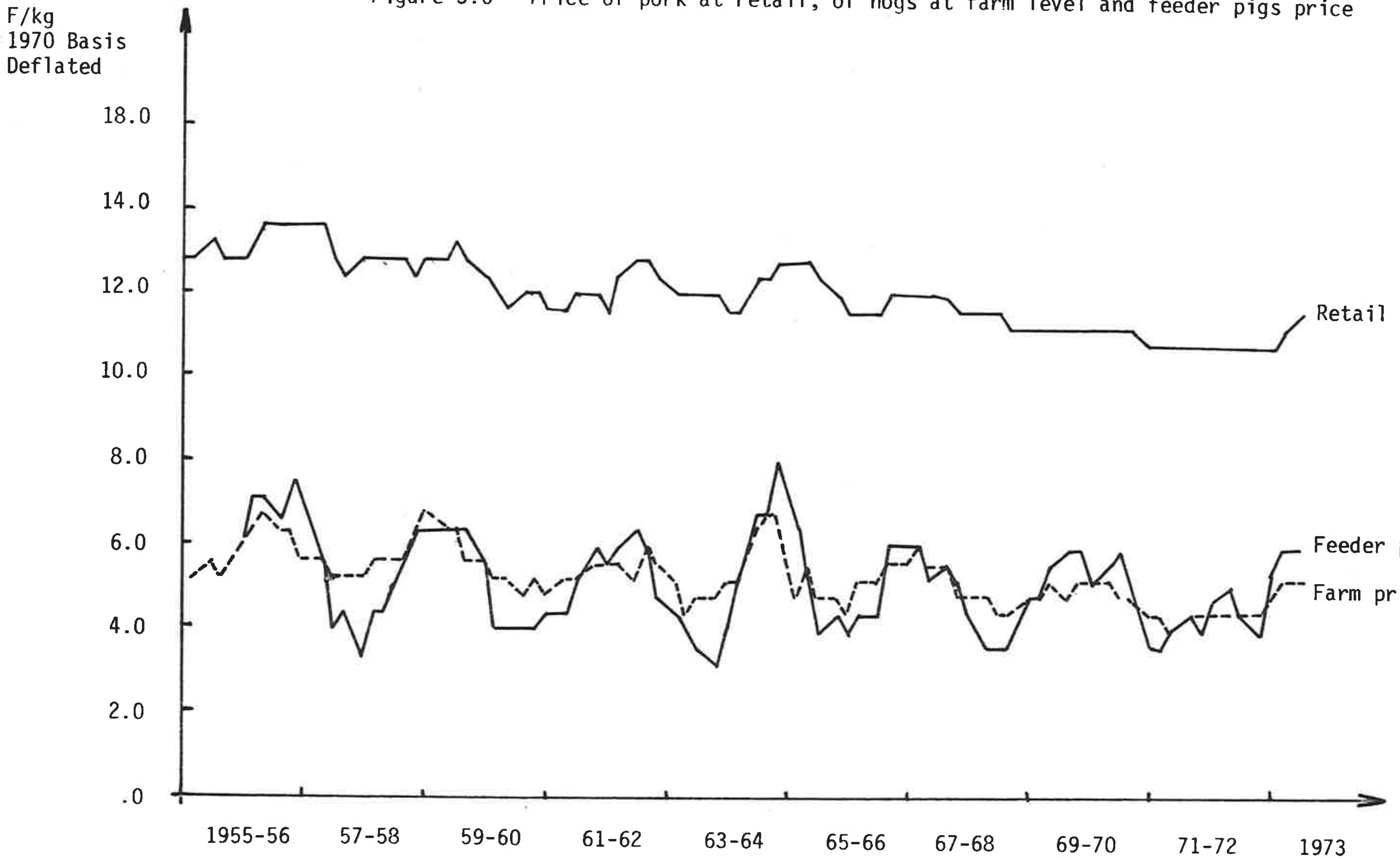
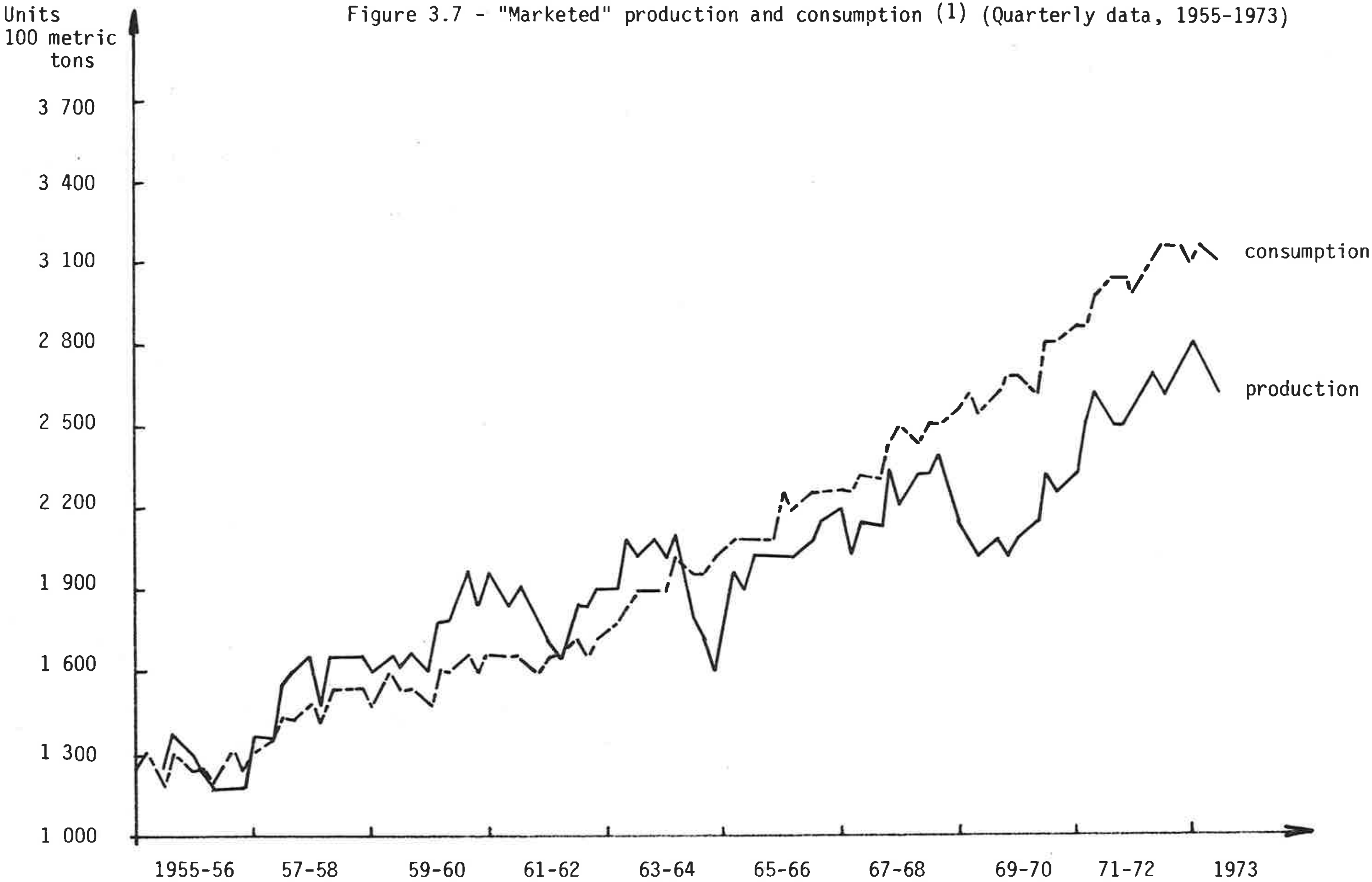


Figure 3.7 - "Marketed" production and consumption (1) (Quarterly data, 1955-1973)



(1) theses series exclude "on farm consumption" which is not marketed.

13 - Trade, EEC and policy

The output mix of French agriculture appears to be rather inefficient since it leads to exporting about 50 % of the grains produced, while 15 to 20 % of pork meat is imported. Hog being mainly a cereal transformer, other members of EEC have demonstrated their competitive position based on grain supply advantages on world market before CAP enforcement and higher feeding efficiency afterwards. Belgium and Netherlands are the main suppliers of pork meat to France. No special study of interregional competition for pork in EEC as been made as yet. The first idea of emphasizing feed cost and proximity of large markets as explanations does not fit well to the new regional pattern. While it applies to Belgium and Netherlands as to their proximity to the large industrial towns of EEC, it does not work for Brittany which is far away from both factor supply and consumption markets. This region has however developped hog production more than any other in EEC, multiplying by 3 or 4 its hog production from 1966 to 1972.

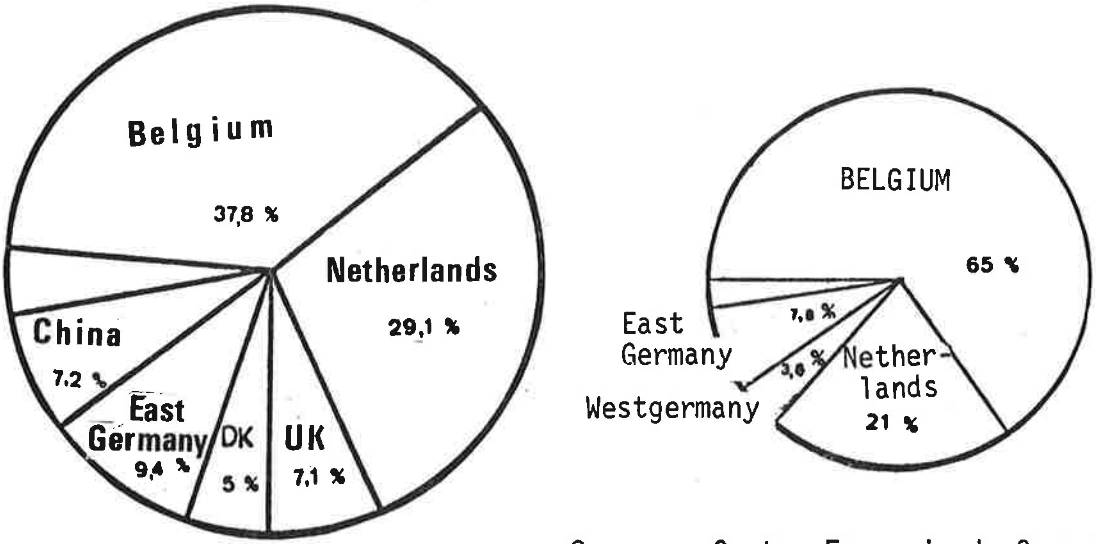
Table 3.7 - Some items of the trade balance for French agriculture (billion Francs)

			1967	1974
1 - Imports				
	Cereals		0.48	0.51
	Feedstuffs		0.7	2.3
	Meat (all)	live	0.14	1.1
		carcass	1.1	3.8
	Pork	live	0.43	0.41
		carcass	0.45	1.2
2 - Exports				
	Cereals		2.3	11.1
	All meat	live	0.36	2.3
		carcass	0.5	2.3
	Pork		ε	ε

Source : INSEE, Compte de l'agriculture 1974

Figure 3.8 - Relative shares of countries in pork imports (1974)

dressed carcass (186 000 t) live hogs (total, 909 000 heads)



Source : Centre Français du Commerce Extérieur

Fig. 3.8 shows the proeminent role played by Belgium and Netherlands in French imports of pork. Table 3.8 gives an account of the relative importance of EEC members as hog producers.

EEC is almost exactly self sufficient in pork meat either with 6 or 9 members. This fact explain in part why no active supporting price policy has been set up thoughout the period under study (table 3.9). Negligible action has been taken for stabilization puposes either. Three percent of the European guaranty fund (FEOGA) was spent on pork and beef meat from 1962 to 1971 (as opposed to 40 % for cereals).

Table 3.8 - Total pork meat produced in EEC countries (1 000 tons)

Member country	1967	1968	1969	1970	1971	1972
Germany	2 317	2 541	2 555	2 619	2 738	2 732
France	1 374	1 401	1 297	1 375	1 491	1 541
Italy	461	542	533	588	644	660
Netherlands	558	627	617	701	795	790
Belgium	334	367	375	465	508	542
Luxembourg	12	12	10	10	10	9
EEC (6 members)	5 056	5 490	5 387	5 758	6 186	6 274
UK	765	797	683	875	953	929
Ireland	738	717	686	720	768	763
Denmark	99	115	131	134	145	152
EEC (9 members)	6 658	7 119	7 067	7 487	8 052	8 118
% variation/preceding year	+ 2,7	+ 6,7	— 0,8	+ 5,9	+ 7,5	+ 0,8

Source : Office statistique des Communautés Européennes OSCE

Table 3.9 - Self sufficiency rate in EEC countries for pork

Country	56-60	69-70	70-71	71-72
Germany	94	95	92	90
France	101	83	86	86
Italy	94	85	82	81
Netherlands	146	188	200	195
Belgium / Luxembourg	106	150	174	166
EEC (6 members)	100	100	101	99
UK	—	67	72	62
Ireland	—	173	158	167
Denmark	—	504	519	507
EEC (9 members)	—	103	105	101

Source : Office statistique des Communautés Européennes OSCE

The trade position is quite different among members however. Larger countries import a significant share of their needs. Since the CAP implies free trade between members, France was unable to take protectionist measures to improve her balance for pork meat. The slow growth of French production has been attributed in part to the 1960-62 Agricultural Orientation Act which limited the size of hog enterprises and restricted this activity to persons having the status of farmer (to avoid corporate pork farming).

National policy measures appeared necessary with the increasing trade deficite ; but they had to comply with CAP principles, i.e. mainly free trade throughout EEC. So called "structural policy" was therefore set up which was based on subsidies granted to building investments in hog enterprises. Those funds amounted to 20 to 40 % of the capital invested by hog farmers. Total goverment subsidies for that program amounted to 1.3 billions francs from 1966 to 1973. In order to receive the grant, farmers have to belong to so called "producers associations" (1) which are the corner stone of French agricultural markets policy. These associations mainly built on cooperatives were supposed to foster in an "organised" way, production and marketing. Besides improving management practices they were expected to "control" production so as to smooth price fluctuations. An aknowledge objective of this policy was to reduce the instability in the subsector by increasing the share of these producers associations in the total output. Table 3.10 shows the significant increase ot these farmers organizations from 1966 to 1971, in the marketing of hogs.

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(1) Groupements de producteurs.

Table 3.10 - Break down of the production according to the type of buyer

	Feeder pigs			Slaughter hogs		
	1966	1969	1971	1966	1969	1971
association	3	15	32	4	19	25.0
merchants	67	54	43	94	78	72.6
farmers	29	28	23	-	-	0.8
miscellaneous	1	3	2	2	3	1.6
Total	100	100	100	100	100	100

Source : SCES Statistique agricole supplément série étude n° 67, 68, 105.

Structural changes encouraged by policy measures were expected to induce more stability in production and prices along with improved efficiency. Some analysts talked frequently in terms of "planned production" that the producers associations would "control". Consequently they expected the hog cycle to dampen shortly. The recent deep crisis of 1974 has brought some reason into the debate and no one would dare say now that the hog cycle is about to disappear due to the increased share of production achieved by specialized and "organized" farmers. One aspect of this problem will be tested for with the help of the model, namely the change of supply elasticity during the sample period.

2 - Data available, implications for specification and possible biases

A well known problem in applied econometric is to find data on variables as close as possible to the economic concepts defined in the theoretical model. Discrepancies between empirical variables and theoretical specifications impose limitations on the meaning of the results and their use for policy purposes. On the other hand, it is often necessary to adjust the specification of the model to set it in form compatible with observed variables. I have used both strategies, specifying the supply and trade blocks in a simplified way to comply with limited available data, while I have done some transformations on certain observed variables to be in a position to estimate the demand block.

21 - The supply block

I have explained in chapter two why the lack of data on inventories of hogs on farms prevented to specify a supply model with farrowings or inventories as the dependent variable, which is the most popular formulation. The only source of data on supply is based on nationally inspected slaughter, which is available since 1949. Therefore I specified a model based on marketed production (numbers and quantities) explained mostly by lagged prices. Although close to the original cobweb exposition, this formulation has been little used where inventories are also available. Heien [18] in USA, Kettunen [26] in Denmark for pig supply, and Strecker and Esselman [42] for piglets supply in Germany are the few examples I know of. The conceptual aspects of this specification have already been discussed, but we may emphasize here the expected difficulties encountered to specify the lag structure since lagged prices are highly intercorrelated when quarterly data are used. The resulting multicolinearity increases the variance of the estimates and the constraints imposed on the lag structure may lead to biases.

There are three time series available on hog production in France. The first is inspected slaughter corrected by trade balance in live animals (1). This is the most reliable set of data and corresponds to the marketed supply both in numbers and in weights. Estimates of total pro-

(1) Marketed production = inspected slaughter + exports (live) - imports (live).

duction have been made by taking into account undeclared slaughter (from small butchers) and on-farm slaughter. In 1953 undeclared slaughter was estimated at 34 % of inspected slaughter while on farm consumption was evalued at 284 000 t i.e. more than a half of inspected slaughter. In 1974 the total production is estimated at 1.4 million tons while marketed production is at 1.130 million. Since the corrections made to get total supply are rather unreliable, especially for the first part of the sample period, I chose the marketed production time series in the estimation of supply. Of course, the coefficient of time in the supply equation has to be interpreted in this light. Since the common interpretation is to relate the trend in supply to technical progress, its impact would be grossly overestimated if one forgets that time is also an instrumental variable for decreasing on-farm consumption and undeclared slaughter. A minor point must be added concerning the slaughter data. In a first stage of the research I used monthly time series ; I worked then with data corrected for the number of working days in each month so as to reduce measurement errors on variables. With quarterly data this correction is less important. Monthly time series on prices at the farm level are available since 1953 for both hogs (in index form) and feeder pigs (nominal price). These data are not free from faults since they are based on local markets with a debatable representativity. It is not clear however in which vay they affect the results.

Since a large share of slaughter hogs are farrowed outside of the fattening units, the proeminent role on available supply is played by feeder pigs producers. It would have been appropriate to specify a market model for feeder pigs, as done by Strecker and Esselman. But again no data on quantities are available, and an attempt to build time series of piglets production based on breeding statistics (1) gave deceiving results. Consequently a "partially reduced form" (2) of the piglet market was used in the supply block.

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(1) From early sixties to 1972, hog forecasting were based on breeding survey.

(2) In the sense of Hildreth and Jarret (quoted by Foote [10], p. 102).

A detailed analysis of the impact of policy measures has not been feasible, due to the lack of data. The only set of homogeneous time series on policy action deals with public storage. This variable is easily included in the supply block and its effects estimated. The magnitude of public storage variations has been quite slim during the period however and never larger than 0.5 % of the marketed production. Moreover it was not possible to know wether the stocks were sold on the national markets or exported. These facts limit considerably the quality of the results about this particular policy instrument. I mentionned earlier that little stabilizing action was taken over the period, and particularly after hog production was included into the Common Agricultural Policy (1967). However noticeable so called "structural policies" were initiated . Some of the measures consisted of investment subsidies granted to producers, processing industry, farmers associations, extension and research agencies. Another group of measures was meant to contribute more directly to stabilization by subsidies granted to private storage holders, and to producers associations. The latter were supposed to set up buffer funds of their own so as to stabilize prices paid to their members and consequently the future supply. as a convenient set of data on all these subsidies was not ready to introduce in the model, I left the policy analysis for later work, since it requires a lot of data collection and working up to put them in a suitable form for statistical use (1). I did not use zero-one variables which could have been a first step, since they have a tendency to pick up any concomitant or accidental event, and also because they do not lead to really meaningful results for future policy action.

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(1) The elaboration made by Houck, Ryan, Abel, Subotnik [21, 22, 40] on the set-aside program is an example of the difficulty of specifying testable policy variables in a supply model.

22 - The demand block

By demand block I mean the equation of demand at retail and the margin equation. The data on consumption have also shortcomings which may affect both the quality of the fit and the meaning of the parameters. They correspond to "apparent consumption" rather than real consumption, since they are derived from inspected slaughter corrected by trade both in live animals and in dressed carcass or cuts. There is no available information on private storage, neither for households nor for processors. Only public storage is taken into account. Since a large part of pork is processed into cold cuts and canned food easily preserved, there are certainly measurement errors on the consumption variable. These errors may not be too bad when aggregation over time is high. It is expected that quarterly data are better than monthly ones on that point of view. I have not tried to set up the demand equation in the framework of errors - on - variables, since I would have needed good information on consumer buying habits (complicated by the increasing use of home freezers) and on processors'storage behavior, in order to make explicite assumptions about the properties of errors in such a model. This work could be done however, when the consumers'panels set up recently will provide the relevant information. For private storage made by processors, a specific statistical survey should be developped, particularly if short run farm price fluctuations are to be understood.

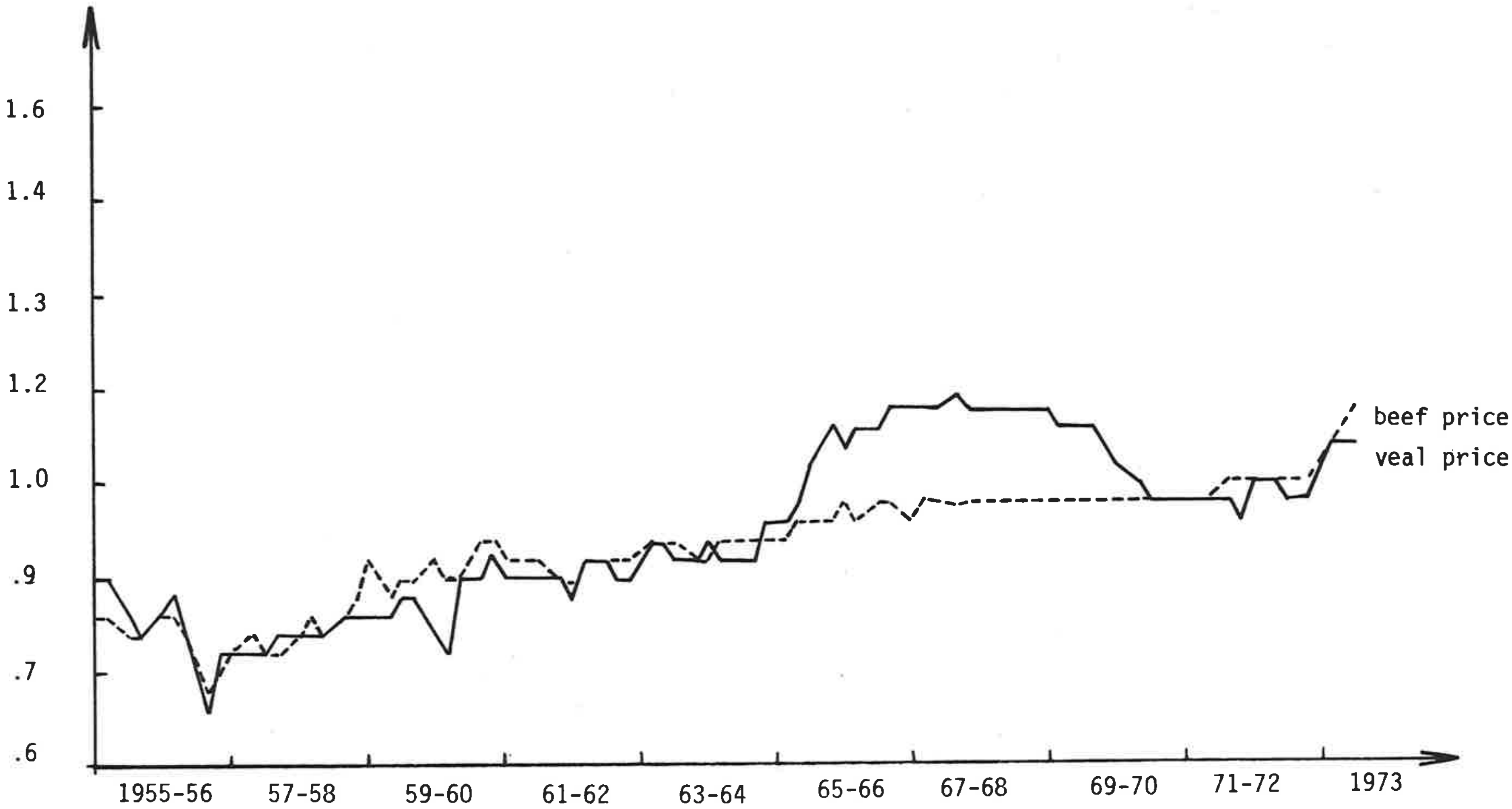
The same remarks as made to marketed supply, apply to consumption. The time series I used is marketed consumption since correction for self-supply and undeclared slaughter are thought to be rather unreliable. Now it is the income elasticity which must be interpreted with caution, since the share of production going to the market has increased. Income elasticity may therefore be biased upwards and should be used cautiously in making long run predictions.

Exclusion of on-farm consumption may still have two more effects. Preliminary analysis showed that it reacts negatively to market price. As expected, farmers keep less pork for they own needs when prices are high. In that sense they behave in a similar way to other consumers, even if they may consider rather the opportunity cost of not selling a hog that the price of the good consumed. The price coefficient is not very significant however (Student's t is 1.1), and the elasticity is about - 0.35 quite lower than the "marketed demande" elasticity (about - 0.5). The aggregate demand price elasticity is therefore over estimated by using the marketed consumption data since we leave out the less elastic component of total demand. The second effect of excluding on-farm consumption is to modify the structure of the seasonnality. On farm-slaughter takes place mainly in winter months, while marketed consumption is higher in spring and fall.

Disposable income was not available on a quarterly basis. Only recently the INSEE has started building up quarterly national accounts. In order to cover the whole 1955-1974 period, I had to disaggregate annual series. Simple linear interpolation and another method using quarterly weights based on industrial production index were used. They did not give significantly different results.

Data on prices at retail are drawn from subsets of the consumer's price index (CPI), relative to pork, beef, veal, poultry meats. The series have the pitfall of reflecting the composition of meat budget bought by the so-called blue collar workers, which certainly include more lower quality cuts than for average consumer. These price indices do not reflect the actual variation of the price of an average carcass at the butcher's stall. This is true for pork but even more for the more expensive beef meat. Moreover because of the psychological importance of beef prices at retail, they are narrowly looked over and submitted to reglementations, so that the representativity of the index may be subject to doubt. The rather flat aspect of the beef index (cf. fig. 3.9) time series strenghten this impression. This may be one of the reasons why I have always obtained a positive sign to the beef price index coefficient when included in the demand for pork. Concluding that the two meats are complementary would certainly need a lot of qualified explanation.

Figure 3.9 - Beef and veal retail price indices



It is known that the parametres of the marign equation are not easily interpreted when price indices are used. If we start with a simple model expressed in terms of prices $P'_t = \alpha + \beta P_t$ where P'_t and P_t are prices respectively at retail and farm level, using indices does not allow to identify simply α and β,

$$\frac{P'_t}{P'_0} = \frac{\alpha}{P'_0} + \beta \frac{P_0}{P'_0} \frac{P_t}{P_0}$$

where the subscript 0 refers to the base year. One would need to know the prices at the base year which is not common. In order to have a more apparent meaning of the above equations, I converted the price indices of pork into prices. This is certainly not free from faults since indices reflect also changes in the weights used to build them. I have done this however, using observed price at farm level in 1970 (average grade) as a norm for farm price. For retail price I have used a weighted price of the retail prices of cuts in 1970, trying to get as close as possible to the average carcass composition. I am not assuming that we fit exactly to the first equation by doing so; I believe however that we get closer to estimating the absolute marging α and the slope coefficient β. Particularly when an adjustment lag is allowed for retail prices, this formulation is more convenient to discuss short run and long run margin behavior.

23 - The trade equation

As said before the trade position of France for pork has changed a lot during the sample period. Data on both quantities and prices were not available over the whole period in a convenient way. Since the stress of the research was not the analysis of this aspect, the trade part of the model was somewhat neglected and left for later work. I recently got data for Belgium and Netherlands which after some working up will be useful to analyse the trade aspects of pork in EEC. This part of the model should include the policy actions taken by the Commission of the EEC both on feed grains and on pork. Since monetary problems have recently complicated the picture, this is a research projects in itself and will be taken up later on. For now, only a net import equation has been estimated, which betrays noticebly the economic problem since quality of exports (fat) differsfrom quality of imports (lean cuts).

All the prices and income were deflated by the consumer's price index. The choice of the deflator may affect the estimation of variables correlated with time. GNP price index was not available on a quarterly basis. CPI deflator was also used for farm level prices, although some authors would prefer using the farm price index. Using two different deflators could alter in an artificial way the parameters of the margin equation for example. When deflating a price by the CPI, the latter was not corrected by excluding the particular price to be deflated. The bias incurred by doing so was felt to be small in view of the small share of particular items in the total consumption budget (about 3 % for pork).

Seasonnality was not eliminated, but the raw data used. Dummy variables were included in the equation to pick up seasonnal effects.

3 - Empirical results

The presentation of the results is organized in the following way. First I shall expose the complete estimated model including the fitted equations eventually chosen after the various specifications tried. This will show in a clearer way the general structure of the price-quantities determination model for the hog market. The nature of the assumptions made on variables as to endogeneity will be more easily discussed in this content along with estimation procedures. The main results about supply and demand behavior will then be described.

In the second part of this section, I will give an account of the work of estimation made on the different equations, emphasizing again the supply part.

Lastly I will discuss briefly the possibility of a change in supply behavior over time in the context of the drastic structural changes which have recently occurred.

31 - The complete model

It is composed of six relations including supply and feeder pigs price equations, demand and margin equations, net import equation and clearing identity.

Let us define the symbols used for the various variables included.

t refers to quarterly data
QS_t quantities of hogs marketed (100 t)
D_t consumption of pork per head (in 0.1 kg)
N_t population (in 10^6 heads)
M_t net imports i.e. imports - exports (100 t)
PSI_t public storage net increase (100 t) i.e. purchases minus sales
RHP_t retail pork price (francs/kg, 1970 basis)
FHP_t farm hog price (francs/kg, 1970 basis)
PGP_t piglets price (francs/kg, 1970 basis)
REV_t disposable income minus investment of individual firms (francs/head, 1970 basis)
VP_t retail veal price index (deflated)
FPI_t feed cost price index (deflated)
SP_t, SU_t, FA_t dummy variables for seasonnality.

. Supply block

Supply : (1955-1973, 75 obs.)

$$\text{(3.1)}\quad QS_t = \underset{(2.3)}{186} + \underset{(4.5)}{103\ SP_t} - \underset{(4.2)}{98\ SU_t} + \underset{(1.8)}{42\ FA_t} + \underset{(3.8)}{3.9\ t} + \underset{(12.3)}{0.76\ QS_{t-1}} + \underset{(4.4)}{30\ WPGP_{t-5}} - \underset{(4.4)}{6.0\ PGP_t}$$

$\bar{R}^2 = 0.963$ d = 1.65 h = 1.76

(estimated under constraint on the coefficients of lagged and current prices, with $QPGP_{t-5} = 0.2\ PGP_{t-6} + 0.6\ PGP_{t-5} + 0.2\ PGP_{t-4}$).

Piglet price equation (partially reduced form of the feeder pigs market) (1961-1973, 48 obs.)

$$\text{(3.2)}\quad PGP_t = \underset{(3.1)}{-5.0} + \underset{(4.0)}{0.69\ SP_t} - \underset{(1.2)}{0.19\ SU_t} - \underset{(2.9)}{0.48\ FA_t} + \underset{(6.7)}{0.035\ t} + \underset{(15.7)}{2.08\ FHP_t} - \underset{(1.86)}{0.018\ FPI_t}$$

$\bar{R}^2 = 0.85$ d = 1.2

. Demand block

Demand (1955-1973, 75 obs.)

$$\text{(3.3)}\quad D_t = \underset{(2.7)}{13.6} + \underset{(4.6)}{1.37\ SP_t} + \underset{(0.08)}{0.02\ SU_t} + \underset{(3.3)}{.99\ FA_t} + \underset{(3.7)}{0.43\ D_{t-1}} - \underset{(2.7)}{0.87\ RHP_t} + \underset{(4.7)}{0.096\ REV_t}$$

$$+ \underset{(1.2)}{1.57\ VP_t}$$

$\bar{R}^2 = 0.99$ d = 1.99

Margin (1955-1973, 75 obs.)

$$\text{(3.4)}\quad RHP_t = \underset{(1.97)}{1.47} + \underset{(2.3)}{0.13\ SP_t} + \underset{(2.3)}{0.14\ SU_t} - \underset{(1.3)}{0.07\ FA_t} + \underset{(12.9)}{0.74\ RHP_{t-1}} + \underset{(6.4)}{0.30\ FHP_t} - \underset{(0.75)}{0.001\ t}$$

$\bar{R}^2 = 0.944 \quad d = 1.5 \quad h = 2.2$

. Trade equation (1955-1973, 75 obs.)

$$(3.5)\quad M_t = -537.6 - \underset{(3.4)}{18.6}\, SP_t + \underset{(2.0)}{54.7}\, SU_t + \underset{(0.1)}{3.1}\, FA_t + \underset{(10.3)}{0.75}\, M_{t-1} + \underset{(3.7)}{0.027}\, REV_t \cdot N_t + \underset{(2.5)}{54.9} FHP_t$$

(3.4) (.7) (2.0) (0.1) (10.3) (3.7) (2.5)

$\bar{R}^2 = 0.90 \quad d = 1.9 \quad h = 0.44$

. Clearing identity

$$(3.6)\qquad QS_t + M_t \equiv N_t . D_t + PSI_t$$

Numbers between parentheses are the Student's t value coresponding to the null hypothesis of the corresponding coefficient. $\bar{R}^2$ is the R^2 adjusted for degrees of freedom. d is the Durbin Watson statistic and h is the Durbin (1) test of serial correlation for auto-regressive models [25, p. 313].

None of these statistics applies rigorously to the present simultaneous model. It was believed that theywould give a rough idea of goodness of fit and properties of the errors. The h statistic should be used instead of the d which is biased towards 2 when the equation is auto-regressive. It is a large sample test which is not inconsistent with the size of our sample. I do not know however how it behaves in the context of a simultaneous model.

The general working of the model implies the following economic behavior. Feeder pig prices level at quarters t-6, t-5, t-4, initiate the

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(1) Durbin J. Testing for serial correlation in least squares regressions when some of the regressors are lagged dependent variables. Econometrica 38, p. 410-21, 1970.

the production process (selection of females, breedings) which will turn up the available supply of slaughter hogs at t, i.e. about a year and half later. This available supply sets the range of possible marketed supply. The exogenous parts of demand and imports together with possible public storage variation complete the clearing conditions on the market. Farm hog prices adjust, altering simultaneously marketed supply, demand and imports so that eventually market equilibrium is achieved at time t. Farm hog prices resulting at this time will react on the derived demand for feeder pigs expressed by slaughter hog producers. Equation (3.2) shows that this derived demand depends a lot more on the output price (FHP) than on the level of feeding costs (FPI), as may be seen also by the relevant elasticities given subsequently. The level of feeder pig prices will in turn induce feeder pig producers to adjust their level of activity to the new expected profitability conditions, initiating a new cyclical process.

Parting the variables into exogenous and endogenous groups follows from the above assumed economic behavior. The previous discussion of chap. 2, supported by the empirical results to be discussed in the next section, justifies the assumption of "some" limited endogeneity of the marketed supply. Demand, imports are clearly endogenous (D_t, M_t). Pork, hogs and feeder pigs prices are also endogenous since they adjust simultaneously with quantities to the general clearing conditions on the market. This makes six endogenous variables consistent with the six structural equations (3.1 to 3.6).

While the exogeneity of some exogenous variables (REV_t, PST_t, N_t) may be easily accepted, the exact nature of others is debatable. The feeder price index is certainly more and more dependent on the outlook on the hog market, the more so as a steadily increasing part of the ration is purchased from the feed-stuff industry. On the demand side the same line of argument applies to veal price as well as to beef and poultry prices eventually excluded because of wrong signs. These remarks show the need for a complete model of the feed-stuff - livestock meats subsector, as done by many authors elsewhere.

The assumed set of exogenous and predetermined variables makes all the equations in the model overidentified from the order condition point of view. The situation may no be so bright on the rank condition, since for example main shifters on supply (time) and demand (income) are highly correlated. Other shifters (FPI_t, VP_t) which are less correlated, seem also to play a limited identifying role. Predetermined variables help improving the identifiability of the structural equations.

Simultaneous equations methods of estimation have been used for the above equations. Since I did not have a self contained routine to get 2 stages and 3 stages least squares estimates, I proceeded in two steps (1) as required by 2 SLS, to get instruments for the endogenous explanatory variables : PGP_t, FHP_t, RHP_t. The estimation method used would be better called instrumental variables methods, since new instruments for the endogenous variables were not built each time a minor alteration of the specification was made on some equations of the model. There is probably a loss of efficiency in the estimates, arising from this procedure, but computer limitations made the task clusy. On the other hand, since the precise lag structure of the supply equation was not known, all the prices lagged from t-1 to t-6 were included into the reduced form of the price equations in order to improve the quality of the instrument. Similarly all the quantities lagged by one period (M_{t-1}, D_{t-1}, S_{t-1}) were not introduced since they almost verify the clearing identity. The multicollinearity was quite bad however in these equations. It is not really important for the instrument itself but it is not so if one wants to draw some economic information from the reduced form. As the estimation of public storage effect can only be done on the reduced form, its measure is quite poor. Its effects on farm hog price for example is apparently negligible (flexibility $\partial \text{Log } FHP_t / \partial \text{Log } PSI_t = 0.0001$), and not significantly different from zero, although

(1) This is why the statistics $\bar{R}^2$, d, and h were available while they are given in 2 SLS and 3 SLS routines, since their properties are not established.

the sign is correct. Similar comments apply to the effect of feed price index on the piglet price, which is much lower (but with correct sign) than the estimate derived from the "structural" equation (3.2). The overall quality of the three instrumental variables used for prices is not good, as seen on the R^2 of the reduced form. This reflects, in part, the great variance of hog prices at farm level.

equation	R	R^2	$\bar{R}^2$
PGP	.93	.87	.83
FHP	.93	.86	.82
RHP	.98	.96	.94

The estimated reduced form of the farm hog price equation is given to illustrate the type of results gotten at this stage (1955-1973, 75 obs.).

$$
\begin{aligned}
(3.7)\quad FHP_t = {} & \underset{(2.0)}{2.8} - \underset{(2.0)}{0.28}\, SP_t + \underset{(2.4)}{0.26}\, SU_t - \underset{(.19)}{0.03}\, FA_t - \underset{(1.5)}{0.02}\, t + \underset{(C.2)}{0.81}\, FHP_{t-1} - \underset{(0.3)}{0.06}\, FHP_{t-2} \\
& - \underset{(0.8)}{0.13}\, FHP_{t-3} - \underset{(0.4)}{0.06}\, FHP_{t-4} - \underset{(1.7)}{0.27}\, FHP_{t-5} + \underset{(0.2)}{0.2}\, FHP_{t-6} + \underset{(1.5)}{0.9}\, VP_t + \underset{(0.9)}{1.8}\, REV_t \\
& + \underset{(0.7)}{0.001}\, PSI_t + \underset{(0.1)}{0.0004}\, FPT_{t-5} - \underset{(.4)}{0.002}\, QST_{t-1} - \underset{(1.1)}{0.00}\, M_{t-1}
\end{aligned}
$$

$\bar{R}^2 = .82 \qquad d = 1.9$

From the fitted model (3.1) - (3.6) we can derive estimates of both long run and short run elasticities of supply, demand and imports as well as multipliers for the farm retail price relationship. The first remark may deal with adjustment speed in the various equations implied by the coefficients of the lagged dependent variable. They have to be interpreted with caution however, even in the present case where the auto-regressive form has been justified by economic rationale for the supply equation, and where similar arguments of slow adjustment to prices may apply to demand, margin and imports equations. It is well known that the lagged endogenous variable may pick up effects due to a serially correlated explanatory variable excluded from the model. Similarly slow changes of the structure of the model may produce positive serial correlation of the residuals and bias upwards the auto-regressive term coefficient and therefore underestimate adjustment speed. This problem is not unlikely to occur in the present case given the length of the sample period and the structural changes in the industry.

Those reservations being made the fitted model suggests a slow adjustment in the supply, the farm-retail price equation, and the import equation. Only one fourth of total adjustment would occur during the current period. Long run elasticities would therefore be about for times SR ones. This results is particularly questionable for the trade equation, since trade flows would be expected to adjust more quickly to price differential between countries. But this expectation remains vague whatsoever and the main reason for doubt is the simple form of the import equation which does not include as it should, foreign current price trade policies variables, and exogenous foreign supply shifters (like foreign (1) lagged price). Demand and particularly piglet price ajdust more quickly.

Equation (3.1) and (3.2) are used to derive "marketed" supply elasticities both SR and LR with respect to feeder pigs and hog prices, and also feed cost index. The marketed supply price elasticity relates to hog price as defined in chap. 2 and as done by most authors. The feeder pigs price equation is only intermediary and reflects the peculiarities of French hog industry.

---

(1) Home lagged price was tried as an instrument for the foreign price, without success.

Table 3.11 - Marketed supply elasticities* with respect to :

	PGP	FHP	FPI
short run	0.075	*0.156*	- 0.037
long run	0.31	*0.65*	- 0.154

* computed at the mean from equation (3.1) for the 1st column and completed by (3.2) for the 2d and 3d.

The marketed supply elasticity with respect to feed cost is small relative to hog price elasticity. This result suggests that using the hog feed price ratio as an explanatory variable is not well founded in this country contrarily to a current practice in United States, although Harlow [15, p. 39] found a corn price elasticity of .42 half of the hog price elasticity (.82). Kettunen [26, p. 48]found a feed elasticity higher than hog price elasticity (.63 and .25). These differences may reflect the feed balance situation fo hog farming units in various countries. One may expect that feed cost will become more important in the supply of hogs in France with the increase of purchased feed-stuffs.

It is hazardous to compare the estimates of supply elasticity with respect to hog price in different studies since specifications and structures of production vary with countries and studies. A sample is given however in table 3.12 as general reference. Estimates vary a lot in the range .13 to .82. It is not easy to sort out specification reasons for different results, from actual differences in "supply elasticity". Specification seems to play the major role in view of the variability of results for the same country. Table 3.12 is not well suited either for illustrating the discussion of chap. 2 relative to the results gotten when inventories or marketed supply are used as explained variable. Canadian results tend to confirm the argument that supply model using marketed supply tend to yield higher supply elasticity. The same is true for the

Table 3.12 - Some published estimates of supply elasticity for hogs with respect to hog price

Authors/ country	sample period	time unit	dependent variable	presence of lag. dep. variable	price elasticity SR	price elasticity LR	R^2	recursive simultaneous
HARLOW [16] U. S.	1949-1960	year	farrowings spring fall	no no	.82 .56		.91 .92	rec.
DEAN, HEADY [9] U. S.	1938-1956	year	farrowings spring fall spring	no no yes	.60 .30 (1)	.65	.93 .92 .76	rec.
KETTUNEN [27] Denmark	1956-1965	quarter 1/2 year	marketed qty produced qty produced qty	no no no	.25 .20 .25		.84 .89 .90	rec.
HIEN [19] U. S.	1950-1969	year	nb of pigs slaughtered	no	(2) .39		.58	rec.
REIMER, KULSHRE-SHTHA [39] Canada	1949-1971	year	inventories	no	.13		.95	rec.
CHIN, PANDO, WEST [7] Canada	1961-1972	1/2 year	nb of heads marketed	yes	.36	.61	.93	rec.
TRYFOS [44] Canada	1951-1971	1/2 year	inventories	yes (3)	.39		(3)	sim.
present study	1955-1973	quarter	marketed quantities	yes	.16	.65	.96	sim. (4)

(1) The adjustment coefficient was not significantly different from one.
(2) Hog corn ratio as explanatory variable.
(3) The coefficient of the lagged inventories is 1.11. Theil's U = .02 (the estimate .39 was termed by Tryfos inventories elasticity w.r.t price)
(4) With a restraint on the lagged and current price coefficient.

the two specifications of Kettunen (production vs marketed quantity). But it is not so fore U.S. results. Again specification are different at too many viewpoints (dependent variable, lags in prices, time unit, presence of partial adjustment), to give a clear cut illustration of the argument. The next section devoted to justify the final form of the supply equation (3.1), will give a more coherent set of evidence as to the consequences of using numbers or quantities, simultaneity or recursiveness. But absence of inventory data will prevent from giving a complete illustration.

Turning now to the other equations of the model let us consider the feeder pig market reduced form (3.2). Feeder pig price adjust almost immediately to hog price. Including PGP lagged by one unit of time gave an adjustment coefficient of .83, not really significant (t = 1.8), giving a long run elasticity of PGP w.r.t. FHP of a similar magnitude (2.16 instead of 2.11). Equation (3.2) should include a lagged piglet price i.e. the cyclical shifter of supply for feeder pigs. This was tried but gave no significant estimates for PGP_{t-5} and PGP_{t-6} coefficients, although they have the correct sign (1). The dominant role of the demand for feeder pigs in the explanation of PGP is obviated by the above results. The positive effect of time on the PGP equation most probably accounts for the slower rate of technical progress in feeder pigs production compared to fattening. Number of piglets saved has increased much less than the feed conversion ratio

The demand equation (3.3) yields elasticities given in table 3.13

Table 3.13 - Demand elasticities (at mean values)

	pork retail price	veal price	income
SR	- .23	+ .03	.45
LR	- .40	+ .05	.79

As announced before, the main surprise in demand estimation, was the consistently negative (non significant) effect of beef prices. Using the wholesale price instead of retail gave similar results. This result contradicts the evidence in most countries. The (unpublished) work on meat demand made by the I.N.S.E.E. does not show clear cut substitution effects, and my results were not thought of as very surprising. An explanation can be proposed for the substitution veal-pork and the independance of pork

(1) When lagged PGP was introduced the feed cost coefficient tended to disappear.

demand w.r.t. beef price. French consumer eats more veal meat than in any country. Veal, pork and poultry belong to the white meat group inside of which substitution could take place, while no substitution would occur between white and red meats, one may also assume that in order to capture pork-beef substitution one should use the prices of beef cuts more likely to be substituted to pork. These cuts have yet to be determined and this study has been left for later work involving a systematic analysis of the demand for various meats.

On a more theoretical view-point it may be argued that including beef price in demand does not measure the true substitution effect of the Slutsky equation, since no compensation takes place. One may then assume that, given the importance of beef in the meat budget, given its positive high income elasticity, given also its psychological importance, an increase of beef prices may depress all meat consumption by the income effect. In any case our results are at variance with known pork demand analyses. Table 3.13 also shows that the homogeneity condition is not satisfied either, demonstrating that more work is needed on the demand side of the model.

The high level of income elasticity may be attributed to the particular definition of consumption mentionned before, i.e. exclusion of self supply on farm. Similarly, since the marketed part of total consumption has increased considerably, we may expect that the price elasticity of marketed demand overestimates the price elasticity of total demand relevant to the first part of the period. In this context, it is useful to check if drastic changes of structures have occured in the model over the years Covariance - like analysis has been applied to the demand equation, although we work with simultaneous equations. It is hoped that the F test for structural change does not behave too badly in this situation. The results given by equations (3.8) and (3.9).

1955-1966 48 obs.

$$(3.8)\quad D_t = +8.7 + \underset{(2.0)}{1.1\,SP_t} - \underset{(3.7)}{.5\,SU_t} + \underset{(1.7)}{1.0\,FA_t} + \underset{(3.2)}{.30\,D_{t-1}} - \underset{(2.0)}{.49\,RHP_t} + \underset{(1.8)}{.099\,REV_t} + \underset{(4.3)}{6.9\,VP_t} \quad (2.0)$$

$R^2 = .977 \qquad d = 1.95$

1967-1973 27 obs.

$$(3.9)\quad D_t = 55.1 + \underset{(2.9)}{1.3\,SP_t} + \underset{(3.4)}{1.48\,SU_t} + \underset{(1.0)}{.46\,FA_t} + \underset{(1.0)}{.24\,D_{t-1}} - \underset{(28\ )}{3.1\,RHP_t} + \underset{(2.4)}{.089\,REV_t} - \underset{(.48)}{2.0\,VP_t}$$

Table 3.14 - Change in demand elasticities

sub period \ w.r.t.		RHP	VP	REV
1955-66	SR	- .15	.16	.45
	LR	- .21	.21	.59
1967-73	SR	- .64	nega-	.42
	LR	- .84	tive	.55

The change of structure is accepted on the face of the F test (calculated $F_{8.59} = 23$, table $F_{8.59} = 2.1$). This change contributes to explain why the adjustment coefficient was .56 in the estimation over the whole period, while subperiods estimates are over .70. The main evidence is the apparent unchanged income elasticity, the fading out effect of veal price, and particularly a noticeable increase of price elasticity in magnitude. Although this last result is consistent with the rapid increase of pork consumption relative to other meats and the fall of pork price in real terms, the magnitude of the change comes out as a surprise. May be the exclusion of undeclared slaughter which has been decreasing sharply over the period, has something to do with it by way of measurement errors. This is an easy expost explanation which cannot be considered as sufficient.

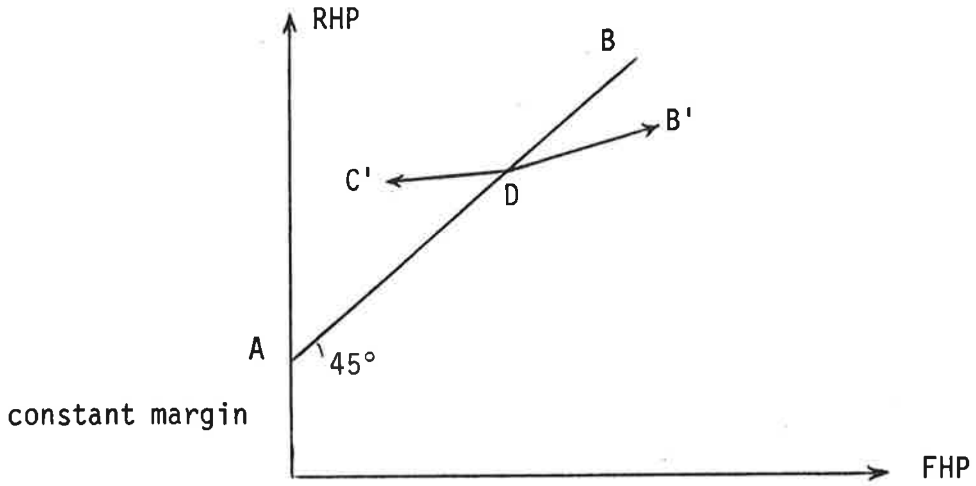
We turn now to the margin equation (3.4). It is a well known fact that retail prices fluctuate more than farm prices, so we expect that the slope parameter of FHP would be less than one on the short run. The estimate .30 is consistent with this general evidence, about a third of the farm price variation would be transmitted to retail in the current quarter. But this is about a fourth of the total adjustment as implied by the lagged retail price coefficient. In the long run the slope would be 1.16. Is the marketing sector behavior based on constant or proportionnal margins ? On the face of the results the margin behavior would be of the mixed type. We cannot test directly if the long run slope is equal to 1 since it involves a non linear transformation. However the short run slope is not significantly different from .25, and it is tempting to accept the model of variable margins in the short run but constant in the long run.

Following many authors [10, 19] marketing costs and production were introduced in the e ation to get closer to the under lying reduced form. Wages in the food industry seem to play a positive role on retail price which is consistent with theory, but t value was low (.65). The time coefficient was still negative as technical progress in marketing implies, but its level of significancy decreased further (t = .56 vs..76). These two effects contributed to maintain margins about constant in real terms in the long run. The production variable was also unsignificant but seemed to play a negative role on retail prices.

One particular point was considered in the marketing behavior, in the line of statements frequently made that retailers are responsible for non symmetric transmission of farm price fluctuations. If this hypothesis were true, it would mean that retailers hold some market power relatively to consumers in the short run which allow them to resist price fall at farm level. In the long run however competition would still work and with the help of inflation real margins would still follow the costs, since equation (3.4) imply constant margins in the long run. If the pricing behavior were not symmetrical in the short run, then the marketing sector would contribute to the inflation process by the food part of the consumers'budget. Fig. 3.10

illustrates this possible margin behavior. In the long run retailers move on the AB line which has slope one. But in the short run they move on the broken line C'DB' if the price transmission is asymmetrical.

Figure 3.10 - Margin behavior



In order to test this hypothesis a dummy variable B_t was built taking the value of one when farm hog price decreases and zero otherwise. The asymmetrical transmission would be reflected by a negative coefficient of the variable $B_t.FHP_t$. Regression were runned for whole pork and for the subset fresh pork the less processed part of the carcass.

(1955-1973, 75 obs.) whole pork

$$(3.10)\quad RHP_t = 1.18 = \underset{(2.2)}{.12\ SP_t} + \underset{(2.2)}{.13\ SU_t} - \underset{(1.4)}{.08\ FA_t} - \underset{(.4)}{0.0009\ t} + \underset{(5.9)}{.29\ FHP_t} - \underset{(.66)}{0.0066\ B_t.FHP_t}$$

$$+ \underset{(10.7)}{.77\ RHP_{t-1}}$$

$R^2 = .944 \quad d = 1.56 \quad h = 2.2$

(1955-1973, 75 obs.) Fresh pork (1)

$$(3.11)\quad RHP_t^f = -\underset{(1.1)}{.07} + \underset{(1.1)}{.013}\, SP_t + \underset{(2.3)}{.026}\, SU_t - \underset{(1.8)}{.02}\, FA_t + \underset{(2.5)}{.0006}\, t + \underset{(4.7)}{.040}\, FHP_t - \underset{(1.7)}{0.003}\, B_t \cdot$$

$$FHP_t + \underset{(16.1)}{.85}\, RHP_{t-1}^f$$

$R^2 = .86 \qquad d = 1.76 \qquad h = 1.0$

The empirical results are not very clear cut, but it is probable that a moderate ratchet effect does exist in retail pricing behavior. Quite small when all pork is considered, the slope differential represents about 10 % in the fresh pork equation. Splitting the margin behavior into two parts seems justified by the reduction of serial correlation which results. The pricing behavior seems different for fresh pork and processed pork meat. Since the latter part accounts for about 2/3 of the whole, the ratchet effect would be quite small for the aggregate pork price index is considered. Nevertheless the existence of a contribution of the marketing sector to inflation cannot be discarded on the basis of these results. It would be small enough and temporary since margins tend to be constant in the long run, which is consistent with a high level of competition remaining in the retail sector.

Last, the net import equation (3.5) though showing an acceptable fit and little serial correlation, is insufficient for useful policy analysis. Elasticies with respect to price and income (both 2.2 in the SR and 8.8 in the long run) are high as usually found in trade equations.

Fig. 3.11 to 3.15 the time series of actual and fitted walues for the five behavioral equations.

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(1) The price variable for fresh pork is an index so that the magnitude of coefficient are not comparable in (3.10) and (3.11).

Figure 3.11 - Actual and fitted value, supply (eq. 3.1)

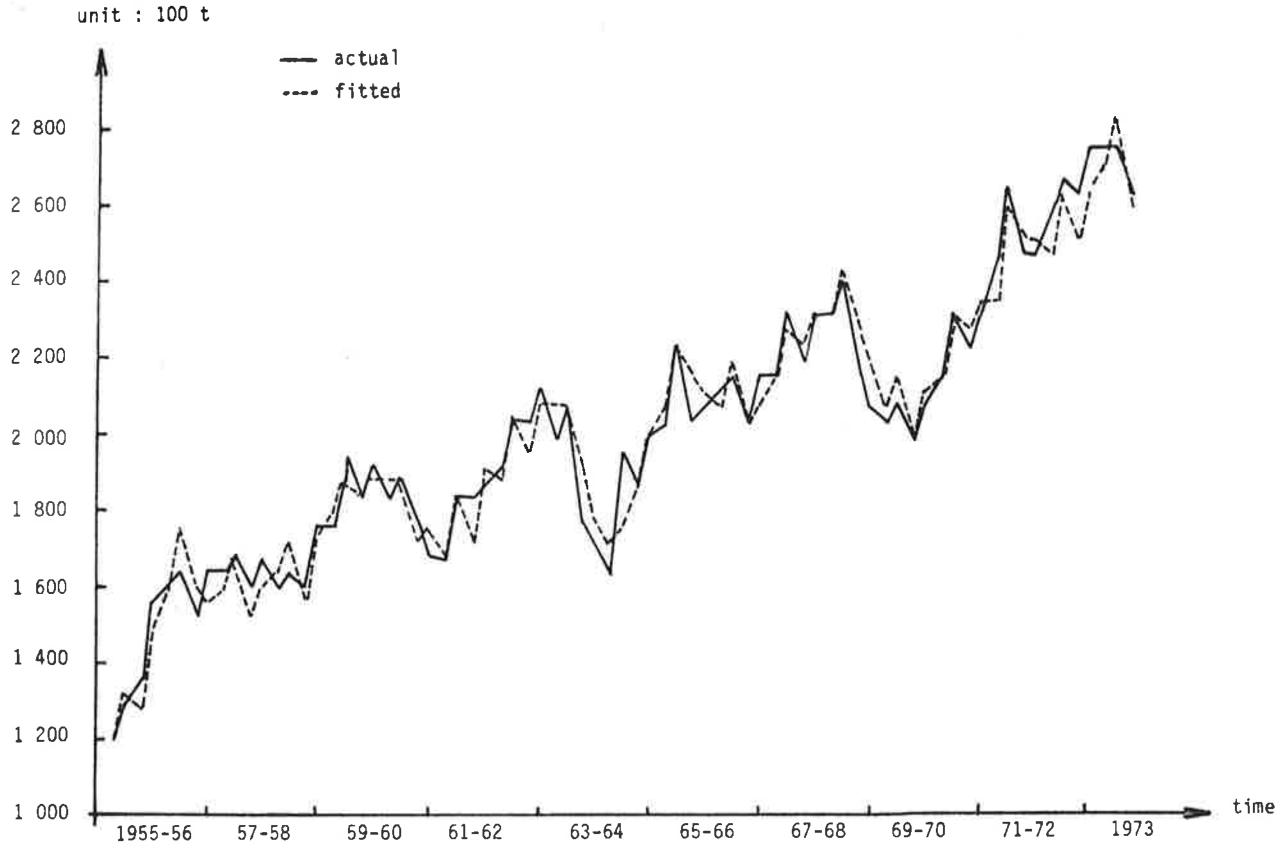


Figure 3.12 - Actual and fitted values : feeder pigs price (eq. 3.2)

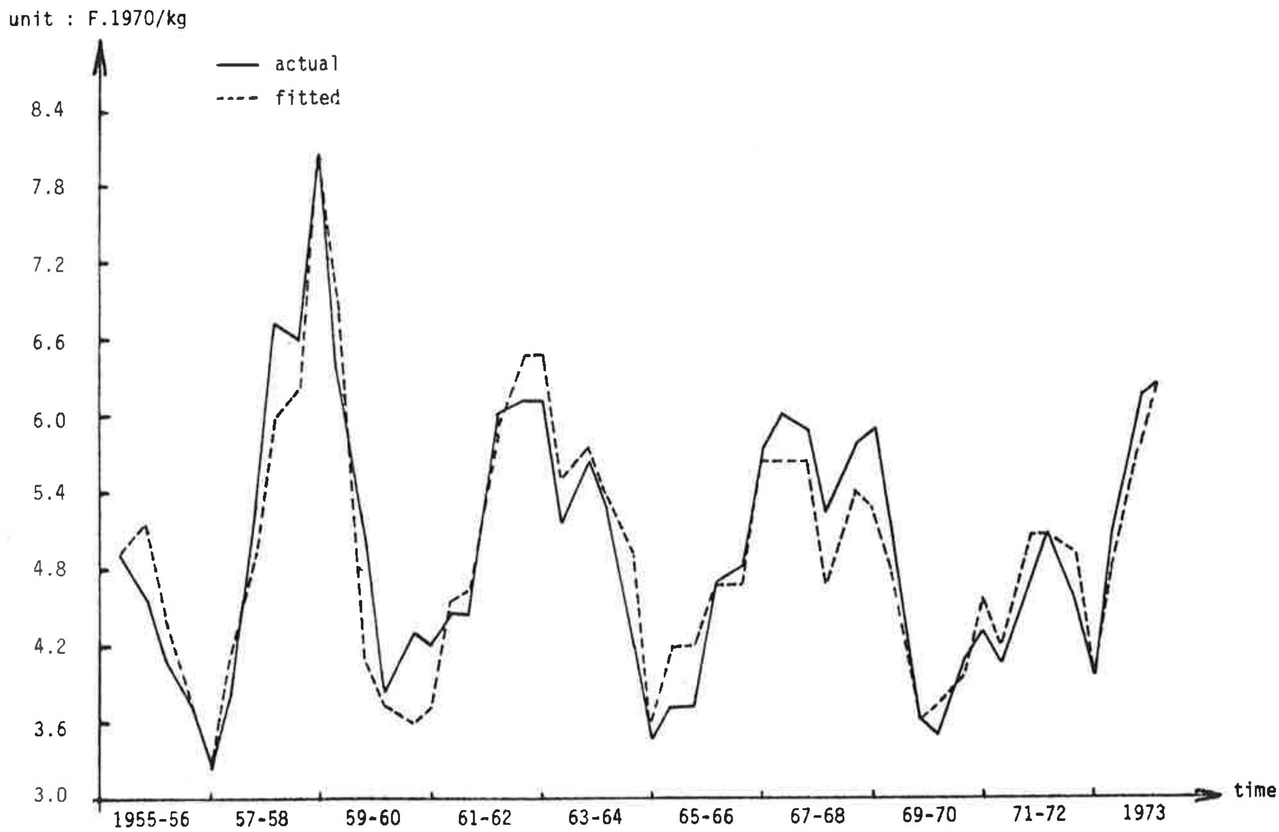


Figure 3.13 - Actual and fitted values : demand (eq. 3.3)

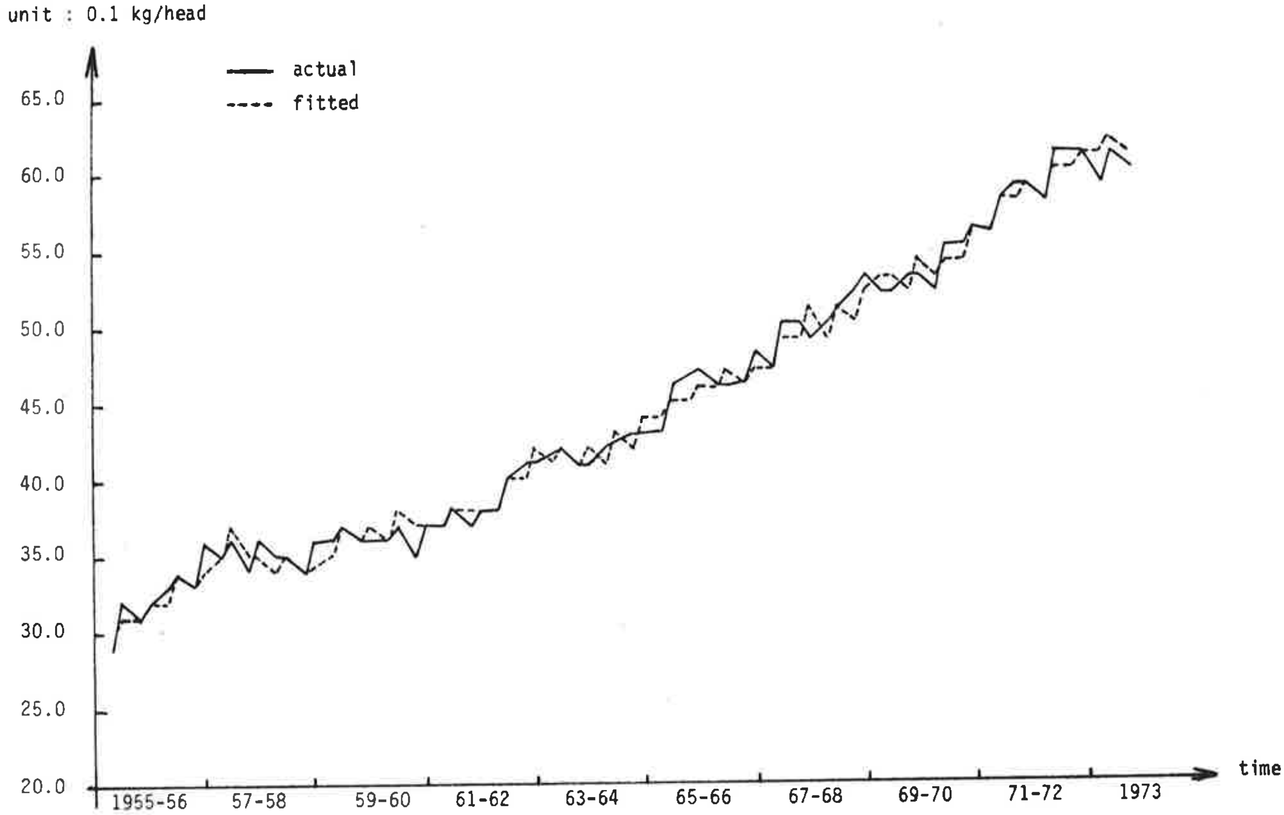


Figure 3.14 - Actual and fitted values : farm retail relation (eq. 3.4)

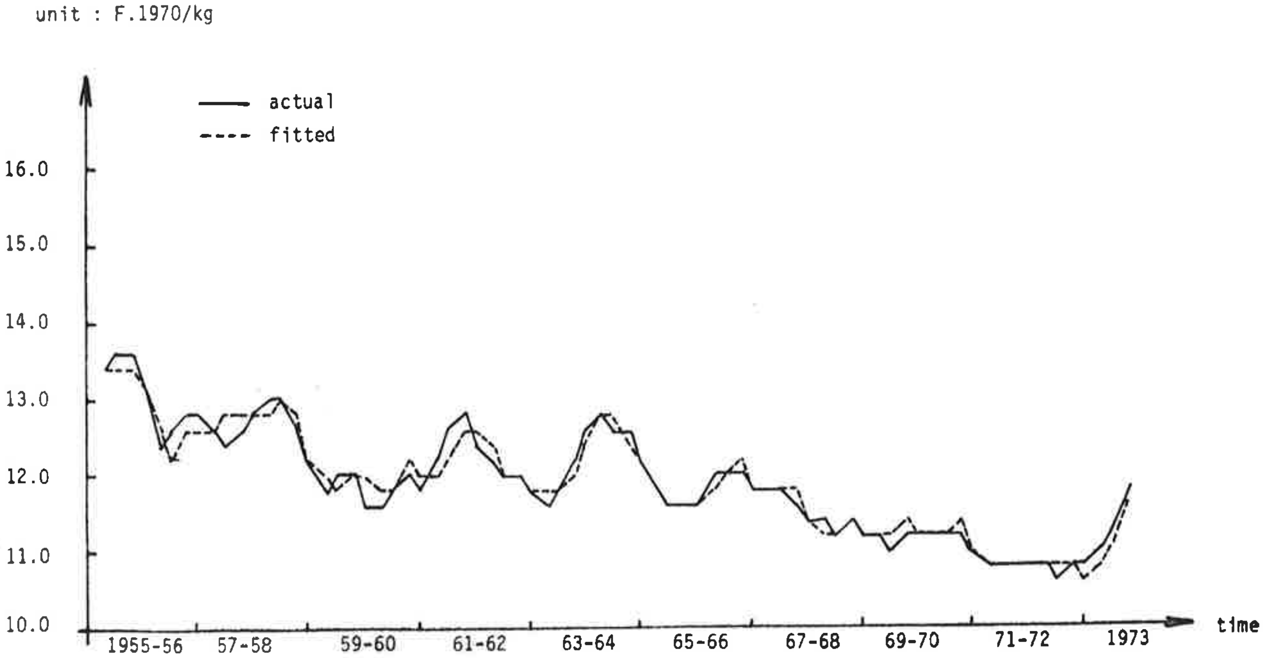
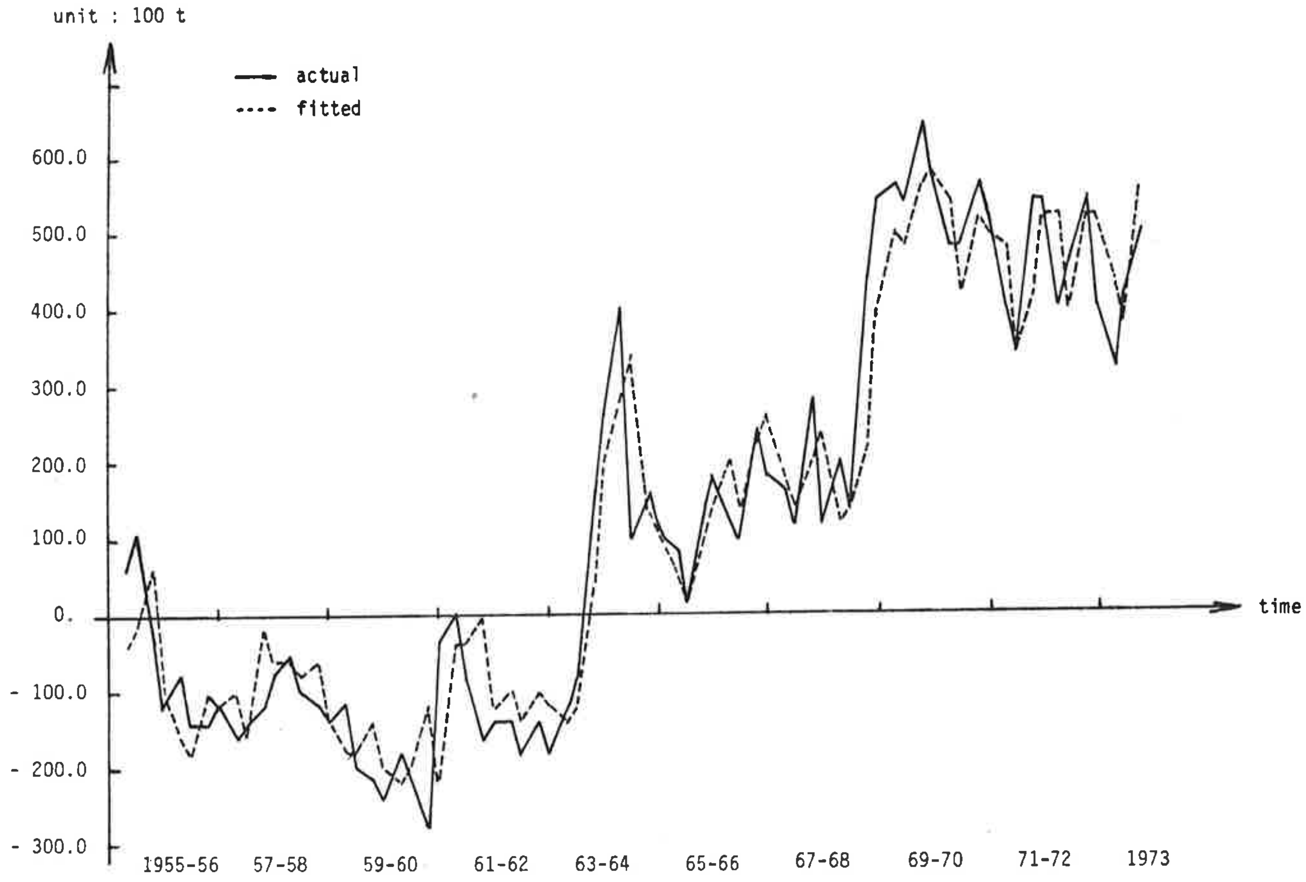


Figure 3.15 - Actual and fitted values : net imports (eq. 3.5)



32 - Preliminary work on the supply part of the model

This section is meant to justify the specification retained in equations 3.1 on one hand and to illustrate some of the arguments developped in chap. 2 on the other hand.

- lag structure

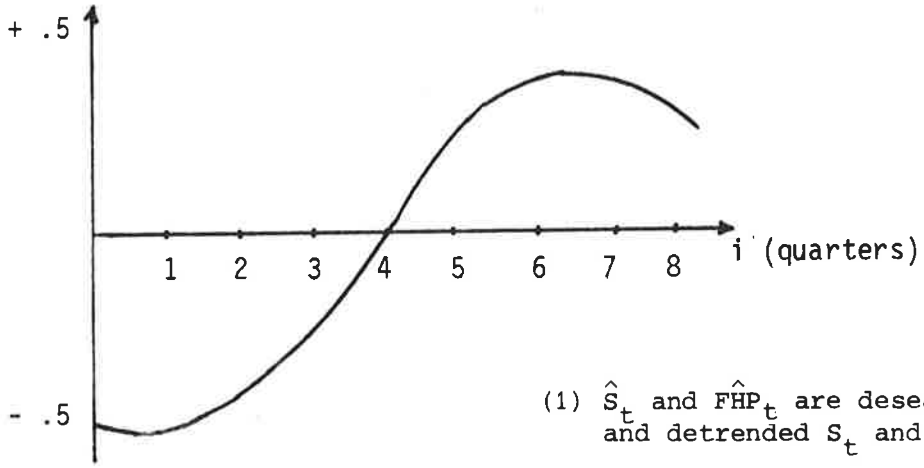
In chap. 2 the marketed supply equation in numbers was specified as depending on lagged and current hog prices.

(2.17) $$S_t = \varphi\alpha_0 (m-1) + (1-\varphi) S_{t-1} + m\alpha P_{t-w} - \varphi\alpha P_t$$

But the exact relevant lag w was not discussed. It is known that w is longer than the shortest production delay which is 3 quarters, since the period of fluctuations is about 3 years i.e. 12 quarters. This fact suggests a lag of about 6 quarters fo w. But breeding decisions may be made on various types of sows with corresponding different production lags. If the main decision would bear on the piglets class, about two quarters are necessary to bring them to breeding age which makes w = 5. If one assumes some further reaction lag, price in t-6 may also play some role. For the suckling sows the production lag is shorter, about 4 quarters, so that we expect P_{t-4} to have also some effect on future supply. Specifying the correct lag structure becomes rather empirical, since it is difficult to constrain it too much on a priori basis.

Almon [2] advises to use the information given by the correlogram to help specifying the lag structure. It is given in fig. 3.16 on deseasonnalized and detrended S_t and P_{t-i}. The correlogram is not of much help since the intercorrelation of lagged prices due to the cycle make them good instruments for each other at neighboring time units. The results of unconstrained regression on prices from P_t to P_{t-6} is not really sufficient either since multicollinearity makes estimates unprecise, fig 3.17. The dominant role of P_{t-5} is however confirmed as well as the presence of negative current price effect. But it is probable that the negative signs of P_{t-4} and P_{t-6} are due to sampling variation, given the high correlation between P_{t-5} and P_{t-4} or P_{t-6} (.80). One also notes that OLS estimates gives larger current price effect than 2 SLS as a result of simultaneous bias.

Figure 3.6 - Cross-correlogram (1) $\hat{S}_t$, $\hat{FHP}_{t-i}$



(1) $\hat{S}_t$ and $\hat{FHP}_t$ are deseassonalized and detrended S_t and FHPt

Figure 3.17 - Unconstrained regression Log S_t = a + Σa_i Log FHP_{t-i}

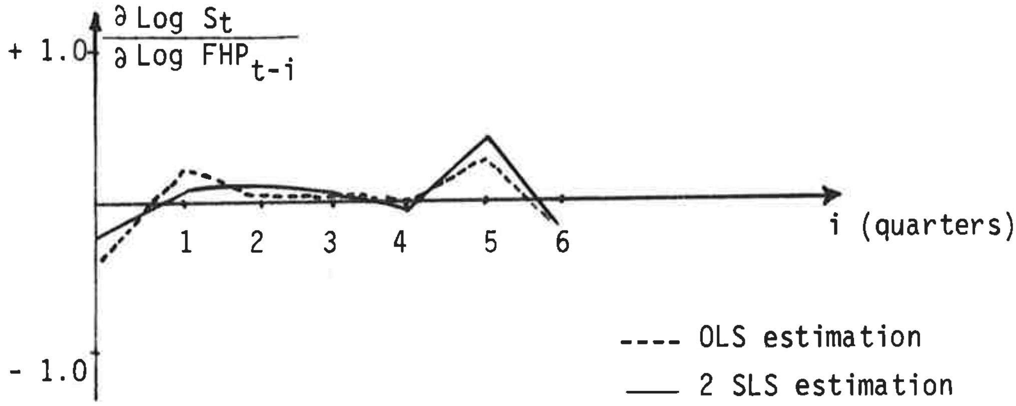
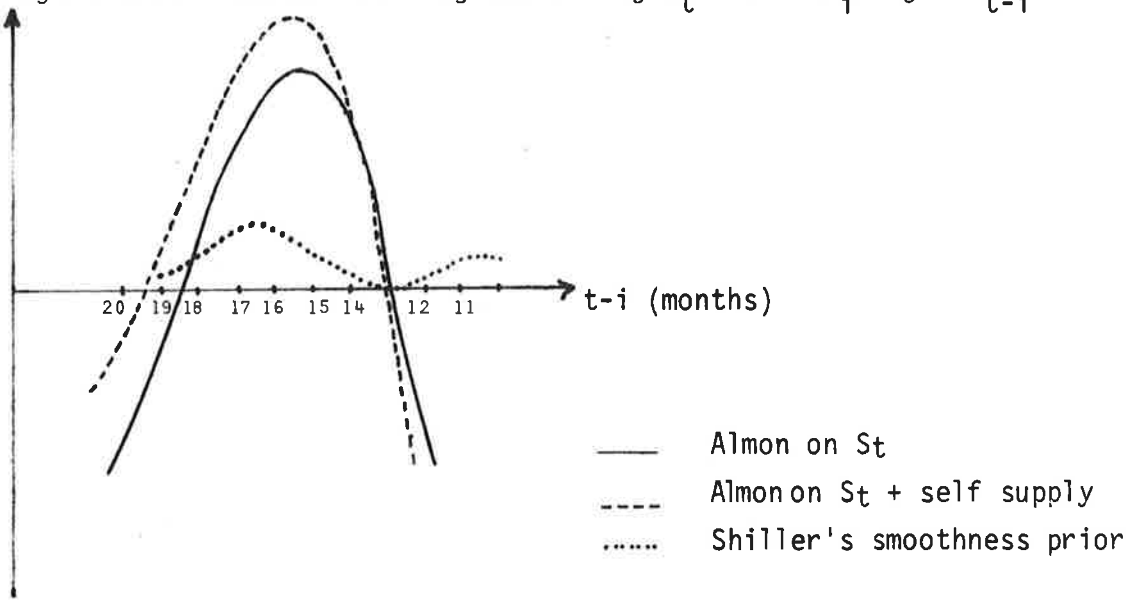


Figure 3.18 - Constrained regression Log S_t = a + Σa_i Log FHP_{t-i}



Preliminary work of estimation was used on monthly data using Almon polynomial constraints [2] and Shiller's smoothness prior |41| (fig. 3.8). They tend to confirm the dominant role of the fifth quarter but suggests that the reaction spreads over quarters t-4 and t-6. Shiller's method gave a flatter curve, which may be due to the prior information fed in. In the quarterly model, it is vain to use the polynomial approach since with 3 points (4, 5, 6) we have no constraint imposed on a quadratic polynomial. As the inverted U function obtained with Almon's method suggested an optimal lag at t-5 and second best at t-4, t-6, the constrained variable $WPGP_{t-5}$ was constructed as a weighted average of the neighboring prices.

$$WPGP_{t-5} = .2\ PGP_{t-4} + .6\ PGP_{t-5} + .2\ PGP_{t-6}$$

The result of spreading the lag over quarters 4, 5, 6 is to increase the coefficient of lagged price and reduce the coefficient of current price as explained by the omitted variable analysis of chap. 2.

(1955-1973 75 obs 2 SLS)

$$(3.12)\quad QS_t = \text{constant} + \text{seasonnals} + \underset{(9.6)}{.73\ QS_{t-1}} + \underset{(3.6)}{4.1\ t} + \underset{(1.6)}{18.3\ PGP_{t-5}} - \underset{(1.1)}{18.1\ PGP_t}$$

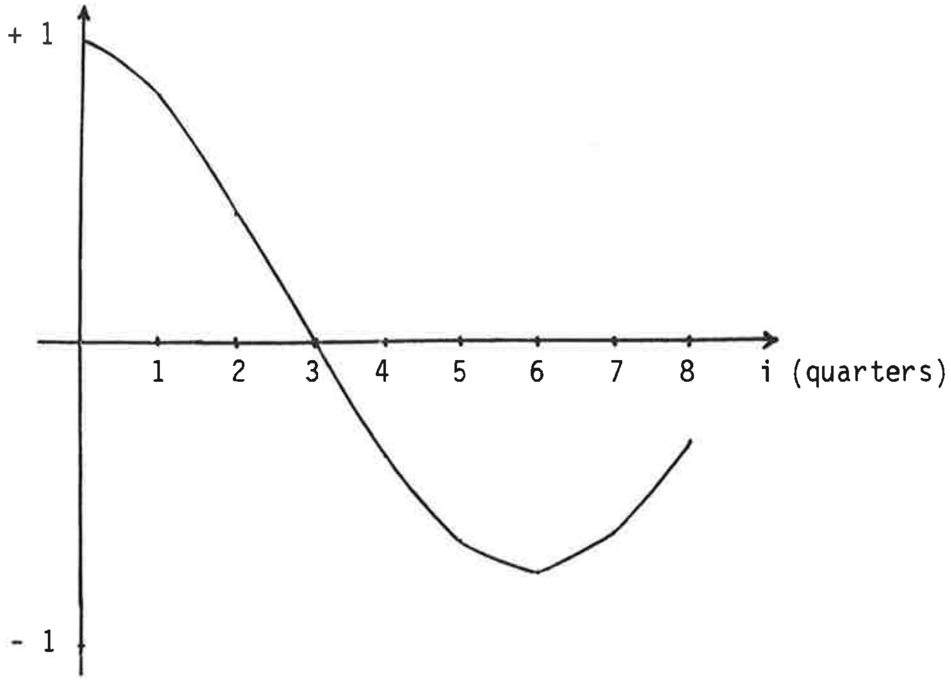
$R^2 = .96 \quad h = 2.1$

$$(3.13)\quad QS_t = \text{const.} + \text{seas.} + \underset{(9.5)}{.75\ QS_{t-1}} + \underset{(3.5)}{4.0\ t} + \underset{(1.9)}{26.4\ WPGP_{t-5}} - \underset{(.6)}{10.5\ PGP_t}$$

$R^2 = .96 \quad h = 2.1$

The overestimation of current price effect resulting from a wrong lag w may be understood by looking at the own correlogram of feeder pig prices (fig. 3.19)

Figure 3.19 - Correlogram PGP_t, PGP_{t-i}



- Simultaneity and true supply elasticity

One of the arguments made in chap. 2 was that a recursive model would lead to overestimate marketed supply elasticity σ_1. This is illustrated by equations (3.14, 3.13) for marketed supply in weights and (3.15, 3.16) in numbers.

Recursive, weights

$$(3.14)\quad QS_t = \text{cst.} + \text{seas.} + \underset{(12.7)}{.77}\, QS_{t-1} + \underset{(3.6)}{3.7}\, t + \underset{(4.3)}{33.1}\, WPGP_{t-5}$$

$R^2 = .96 \quad h = 1.69$

Recursive, numbers

$$(3.15)\quad S_t = \text{cst.} + \text{seas.} + \underset{(13.5)}{.78}\, S_{t-1} + \underset{(3.7)}{4.9}\, t + \underset{(5.0)}{48}\, WPGP_{t-5}$$

$R^2 = .97 \quad h = 1.67$

Simultaneous, numbers 2SLS

$$(3.16)\quad S_t = \text{cst.} + \text{seas.} + .71\ S_{t-1} + 5.9\,t + 26\,WPGP_{t-5} - 34\ PGP_t$$
$$\qquad\qquad\qquad\qquad (4.0) \qquad\qquad\qquad (1.4) \qquad\qquad (1.4)$$

$R^2 = .97$ h = 2.2)

The marketed supply elasticities estimates (σ_1) are given in table 3.15 for the four specifications at mean values.

Table 3.15 - Short run marketed supply elasticities estimates σ_1 for various specifications

	recursive	simultaneous
weight	0.175	0.139
numbers	0.196	0.106

As expected we find that recursive models give quite higher estimates than simultaneous model do. The offsetting role of the positive effect of current price on average wieght works also as expected in yielding a smaller difference between recursive and simultaneous estimates when marketed supply is defined by weight instead of numbers. Equation (3.17) below shows the effect of price on average wieght with a corresponding SR supply elasticity of + .06.

(1955-1973, 75 obs., 2 SLS)

$$(3.17)\quad W_t = .73 + 0.0019\ SP_t - 0.009\ SU_t + 0.004\ FA_t - 0.002\ t + 0.009\ FHP_t$$
$$\qquad (46.6)\ (.56) \qquad (2.9) \qquad (1.3) \qquad (2.9) \qquad (3.5)$$

$R^2 = .47$ d = .6

Now, by the argument of chap. 2, and particularly note (1) p. 19, an approximation of the true supply elasticity could be derived form (3.16) by summing algebraicly the elasticities of S_t with respect to lagged and current prices. But this would yield a negative number. This shows that simultaneous equations in supply may indeed lead to greater evils than simple recursive. It is hard to know whether this result inconsistent with theory is due to the so called demand effect in spite of the use of 2 SLS, or to mespecification in the lag structure. This has led to setting a constraint in the supply equation (3.1) expressed in weight, in order to get it closer to the theoretical specification of (2.17). The value of m chosen was 5 which is meant more as an order of magnitude than as an exact value. This constraint does not seem to affect either the fit or the residuals properties, while unconstrained 2 SLS equations usually give signs of serial correlation.

A similar equation with numbers as dependent variable was runned with the constraint m = 5 and gave the following estimates :

$$(3.18)\quad S_t = \text{cst.} + \text{seas.} + \underset{(13.1)}{.76\, S_{t-1}} + \underset{(3.9)}{5.2\, t} + \underset{(5.1)}{43.0\, WPGP_{t-5}} - 8.6\, PGP_t$$

$$R^2 = .967 \qquad d = 1.66 \qquad h = 1.7$$

Deriving SR marketed supply elasticity $\hat{\sigma}_1$, from this equation gives + .175, the current price elasticity of S_t is $\hat{\sigma}'_0$ = - 0.034 gives an estimate of the true SR supply elastiticy of + .141 and .58 for the long run. These results are somewhat different form recursive results in weight (.175 and .73) and even more in numbers (.196 and .82)

It is felt that internal consistency of the supply behavior does imply some simultaneity (1) and therefore justifies the introduction of current price in the equation. Practical problems obviously arise which I have not been able to solve in a nicer way than by a priori constraints.

---

(1) Since the intercorrelation was assumed to prevent a clear evidence of the simultaneity, a dummy variable was introduced in the supply equation, taking the value one when price rises and zero otherwise. It was of the correct sign in both S_t and QS_t equations with t values of about 1.2. The coefficients $WPGP_{t-5}$ were much more significant than in unconstrained 2 SLS and with values 41 and 28 respectively, close to the results of constrained 2 SLS equations (3.18) and (3.1) respectively.

Improvements are clearly needed for a more complete test of the theory. The regular cyclical pattern of prices accounts certainly for a large responsability in the encountered problems by the resulting colinearity.

Current price effect is expected to better represent very short run supply variations ; this will be tested by forecasting the supply outside of the sample period.

33 - Structural changes and supply elasticity

Many commentators have written that the recent structural changes would induce a stabilization of the supply and a dampening of the hog cycle. Economic arguments were not given in detail but it was felt that specialization, fixed cost to cover and the action of producers'associations would stabilize supply.

Irwin [23] has argued similarly that specialization reduces output substitution opportunities on farms, and that fixed factors, also linked to specialization, tend to reduce the supply elasticity.

Tweeten and Quance [45] emphasized that the increased use of variable inputs purchased outside of the farm, tend to push supply elasticity upwards. Output price supply elasticity may be expressed as $\Sigma w_i \varepsilon_{ip}$, where w_i are the input elasticities of output and ε_{ip} the demand elasticities of input with respect to output price [Griliches, 13]. Assuming further that factors are paid at their marginal product, the w_i become factor shares. Then if an increased part of variable inputs are purchased it seems likely, other things unchanged, that supply elasticity would increase. As mentionned before, purchased inputs have grown a lot in hog production recently and one may expect an increased supply elasticity contrarily to the wide-spread opinion. Tweeten and Quance did not find clear cut evidence about supply elasticity change over time, but they dealt with aggregate farm supply.

Dean and Heady [8] found a higher supply elasticity of spring farrowings (only), for the period 1938-1956 than for the years 1924-1937. Their explanation is based on technical change in breeding, feeding and facilities, which shift the production function and flattens the marginal cost curve.

There seems to be a need for a self contained analysis of possible effects of structural changes on supply elasticity. For now the question is rather empirical. I have tried to test a change of structure in the supply equation by using covariance analysis. There are at least two difficulties in carrying the test : first the simultaneity, second the short period of observation on structural changes in the industry (1966). I have used the easy way by working with a recursive model since there is a linear relation between true elasticity σ and marketed elasticity σ_1. And I have splitted the sample period in year 1966, in order to be able to compare not only slopes but also elasticities computed at mean values of both samples. This gives more information than the strict Chow test [8].

The results are given by the two equations below for respectively the 1955-1966 and 1967-1973 subperiods.

(1955-1956, 48 obs.)

$$QS_t = 246 + 121\,SP_t - 67\,SU_t + 69\,FA_t + 4.9\,t + 35\,WPGP_{t-5} + .66\,QS_{t-1}$$

(2.1)(4.3) (2.3) (2.4) (3.4)

$R^2 = .92$ $h = .57$

(1967-1973, 27 obs.)

$$QS_t = 206 + 52\,SP_t - 164\,SU_t - 12\,FA_t + 6.8\,t + 41\,WPGP_{t-5} + .81\,QS_{t-1}$$

(1.1)(1.4) (4.4) (.3) (2.4)

$R^2 = .93$ $h = 1.99$

Using the error sum of squares of the equation estimated on years 1955-1973, an F test is constructed [25, p. 199] with 7 and 61 degrees of freedom. Computed $F_{6, 61}$ is 7.8 compared to the 2.2 value of the table. Structural change may be accepted on this basis. And the supply slope does have increased from 35 to 41. But it is not so for SR supply elasticity (1) at mean values respectively .10 and 0.08, the decreasing ratio $\frac{P}{S}$ over compensates the increasing supply slope. However if one compares the LR supply elasticities in the two subperiods the order is reversed since adjustment speed appears to be smaller in the more recent years, respectively (.29 and .43). A similar result was obtained previously on monthly data, with a log specification of the equation. This overall evidence tends to confirm the increase of the long run supply elasticity over time. We may note that the opposite rank of SR and LR estimates is consistent with both the fixed factor specialization argument of Irwin which works more for the SR and the increased share of purchased inputs argument which would work in the LR (acquisition of new facilities, ...).

With respect to the possible dampening of the cycle, we should relate this result to the demand side of the market. Demand price elasticity seems to have increased noticebly in the recent years, which work in a stabilizing direction. If one computes LR elasticities of supply (2) and demand with respect to farm hog prices for the last subperiod one gets respectively + .68 and - .43 which suggest a strong divergent tendency of the hog cycle in the range of validity of those estimates, particularly in view of the further destabilizing role of current price effect. These results tend to show that hog cycle remains quite unstable around equilibrium. They also suggests that the linear model is not sufficient to account for the stability conditions, since it would imply an explosive cycle.

*

* *

(1) With respect to feeder pigs price.

(2) Making the correction $\sigma = \sigma_1 \frac{m-1}{m}$ to get closer to the true supply elasticity.

Chap. 4 - WELFARE ANALYSIS OF THE HOG CYCLE IN FRANCE

The welfare aspect of price instability has been extensively studied in the litterature, but it deals only with random fluctuations [4.1]. It seems appropriate to apply the approach to cyclical fluctuations.

Price and quantity fluctuations entail distorsions form equilibrium and therefore misallocations of ressources. They also bear consequences on the welfare of the economic agents : producers, consumers, marketing firms.

I first consider the welfare loss to society due to fluctuations in a simple cobweb framework. Second, I deal with the distribution effects in the same framework. Then I try to extend the analysis to a complete model including marketing margins, trade and shifting exogenous variables.

1 - Welfare loss in a simple cobweb

Distorsion between supply and demand prices is widely considered as a discrepancy from optimality under general conditions [e.g. Harberger, 4.2].

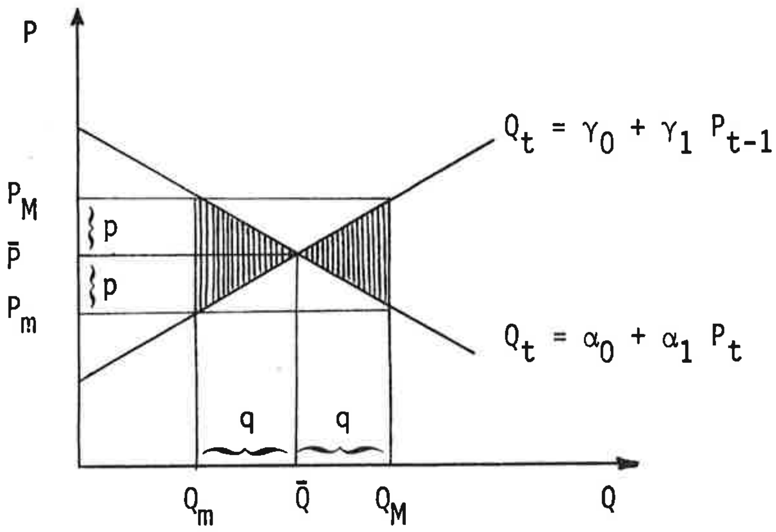
Suppose we have a "stationary cobweb" with constant magnitude fluctuations.

(4.1) supply : $Q_t = \gamma_0 + \gamma_1 P_{t-1}$

(4.2) demand : $Q_t = \alpha_0 + \alpha_1 P_t$

$$\gamma_1 = - \alpha_1 = \gamma$$

Figure 4.1 - Symmetrical stationary cobweb



The prices oscillate with period 2 between P_m and P_M, the quantities between Q_m and Q_M. In a complete cycle the welfare loss is given by the shaded areas (by the symmetry),

$$L = 2 \int_{\bar{Q}}^{Q_M} [P^S (Q) - P^D (Q)] \, dQ$$

where $\bar{Q}$ is the equilibrium quantity ; P^S, P^D are respectively the supply and demand prices and $Q_M = \gamma_0 + \gamma_1 \; P_m$, $\bar{Q} = \gamma_0 + \gamma_1 \; \bar{P}$

In the linear case we have (geometrically) :

(4.3) $$L = 2 \times \frac{1}{2} (Q_M - \bar{Q}) (P_M - P_m)$$

or by (4.1), $L = \gamma (P_M - \bar{P}) (P_M - P_m)$

$$L = 2\gamma (P_M - \bar{P})^2 \text{ by symmetry again}$$

(4.4) $$L = 2\gamma \, p^2 = 2 \, pq, \text{ with } p = P_M - \bar{P}, \; q = Q_M - \bar{Q}$$

If the cycle goes on indefinitely the present value at t = 0 of the welfare loss is the limit of :

$$L_0^t = \sum_{i=0}^{t} pq\ (1 + \rho)^{-i}, \qquad \rho = \text{discount rate}$$

$$\lim_{t \to \infty} L_0^t = \frac{1 + \rho}{\rho}\ pq$$

It would therefore be appropriate to distroy (or give away) the excess supply if the corresponding cost is smaller than expected social loss i.e. if,

$$(4.5) \qquad \bar{P}q < pq\ \frac{1 + \rho}{\rho}$$

then the condition is :

$$(4.6) \qquad \frac{p}{\bar{P}} = \frac{P_M - \bar{P}}{\bar{P}} > \frac{\rho}{1 + \rho} \simeq \rho$$

If the relative magnitude of price fluctuations around equilibrium price is about the chosen discount rate, it would be worth to use the extreme policy of destroying excess supply, in the case of a stationnary symmetrical cobweb.

One could study more flexible policies using buffer stocks or funds, which are more relevant in the general case of random fluctuations added to the model (as well as exogenous less predictable shifts in the demand).

2 - Distribution effects

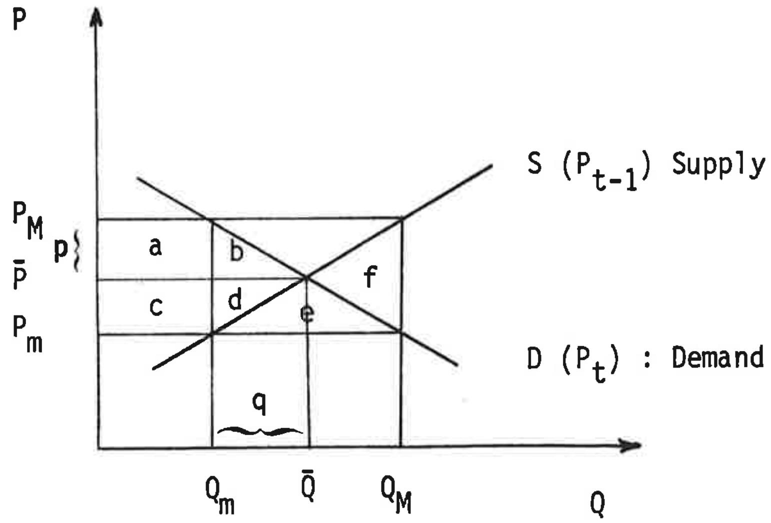
The distribution effects may be studied by means of producer's and consumer's surpluses. These concepts are widely used and widely criticized in the litterature (e.g. [4.3]). I make only few remarks which help justifying their use in the present case.

The limits of the partial analysis may not be too damaging because of the small importance of the hog industry in the economy. With respects to the consumer's suplus, the use of the area under the ordinary demand curve may be used, not because of the small income elasticity but in view of the small share of pork consumption in the consumer's total expenditures. The aggregation over consumers is certainly more questionable, since we get into distribution problems, and it is difficult to accept the assumption of optimal distribution of income.

On the producer's side two main aspects are to be considered. First there is the distinction between the producer's surplus and the rent to the factors [4.3]. Since farmers own most of the inputs, the distinction does not seem too important, the more so as hog production is rather independent of land in France. The second remark deals with the meaning of the aggregate supply function used. Is it linked to the LR marginal cost curves or to the SR one ? Price fluctuations are a short run problem, it seems likely that disequilibria observed in the firms as a consequence of the cycle bear upon a cost curve with investment and labor fixed. The upward sloping supply curve is therefore close to the concept of SR marginal cost curve, which is more relevant to the use of producer's surplus than is the LR cost curve. The aggregation problem remains unsolved on the production side too, and one should certainly try to analyse which firms are more likely to be affected by price fluctuations.

Let us consider now the effects of price <u>stabilization</u> on consumer's suplus when price is set at $\bar{P}$, in the simple model (fig. 4.2) ; the variation deals with the surplus difference between the stabilized market and the fluctuating market as a reference.

Figure 4.2 - Distribution effects



$\Delta CS = -(c + d + e) + a + b = -e$, by using symmetry

using $q = Q_M - \bar{Q} = \bar{Q} - Q_m$

$p = P_M - \bar{P} = \bar{P} - P_m$, we have,

(4.7) $\Delta CS = -qp < 0$

The consumers loose from price stabilization. This is a known result when the source of fluctuation is on the supply side [Waugh, 4-4]

For the producers the effect of price statilization at $\bar{P}$ is :
$\Delta PS = (c + d + e + f) - (a - d) = 2d + f + e$

(4.8) $\Delta PS = 3pq > 0$

Producers gain from stabilization when disturbances originate in the supply [4.1]. When the price is at P_m, producers loose more than the strict producers surplus variation form ($\bar{P}$, $\bar{Q}$) to (Q_M, P_m), i.e. (c + d) ; they also incur a net loss since they sell $Q_M - Q_m$ at a marginal price P_m smaller than marginal cost. This loss (1) amounts to areas e + f.

Aggregating over producers and consumers yields the net social loss for a whole cycle, and therefore the stabilization social gain.

(4.9) $$G = 2\,d + f = b + d + f = 2\,pq > 0$$

It would therefore be worth it for the producers to bribe consumers into accepting stabilization

3 - Welfare effects of fluctuations in a more general model

31 - Consumers' surplus and marketing margins behavior

The simple model mistakenly assumes that retail price (P') is identical to farm price (P). I shall assume however that quantities (2) are the same at retail and farm level : Q' = Q.

1 - constant margins $P' = P + \bar{M}$

The variation of consumers' surplus is the same at farm and retail level (fig. 4.3). There are no further distribution effects generated by the marketing sector.

(4.10) $$dCS' = -\,Q'\,dP' = -\,Q\,dP = dCS$$

Where the' refers to retail market.

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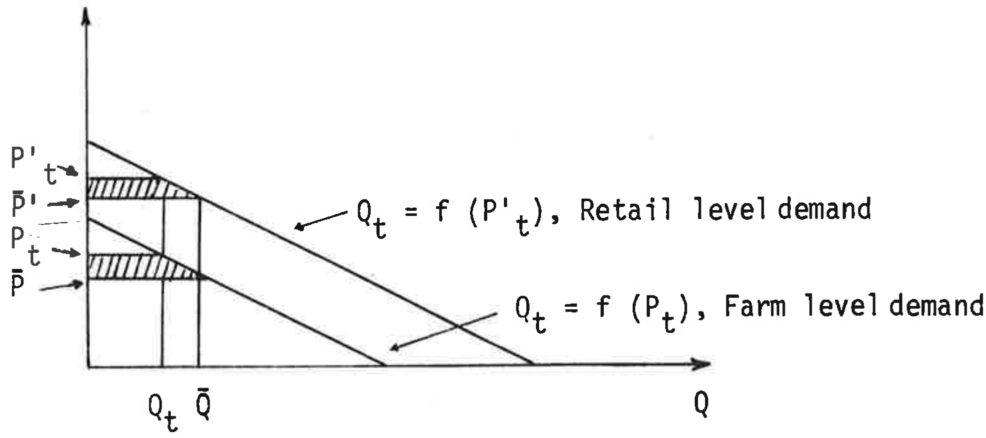
(1) Turnovsky did not take this loss into account in the purely random fluctuations case.

(2) This means no transformation of the farm product except for services. Intuitively the results would be the same if constant proportions prevail in the food industry as shown by GARDNER [4.5].

Figure 4.3 - Constant margins and consumers' suplus



2 - proportional margins $P' = (1 + \alpha) P, \quad \alpha > 0$

$M = \alpha P$

$dCS' = - Q' \, dP'$

(4.11) $dCS' = - (1 + \alpha) \, QdP$

Because price variations are amplified, we guess that consumers' welfare will be more affected than in the previous case. Since consumers gain from price fluctuations in a complete cycle, we expect they will gain more in the proportional margins case.

Let q and p be again the absolute deviations form equilibrium in a symmetrical cobweb. Let p' be the price deviation at retail, $p' = (1 + \alpha) p$. Call $m = \alpha p$ the margin absolute deviation.

- Consumers loose from stabilized prices, in a whole cycle :

(4.12) $\Delta CS' = - qp' = - q (1 + \alpha) p$

- Marketing firms gain grom price stabilization :

$$\Delta MS = 2\,\bar{Q}\bar{M} - (\bar{Q} + q)\,(\bar{M} - m) - (\bar{Q} - q)\,(\bar{M} + m)$$

where $\bar{M}$ is the equilibrium margin $\bar{M} = \alpha\bar{P}$; after cancellation :

(4.13) $\Delta MS = 2\,mq$

$\Delta MS = 2\alpha pq$ (area 2 c in fig. 4.4 b)

- Producers gain the same amount as before i.e. 3pq

Figure 4.4 - Proportionnal margins

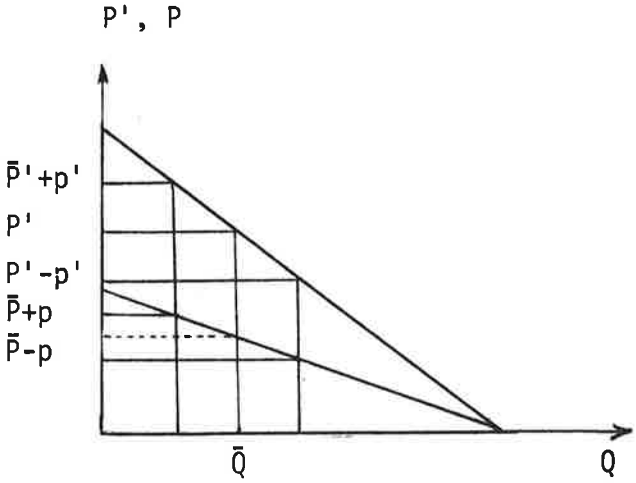


Fig. 4.4 a

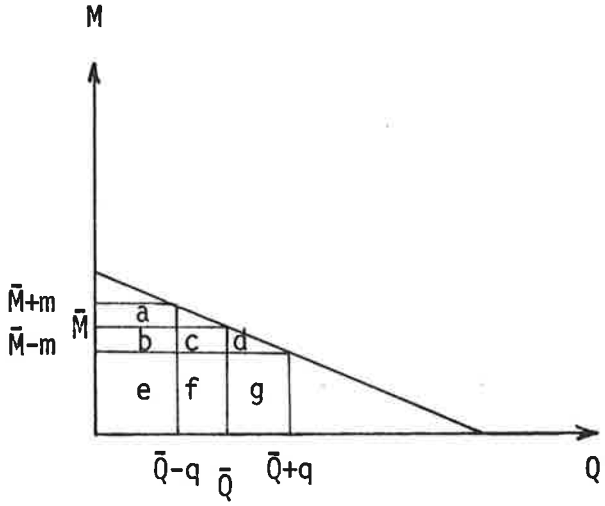


Fig. 4.4 b

The net social gain from stabilization in that case would be :

$$G = 3pq - (1 + \alpha)\,pq + 2\,\alpha pq$$

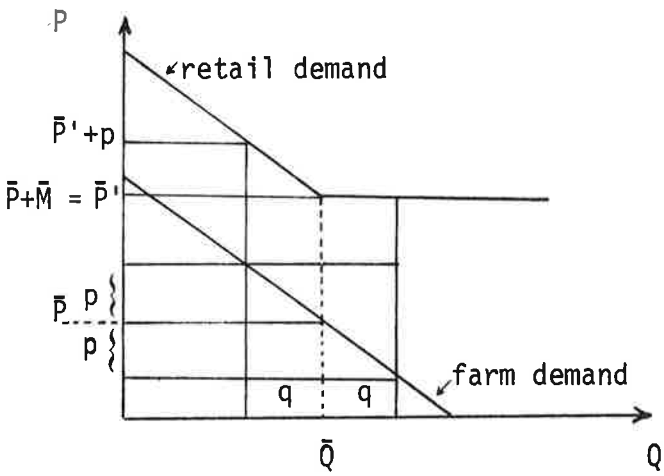
(4.14) $G = 2\,pq + \alpha pq$

It turns out that proportional margins associated with symmetrical fluctuations benefit more to consumers than constant margins. Marketing firms are even more hurt than the extra consumers' surplus gain. This seems to indicate that proportionnal margins are not necessarily associated with market power since marketing firms do not benefit from them, in the case of symmetrically reversible price fluctuations [Ruttan, 4.6].

3 - non reversibility of retail price fluctuations

The casual observation of prices at various levels leads to contrasting wide reversible farm prices to more stable retail food prices. So that the two previous models do not stick very well to reality at least in the short run. One interesting assumption to consider is the non reversibility of retail food price increases when farm prices take a downward direction. Suppose the extreme case of constant margin when farm price increases, and unchanged retail price relative to their previous level, when farm prices fall.

Figure 4.5 - Non reversibility of retail prices



In the stationary cobweb again this means :

$$p' = \begin{cases} p \text{ when } dP > 0 & \text{i.e. } dM = 0 \\ 0 \text{ when } dP < 0 & \text{i.e. } dM = p \end{cases}$$

The marketing firms will clearly benefit from such a situation when price fluctuate. The consumers will only suffer surpluslosses but no surplus gain will accrue to them. In the previous particular case, the welfare effect of stabilization will be :

(4.15) $\Delta CS' = \bar{Q}p - \frac{1}{2}\, pq > 0$

(4.16) $\Delta MS = 2\,\bar{Q}\bar{M} - (\bar{Q} + q)\,(\bar{M} + p) - (\bar{Q} - q)\,\bar{M}$

$\Delta MS = -\,\bar{Q}p - pq < 0$

The marketing firms loose more from stabilization than consumers gain. But one of the limits of the model appears clearly here. It is questionable to apply consumers'surplus analysis to such a kinked demand curve (the kink being in the opposite direction from the oligopoly kinked demand curve). One wonders how consumers would buy more than $\bar{Q}$ at the same price $\bar{P}$, when farm prices fall as a result of excess supply. Less extreme case are conceivable however, with intermediate kinds of distribution effects.

Moreover, the relationship between marketing margins and marketing cost is forgotten about in the above analysis. If marginal cost in marketing is increasing around $\bar{Q}$, then the situation is comparable to the producers'caseif margins are constant. It could be a partial justification of weakly reversible retail prices (margins would have to the higher when quantities are larger and farm price lower, Appendix 4.3).

32 - A first application to he hog market

(i) moving equilibrium path

One of the major problems to solve when coping with an actual market, is to define and estimate the dynamic equivalent ($\bar{P}_t$, $\bar{Q}_t$) of the stationary equilibrium ($\bar{P}$, $\bar{Q}$) of the simple case. Over time, technical progress, feed prices shift the supply curve, and so is it for income and substitute prices on the demand side. It seems intuitively appealing to assume the existence of a moving equilibrium going through the actual cycles and displaced only by exogenous variables. Samuelson [4.7, p.320] has warned that there is a lot of arbitrary in the concept of moving equilibrium ; it is a particular solution of interest of the difference equation. More, "if the functions of time involved are not the simple elementary ones, the above criterion does not specify unambiguously a unique function". If income and technical progress may be considered as smooth shifters, and may be expressed as simple functions of time, it is not so for feed prices and pork substitutes. The notion of moving equilibrium free from cyclical fluctuations has therefore important shortcomings which should be kept in mind.

I have made an attempt at determining a smooth path as an approximation to a moving equilibrium conditioned by exogenous variables. It is a rough extension of the simple stationary model (4.1) (4.2) to the model with exogenous variables, whose role may be represented by making intercepts depend on time.

actual path — equilibrium path

- Stationary cobweb

(4.1) $Q_t = \gamma_0 + \gamma_1 P_{t-1}$

(4.2) $Q_t = \alpha_0 + \alpha_1 P_t$

(4.18) $$\begin{bmatrix} \bar{Q} \\ \bar{P} \end{bmatrix} = \begin{bmatrix} 1 & -\gamma_1 \\ 1 & -\alpha_1 \end{bmatrix}^{-1} \begin{bmatrix} \gamma_0 \\ \alpha_0 \end{bmatrix}$$

- Cobweb with shifters

(4.1') $Q_t = \gamma_t + \gamma_1 P_{t-1}$

(4.2') $Q_t = \alpha_t + \alpha_1 P_t$

(4.19) $$\begin{bmatrix} \bar{Q}_t \\ \bar{P}_t \end{bmatrix} = \begin{bmatrix} 1 & -\gamma_1 \\ 1 & -\alpha_1 \end{bmatrix}^{-1} \begin{bmatrix} \gamma_t \\ \alpha_t \end{bmatrix}$$

Clearly (4.19) yields only an approximation since we are in fact assuming that $\bar{P}_t = \bar{P}_{t-1}$ in model (4.1') (4.2'), while (4.19) shows clearly that it is not so. Samuelson [4.7, p. 323] advises to proceed by successive approximations of the path $\bar{P}(t)$ and feed then in (4.1'), which could be written as :

$$\bar{Q}_t^i = \gamma_t + \gamma_1 \; \bar{P}^{\,i} \; (t - 1), \quad \text{for iteration i} \tag{4.20}$$

$$\bar{Q}_t^i = \alpha_t + \alpha_1 \; \bar{P}^{\,i} \; (t)$$

I did not have time to get a routine set up for this iteration procedure. But the solution given by (4.19) was used as a first try. The results were rather bad and I suspect that the reason comes more from the estimated structure of the model than from the approximation made. In particular the net imports equation seems to be the cause of the difficulty, in view of the changing position of France from net exporting to net importing (20 % of domestic production) over the whole period, and also because of the unsufficient specification of this equation.

In order to give an idea of the welfare effects in a real case, I wanted an approximation of the equilibrium path for the hog market in France over the sample periode 1955-1973. The suggestion of Moore [4.7, p. 322] is to use the fitted trend as an approximation. The economic basis of this approach is clearly weak, since time is only one of the possible exogenous variables. A natural extension of this method is to regress each of the endogenous variables an all the truely exogenous variables of the model excluding predetermined variables which create the cycles. All cyclical and seasonnal movements are eliminated and we get a path corresponding to the slow effects of income, substitute prices, time, on the endogenous variables of the model (production, demand, imports, farm price, retail price). The time series of actual path and "estimated equilibrium path" are shown on fig. (4.9) to (4.12). Of course this estimated particular reduced form has an important shortcoming. Nothing constrains the method to yield equilibrium values consistent with all the structural equations of the model, in particular no balance of supply and demand is imposed (1). Therefore I think that

(1) Such a constraint could certainly be fed in the estimation procedure, but this is left for later work.

numerical illustration can only be made on the basis of a particular period where the cycle has a clear cut face.

(ii) Expressions for the surplus variations

Assuming we have correctly determined equilibrium paths, we have to define first the deviations fo the various agents'surplus relatively to their equilibrium position, for each unit of time. The notations are as follows :

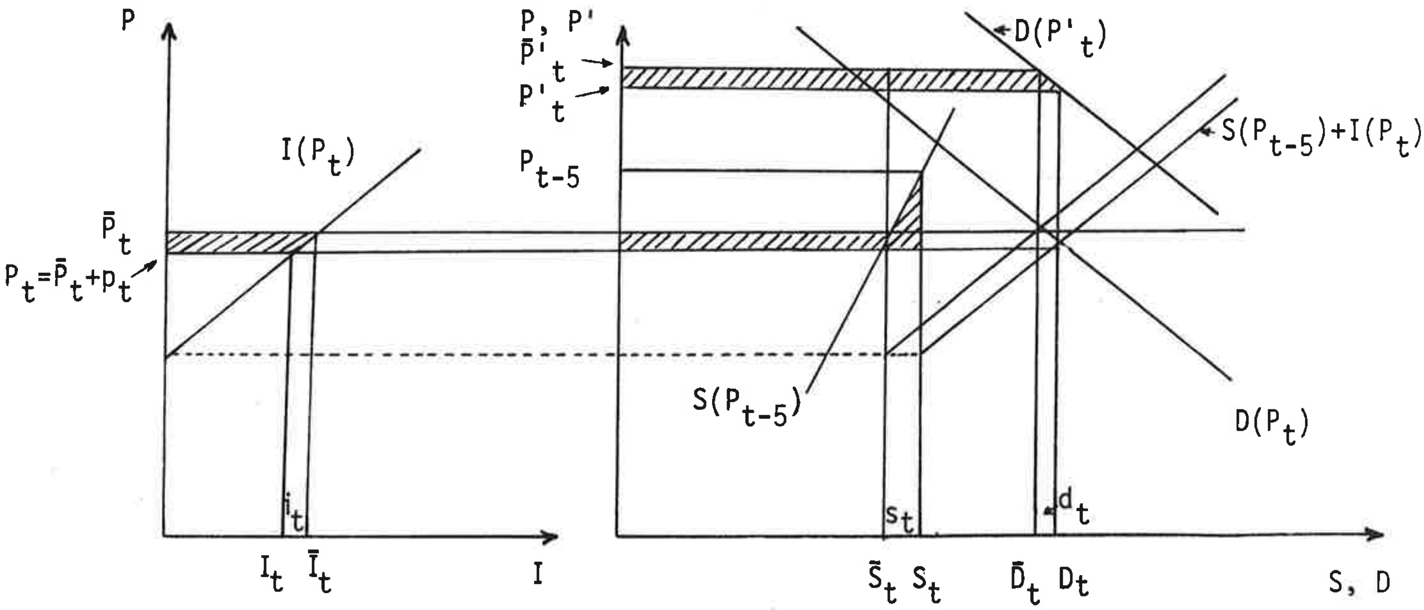
S_t, D_t, I_t are quantities supplied, consumed and imported at time t.
P_t, P'_t, M_t are respectively farm prices, retail prices and marketing magins.
ΔPS_t, ΔCS_t, ΔMS_t, ΔIS_t are the deviation of supluses from their equilibrium values at time t for producers, consumers, marketing firms, exporters (i.e. effects of fluctuations).

A bar on a variable denotes the equilibrium value at t of this variable. Lower case letters denote the algebraic deviations from equilibrium values :

$s_t = S_t - \bar{S}_t$, $p_t = P_t - \bar{P}_t$, ... The formulae are given for the linear case only. They illustrated by fig. 4.6 which corresponds to an excess domestic supply. The same algebraic formulae apply to shortage of supply (1).

(1) This is valid only when the import equation does not shift. If it does, we may have for example excess aggregate supply, prices below equilibrium, but still a shortage of domestic production. Such a situation would lead to find a net social welfare gain by using (4.24), below i.e. $(P_t - P_{t-5})(S_t - \bar{S}_t) > 0$, while it is clearly a loss.

Figure 4.6 - Surplus deviations in the complete model



(i) producers

Given the specification of the supply of pork (1) the lagged price which induces the quantity supplied S_t is P_{t-5}. Therefore the point (P_{t-5}, S_t) is supposed to belong to the relevant supply curve for computing producers'surplus (2).

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(1) The purely recursive supply case is considered here. The destabilization due to current price effect increases the producers'loss (cf. Appendix 4.1).

(2) Partial adjustment is skipped over here (Appendix 4.2).

The same line of reasonning is used as in the simple static case. Producers loose the producers'surplus variation plus the net loss of having to sell at P_t what cost marginally to them P_{t-5} (by the assumed relation between supply and marginal cost).

(4.21) $$\Delta PS_t = p_t S_t + \frac{1}{2} (\bar{P}_t - P_{t-5})\ s_t < 0 \text{ , when } p_t < 0$$

$$= p_t S_t + \frac{1}{2} (\bar{P}_t - P_t + P_t - P_{t-5})\ s_t$$

$$= p_t S_t - \frac{1}{2} p_t s_t + \frac{1}{2} (P_t - P_{t-5})\ s_t$$

(ii) consumers

(4.22) $$\Delta CS_t = - D_t p'_t + \frac{1}{2} p'_t d_t > 0 \text{ , when } p_t < 0$$

The sign is relevant to constant or proportinal margins

(iii) marketing firms

Here again we assume that marginal cost is constant over the quantity range and surplus variation is defined as profit variation :

$$\Delta MS_t = D_t M_t - \bar{D}_t \bar{M}_t$$

(4.23) $$\Delta MS_t = D_t\ (P'_t - P_t) - \bar{D}_t\ (\bar{P}'_t - \bar{P}_t)$$

The sign depends on the actual margin behavior.

(iv) exporters

It is tempting to apply the producers surplus formulae to the upward sloping supply curve for exports (i.e. French imports). The interpretation of that surplus seems quite hazardous. The more so as this supply curve depends on current prices which are more related to exportation cost than to production cost. I shall stay away from that extrapolation.

Let us check however that if this assumption were made, along with constant margin, the algebraic sum over agents of suplus variations would give a net social loss, by a similar expression ot the symmetrical cobweb one.

Constant margins imply $p'_t = p_t$, then dropping the marketing sector (neutral to surplus distribution) we get :

$$\Delta W_t = \Delta IS_t + \Delta PS_t + \Delta CS_t$$

$$= I_t p_t - \frac{1}{2} i_t p_t + S_t p_t + \frac{1}{2} (\bar{P}_t - P_{t-5}) s_t - D_t p_t + \frac{1}{2} pd_t$$

using (4.21)

$$\bar{P}_t - P_{t-5} = (\bar{P}_t - P_t) + (P_t - P_{t-5})$$

$$\Delta W_t = p_t (I_t + S_t - D_t) + \frac{1}{2} p_t (d_t - s_t - i_t) + \frac{1}{2} (P_t - P_{t-5}) s_t$$

by the equality between quantities,

(4.24) $$\Delta W_t = \frac{1}{2} (P_t - P_{t-5}) s_t < 0, \text{ when } s_t > 0$$

which corresponds to pq of the stationary cobweb. This formula might be used then to give an indication of the welfare loss to society of fluctuating prices.

(ii) Results

Given the severe limitations mentionned previously the numerical results are meant only as an indication of the importance of price fluctuations on both efficiency and distribution view points.

Since we know that the shortcomings of the method limit us to look for an approximation for the magnitudes of the analysed welfare effects we may proceed in two different ways. (1) use the formulae giving the balance of various effects for a complete symmetrical cycle, and relate the measure to the cash value of production and consumption. (2) use the formulae of surplus deviations at every unit of time (4.21) to (4.24) and evaluate the balance of the effects over some particular period of time. The second type of results may be related to the cash value of total production to check the first approach.

(1) Welfare effect as a percentage of the value of production, on the basis of the stationnary cobweb.

The balance of the effects for a complete cycle depend only on the product of deviations p.q. In a complete cycle producers would loose a fraction 3 pq/2 $\bar{P}\bar{Q}$ of the equilibrium cash receipt. Looking at the price time series, the magnitude of the relative price deviation p/$\bar{P}$ is about 10 %. The demand price elasticity is about 0,5, then we may estimate q/$\bar{Q}$ at 5 % (which is consistent with time series of quantitities). Then pq/$\bar{P}\bar{Q}$ amounts to 0,10 x 0,05 = 0,005, i.e. 0,5 %. Under these assumptions (in particular, constant marketing margins) consumers xould gain from fluctuating prices only 0,25 % of their consumtion expenditure on pork whose price and quantitities fluctuate respectively by 10 % ans 5 % around equilibrium. Similarly producers eventually loos 0,75 % of the cash average value in a whole cycle. The social welfare loss is also very small i.e. 2 pq/2 $\bar{P}\bar{Q}$ for a cycle, i.e. 0,5 %.

When a product is governed by a regular symmetrical cycle of small relative magnitude, the balance of the welfare effects is not important, i.e. it is of the order of the product of relative deviations on prices and quantities.

Of course the welfare position of economic agents is more affected during the two parts of the cycle. The relative magnitude depends on price deviation as may be seen by (4.15) or (4.21), i.e. $\bar{Q}p/\bar{P}\bar{Q}$ which is $p/\bar{P}$ and about 10 % in the present case, alternatively positive and negative over agents and periods.

We should note that distribution effects are more important to consider when the retail prices are not reversible. In such a situation equations (4.15) and (4.16) show that a windfall gain of 10 % of the consumer expenditure is transfered from consumers to marketing sector in a cycle. The producers are not further affected. Such a situation is very unlikely however. The results of the margin behavior estimation of chap. 3, show that the asymmetry is fare from being so extreme ; it is even questionable if the asymmetry is apparent when whole pork retail price is considered. Since this equation suggests strongly that margins are variable in the short run but constant in the long run, the distribution effects of the marketing sector are of limited importance between consumers and producers, over a long period of time.

(2) Direct method. Money value of surplus deviations over time derived from the moving equilibrium path.

The period chosen to comment the numerical results is the three years 1962, 1963, 1964 (observations 29 to 40, 12 quarters). One way to cheek the "clear cut face" of the cycle is to check the sign of $(P_t - P_{t-5})\ s_t$; as it is negative for all points except two, price changes may be explained by domestic supply changes.

On the production side we may verify that ΔMS has reached the maximum of + 244 millions (1) francs (MF) and the minimum of - 192 millions for quarters spring 1962 (table 4.1) and fall 1963 respectibely at that time the average cash value of hogs was 1 000 millions for a quarter. Price

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(1) 1970 basis, see table 4.1.

fluctuations had certainly a drastic influence (20 % at the maximum) on the cash equilibrium of hog farms. Over the whole cycle the farmers seem to have lost about 170 MF which represents about 1,4 % of the cash receipt for the 12 quarters.

The consumers seem to have successively gained about 200 MF and lost about 750 MF over this 3 years cycle. The balance is a loss of about 550 MF which accounts for about 2 %, of consumer expenditure on pork over the period. In the same time the marketing sector appears to have successively gained about 930 MF and lost about 450 MF. The retail and processing industry seem to have been gaining what consumers lost in these particular circumstances.

The net welfare loss to society evaluated by (4.23) comes to 100 MF over the cycle, which is about 0,8 % of the farm cash value of the production.

The balance of the welfare effects of this particular cycle is small, i.e. of the order of 1 % of the cash value of production. The distribution effects hurt consumers to the benefit of marketing firms. Do these distribution effects last in the long run ? Summing ΔMS_t on the one hand and ΔCS_t on the other hand, over the whole 1955-1973 period, gives very small numbers i.e. + 25 MF for consumers and + 30 MF for the retail sector. The same operation for ΔPS_t gives - 400 MF, and for ΔW_t (the net welfare effects), - 250 MF.

<u>Conclusion to chap. 4</u>

The overall impression gathered about the welfare aspects of the hog cycle in France is that it is a "1 % percent problem" respectively to the aggregate product of the industry, in the long run.

Efficiency loss due to fluctuations counts for less than 1 %.

During some particular cycles the balance of the welfare effects may be positive or negative by a few percentage points relatively to the average income or spending position. In the long run, however the distribution effects seem to cancel out especially between consumers and retail sector. This conclusion is consistent with both the margin behavior equation estimated and the results of the "direct method".

There seems to remain a net loss to producers in the long run, but its magnitude is rather negligible i.e. about 0,5 % of cash value of production.

These aspects seem to advocate for considering prices cycles as a minor problem in the economy. However, in the short run the welfare position of some agents is affected by a considerable amount. Under certain circumstances, this may by more than 20 % from equilibrium, if we note have that using quarterly data we have under estimated price fluctuations to a considerable extent. The conflicts of interest between economic agents at successive levels of the industry are exagerated by price fluctuations and create violent tension in the social group. This is an extention of the dimension of the problem which may deserve some attention.

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Table 4.1 - Time series of surplus deviations (105 francs, base 1970)
(quarterly, 1955 (1) to 1973 (3))

1) NET SOCIAL LOSS : W_t (equat. 4.24)

-165.8455	22.3367	76.1995	-7.5315	-42.4795	-71.1158	5.3867	.3190	6.0751	16.4297
-45.6803	9.2307	-20.5352	-.1319	5.3335	-59.1665	-58.3164	-231.9421	-29.0192	-88.0860
5.9477	12.9472	-4.6984	-15.9277	-46.9098	.2022	6.6652	.5106	-11.5006	-107.6812
-29.2696	-102.5381	-21.8591	9.4003	-165.7461	-259.1935	-350.9129	1.8431	-5.1755	8.8705
11.0352	-207.9514	-2.4012	-.2913	13.1363	28.5216	-66.2631	6.2248	-.3254	-58.5334
-10.6930	-68.1947	-64.1090	-93.8979	.6407	-17.3909	-65.6045	-50.9900	-128.6415	-42.9785
-23.1723	7.6299	21.4703	46.3375	-15.2946	-87.0134	.1865	.6355	2.9059	6.5813
6.3576	-6.0629	35.1465	57.7551	-2.2496					

2) PRODUCERS' SURPLUS : ΔPS_t (equat. 4.21)

1048.9289	121.1198	-237.6468	-711.1015	-1063.1715	-1133.2651	-385.7865	-515.6896	-233.7725	106.6499
1282.0105	1341.6012	1591.9005	265.6860	446.1422	-552.6050	-570.9929	-1385.6844	-309.6238	-910.4253
-93.6819	-226.9801	336.5550	411.7224	535.9620	-91.8499	837.4530	491.0723	-296.0921	-1919.1874
-1352.4817	-1709.2468	-772.7421	-194.0402	1535.8691	2447.0676	2071.0419	-837.1703	-180.7899	-865.2023
-1138.7765	-1919.8772	-111.8940	284.0851	1092.4233	800.0243	1446.7844	1167.3659	727.6556	-585.2138
-734.7274	-1043.1127	-1094.2205	-1406.3757	67.3029	362.5643	-502.0358	83.5024	652.1498	901.9859
994.8109	172.3593	-229.7934	-1136.0307	-1405.0465	-1410.1599	-505.6192	-512.4820	-634.6912	-857.7310
-512.5502	-106.4098	835.9102	1544.0290	2014.2375					

3) CONSUMERS'S SURPLUS : ΔCS_t (equat. 4.22)

-709.0751	-826.9337	-1041.2787	-72.0142	719.8168	297.9318	12.3010	164.3144	373.8583	887.2381
346.1001	-42.3598	-663.2219	-627.8841	-189.5223	462.3759	987.4665	706.7993	448.3964	999.6097
1103.1947	741.8765	517.3433	673.1571	-109.4659	-781.2169	-1164.5804	-701.5251	-151.0835	271.7179
161.6541	477.7349	735.5433	435.0742	-631.7840	-1244.5977	-1758.6184	-1547.0460	-1634.7732	-721.5209
227.1664	573.9174	411.2791	350.2566	-319.9900	-454.4338	-525.4725	-464.4268	-447.5349	-173.9679
-15.4403	330.2818	195.2901	587.7541	195.5555	286.2020	1094.3429	559.2694	33.4245	-141.2981
-239.8897	-363.7230	-283.4097	422.7728	805.8429	900.9295	474.6963	356.2114	781.8203	835.2950
401.8126	348.7696	-6.3117	-807.9748	-2590.7355					

4) MARKETING' SURPLUS : ΔMS_t (equat. 4.23)

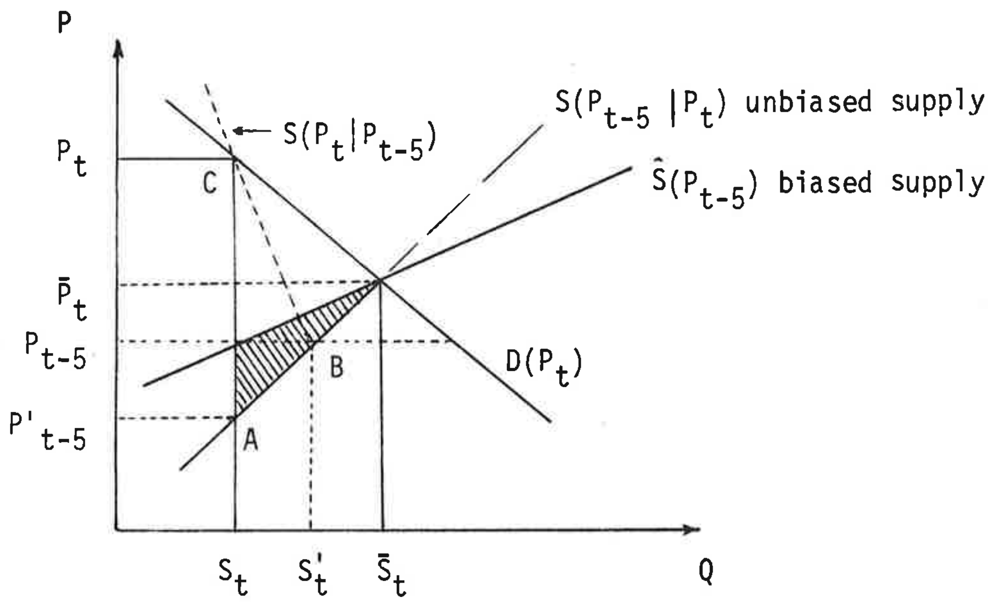
-1107.2135	876.2337	946.0717	678.8872	446.0347	965.5037	175.9252	947.8634	190.5200	-710.8573
-1900.7704	-825.4304	-701.9516	536.7149	-603.6338	351.9510	-222.9176	783.5179	-191.9729	-223.5591
-1059.6313	-442.0727	-1516.4114	-1235.0028	-898.6546	779.2468	-252.4116	-144.1662	86.4776	1517.0597
1157.8313	1103.7952	-313.8799	103.5649	-1391.8160	-1803.8444	-967.8968	2507.5700	1239.7270	1619.6187
688.3642	1749.6554	-385.2831	-316.8761	-847.6626	-370.3367	-1320.1752	-751.5487	-771.5959	1071.3695
1291.9075	604.3290	1142.1430	972.1144	17.0179	-287.3701	-922.6678	-787.8867	-1009.5303	-1235.0822
-1553.1284	482.6962	694.7107	1078.8107	838.3820	1038.7451	642.8690	558.8412	-182.0923	624.4343
637.9641	60.4789	-1487.2882	-1409.1028	-792.4167					

Appendix 4.0

4.1 Implication of the current price effect

The cause of the current price effect is the relationship between breeding inventory and current sales. I made an argument that by using the purely recursive model, the supply elasticity is overestimated. This means also that the point (P_{t-5}, S_t) does not belong to the true supply curve S (P_{t-5}, P_t) which is more rigid that the one S(P_{t-5}) implied by the point (P_{t-5}, S_t). If we take the current price effect into account, then the appropriate point which belongs to the supply curve is (P'_{t-5}, S_t) ou fig. 4.7.

Figure 4.7 - Implication of current price effect on welfare



The shaded area should therefore be added to the net social loss since the "marginal cost" P'_{t-5} is smaller than the observed price P_{t-5}.

The ratio between real loss $(P_t - P'_{t-5})\ s_t = W'_t$ and apparent loss $(P_t - P_{t-5})\ s_t = W_t$ depends on price differentials only. Starting from the true supply equation $S_t = k + \eta_0 P_t + \eta_1 P_{t-5}$ we can find the relation of $P_{t-5} - P'_{t-5}$ to $P_t - P_{t-5}$ by their expression in $S'_t - S_t$ moving along AB, which follows equation $S(P_{t-5}|P_t)$

$$S'_t - S_t = \eta_1\ (P_{t-5} - P'_{t-5})$$

moving along BC, which is by equation $S\ (P_t|\ P_{t-5})$

$$S'_t - S_t = \eta_0\ (P_{t-5} - P_t)$$

This yields after simplication :

$$W'_t = W_t\ (1 - \frac{\eta_0}{\eta_1}) > W_t \qquad \text{by } \eta_0 < 0,\ \eta_1 > 0$$

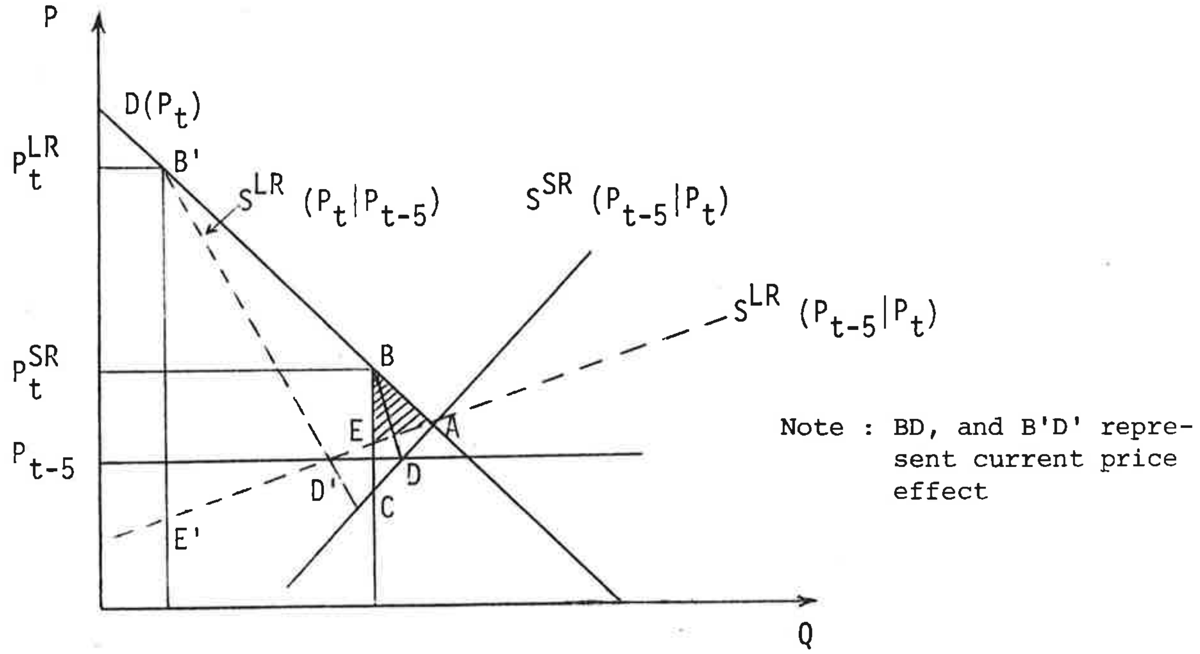
As the ratio η_0/η_1 is about minns one fith, then social loss would be increased by 20 %.

. . .

4.2 Implication of partial adjustment and adaptive expectations (with current price effect)

The estimated supply curve contains an autoregressive term, justified by either partial adjustment behavior or adaptive expectations. The two models are not distinguishable empirically. However they seem to have different welfare implications.

Figure 4.8 - Slow adjustment and welfare effects



The autoregressive model implies that producers move along S^{SR} instead of S^{LR}. The result is a reduction of price variation from P_t^{LR} to P_t^{SR}, and a smaller welfare loss from area A E'B' to AEB assuming that it is adaptive expectations which induce cautionsness and that the supply curve reflecting marginal cost is S^{LR}. If we assume partial adjustment however, it is more correct to assimilate S^{SR} to marginal costs, since partial adjustment is based upon further costs incurred when moving to a new equilibrium position for the firm. Then the actual loss is ABC and not ABE. Therefore adaptive expectations reduce the actual welfare losses compared to naïve expectations. Partial adjustment imply also a reduction of welfare loss from ABE' to ABC, compared to immediate adjustment. They both seem to imply in general a reduction of losses with respect to the case of full adjustment to price in the current period. However, partial adjustment means a larger welfare loss (ABC) than adaptive expectations (ABE), since the SR cost curve AD is assumed steeper than the long run curve AD'.

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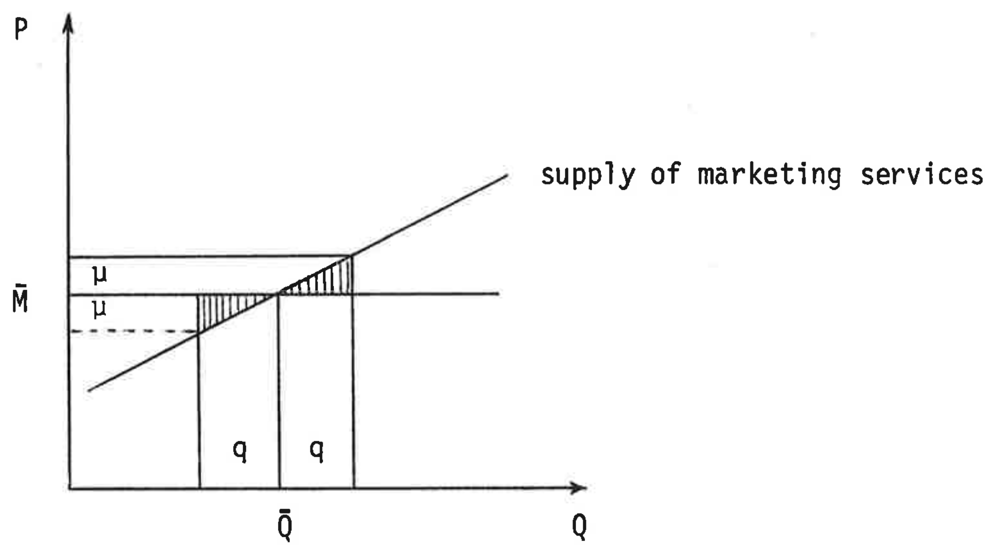
4.3 Rising marginal cost in marketing

Figure 4.9'- Constant margins and welfare losses



Suppose that marginal cost is rising around equilibrium. Constant margin would imply a loss to the industry when quantities fluctuate between $\bar{Q}$ - q and $\bar{Q}$ + q i.e. for a whole cycle qμ (fig. 4.9'). Therefore there seems to be an argument here, for margins to vary in opposite direction to farm prices, which is actually the case. However wide margin fluctuations do not seems to be close to marginal cost change, especially if we note that relative variation of quantities $q/\bar{Q}$ is generally small.

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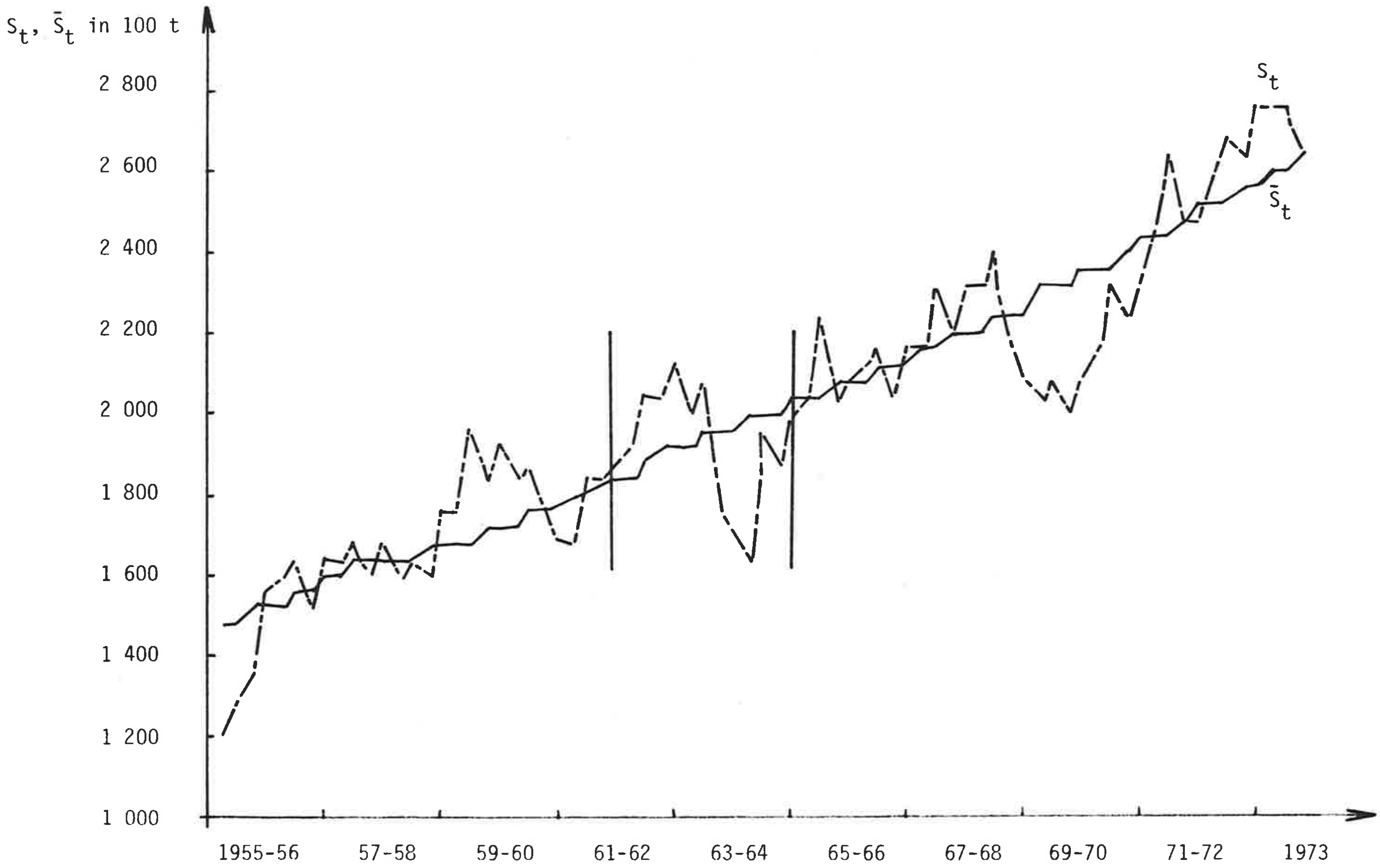
Figure 4.9 - Equilibrium path $\bar{S}_t$ production



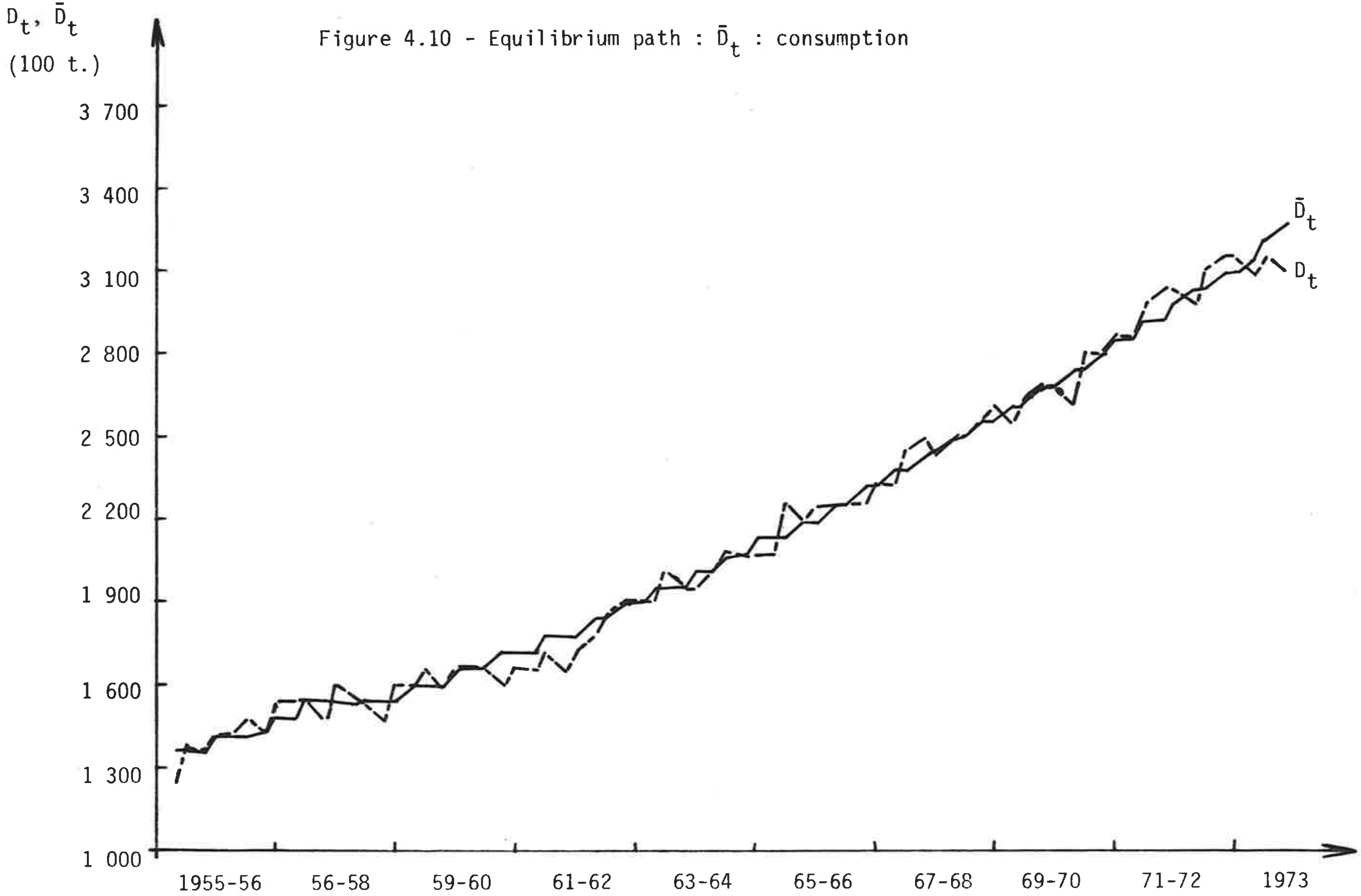
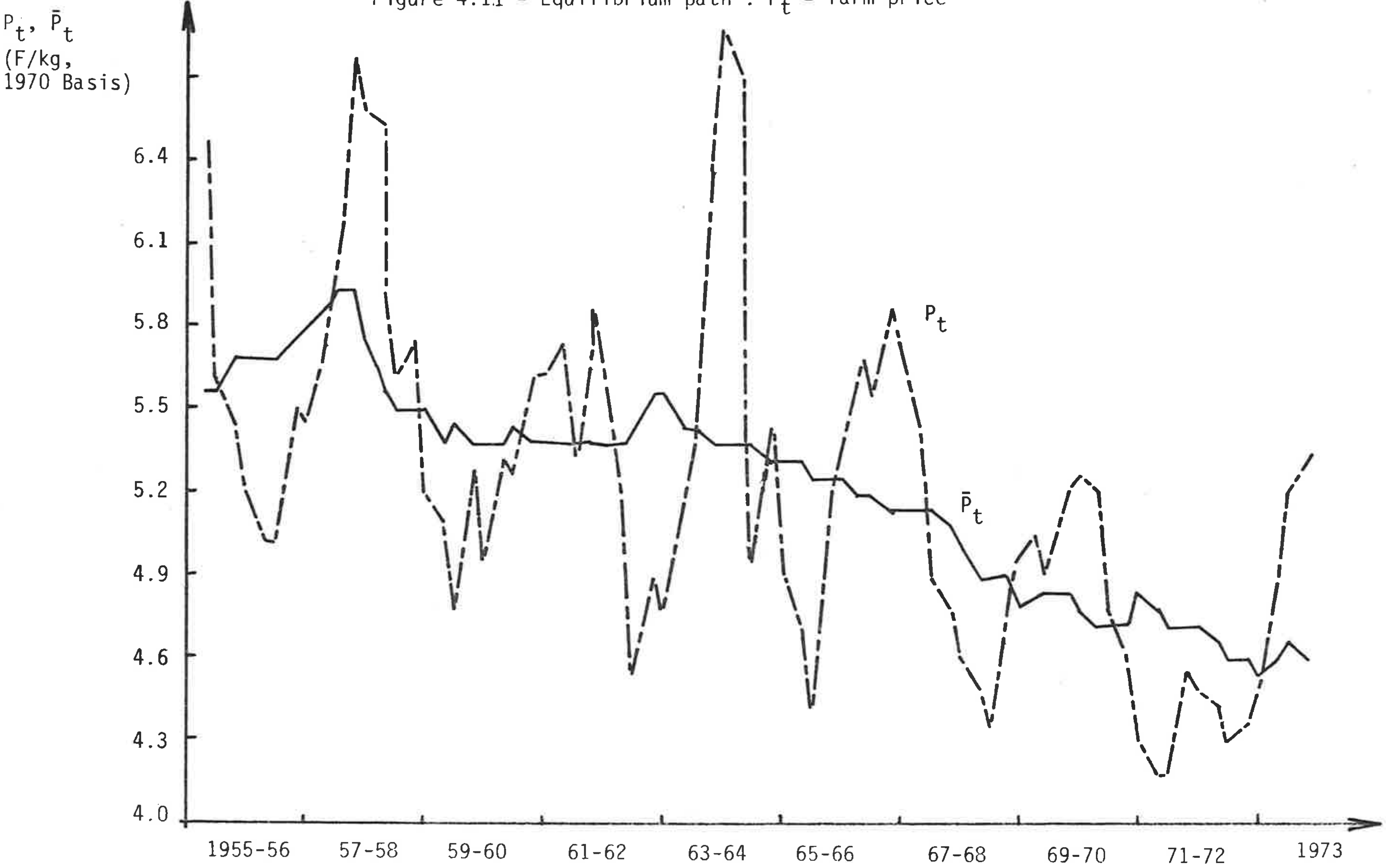


Figure 4.10 - Equilibrium path : $\bar{D}_t$: consumption

Figure 4.11 - Equilibrium path : P_t = farm price



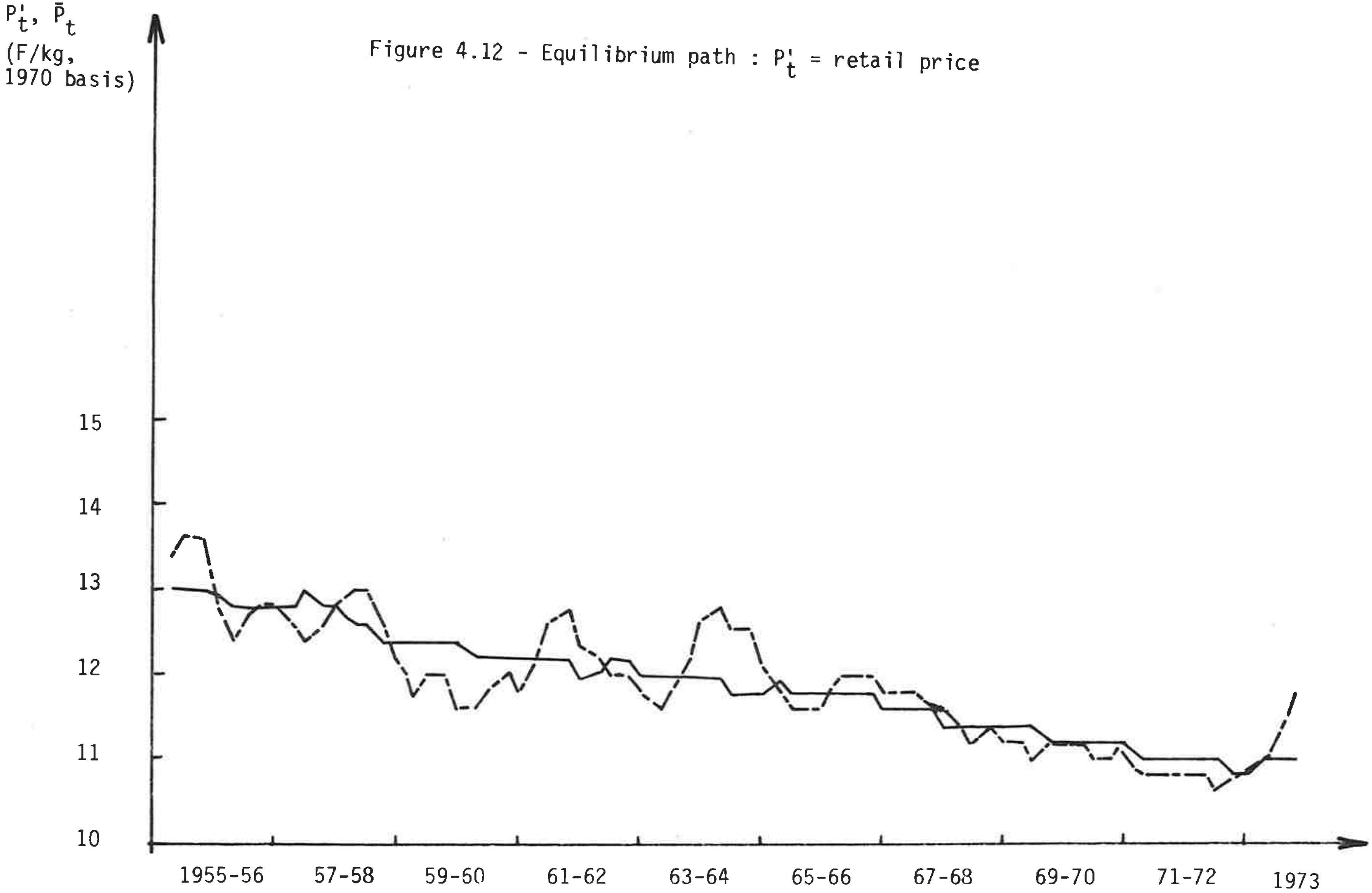
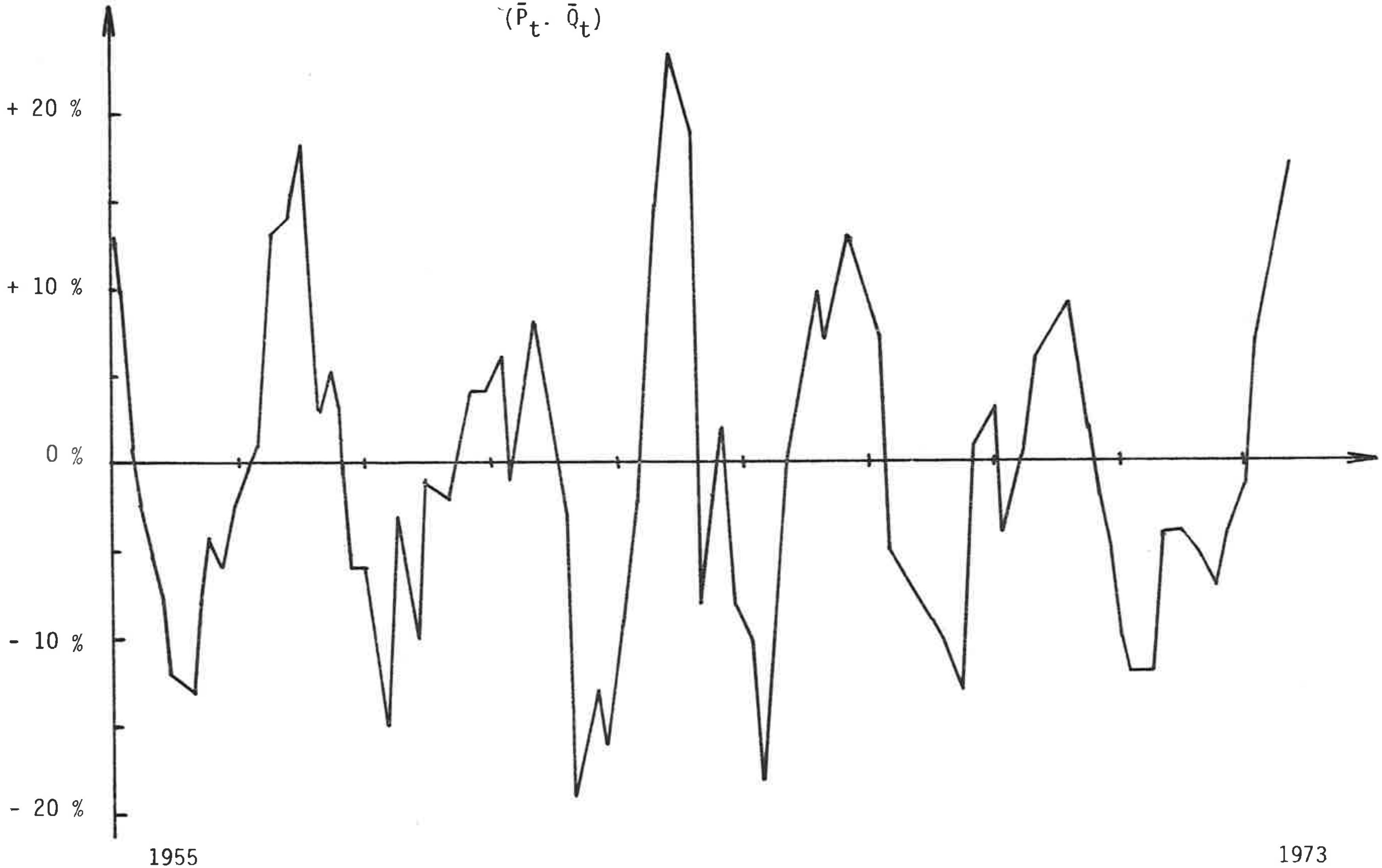


Figure 4.12 - Equilibrium path : P'_t = retail price

Figure 4.13 - Producers surplus variation as a % of equilibrium receipt
$(\bar{P}_t \cdot \bar{Q}_t)$



C O N C L U S I O N

The simplicity of theories advanced to explain the hog cycle namely cobweb and harmonic motion models, contrasts with the complexity and the numerous specifications of actual models. I have tried to argue that the two theories do not provide a basically different explanation of the cycle and that the superiority of the cobweb rests upon its micro-economic fundations. The cobweb has to be slightly modified however in the context of livestock cycles, since the decision process is continuous over time and deals with a capital good, the breeding stock, that can be either invested or consumed. This fact introduces an interdependency between current and lagged supply, implying a simultaneous determination of supply, demand and prices. Failing to take this fact into account, by using the simple recursive cobweb, may lead to biases in both supply and demand.

The results confirm broadly the validity of the approach, although practical estimation problems have not been overcome in a nice way. The results gotten suggest also that the bias on the supply elasticity may be far from negligible. The great variability of specification of published models prevent a clear cut exogenous illustration of the question raized.

This observation has led to investigate another point relative to the interpretation of models in term of supply elasticity. It was argued that models using marketed supply and those using inventories do not yield identical concepts of supply elasticity on an a priori basis. This fact added to the assumed away simultaneity may lead to severe errors on the estimates of supply elasticity. The lack of data on inventories made impossible to illustrate this particular point and other studies are different in too many ways to show confirmation or contradiction.

The complete model of the hog market in France provides an acceptable representation of the subsector, as far as fit and expected behavior are concerned. The piglet market seems to play a central role in the cycle process and the cost of feed does not have a great importance yet in the industry on the face of the results. On the demand side, price and income are still important factors, but substitution effects have been obviated only for veal meat. Farm-retail price transmission is slow in the short run, but real margins turn out to be constant in the long run. A slight ratchet effect of retail prices seems to exist, implying some market power of retailers in the short run together with a minor contribution to the inflation process. The trade aspects of the hog market has not been fully explained, neither completely represented, particularly in terms of international competition and EEC policy action ; net imports however, are shown to react rapidly and strongly to French price and income.

Although policy uses of the model are far from being fully explored, it was shown that public storage had a very small impact on prices which raises the question of the real exogeneity of public action. Another group of policy measures, i.e. subsidies to improved structures of production and marketing, were shown not to have the expected stabilizing effect on the hog cycle.

Since price and quantity cyclical fluctuations are at the heart of the subsector problems an attempt to analyse their welfare implications was made. The social cost of the hog cycle looks rather negligible on the efficiency point of view. Distribution effects are much more important. Quite large in the short run they may and they do indeed create acute tension between economis atents involved. In the long run however they cancel almost exactly but the producers seem to loose from them, although to a rather negligible amount.

A the end of this research effort, I get the impression to have been dealing with rather minor problems on the theoretical aspects of the hog cycle. I hope however to have made clearer the working of the economic forces on the French hog industry. A lot remains to be done to explore fully the policy use of the model.

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JFE : Journal of farm economics
JAE : Journal of agricultural economics

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