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

A THESIS

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

By

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEGREE GRANTED

December 1976

Acknowledgements

I would like to express my gratitude to Pr. L. Martin fo his guidance during my graduate program and for his helpful suggestions during my research effort. I would like also to express my appreciation to Pr. M. Abel for his encouragements and comments which contributed greatly to my research. Pr. C. Swan and T. Roe also helped me clarify several points in the dissertation.

I also benefited from several colleagues of the INRA and the Direction de la Prévision, where the research was carried.

I owe a special mention to Mrs Leclainche for having agreed to type a manuscript not written in her mother language.

To my Parents

To Marie-Monique, Chantal and Tristan-Loup

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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)

INTRODUCTION

Livestock cycle theory has received a lot of interest from agricultural economists. However two points seem to deserve more attention and are the subject of this thesis: the problem of simultaneity in cobweb models applied to livestock and the welfare analysis of cobweb-like fluctuations.

The first question raised is: should a livestock supply model be recursive or simultaneous ? This point is not really new in the literature but it has been quite neglected as to its theoretical foundations and implications. An analytical discussion is needed to bring some light on the subject; such an attempt is made in the dissertation with pork production as a reference. It shows that there exists a built-in interaction between supply and inventories in the hog cycle.

The second topic deals with an effort to evaluate the welfare losses resulting from cyclical fluctuations. Applied welfare analysis is used in the context of the cobweb and it allows to evaluate both allocation and distribution effects of the hog cycle.

In the first chapter, I review some of the literature dealing with livestock cycles and particularly the two wellknown theories, namely, the cobweb and the harmonic motion. The alleged superiority of the latter is questionned. Furthermore, its published formulation does not bring any light on the supply-inventories relationship although it is a natural part of this approach to livestock cycles. Previous expositions of the simultaneity problem are then reviewed and their shortcomings pointed out.

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 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 estimated parameters and essentially the supply elasticity. The next step is to formulate explicitly the consequences of the inventory-supply interaction on the dynamics of the cobweb and on the stability conditions. The third aspect of this addition to the cobweb theory is the analysis of its implications for estimation procedures. The biases which may arise in both supply and demand elasticities when recursiveness is improperly assumed, are discussed analytically.

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, feeder pig market, and imports, emphasis has been placed on supply, and the other equations have not received as much attention. Some particular features of the French hog industry are discussed in the light of these empirical results.

Chapter four deals with the welfare aspects of cyclical fluctuations. The approach is based on consumer and producer surpluses, already applied to the welfare analyses of random fluctuations of agricultural prices. An empirical illustration is presented on the basis of the estimated model of chapter three. It gives 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 out in the cobweb framework, and since the concept of surplus used must be consistent with micro-economic foundations, the discussion of the nature of the supply of chapter two is used in this welfare application of the estimated model.

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Chapter I

A SHORT REVIEW OF LIVESTOCK CYCLES THEORY

Basically two schemes 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 [35], Larson [32] 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 to write "there is a basically different model, which 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 McClements [36] criticizes 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 function. 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 [11, p. 272] states three conditions for the theory to be relevant to a commodity: (i) where production is completely determined by producers' response to price, under conditions of pure competition (where producers base plans for future production on the assumption present prices will continue, and that his own production plans will not affect the market); (ii) where production cannot be changed, once plans are made; and (iii) where price is set by the supply available.

These features may be expressed in the following simple model:

COBWEB MODEL

(1.1) demand $p_t = a + b\,Q_t^d \quad , b < 0$

(1.2) supply $Q_t^s = c + g\,P_{t-w} \quad , g > 0$

(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 2w, 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 nonzero short-run elasticity of supply and mentioned 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 rule which is highly 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" [33, 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	$Q^s_{t+w} = m\, B_t$
(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 production and price cycle of period 4w.

1 - Periodicity

"The chief difficulty in accepting the 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" [33, 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. The period is about 4 years in the United States, but it varies from 36 to 40 months in most European countries and it is 52 months in the Netherlands [25, 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 [19, 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" [36, p. 145]. It is clear however in Nerlove's article [40, p. 232], that neither adaptive expectations nor the 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.

Since observed cycles have a period longer than twice the usual production lag, we cannot 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 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, but says only, "First there is a shift of 90 degrees (i.e. one fourth of the period) caused 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" [32, p. 379]. The solution in deviations from equilibrium of the differential equation derived from model (1.4) to (1.7) given by Larson [32, 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 explicitly with respect to time, have built-in an implicit relationship between q_t and p_{t-2w}. Taking $e_p = 0$ and $e_q = \pi$, as required by Larson for resonance we get 1/ :

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

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

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: $q_t = p_{t-2w}$. This relationship comes from the reduced form of (1.4) through (1.6), but the lag cannot originate in the demand where adjustment is instantaneous. I must therefore be built-in the "supply" equation, which supposes, just as cobweb users do, that there is a lag between price changes and response to them. Moreover the constraint that makes the 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 supeiority of harmonic motion over the cobweb is open to question, at least on the periodicity point of view, to which Larson gives great weight.

1/ The assumptions on the coefficients which lead to this equality between lagged prices quantities deviations, seem quite unrealistic.

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, p. 6]. It is clear that the domain of application of the cobweb is in the explanation of short-run fluctuations. However the reversibility implied by Ezekiel 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 is assumed in the traditional 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. 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 in 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 [32], French and

Bressler [1/] [12] or others [20], are based only on the periodicity argument using spectral analysis or similar techniques. This is a rather doundabout 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 exist a constraint on decisions a 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 a t is fixed by past decisions. Therefore sales Q at t do not depend only on the breeding stock at $t-\bar{w}$ as 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 fare as interpretation and estimation are concerned. We will see that if this biological counstraint is accounted for, modification of the supply equation is required with an interpretation of supply parameters going along with it. A negative instantaneous supply response to price follws, which changes the dynamics of the cobweb and the stability conditions. A practical consequence of this current price effect is that the model loses its recursiveness and simultaneous equations are then required throughout.

1/ Considered by Larson "most dramatic verification of the model".

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 the dependent variable [19], others use quantities marketed measured through slaughter [7, 22, 30]. Most use both inventories and slaughter [24, 37, 42, 52]. As data on farrowings and inventories are not available in many countries including France, we may raise the question of the relationships between the various specifications. To be more specific, one may wonder if the supply elasticity derived from the different specifications has the same meaning. This can be done by trying to find out the analytical correspondence between 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 aspect of hog supply specification to be discussed is the theoretical foundation of the interaction between inventories and supply which leads to drop the assumption of an inelastic short-run supply as will be seen later. Although it has been quite neglected by many authors, this is not really a new idea. Ezekiel already mentioned a possible short-run adjustment of the level of production in the short-run for commodities subject to cycles [11, p. 272].

"In many commodities farmers can do little to increase their future production, once they have made their initial commitment in acres seeded or in animals bred. But altho they cannot increase, they can reduce at any time until the product is finally marketed, by plowing up portions of the crop or letting it go un-

1/ And more generally, or course, with factor prices and prices of output substitutes.

harvested, by slaughtering breeding stock, or by slaughtering pigs young instead of fattenning them. There is then in practice some elasticity of response left, on the downward side at least".

Lorie [35] and Shepherd [47] discussed again the problem later (1947) and also Breimyer in 1955. The first formal version of this idea is due to Hildreth and Jarrett [24, chap. II and VI].

"One question about livestock supply that has been the subject of much discussion is whether an increase in current prices tend to increase or decrease current marketings, It has often been asserted that in the absence of offseting factors, an increase in the price (particularly of cattle) leads to favorable anticipations, to an attempt to build up inventories and lower current sales, and to a strengthening of the tendency for current price to rise. This is cited as a destabilizing tendency in livestock production".

Their model may be summarized as follows

(1.10) $A_t = g\ (I_t)$

(1.11) $S_t = f\ (P_t, I_t, A_t)$

(1.12) $I_{t+1} = I_t + d\ (A_t - S_t) + v_t$

where

I_t = number of animals at hand at the beginning of the t^{th} time period

A_t = quantity of livestock produced during the t^{th} period

S_t = quantity of livestock and livestock products sold during the t^{th} period

P_t = price of livestock products
v_t = random variable

Exogenous variables are not repeated here for simplicity. Equation (1.10) says that quantity of livestock produced is determined by beginning inventories, but supply S_t is not necessarily equal to quantity produced A_t, it is affected by price according to equation (1.11). The supply system is closed by the inventory relation (1.12), which is not defined as an exact accounting identity because of the aggregation over various animal types [24, p. 21]. The results gotten by the authors by both ordinary least squares and limited information maximum likelihood are consistent with the assumed interaction between breeding-stock and supply i.e. the current effect of price on the supply of livestock is negative.

Several authors have failed to refer to this analysis to explain their results showing a negative current price effect on supply of meat [30, 21, 31, 39]. One of the reason may be that another rationale exists to explain a positive effect of current price on meat supply: the increase in weights in response to higher prices. Several authors found results consistent with this effect [39, 10, 21, 19, 52] . The reason why opposite results were obtained by different authors may depend on definition and measurement of the supply. This point will be discussed in chapter II.

The inventory-supply interaction was discussed again in a formal model by Reutlinger in 1966 on beef and by Tryfos in 1974 on beef, veal, pork and lamb. Tryfos builds on Reutlinger's work which dealt with a recursive model. He sets up a model in a simultaneous framework and shows clearly the rationale of the negative current price effect on the number of animals marketed.

Neither of these two authors refer to Hildreth and

Jarrett's work although their model is quite similar from this viewpoint, as may be seen below with Tryfos' model.

(1.13) $A_t = a_0 + a_1 I_t$. (Available supply)

A_t = quantity of livestock available during period t,
I_t = inventories at the beginning of period t.

(1.14) $I^*_{t+1} = b_0 + b_1 P_t + b_2 C_t$ (desired inventory)

P_t = live animal price
C_t = lost of feed
I^*_{t+1} = desired livestock inventory at the end of period t.

(1.15) $I_t - I_{t-1} = C\,(I^*_t - I_{t-1})$ (partial adjustment hypothesis)

(1.16) $S_t = A_t - d\,(I_{t+1} - I_t)$ (inventory relation)

The two equations to be estimated simultaneously are the following :

(1.17) $I_{t+1} = cb_0 + cb_1 P_t + cb_2 C_t + (1 - c)\, I_t$

(1.18) $S_t = a_0 + (a_1 + d)\, I_t - dI_{t+1}$

Empirical results confirmed the expected signs in the functions, namely the positive effect of current prices on ending inventories and the corresponding negative effect of enfing inventories (I_{t+1}) on current supply (S_t). The problem with Tryfos' article is that the relation of his model to the supply function of the cobweb is not abviated. This may be the reason why he calls price elasticity of supply the negative current price effect and price elasticity of inventories the positive effect of current price on ending inventories. Although literally correct this wording may be misleading. The negative price response is rather inconsistent with the micro economic fundations of supply theory. I would prefer to relate this response to the investment demand for breeding stock and to derive the long-run supply elasticity which one expect to be positive from the inventory relation (1.17). this is the subject of chapter II where I show the relationship between the parameters of various supply specifications, and several consequences of the inventory-supply interaction on the dynamics and the estimation of the model.

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Chapter II

THE INVESTMENT DEMAND FOR BREEDING STOCK AND SUPPLY FUNCTION

In this chapter I will develop a model of hog supply along the line of Hildreth, Jarrett and Tryfos' work, but I will set it in the cobweb framework, so that the interpretation of the different specifications becomes easier. I will also show that this model, where marketings depend 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 type models. This form is particularly useful when there is little aggregation over time, such as when quarterly data on marketings are used.

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 analyze in a formalized way the consequences of the current price effect on the dynamics of the cobweb and the possible biases incurred by assuming away the current price effect.

1 - A supply function derived from the investment demand for breeding stock

The authors quoted above 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, and consequently the inventories are substituted for a narrower animal group in the herd, namely the breeding stock.

Let us define the variables included in the model.

B_t, is the number of sows bred during period t.
H_t, is the number of animals (males and females) which may be bred or slaughtered during period t.
S_t, is the number of animals sold or slaughtered during period t.
P_t, is the price of meat, i.e. the output price, but it may be thought of as a vector of output, substitutes and factor prices. It is defined as output price to keep notations simple.

Given the production lag w, the offspring of the females bred in period t-w will be available for slaughter in period t. For hogs, adding the gestation period (about 4 months) to the slaughter age (6 to 8 months) makes a production lag of about a year. We can write a technical relationship derived from the biology of the species :

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

Where m is a technical parameter, approximately the number of piglets saved per litter. It is a little different since H_t is defined so as to include older sows which may be bred again or slaughtered. One may raise the question whether the lag w is the same for this component of H_t, as for the young sows. If sows are in the average kept about a quarter after weaning, the lag would be 5 to 6 months. Moreover some bred sows may also be discarded at the beginning of the gestation. All these arguments may lead to a production lag overlapping several time periods especially if the data refer to a short time unit (month, quarter). In practice, it may be necessary to generalise [1/] relation (2.1), but this does not alter the argument carried in the model.

Given the definition of the variables, we can write the equivalent of the inventory relations of Hildreth and Jarrett (1,12) or of Tryfos (1,16) as an exact accounting identity [2/]

(2,2) $$H_t \equiv B_t + S_t$$

The three variables are dated by the same period since they are all flow variables while previous models use stock variables (inventories). Here B_t refers to the change in the breeding stock. We can note that all the animals present in the herd in period t are not included in the variable H_t, but only those eligible for breeding or slaughter [3/]. The model includes only the animals which may be affected by farmer's decision during period t. Identity (2.2) means that the output (H_t) of the herd

1/ (2.1) could be written as $H_t = \sum_{i=0}^{\tau} m_i B_{t-w-i}$, where the production lag lies between w and w + τ.

2/ In the case of Tryfos, the reason he gives for writing a less constrained relation is questionnable. The fact that A_t (here H_t) is not observable does not matter. It does not appear in the estimated relations.

3/ Again, although the young sows may be bred a little older than usual slaughter age, identity (2.2) still holds when the lag is allowed to spread over several time units in relation (2,1).

may be either bred (B_t) or sold during a given time unit. While H_t is predetermined it is not so for supply S_t since it is affected indirectly by the investment demand for breeding stock B_t.

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

Equation (2.3) is a usual demand for investment. Increase of output price is assumed to affect positively the demand for breeding stock. Price expectations will be discussed later.

Relations (2.1)-(2.3) are the structural equations of the supply behavior of hog producers. Depending on data availability, estimable functions may take different forms, but the structural form imposes an overall consistency on the parameters of the different partially reduced forms derived from the structure.

Combining (2,1) and (2,3) we get what, I believe, should be considered as the true supply equation in livestock models i.e. the form consistent with the microeconomic definition of supply.

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

This is the relationship between the available supply at t and the lagged price which has actually induced this level 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. Because of the linear form the supply elasticity at mean values is given by :

(2,5) $$\sigma = m\,\alpha\,\frac{\bar{P}}{\bar{H}}$$

This is the procedure used by Harlow [19, p. 39], whose model explained the farrowings by lagged price. Available supply is just m times the farrowings and both models yield the same concept of supply elasticity.

Several workers have used marketings as the dependent variable with lagged prices as explanatory variables [7, 30, 22]. This specification is intuitively appealing when one wants to explain directly marketed quantities. From the 3 structural equations we can also derive an expression for marketings or sales.

$$S_t = H_t - B_t$$

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

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

- Equation (2.7) is not strictly speaking a supply equation, since marketings depend not only on lagged price but also on current price. This equation reflects the dual nature of invesment decisions concerning the breeding stock which have both lagged and instantaneous effects on supply. I would suggest to call (2.7) sales or marketings equation.

- While Harlow's specification of supply (2.5) is consistent with the invesment demand approach to the hog cycle, it is not so for "supply equations" defined by S_t depending only on lagged price P_{t-w}. The present model is consistent with a purely recursive farrowing equation, but requires a sales equation with both lagged and current price. In that sense a purely recursive sales equation is not correctly specified.

- Such a recursive sales equation does not provide an appropriate concept of supply elasticity as in (2.5). Suppose for the moment that a consistent estimate of the parameter $m\alpha$ could be derived from the recursive sales equation 1/. A natural way to evaluate supply elasticity would then be from

$$(2.8) \qquad \sigma_1 = m\,\alpha \frac{\bar{P}}{\bar{S}}$$

But this is just an apparent supply elasticity, not equivalent to the one used by Harlow for example. Moreover the true supply elasticity σ is overvalued by σ_1, since consistency of the model implies $\bar{H} > \bar{S}$. How large is the discrepancy between σ_1 and σ ? An approximation may be derived by noting 2/ that $\bar{H} \simeq \bar{S}\ m/(m-1)$. For hogs the magnitude of m lies between 5 and 10 and the relative error on supply elasticity is in the domain 25 % to 10 %, since we have

$$(2.9) \qquad \frac{\sigma_1}{\sigma} \simeq \frac{\bar{H}}{\bar{S}} = \frac{m}{m-1}$$

Kettunen found an apparent supply elasticity of 0.25 and a true supply elasticity (by using quantities produced instead of sales as dependent variable) of 0.20 [30, p. 48].

- The sales equation (2.7) may be used however to evaluate the true supply elasticity σ defined in (2.5). The total derivative of S with respect to price P will give the total effect of a price change ou future sales whenever they occur (immediately or later). This corresponds intuitively to a notion of supply multiplier or elasticity. The long-run multiplier is :

1/ This is unlikely because of, the specification error resulting from dropping P_t. This point will be treated in section 5.

2/ From (2.1) and (2.2) ; $\bar{H} \simeq m\ \bar{B}$; $\bar{H} = \bar{B} + \bar{S}$; $\bar{B} \simeq \bar{S}/(m-1)$ and therefore $\bar{H} = m\ \bar{S}/m - 1$.

$$\frac{dS}{dP} = \sum_{i=0}^{\infty} \frac{\partial S_t}{\partial P_{t-i}} = m\,\alpha - \alpha = \alpha\,(m - 1)$$

The long-run elasticity 1/ is then given by

(2.10) $$\frac{dS}{dP} \cdot \frac{\bar{P}}{\bar{S}} = \alpha\,(m - 1)\,\frac{\bar{P}}{\bar{S}}$$

recalling the relationship between $\bar{H}$ and $\bar{S}$ we get

(2.11) $$\frac{dS}{dP} \cdot \frac{\bar{P}}{\bar{S}} = m\,\alpha\,\frac{\bar{P}}{\bar{H}} = \sigma$$

consequently we derive from (2.10) and (2.11)

(2.12) $$\frac{\bar{P}}{\bar{S}}\left(\frac{\partial S_t}{\partial P_{t-w}} + \frac{\partial S_t}{\partial P_t}\right) = (m\,\alpha - \alpha)\,\frac{\bar{P}}{\bar{S}} = \sigma$$

The true supply elasticity is given by the algebraic sum of the elasticities of sales with respect to lagged and current prices.

Relation (2.12) as well as the sales equation (2.7) show that there is a relationship between elasticities with respect to lagged and current prices. Lagged price effect should be m times current price effect. This gives a way to check the results of a fitted model: current price effect on sales may not be "too large". At the minimum current price effect must be smaller in magnitude than lagged price parameter for the supply elasticity derived from (2.12) to be positive.

1/ When partial adjustment will be added to the model, this is no longer the long run concept of elasticity.

- The true supply elasticity may also be derived from the investment demand function (2.3) for breeding stock

$$\frac{\bar{P}}{\bar{B}} \cdot \frac{d\ B_t}{d\ P_t} = \alpha \frac{\bar{P}}{\bar{B}} \text{, using } \bar{H} \simeq m\ \bar{B}$$

$$\frac{\bar{P}}{\bar{B}} \cdot \frac{d\ B_t}{d\ P_t} \simeq m\ \alpha \frac{\bar{P}}{\bar{H}} = \sigma$$

Although inventory functions are not strictly indentical to the investment demand, since inventories include not only the breeding stock but also the offspring, the inventory elasticity (in Tryfos'model for example) is closer to the notion of supply elasticity than the negative response of sales to current prices. Inventories are often the only stock data available on the herd, so that workers estimate inventory demand functions. However, the investment demand function appear to be a more rigorous way to formulate the decision making, since changes in the breeding stock depend only on current decisions, while changes in inventories are also affected by decisions made in the past.

2 - Long run supply elasticity and the sales equation

It is misleading to qualify short-run supply response 1/ the current price effect in the sales equation (2.17). It is related to investment demand and should be called accordingly. The possible confusion appears when one drops the assumption of full adjustment of breeding stock to prices, i.e. the full adjustment of supply. The introduction of the partial adjustment hypo-

1/ As done by Kettunen for example [30].

thesis into the behavioral model should be made through the investment demand equation and not directly into the sales equation (2.7) as done by some authors [7, 30].

Let B_t^* , the desired level of breeding stock invested in period t. The partial adjustment hypothesis implies a new form of model (2,1)-(2.3)

(2.13) $$B_t^* = \alpha_0 + \alpha P_t$$

(2.14) $$B_t - B_{t-1} = \psi (B_t^* - B_{t-1}) , \quad 0 \leqslant \psi \leqslant 1$$

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

Equation (2.15) may provide estimates of both long run and short run elasticity if data on breeding stock are available. $\alpha \bar{P}/\bar{B}$ is the LR supply elasticity and $\psi \alpha \bar{P}/\bar{B}$ is the SR supply elasticity, both are positive as usually expected. Now, equation (2.15) can be written in terms of available supply H_t by using (2.1)

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

This may not be a practical equation to estimate because of data limitations, but the sales equation is much nicer to both estimate and interpret. By using (2.15) and (2.16)

$$S_t = H_t - B_t$$

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

Using the relation between H_{t-1} and B_{t-w-1} we get the simple autoregressive sales equation, (2.17) $$S_t = \psi \alpha_0 \ (m - 1) + (1 - \psi) \ S_{t-1} + m \ \psi \alpha P_{t-w} - \psi \alpha P_t$$

This equation includes both partial adjustment and inventory-supply interaction in a form close to the cobweb. In this equation $\psi \alpha (m - 1) \ \bar{P}/\bar{S}$ will serve to calculate short run supply elasticity, $\alpha \ (m - 1) \ \bar{P}/\bar{S}$ long run supply elasticity, $\psi \alpha$ the invesment demand effect.

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 obvious if one specified supply behavior directly with a sales 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 the time unit in the following way

$$S_t - S_{t-w} = \psi' \ (S^*_t - S_{t-w})$$

which would lead to an estimable equation

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

where the coefficient of S_{t-w} would be interpreted as one minus the adjustment coefficient ψ'. At one time I made such an attempt, without success. Kettunen also did the same [30, p. 51], but the coefficient was very small (0.08) and not significant. The simple form given to the sales equation with slow adjustment by the breeding-stock, supply interaction seems to add a nice coherence to the overall supply behavior implied by the model 1/.

3 - Supply in numbers, supply in weights

All the previous models have been specified in numbers. But the relevant variable for market equilibrium is the live-weight marketed. Current prices have a positive effect on average carcass weights, as is well known, e.g. Harlow [19, p. 40]. More recently, Myers, Havlicek and Henderson [38, 39] provided us with a more sophisticated model of short-run 2/ 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 aware, making it 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 two components of supply: numbers and weight per head. What they really tended to show is that when prices go up, farmers anticipate further increases 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 live weight as they did leads to

1/ Marketings lagged by just one unit of time (S_{t-1}) are introduced in a recursive sales equation in Chin, Pando and West [7] without discussion of the different lag for the price and the dependent variable.

2/ Compared to the previous notion of short-run elasticity this a "very short-run problem".

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

$$(2.18) \qquad Q_t = g\ H_t - \alpha_0 - \alpha\ P_t$$

where Q_t is the total liveweight marketed.

But one may also explain the negative sign by the investment 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 [52, 10, 13]. In the context of Tryfos' model where he discussed the current price effect, I consider this specification to be inadequate 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. Both depend, 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

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

If we formulate a similar constant elasticity model for average weight, with also partial adjustment we get

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

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

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

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

The only parameter which deserves the name of (very) short-run elasticity is $\sigma_0"$ 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 related to weights). The parameter σ_0' (in 2.19) refers to future production by the investment demand. This is why $\sigma_0" > 0$ is consistent with the usual sign of a supply elasticity, while $\sigma_0' < 0$ is not.

I have argued previously that the true supply elasticity is given in the model expressed in <u>numbers</u> by the sum of lagged and current price elasticities. In the present notations

(2.22) $$\sigma \simeq \sigma_1 + \sigma_0'$$

But the decision on numbers determines only one component of the supply in liveweight. Taking the weights into consideration one may argue that the total derivative of Q with respect to P in (2.21) is in fact the relevant parameter to call supply elasticity. Calling σ_Q this parameter, we have

(2.23) $$\sigma_Q = \sigma_1 + \sigma_0' + \sigma_0"$$

σ_Q measures the complete effect of a 1 % change in prices on future production measured in weight. Since we know a priori that σ_0' and σ_0'' have opposite signs it may well be that a recursive sales equation in liveweight would provide with σ_1 a good approximation of σ_Q; but one cannot be sure that it is the case in general.

Equation (2.21) is suitable for discussing the consequences on the dynamics and the stability of the cobweb, with the investment demand effect and the (very) short-run supply elasticity on weights working in opposite directions.

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 sales equation. In the constant elasticity case,

$$\text{(i)} \qquad q_t = s + \sigma_1 \, p_{t-w} + \sigma_0 \, p_t \qquad \text{(sales equation in liveweight)}$$

where lower case letters stand for the logarithms of corresponding variables.

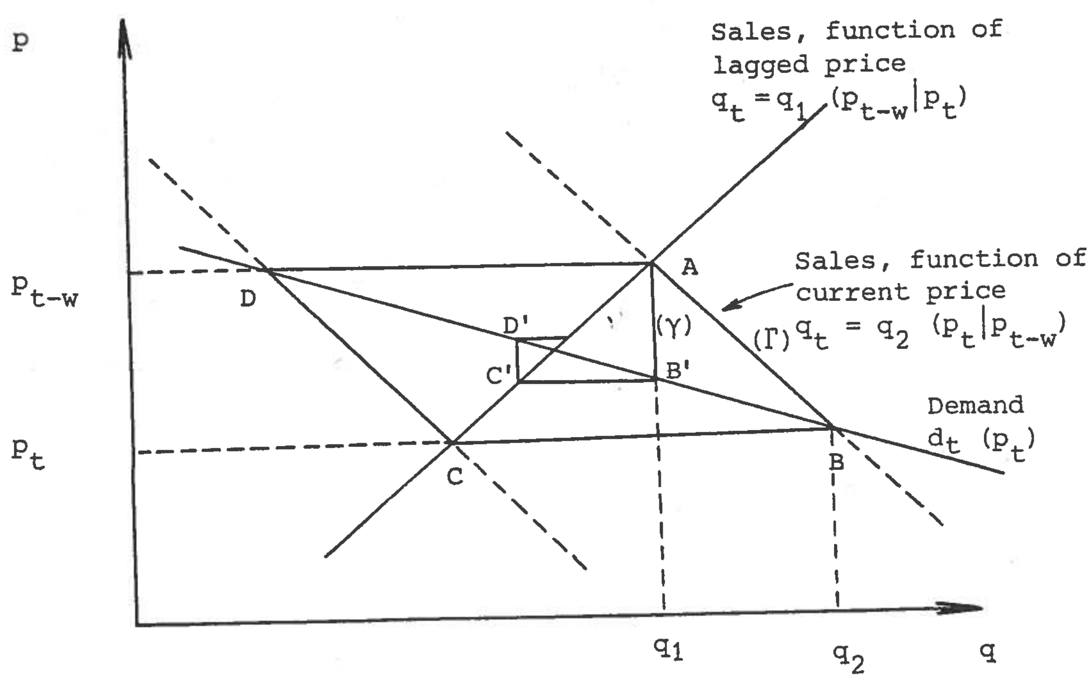
Assuming a constant elasticity of demand for simplicity,

(ii) $d_t = \theta_0 + \theta \; p_t$ (demand)

(iii) $q_t = d_t$ (clearing equation)

Figure 2.1 gives an illustration of the inventory-supply interaction 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 price. Figure 2.1 assumes that investment demand effect on numbers ($\sigma_0' < 0$) dominates (very) short run price elasticity of average weights ($\sigma_0'' > 0$).

Figure 2.1 - Cobweb with current price effect



A change in the price at t-w means a movement along CA, which sets the level of production or available supply. But since in A there is an excess supply, prices start to decrease, breeding stock is reduced, sales are therefore increased according to line AB. Market equilibrium occurs where AB (whose intercept is set by P_{t-w}) meets the demand curve DB.

Under these circumstance 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 [21, 13, 39]. Putting together Harlow's results on average weight ($\sigma_0'' = 0.05$) and Tryfos'results on numbers ($\sigma_0' = -.13$) tends to confirm this evidence, but their work does not cover the same sample, and may not be comparable.

Dean and Heady [10, p. 856] estimated a supply equation for hogs with a current price effect,

$$(2.24) \qquad \hat{Q} = -0.11 + 0.08\,P + 1.0\,Z$$

where Q is total liveweight of hogs slaughtered, Z is an "estimate of Q based on predetermined variables". The positive sign of the coefficient of P contradicts the above results 1/, but it consis-

1/ Particularly Fox'results reproduced in the next section.

tent with the authors'expectations, since they assumed it reflected the short-run supply response on average weights. The standard deviations of estimates are not given in this article and the exact nature of Z is rather ambiguous. I believe these contradictory results illustrate the possible misinterpretations of the various specifications of the supply function.

The dynamics of the cycle may be derived analytically, leading to slightly different stability conditions from the usual cobweb ones.

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

$$p'_t = \frac{\sigma_1}{\theta - \sigma_0} p'_{t-w} \tag{2.25}$$

Naturally both lagged and current price coefficients matter for the stability condition which requires:

$$-1 < \frac{\sigma_1}{\theta - \sigma_0} < 0 \tag{2.26}$$

Since $\sigma_1 > 0$, the expression is negative 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

$$\sigma_1 < \sigma_0 - \theta \tag{2.27}$$

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

Since it was shown previously that $\sigma < \sigma_1$, the elasticity of supply may be quite a bit smaller in magnitude than the demand elasticity and still yield a continuing cycle. Naturally, the stationary cycle of Fig 2.1 is obtained when $\sigma_1 = \sigma_0 - \theta$.

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 2/ mentioned by Waugh [55]; they prevent the cycle from exploding. In a sense, the current price effect considered here is the kind of destabilizer whose existence was pointed out by Waugh.

5 - Simultaneous or recursive cobweb ? Biases resulting from inappropriate estimation procedures

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 [10, 39]. Others justified this approach by the inventory-supply interaction [52, 13, 24]. Hildreth and Jarrett were probably the first to interpret correctly the negative sign they obtained on the current price parameter. Fox [13, p. 73] was interested in the possible bias on demand elasticity resulting from the erroneous assumption that supply is predetermined, i.e. assuming recursiveness instead of simultaneity. His results are presented below since they illustrate the analytical discussion of the biases given in this section.

1/ Essentially a supply elastic around equilibrium and less elastic as we move away from equilibrium of the cobweb.

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 function in weight specified as in (2.18) and a demand with price and income.

OLS

(2.28) $p = - 1.16\, q + .90\, y$ (demand)
$\qquad\qquad (.07) \quad (.06)$

(2.29) $q = .84\, h$ (supply)
$\qquad (.06)$

ILS

(2.30) $p = - 1.14\, q + .89\, y$ (demand)

(2.31) $q = - .06\, p + .77\, h$ (supply)

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

The current price effecton sales in weight is actually negative, but it is not significantly different from zero, as seen on the reduced form equation (not shown here). The differences between the estimates derived from the two methods are quite small as pointed out by Fox. Assuming recursivity does not seem to be a damaging simplification on the basis of the evidence.

It is interesting however to determine in a systematic manner the direction and magnitude of the bias arising from the improper use of a recursive model. I do this in the context of a simple cobweb-like model with lagged price as an explanatory variable in the sales equation. As stated before, when farrowings are used as a dependent variable as in Harlow [19], supply elasticity is correctly estimated by assuming recursiveness. On the other hand, when sales are explained by inventories (or production) as in (2.18) and (2.31), the coefficient of inventories is not used in most cases to estimate supply elasticity. If however, one derives supply elasticity by tracing out the lagged price effect through available supply h, as in [37]

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

Then the bias would still exist, since the first derivative $\partial q/\partial h$ would be biased as we shall see below, and as illustrated by Fox'results (i.e. 0.84 instead of 0.77).

Let us rewrite a simple simultaneous model suitable for the discussion of the biases which are likely to occur when the current price effect is assumed away.

(2.33) $s_t = s' + \sigma_1 \, p_{t-w} + \sigma_0' \, p_t$ (sales equation, 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 for identifying the parameters we have termed apparent 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 to have at least one shifter in the demand equation for the supply to be identified. Average weight

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

equations like (2.34) have not been regarded favorably by research workers because they usually lead to poor fit (see Harlow, p. 40, $R^2 = .32$). As this variable acts in a multiplicative way on the liveweight marketed, it may be more desirable 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.

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

$$(2.38) \qquad p_t = \delta_0 + \delta q_t + u_t \qquad \text{(demand)}$$

where δ is the price flexibility of demand, assimilated for simplicity to the inverse of the price elasticity. Since we are interested mostly in σ_1 and δ, we want to know the bias and inconsistency of OLS estimates from the classical cobweb below, which drops the current price effect on sales and therefore is strictly recursive 1/.

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

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

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 variables with primes denote deviations from mean values.

1/ Recursiveness requires also cov $(\varepsilon_{1t}, u_{1t}) = 0$ which may have been accepted without enough justification especially in the context of a block recursive model [52, p. 112], since the decision process on weights is not independent of the decision on numbers (e.g. sows slaughtered).

Now, since the observed time series is assumed to be generated by equations (2.37) and (2,38) we solve these equations for p'_t, q'_t.

(2,42) $$q'_t = \lambda\ (\sigma_1\ p'_{t-w} + \sigma_0\ u'_t + \varepsilon'_t)$$

(2,43) $$p'_t = \lambda\ (\delta\sigma_1\ p'_{t-w} + u'_t + \delta\varepsilon'_t)$$

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 of equations (2.39) and (2.40). 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) $$p\lim \hat{\sigma}_1 = \lambda\sigma_1 = \frac{\sigma_1}{1 - \delta\sigma_0}$$

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 apparent supply elasticity will be overestimated even when sample size goes to infinity.

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

How large could be the overestimation ? Fox's results (2,28) to (2,31) suggest that it is about 10 % on the coefficient of h which is an instrumental variable for lagged price. As an example, let $\sigma_0 = -\ ,05$ and $\delta = -\ 1,2$; then $\lambda \simeq 1,06$ and the over-estimation is 6 % which is not negligible.

Now, what is the error made by taking $\hat{\sigma}_1$ as an estimate of the true supply elasticity as defined in (2.22) or (2.23) ?

(2,22) $\quad \sigma = \sigma_1 + \sigma'_0$ $\quad$ true supply elasticity defined in numbers

(2,23) $\quad \sigma_Q = \sigma_1 + \sigma'_0 + \sigma''_0$ $\quad$ true supply elasticity defined in liveweight

$$\sigma_Q \simeq \sigma_1 + \sigma_0$$

- Supply elasticity in liveweight σ_Q

If we assume that the weight effect ($\sigma''_0 > 0$) does not cancel the investment demand effect ($\sigma'_0 < 0$), then not only σ_Q is overstated by σ_1, but it is furthermore overestimated by the OLS estimate $\hat{\sigma}_1$ derived from a recursive model.

$$\text{p lim } \hat{\sigma}_1 > \sigma_1 > \sigma_Q$$

The relative error of $\hat{\sigma}_1$ relative to σ_Q is given by plim $\hat{\sigma}_1/\sigma_Q$

(2,46) $$\text{plim } \frac{\hat{\sigma}_1}{\sigma_1 + \sigma_0} = \frac{1}{1 + \sigma_0/\sigma_1} \cdot \frac{1}{1 - \delta\sigma_0} \quad , \sigma_0 < 0$$

Assuming a ratio σ_1/σ_0 of - 20 and $\lambda = 1.06$ the relative error is about 11 %.

- supply elasticity in numbers σ

Given the definition (2.22) and (2.23) the error made on σ by using estimate $\hat{\sigma}_1$ is larger than the error made on σ_Q:

$$\text{plim } \hat{\sigma}_1 > \sigma_1 > \sigma_Q > \sigma$$

But the largest error on σ would be made by using a recursive model on a sales equation in numbers, i.e. assuming $\sigma_0' = 0$ in (2.33). The OLS estimate of σ_1 would then be

$$\hat{\hat{\sigma}}_1 = \frac{\Sigma s'_t \, p'_{t-w}}{\Sigma p'^2_{t-w}}$$

Equations (2.33) to (2.36) may be used to evaluate the bias as done above for $\hat{\sigma}_1$.

$$\text{plim } \hat{\hat{\sigma}}_1 = \frac{\sigma_1}{1 - \dfrac{\sigma_0'}{\theta - \sigma_0''}}$$

where θ is the price elasticity of demand.

The relative error made on σ by using the estimator $\hat{\hat{\sigma}}_1$ is given by

$$\text{plim } \frac{\hat{\hat{\sigma}}_1}{\sigma} = \frac{\sigma_1}{\sigma_1 + \sigma_0'} \cdot \frac{1}{1 - \dfrac{\sigma_0'}{\theta - \sigma_0''}}$$

$$\text{plim } \frac{\hat{\hat{\sigma}}_1}{\sigma} = \frac{1}{1 + \dfrac{\sigma_0'}{\sigma_1}} \cdot \frac{1}{1 - \dfrac{\sigma_0'}{\theta - \sigma_0''}}$$

In the case $\sigma_0 = \sigma_0' + \sigma_0'' < 0$, it can be shown [1/] that both terms of the product in (2.46) are in general smaller that the corresponding terms in plim $\hat{\hat{\sigma}}_1/\sigma$. The relative error made by using a recursive sales equation to estimate supply elasticity (in numbers) is larger than the relative error made on σ_Q, by using a recursive sales equation in weights. As an illustration, recalling equation (2.9), m = 10, $\sigma_0' = -.08$, $\sigma_0'' = .03$, $\theta = \frac{1}{\delta} = -0.8$ would lead to a relative error of about 20 % .

The bias on the supply side is illustrated on Fig. 2.2. When the cobweb is assumed to be 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.

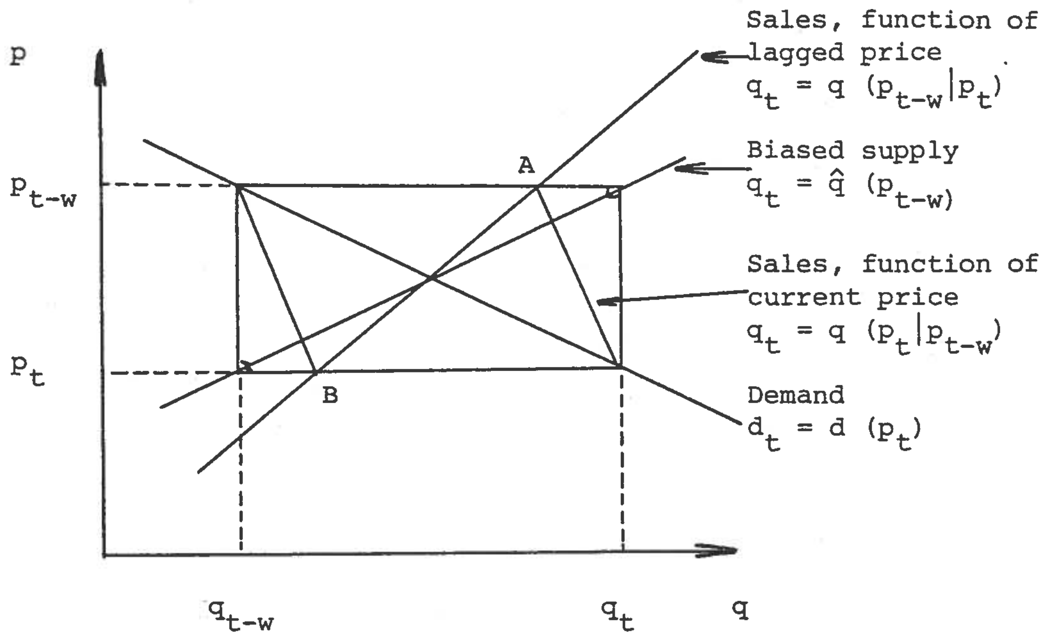
While the bias on the supply side results from the exclusion of the variable p_t, there is also a bias on the demand which comes from assuming away simultaneity. The recursive model (2.39) and (2.40) gives the OLS estimate of the price flexibility δ.

1/ First term $|\sigma_0'| > |\sigma_0|$; The second terms rank as stated if

$$\frac{\sigma_0'}{\theta - \sigma_0''} > \frac{\sigma_0}{\theta} = \frac{\sigma_0' + \sigma_0''}{\theta} \quad \text{or} \quad \theta\sigma_0' > \theta\sigma_0' + \theta\sigma_0'' - \sigma_0''\,\sigma_0$$

i.e. if $\sigma_0''(\theta - \sigma_0) < 0$; given that $\sigma_0'' > 0$, this is part of the stability conditions for the cobweb (2.26).

Figure 2.2 - Specification bias from assuming mistakenly a recursive cobweb



(2.47) $$\hat{\delta} = \frac{\Sigma p_t' \, q_t'}{\Sigma q_t'^2}$$

$$\Sigma p_t' \, q_t' = \lambda^2 \{ \delta\sigma_1^2 \ \Sigma p_{t-w}'^2 + \delta\Sigma\varepsilon_t'^2 + \sigma_0 \Sigma u_t'^2 + 2\delta\sigma_1' \Sigma p_{t-w}' \varepsilon_t'$$

$$+ \sigma_1 (1 + \delta\sigma_0) \ \ \Sigma p_{t-w}' \ u_t' + (1+\delta\sigma_0) \ \Sigma u_t' \varepsilon_t' \}$$

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

$$\text{plim} \ \frac{1}{N} \Sigma p' q_t' = \lambda^2 \left[\delta\sigma_1^2 \pi + \delta\sigma_\varepsilon^2 + \sigma_0 \sigma_u^2 + (1+\delta\sigma_0) \ \sigma_{u\varepsilon} \right]$$

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

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

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

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

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

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

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

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

$$\text{(2.48)} \qquad \text{plim}\ \hat{\delta} = \delta\ \frac{1 + \frac{1}{\sigma_1^2\ \pi}\ (\sigma_\varepsilon^2 + \frac{\sigma_0}{\delta}\ \ \sigma_u^2)}{1 + \frac{1}{\sigma_1^2\ \pi}\ (\sigma_\varepsilon^2 + \sigma_0^2\sigma_u^2)}$$

Equation (2.48) shows that except for special cases ($\sigma_u^2 = 0$, $\sigma_0 = 0$) OLS estimation of δ does not provide a consistent estimate. The demand flexibility will in general 1/ be overestimated in magnitude, and therefore the absolute value of price elasticity of demand under estimated by OLS.

(2.49) $\text{plim}\ |\hat{\delta}| > |\delta|$

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

While the nature of the bias on the demand side is a simultaneous bias, it is not stricltly so on the supply side. We may still have a bias on the supply elasticity estimated on time-series data 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 2/.

1/ "In general" refers to the most probable situation where $\sigma_0/\delta > \sigma_0^2$ or $\theta\sigma_0 > \sigma_0^2$ i.e. $\theta - \sigma_0 < 0$, which is again part of the stability condition (2.26).

2/ For monthly or quarterly data it may be appropriate to write the investment function (2.3)

$$B_t = \alpha_0 + \alpha P_{t-1} \quad \text{or} \quad B_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i\ P_{t-i}$$

The supply would then be recursive, but the inventory-supply interaction would remain in the model.

This discussion may appear to be rather trivial, I shall present it in some detail however, because it throws some light on further difficulties encountered in estimating the sales equation including both price at time 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 and not $P_{t-w'}$, with w' close to w.

I use the following notations to simplify the presentation. Let

$Y_t = S_t$

$X_{1t} = \hat{P}_t$ 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 instrumental variable 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

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

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

(2,51) $$y_t = \beta_2 x_{2t} + v_t$$

As is well known, $\hat{\beta}_2$ qill be biased if X_1 and X_2 are correlated, which is necessarily the case in any fairly 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 Kettunen did [30, p. 50], could 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 that mistakenly including 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 β_1

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

of course, $\hat{\beta}_1$ is unbiased since $E(\hat{\beta}_1)$, is identically zero. Calling D the denominator in (2.52) we have

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

However, it is not unlikely that for some samples we would get a point estimate $\hat{\beta}_1$ different from zero, especially if there is a strong empirical correlation between Y and X_1, relative [1/] 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, can also be used to explain why we tend to find a short-run effect overestimated in absolute value, as we shall see in the next chapter.

The situation is even worse if we are not quite sure what the relevant lag is exactly 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 a time t can be made on females at different ages with correspondingly 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 perhaps some other lagged prices. Again because of collinearity it is almost hopeless to try drawing from 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 interrelastionships between the various variables" [Griliches, 17, 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

(2.54) $$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + u_t$$

1/ Since $X_1 = P_t$ and $X_2 = P_{t-w}$ we expect $|\Sigma x_1 x_2| < \Sigma x_2^2$.

while we estimate (2.50) i.e. the model including only x_1 and x_2. Then we again get a biased estimate of β_1 given by (2.52). Substituting y from (2.54) in (2.52), taking the expectation,

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

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 on the pattern of the price cycle gives the following signs, $\beta_1 < 0$, $\beta_3 > 0$, $\psi_{13} < 0$. Therefore β_1 will be overestimated in magnitude, when the structure of lagged prices is not specified properly.

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

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

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Chapter III

AN ECONOMETRIC MODEL OF THE HOG SUBSECTOR IN FRANCE

Before presenting the economic relationships estimated for the French pork subsector, I will describe briefly the main features of the hog industry. 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. Finally I will present the results with their implications for 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 price 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 billion 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 the 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 gross farm output

	1971	1972	1973	1974
	Unit : billion 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. Comptes de l'Agriculture, 1974 (C39)

Detailed information on hog enterprises was not available before 1966. The Common Agricultural Policy (CAP) has included 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 hog operations and number of hogs, along with specialization in feeder pigs, slaughter 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 farms with less than 5 slaughter hogs, those mainly raising hogs for self consumption, only 275,000 units were involved in commercial production to any significant degree.

Table 3.2 - Size distribution and concentration of feeder pig units, 1966-1972 (mesured in sow numbers)

		Size class (# of sows)				
		1-4	5-9	10-19	⩾ 20	total
april 66	# of unit (1,000)	239	51	14	2	308
	% of total units	*77*	*16*	*4*	*0*	
	cumulated %	77	94	99	100	
	# of sows (1,000)	498	320	185	86	1,090
	% ot total units	*45*	*29*	*17*	*7*	
	cumulated %	45	75	92	100	
dec. 68	# of unit (1,000)	188	46	15	5	256
	% of total units	*73*	*18*	*6*	*2*	
	cumulated %	73	91	97	99	
	# of sows (1,000)	389	299	198	188	1,076
	% of total units	*36*	*27*	*18*	*17*	
	cumulated %	36	64	82	99	
dec. 69	# of unit (1,000)	172	48	20	8	250
	% of total units	*69*	*19*	*8*	*3*	
	cumulated %	69	88	96	99	
	# of sows (1,000)	378	306	272	291	1,248
	% of total units	*30*	*24*	*22*	*23*	
	cumulated %	30	54	76	100	
dec. 70	# of unit (1,000)	154	51	19	14	239
	% of total units	*64*	*21*	*8*	*6*	
	cumulated %	64	85	94	100	
	# of sows (1,000)	333	326	252	469	1,382
	% of total units	*24*	*23*	*18*	*34*	
	cumulated %	24	47	65	100	
dec. 71	# of unit (1,000)	139	41	19	14	215
	% of total units	*64*	*19*	*9*	*6*	
	cumulated %	64	84	93	100	
	# of sows (1,000)	296	269	260	521	1,347
	% of total units	*22*	*20*	*19*	*38*	
	cumulated %	22	42	61	100	
dec. 72	# of unit (1,000)	121	35	18	15	190
	% of total units	*63*	*18*	*9*	*8*	
	cumulated %	63	82	91	100	
	# of sows (1,000)	247	232	242	572	1,295
	% of total units	*19*	*18*	*18*	*44*	
	cumulated %	19	37	55	100	

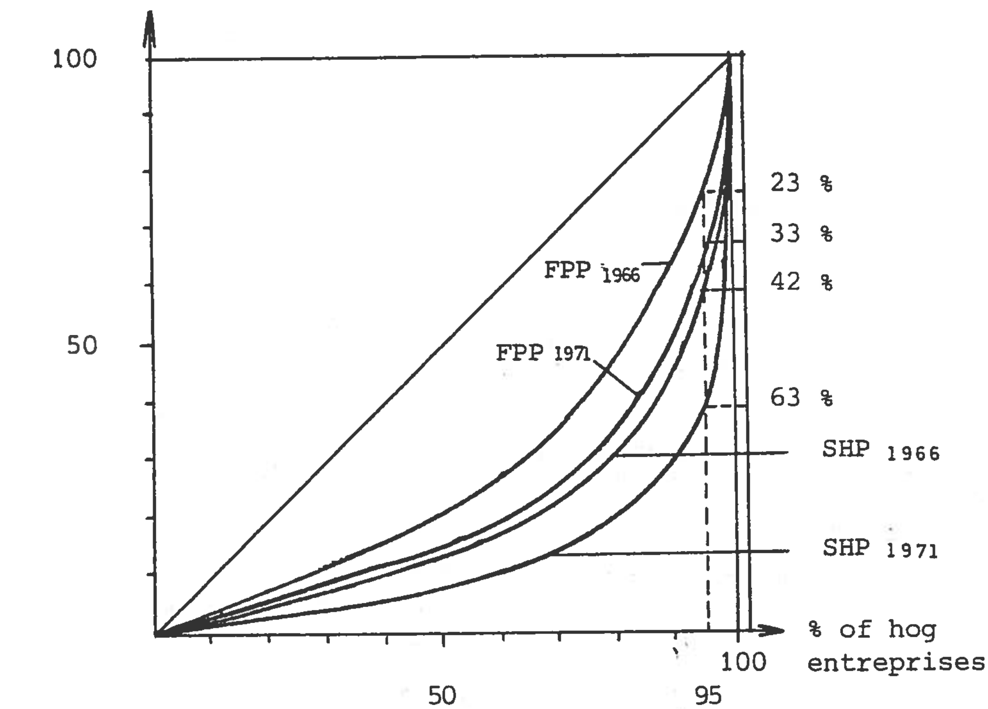
Source: Statistique Agricole [49].

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

		Size class (slaughter hogs over 50 kg)					
		1-4	5-19	20-49	50-99	≥100	total
april 66	# of units (1,000)	273	115	18	3	2	413
	% of total units	*66*	*27*	*45*	*0*	*0*	
	cumulated %		94	98	99	100	
	# of sl. hogs* (1,000)	577	998	540	215	488	2,820
	% of total hogs	*20*	*35*	*19*	*7*	*17*	
	cumulated %		56	75	82	100	
dec. 68	# of units (1,000)	517	95	18	6	4	641
	% of total units	*80*	*14*	*2*	*0*	*0*	
	cumulated %	80	95	98	99	100	
	# of sl. hogs* (1,000)	930	818	539	432	937	3,658
	% of total hogs	*25*	*22*	*14*	*11*	*25*	
	cumulated %		47	62	74	100	
dec. 69	# of units (1,000)	454	83	19	6	5	570
	% of total units	*79*	*14*	*3*	*1*	*0*	
	cumulated %		94	97	99	100	
	# of sl. hogs* (1,000)	803	732	572	464	1,172	3,744
	% of total hogs	*21*	*19*	*15*	*12*	*31*	
	cumulated %		41	56	68	100	
dec. 70	# of units (1,000)	411	79	18	5	7	522
	% of total units	*78*	*15*	*3*	*1*	*1*	
	cumulated %		94	97	98	100	
	# of sl. hogs* (1,000)	765	696	548	365	1,341	3,808
	% of total hogs	*20*	*18*	*14*	*9*	*37*	
	cumulated %		38	52	62	100	
dec. 71	# of units (1,000)	420	74	16	7	7	526
	% of total units	*79*	*14*	*3*	*1*	*1*	
	cumulated %		94	97	98	100	
	# of sl. hogs* (1,000)	776	631	501	492	1,652	4,055
	% of total hogs	*18*	*15*	*12*	*12*	*40*	
	cumulated %		34	97	59	100	
dec. 72	# of units (1,000)	399	67	12	6	9	
	% of total units	*80*	*13*	*2*	*1*	*2*	
	cumulated %		94	96	98	100	
	# of sl. hogs* (1,000)	720	565	387	483	2,153	4,309
	% of total hogs	*16*	*13*	*8*	*11*	*51*	
	cumulated %		29	37	49	100	

* slaughter hogs
Source: Statistique Agricole [49].

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



Average size of hog raising units was 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) was about thirty. With respect ot the size of operations French producers lagged behind most of the other EEC members. From 1968 to 1972 concentration increased quite drastically however. Facilities with more than a 100 hundred heads went from 2,300 to 9,800, picking up a much larger share of the total production (25% in 1968 to 51% in 1972). Structural changes also occurred among FPP. Units with over 20 sows were 2,500 in 1966 and 15,400 in 1972, increasing their share of sow numbers from 8% to 44%. Fig. 3.1 shows the importance of the concentration for both activities in 1966 and 1971. Concentration is higher for SHP than for FPP, and the concentration in the SHP 1/ has been rising faster.

Table 3.4 - Changes in the shares of production according to specialized hog operations

		1966 april	1968 april	1968 dec.	1969 dec.	1970 dec.	1971 dec.	1972 dec.
Feeder Pig Producers	# of units (1,000)	154	119	79	83	75	70	-
	% of sow herd	*49*	*36*	*29*	*33*	*32*	*32*	*30*
Mixed hog-farms	# of units (1,000)	154	175	176	167	164	145	-
	% of sow herd	*51*	*63*	*71*	*67*	*68*	*68*	*70*
	% of slaughter hog herd a/	*43*	*43*	*38*	*37*	*39*	*39*	*38*
Slaughter Hog Producers	# of units (1,000)	259	286	465	403	358	381	-
	% slaughter hog herd	*57*	*57*	*62*	*63*	*61*	*61*	*62*

a/ Slaughter hogs (over 50 kg weight)

Source : Statistique Agricole [49].

1/ Concentration change is overestimated for SHP since the survey of 1966 was not made in December but in April when the hogs raized for home consumption had already been converted into cold cuts.

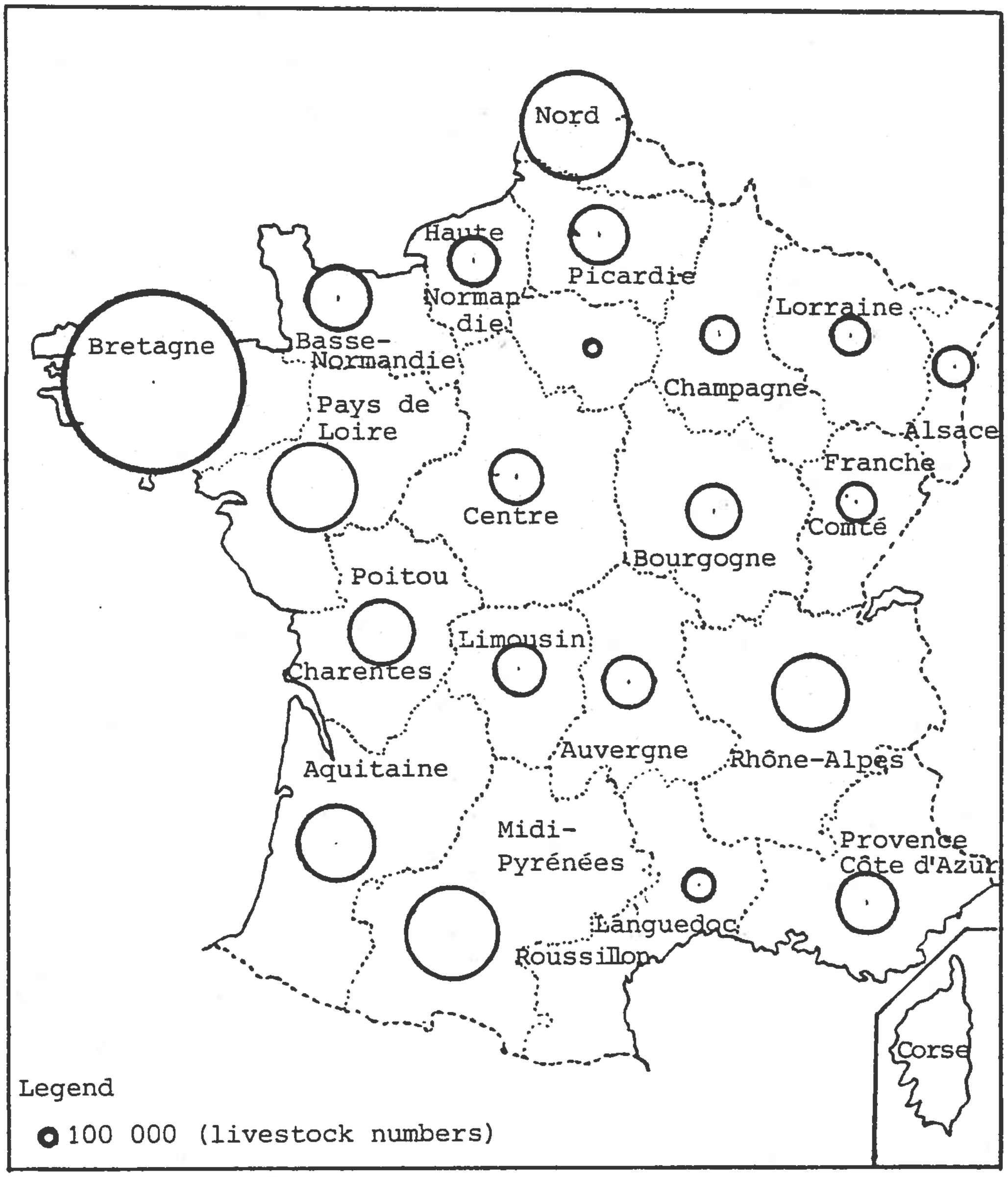
An important point must be made about the share of total production marketed by the three groups of specialization. Table 3.4 shows that the SHP group produced 62% of marketed slaughter hogs in 1972. This share has not changed really from 1968 to 1972, in spite of extension programs pushing the mixed type operation; among the advantages suggested would be escaping the price fluctuations of feeder pigs which are about twice as large as those of slaughter hogs. This structural situation creates some difficulty in choosing 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 occurred with size increase and concentration, as well as resulting from agricultural policy which I shall discuss briefly later on. Hog production used to be a by-product of milk production when it was still being transformed into butter on the farms. Potatoes and other roots were complementary sources of feed, with little protein and barley used in the 1950's. By that time consumption of home produced pork amounted to about one-third of total production, and one half of nationally inspected slaughter. Milk processing in large facilities, along with farm labor shortages broke 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 mixtures and more recently, automatic feeding. There are no complete data on invested capital in hog production, but on the basis of subsidies granted to new construction one may estimate the total capital invested from 1966 to 1973 to be an amount close to 8.5 billion Francs, which is about equal to the cash farm receipts from hogs in 1973. Another way to measure the investment effort in this decade is to compare the new lodging capacities with actual herd growth. Construction of new buildings has moved much faster than herd growth. Considerable replacement of facilities has therefore occured along with creation of large new hog operations.

Feeding practices have changed much during the same period. Increasing opportunity cost of farm labor has shifted feed rations toward feed grains and concentrated protein sources (oil-cakes), much easier to feed to hogs raised in confinement.An important feature of the French hog industry is its location away from the main feed grain producing areas (Figs 3.2 and 3.3). Therefore the individual hog operation has become more and more independent of the available land on the farm. Consequently a larger share of feed is now produced off 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 and mineral supplements) accounted for only 30% of the rations fed to hogs. At that time 60% of the energy nutrients was produced on the hog farm operation itself. In 1971, the situation has changed a lot under the influence of the feed mixing industry, which has grown tremendously during these five years. It provided 65% of the ration in 1971.

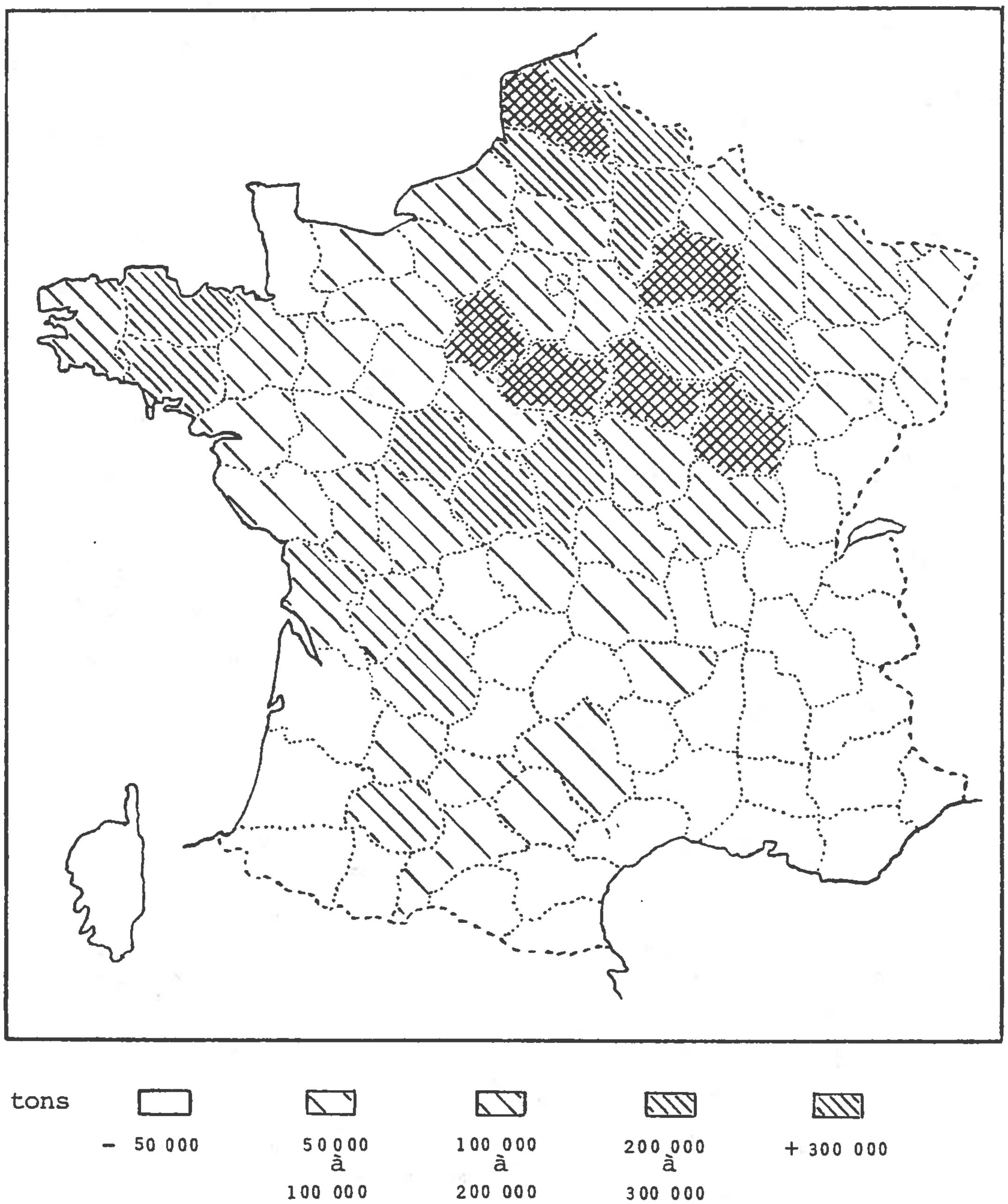
Some economists have used the term of industrialization to define the structural changes in hog farming. This concept, however vague it is, is certainly an exaggeration. But there is no doubt that hog framing has become specialized and more involved in commercial channels for both input supply and output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

Figure 3.2 - Location of hog production in France (1974)



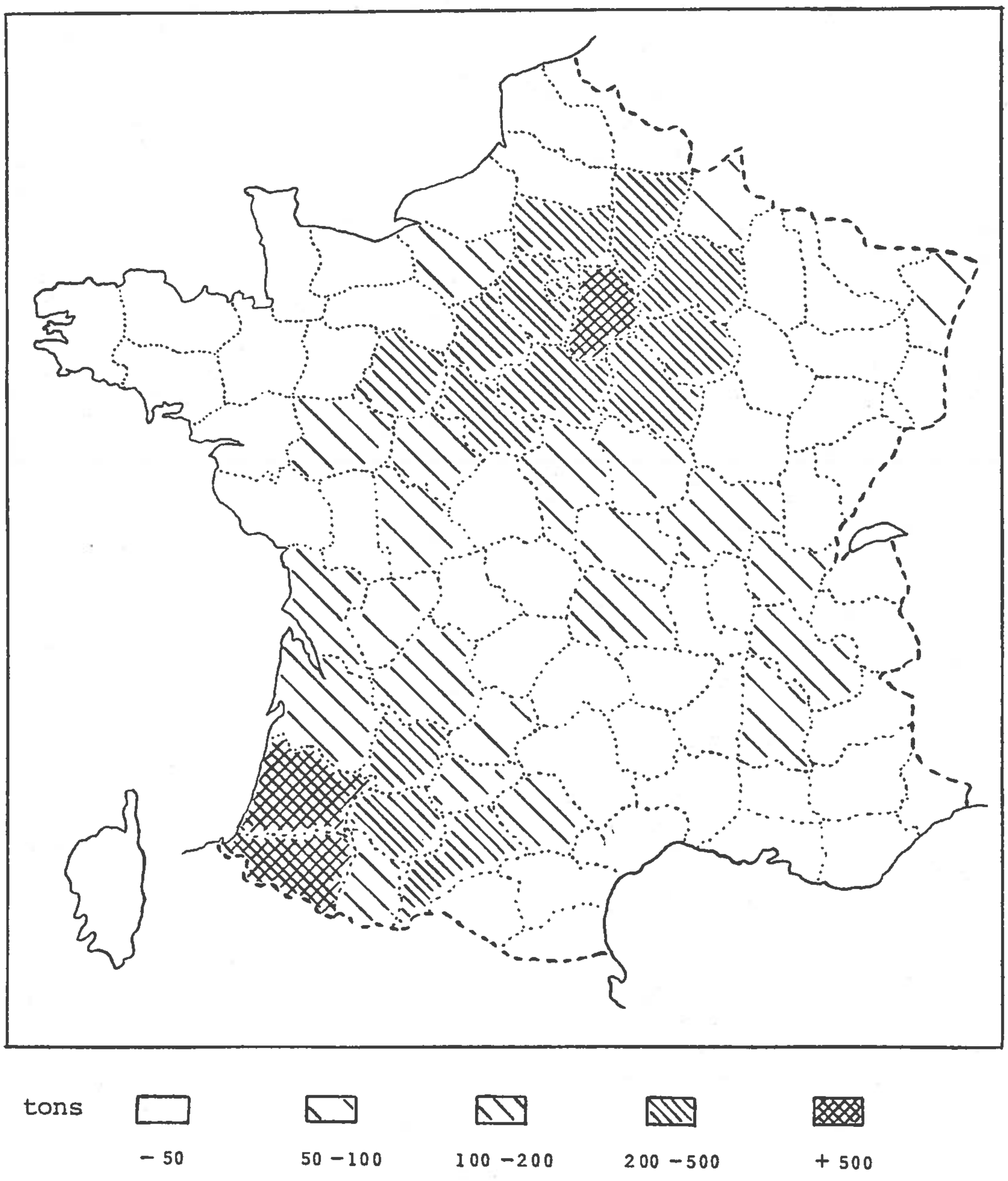
Drawn with data from [49].

Figure 3.3 - Map of feed grains production in 1974
a) BARLEY



Source : Office National Interprofessionnel des Céréales, Rapport Annuel, Paris, 1974

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



Source : Office National Interprofessionnel des Céréales, Rapport Annuel, Paris, 1974.

12 - Consumption, prices

France ranks fifth in the world for meat consumed per capita (Table 3.5); French consumers eat more meat per capita than any other EEC member. For pork however Germany leads 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 largest source of meat and accounts for 11% of consumer expenditure on food.

Increased consumption of pork as well as poultry meat, is mainly dueto the steadily decreasing real prices of these two kinds of meat, At the retail level their relative price has improved their competitive position considerably with respect to beef and veal (Fig 3.4), As in all countries, technical progress in feed-conversion ratios and "labor efficiency" have lowered production costs to a considerable extent.

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

	Belg.	Den-mark	Fran-ce	Ger-many	Ire-land	Ita-ly	Nether-lands	U.K.	Austra-lia	Cana-da	Ja-pan	New Zealand	Spain	Swe-den	Swit-zerland	U.S.A.
Beef	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
Veal	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
Pork	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
Mutton	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
Horse meat	3,5	0.2	1.7	0.1	-	1,0	2.6	-	-	-	0.5	-	0.5	0.7	0.6	-
Poultry	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
Other meat	1.4	0.6	2,0	0.9	-	2.5	-	0.7	-	-	1.2	-	0.8	-	1.2	1.1
Eatable offal	6.0	6.6	8,8	4,5	12.3	3.1	4.9	4,4	5.7	1.8	1.7	5.1	1.9	2,5	4.9	4.8
	83.0	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 : INSEE, Division : condition de vie des ménages, préparation du VII Plan, janvier 1974

1/ carcass weight without blood, head, offal and dressing fat.

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

	1950	1060	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, Division : condition de vie des ménages, préparation du VII Plan, janvier 1974

Figure 3.4 - Changes in French per capita consumption of different kinds of meat, 1963-1973

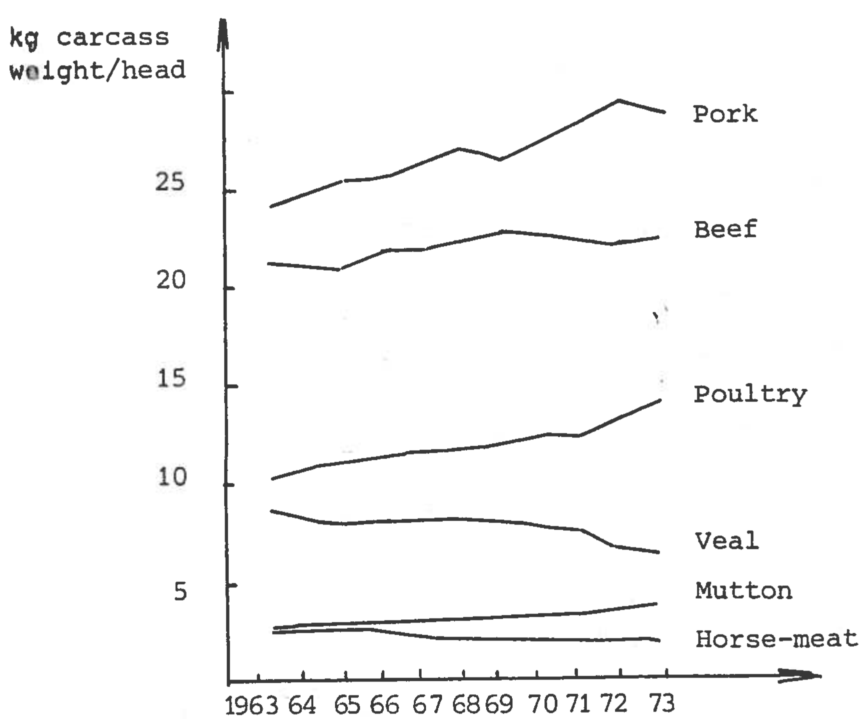
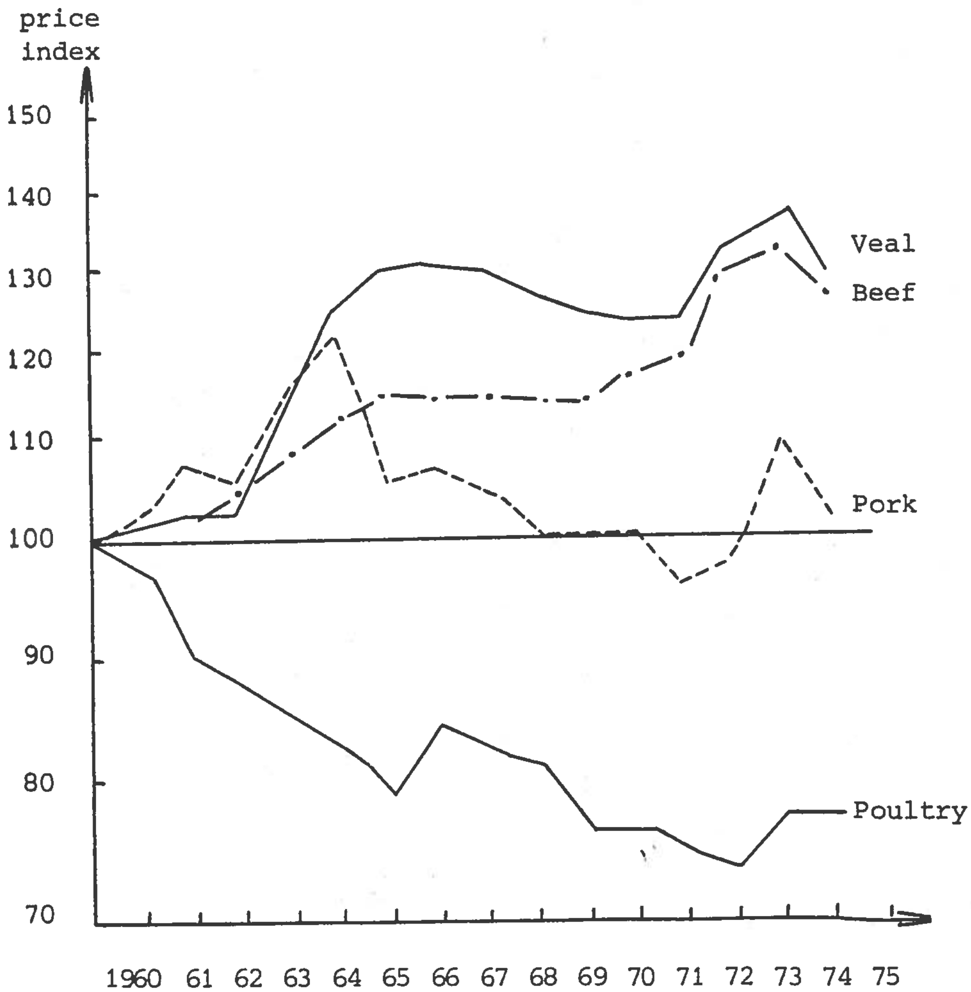


Figure 3.5 - Retail meat price index for principal meats, 1960-1974



Source : Cahiers du BAC, Paris, 1974, n° 4.

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

As for cyclical production, price fluctuations originate mostly in supply, which also exhibits 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 export position to a net deficit, which has remained at a rather constant level since 1969. The slower growth of production relatively to consumption goes back before the EEC removal in 1967 of trade barriers on pork as well as on cereal grains.

Figure 3.6 - Price of pork at retail, price of hogs at the farm and feeder pig price

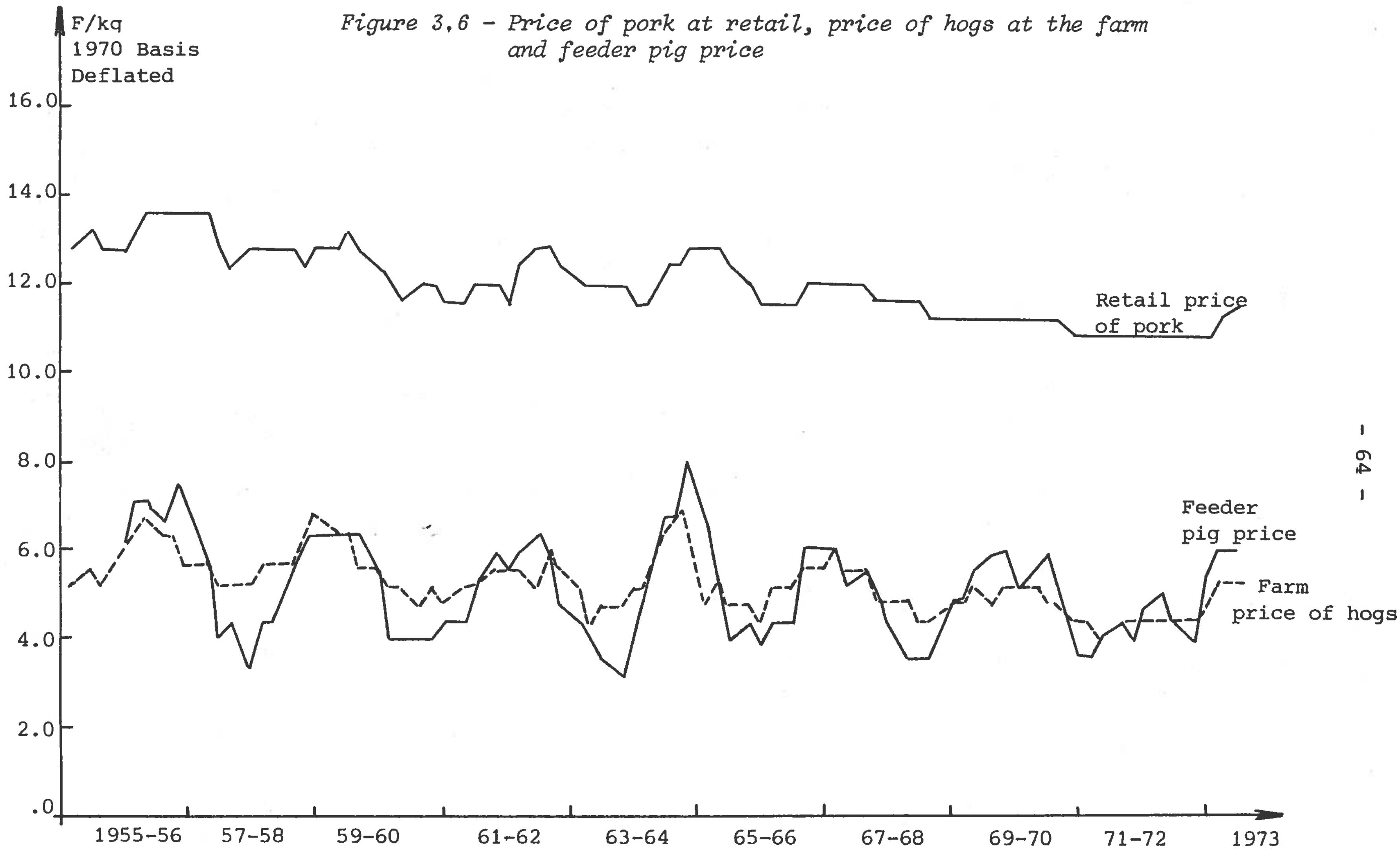
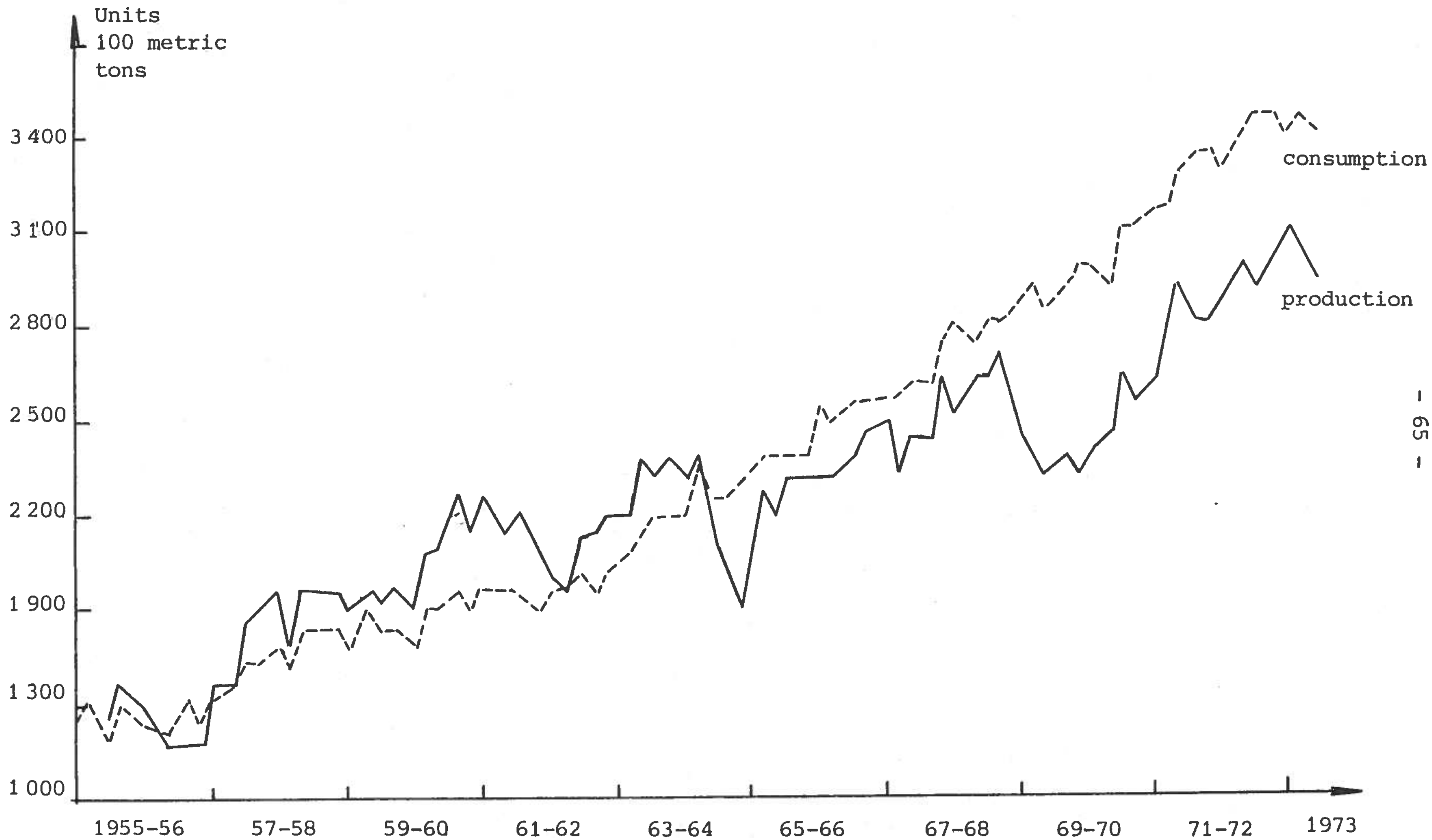


Figure 3.7 - "Marketed" production and consumption 1/ , Quaterly data, 1955-1973



1/ These series exclude "on farm consumption" which is not marketed. Source : Appendix I, p. 157.

13 - Trade, EEC and policy

The output mix of French agriculture appears to be inefficient because it leads to exporting about 50% of the grains produced, while 15 to 20% of pork is imported. Because hogs are mainly a cereal transformer, other members of EEC have demonstrated their competitive position based on grain supply advantages on world market before Common Agricultural Policy (CAP) enforcement and higher feeding efficiency afterwards. Belgium and Netherlands are the main suppliers of pork to France. No analytical study of interregional competition for pork in EEC has been made as yet. The first thought of emphasizing, feed cost and proximity of large markets as explanations for the location of pork production does not fit the new regional pattern well. While it applies to Belgium and Netherlands as to their proximity to the large industrial towns of EEC, it does not hold for Brittany which is far away from both factor supply and consumption markets. This region has however been developping hog production more than any other EEC country multiplying by 3 or 4 times 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
	Feestuffs		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

ε: negligible.
Source : Les comptes de l'agriculture française en 1974.
Les Collections de l'I.N.S.E.E. C 39, nov. 1975.

Figure 3.8 - Relative shares of countries in French pork imports in 1974

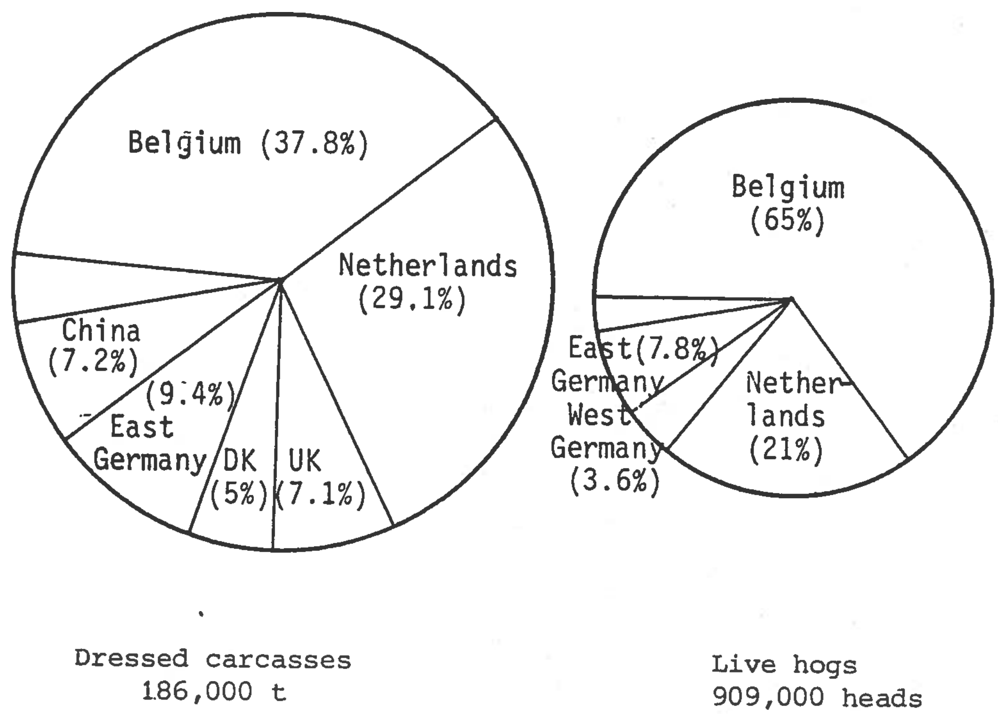


Fig 3.8 shows the predominant role played by Belgium and Netherlands in French imports of pork. Table 3.8 also gives an account of the relative importance of EEC members as hog producers.

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

Table 3.8 - Total pork produced in EEC countries, 1,000 metric 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
U K	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 : Les dossiers de la politique agricole commune, la viande porcine n° 29, sept-oct. 1974, p. 4.

Table 3.9 - Self sufficiency rate in EEC countries for pork

Member 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	100	100
U K	-	67	72	62
Ireland	-	173	158	167
Denmark	-	504	519	507
EEC (9 members)	-	103	105	101

Source : Les dossiers de la politique agricole commune, la viande porcine n° 29, sept-oct. 1974, p. 6.

This 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. 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 deficit; but they had to comply with CAP principles, i.e. mainly free trade throughout EEC. A so-called "structural policy" was set up, based on investment subsidies to hog enterprises. Those funds amounted to 20 to 40% of the capital invested by hog farmers. Total government subsidies for that program amounted to 1.3 billions francs from 1966 to 1973. In order to receive the grant, farmers must belong to so-called "producers associations" 1/ which are the cornerstone of French agricultural markets policy. These associations, mainly built on cooperatives, were supposed to foster production and marketing in an "organized" way. Besides improving management practices they were expected to "control" production so as to smooth price fluctuations. An acknowledged objective of this policy was to reduce the instability in the subsector by increasing the share of these producer associations in the total output. Table 3.10 shows the significant 1966-71 increase of these farmers organizations in the marketing of hogs.

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

Table established with data from [49].

Structural changes encouraged by these policy measures were expected to bring about 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 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 examined 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 econometrics 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 put it in a form compatible with observed variables. I have used both strategies, specifying 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 the specification of supply model with farrowings or inventories as the dependent variable; The only source of supply data is based on nationally inspected slaughter, which is available since 1949. Therefore I specified a model based on sales, i.e. 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. Chin, Pando and West in Canada [7], Heien [22] in USA, Kettunen [30] in Denmark for pig supply, and Strecker and Esselman [50] 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 difficulties encountered in specifying the lag structure since lagged prices are highly intercorrelated when quarterly data are used. The resulting multicollinearity 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

1/ Sales or marketed production = inspected slaughter + exports (live) - imports (live).

corresponds to sales or marketed supply both in numbers and in weights. Estimates of total production 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 estimated at 284,000 metric tons i.e. more than a half of inspected slaughter. Total production for 1974 was estimated at 1.4 million tons, marketed production at 1.130 million. Since the corrections made to get total supply are rather unreliable, especially for the first part of 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 direction these faults affect the results.

Since a large share of slaughter hogs are farrowed outside of the fattening units, the predominant role on available supply is played by feeder pig producers. It would have been appropriate to specify a market model for feeder pigs, as was done by Strecker and Esselman. But again no data on quantities are available, and an attemps to build a time series of feeder pig production based on breeding statistics 1/ gave deceiving results. Consequently a "par-

1/ From the early sixties to 1972, hog forecasts were based on breeding surveys.

tially reduced form" 1/ of the feeder pig market was used in the supply block.

A detailed analysis of the impact of policy measures was not feasible, due to the lack of data. The only homogeneous time series related to 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 small during the period however and never larger than 0.5% of the marketed production. Moreover it was not possible to know whether the stocks were sold on national markets or exported. These facts limit considerably the quality of the results related to this particular policy instrument. I mentioned earlier that little stabilizing action was taken during 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. Because a convenient set of data on all these subsidies was not available to introduce in the model, I left the policy analysis for later work, since it requires a lot of data collection and processing to put them in a suitable form for statistical use 2/. I did not use zero-one variables which could have been a first step, because 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.

1/ In the sense of Hildreth and Jarrett [24, p. 108].

2/ The elaboration made by Jouck, Ryan, Abel, Subotnik [86, 27, 45] on the set-aside program is an example of the difficulty of specifying testable policy variables in a supply model.

22 - 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, either for households or 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, from that point of view. I have not tried to set up the demand equation in the framework of errors-on-variables, because 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 explicit assumptions about the properties of errors in such a model. This work could be done however, when the consumers' panels recently set up are able to provide the relevant information. For private storage by processors, a specific statistical survey should be developed, particularly if short-run farm price fluctuations are to be understood.

The same characterization of marketed supply, apply to consumption. The time series used was marketed consumption since correction for self-supply and undeclared slaughter were thought to be 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 have two further effects. Preliminary analysis 1/ showed that it reacts negatively to market price. As expected, farmers keep less pork for their own needs when prices are high. In that sense they behave in a similar way to other consumers, even if they may consider the opportunity cost of not selling a hog instead of 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 lower than the "marketed demand" elasticity (about - 0.5). The aggregate demand price elasticity is therefore overestimated 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 seasonality. On-farm slaughter takes place mainly during winter months, while marketed consumption is higher in spring and fall.

Disposable income was not available on a quarterly basis. Only recently the INSEE 2/ has started building up quaterly 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 the industrial production index were used. These two methods did not give significantly different results.

1/ Using monthly data the fitted equation was :

$$Q_t = Dm - \underset{(1.1)}{0.11}\, P_t - \underset{(11.4)}{0.35}\, t \qquad R^2 = 0.98$$

where Q_t = on-farm consumption

Dm = intercept for each month (dummy variable)

P_t = hog price

t = time

2/ Institut National de la Statistique et des Etudes Economiques.

Data on prices at retail are drawn from subsets of the consumer's price index (CPI), relative to pork, beef, veal and poultry meat. The subsets have the pitfall of reflecting the composition of meat budget bought by blue collar workers, who purchase more lower quality cuts than the 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. Moreover because of the psychological importance of beef prices at retail, they are narrowly watched and submitted to regulations, so that the representativity of the index may be subject to doubt. The flatness of the beef index (Fig 3.9) time series strengthens 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.

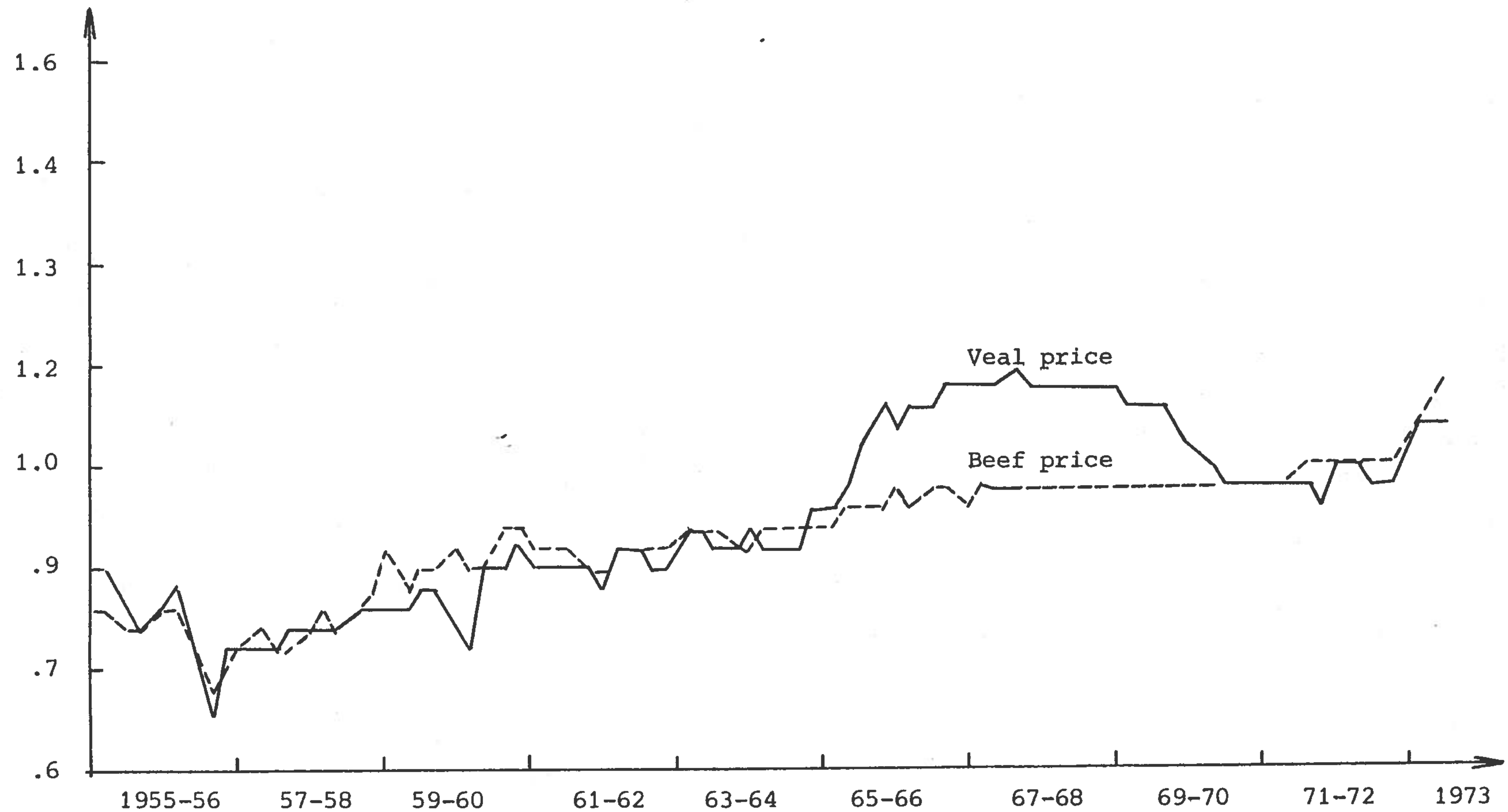
It is known that the parameters of the margin equation are not easily interpreted when price indices are used. If we start with a simple model expressed in terms of prices $P'_t = \alpha + \beta P_t$ where P'_t, P_t are prices respectively at retail and farm level, using indices does not allow simple identification of 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 1/. 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

1/ These prices are not always published and moreover the weights and items in the index often changes over time.

Figure 3.9 - Beef and veal retail price indices (deflated by CPI)



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 absolue 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 stated earlier the trade position of France for pork has changed substantially during the period. Satisfactory data on both quantities and prices were not available over the whole period. Since the focus of the research was not the analysis of this aspect, the trade part of the model was neglected somewhat and left for later work. I recently obtained 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 project in itself and will aslo be taken up later on. For now, only a net import equation has been estimated, which does not portray the economic problem satisfactorily since quality of exports (fat) differs from quality of imports (lean cuts).

All prices and income data 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 artifical 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).

Seasonality was not eliminated, but raw data were used. Dummy variables were included in the equation to pick up seasonal 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 various specifications were tried. This will show in a clearer way the general structure of the price-quantities determination model for the hog market. 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. Finally, 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 pig 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 metric tons)
D_t	consumption of pork per head (in 0.1 kg)
N_t	population (in 10^6 heads)
M_t	net import i.e. imports - exports per head (in 0.1 kg)
PSI_t	public storage net increase (100 metric tons) 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	feeder pig 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 price index (deflated)
SP_t, SU_t, FA_t	dummy variables for seasonal effects (spring, summer fall).

Numbers between parentheses are the Student's t values. Numbers between brackets are elasticities at mean values. $\bar{R}^2$ is the R^2 adjusted fro degrees of freedom. d is the Durbin Watson statistic and h is the Durbin test of serial correlation for auto-regressive models [29, p. 313]. Variables with a hat are the fitted values obtained from the first stage of 2 SLS procedure.

Nome of these statistics applied rigorously to the present simultaneous model. It was believed that they would 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 : it includes 75 observations running from 1955 to 1973.

. Supply block

Supply

(3.1)
$$QS_t = \underset{(.9)}{235} + \underset{(4.4)}{105}\, SP_t - \underset{(3.7)}{96}\, SU_t + \underset{(1.6)}{40}\, FA_t + \underset{(3.5)}{3.9}\, t$$
$$+ \underset{(9.5)}{0.75}\, QS_{t-1} + \underset{\substack{(1.9)\\ [0.07]}}{26.7}\, WPGP_{t-5} - \underset{\substack{(.5)\\ [-0.02]}}{9.8}\, \hat{PGP}_t$$

$\bar{R}^2 = 0.962$ $\quad d = 1.65$ $\quad h = 2.07$

where $WPGP_{t-5}$ is the weighted sum $0.2\, PGP_{t-4} + 0.6\, PGP_{t-5} + 0.2\, PGP_{t-6}$

This specification will be discussed in section 3.2.

Feeder pig price equation (a reduced form of the feeder pig market)

(3.2)
$$PGP_t = -\underset{(.8)}{1.7} + \underset{(.25)}{0.06}\, SP_t - \underset{(2.5)}{0.53}\, SU_t - \underset{(4.7)}{0.85}\, FA_t$$
$$+ \underset{(1.9)}{0.01}\, t + \underset{(3.1)}{0.55}\, PGP_{t-1} + \underset{\substack{(2.6)\\ [1.08]}}{1.05}\, \hat{FHP}_t$$
$$- \underset{\substack{(.45)\\ [-0.15]}}{0.005}\, FPI_t - \underset{\substack{(1.6)\\ [-0.19]}}{0.18}\, PGP_{t-3}$$

$\bar{R}^2 = 0.83$ $\quad d = 1.9$

. Demand block

Demand

(3.3)
$$D_t = \underset{(2.8)}{14.1} + \underset{(4.6)}{1.3}\ SP_t + \underset{(0.1)}{0.03}\ SU_t + \underset{(3.3)}{0.98}\ FA_t + \underset{(3.6)}{0.43}\ D_{t-1}$$

$$- \underset{\underset{[-0.24]}{(2.8)}}{0.90}\ \hat{RHP}_t + \underset{\underset{[0.45]}{(4.7)}}{0.09}\ REV_t + \underset{\underset{[0.03]}{(1.2)}}{1.6}\ VP_t$$

$\bar{R}^2 = 0.99 \qquad d = 2.0$

Margin equation

(3.4)
$$RHP_t = \underset{(1.8)}{1.37} + \underset{(2.2)}{0.13}\ SP_t + \underset{(2.5)}{0.14}\ SU_t - \underset{(1.2)}{0.07}\ FA_t$$

$$+ \underset{(12.6)}{0.75}\ RHP_{t-1} - \underset{(0.6)}{0.001}\ t + \underset{\underset{[0.13]}{(5.9)}}{0.29}\ \hat{FHP}_t$$

$\bar{R}^2 = 0.94 \qquad d = 1.4$

. Trade equation

(3.5)
$$M_t = - \underset{(5.8)}{31} - \underset{(0.4)}{0.4}\ SP_t - \underset{(0.0)}{0.04}\ SU_t + \underset{(0.1)}{0.11}\ FA_t$$

$$+ \underset{\underset{[4.3]}{(2.6)}}{1.95}\ \hat{FHP}_t + \underset{\underset{[9.9]}{(12.8)}}{0.11}\ REV_t$$

$\bar{R}^2 = 0.74 \qquad d = 0.4$

. Clearing identity

(3.6) $$QS_t + N_t M_t = N_t D_t + PSI_t$$

The general working of the model implies the following economic behavior. Feeder pig prices at quarters t-6, t-5, t-4 initiate the production process (selection of females, breedings) which turns out 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 quantities. 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 sales, 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 by the elasticities and the t values. 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 1/.

Separating the variables into exogenous and endogenous groups follows from the economic behavior assumed above. The previous

1/ Since production of feeder pigs is not given by the available statistics, one cannot estimate supply and demand on the feeder pig market. Equation (3.2) is a reduced form of this submodel where PGP_{t-3} is the relevant price for feeder pig supply, and where FHP and FPI are shifters of the demand for feeder pigs, namely output price (slaughter hogs) and input price (feedstuff).

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 sales QS_t. Demand and imports are clearly endogenous (D_t, M_t). Pork, slaughter hog and feeder pig 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 variables (REV_t, PSI_t, N_t) may be easily accepted, the exact nature of others is debatable. The feed price index (FPI) is certainly more and more dependent on the outlook of the hog market, the more so as a steadily increasing part of the ration is purchased from the feedstuff industry. On the demand side the same line of argument applies to veal price as well as beef and poultry prices that were eventually excluded because of wrong signs. These remarks show the need for a complete model ot the feedstuff - livestock 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 conditions point of view. The situation may not be so bright on the rank condition, since the main shifters on supply (time) and demand (income) are highly correlated. Other shifters (FPI_t, VP_t) which are less correlated, seem 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

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

for the endogenous explanatory variables i.e. $P\hat{G}P_t$, $F\hat{H}P_t$, $R\hat{H}P_t$. As expected, multicollinearity is high in the reduced form equations, so that it is hardly possible to draw reliable information from them. These limitations may explain why the flexibility of hog price relative to public storage, derived from the reduced form is surprisingly low (less than 0.0001). But this result also suggests that public storage played a negligible role of stabilisation during the period.

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 deals 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 autoregressive 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 feeder pig price 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 autoregressive term coefficient and therefore underestimate adjustment speed. This problem is not unlikely to occur in the present case given the lenhgt of the sample period and the structural changes in the industry.

With those reservations, the fitted model suggests a slow adjustment in the supply and the farm-retail price equation. Only one fourth of total adjustment would occur during the current period. Long-run elasticities would therefore be about four time SR ones. Adjustement is faster in the final demand equation as well as in the feeder pig market, a result that one expects in view ot the predominent role of slaughter hog price in the latter equation.

Equation (3.1) and (3.2) are used to derive apparent supply elasticity with respect to feeder pig and hog prices and also feed cost index. The apparent supply price elasticity with respect to hog price is the estimate of σ_1 defined in Chap. 2 used by most research workers. The feeder pig price equation is only intermediary and reflects the important role played by the feeder pig market in the French hog industry. The discussion of Chap. 2 about finding the true supply elasticity will be illustrated in the next section.

Table 3.11 - Apparent supply elasticities with respect to :*

	Feeder pig price	Farm hog price	Feed price index
Short run	0.07	0.07	- 0.01
Long run	0.28	0.52	- 0.07

* computed at the mean from equation (3.1) for the first column and completed by (3.2) for the second and third columns.

The apparent 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 France contra to a current practice in United States, although Harlow [19, p. 39] found a corn price elasticity of 0.42, one half of the hog price elasticity (0.82). Kettunen [30, p. 48] found a feed elasticity higher than hog price elasticity (0.63 and 0.25). These differences may reflect the feed balance situation of hog farming units in different countries. One may expect that feed cost will become more important in the supply of hogs in France with the increase of purchased feedstuff.

It is hazardous to compare 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 a general reference. Estimates vary in the range 0.13 to 0.82. It is not easy to sort out specification reasons from actual differences in observed values of supply elasticities. 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 from using inventories or sales as explained variable. Canadian results tend to confirm the argument that supply model using marketed quantities tends to yield higher supply elasticity. This is also true for Kettunen's results. But it is not the case for U.S. results. Again specifications are different at too many viewpoints (dependent variable, price lags, time unit, presence of partial adjustment) to give a clear-cut illustration of the argument. The next section, devoted to justifying the final form of the supply equation, will give a more coherent set of evidence as to the implications of different specifications. But unavailability of French inventory data will prevent us from giving a complete illustration.

Turning now to the other equations of the model let us consider the reduced form equation (3.2) of the feeder pig market. Feeder pig price adjusts quickly to hog price. Equation (3.2) includes lagged feeder pig price i.e. the cyclical shifter of supply for feeder pigs. The dominant role of the demand for feeder pigs in the explanation of PGP is obviated by the results. The long run elasticity of PGP w. r. t. FHP is about 2.0 in agreement with the larger magnitude of feeder pig price fluctuations relative to hog prices. The positive effect of time on the PGP equation most probably accounts for the slower rate of technical progress in feeder pig production compared to fattening. Number of feeder pigs saved has improved at a slower rate than the feed conversion ratio.

Table [illegible] - 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. var.	price elasticity SR	price elasticity LR	R^2	recursive simulta-neous
Harlow [19] U.S.	1949-1960	year	farrowings					rec.
			spring	no		.82	.91	
			fall	no		.56	.92	
Dean, Heady [10] U.S.	1938-1956	year	farrowings					rec.
			spring	no		.60	.93	
			fall	no		.30	.92	
			spring	yes	(1)	.65	.76	
Kettunen [30] Denmark	1956-1965	quarter	marketed qty	no		.25	.84	rec.
			produced qty	no		.20	.89	
		1/2 year	produced qty	no		.25	.90	
Heien [22] U.S.	1950-1969	year	# of pigs slaughtered	no		(2) .39	.58	rec.
Reimer, Kulshreshtha [42] Canada	1949-1971	year	inventories	no		.13	.95	rec.
Chin, Pando, West [7] Canada	1951-1972	1/2 year	#of heads marketed	yes	.36	.61	.93	rec.
Tryfos [52] Canada	1961-1971	1/2 year	inventories	yes (3)		.39	(3)	sim.
present study	1955-1973	quarter	marketed quantities	yes	.07	.53	.96	sim.

(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. Theils's U = 0.02 (the estimate 0.39 was termed by Tryfos inventories elasticity w. r. t. price).

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	- 0.24	+ 0.03	0.45
LR	- 0.55	+ 0.07	1.0

As stated earlier, the main surprise in demand estimation was the consistently negative (nonsignificant) effect of beef prices. Using the wholesale price of beef instead of retail gave similar results. This result contradicts the evidence in many countries. Unpublished work on meat demand 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 veal-pork substitution and the independence of pork demand w. r. t. beef price. The French consumer eats more veal than in any country. Veal, pork and poultry belong to the white meat group 1/ inside of which subsitution 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 for 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.

From a theoretical viewpoint it may be argued that including beef price in demand does not measure the true substitution ef-

1/ Although veal meat is a much more expensive meat than pork and poultry.

fect 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, also given its psychological importance, an increase in 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 mentioned before, i.e. exclusion of self supply on farm. 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 nos behave too badly in this situation. The results are given by equations (3.8) and (3.9).

1°) 1955-1966, 48 observations

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

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

2°) 1967-1973, 27 observations

(3.9)

$$D_t = 55.1 + 1.3\ SP_t + 1.48\ SU_t + .46\ FA_t + .24\ D_{t-1}$$
$$(2.9) \quad (3.4) \quad (1.0) \quad (1.0)$$

$$- 3.1\ RHP_t + .089\ REV_t - 2.0\ VP_t$$
$$(28) \quad (2.4) \quad (.48)$$

$R^2 = 0.97 \quad d = 2.26$

Table 3.14 - Change in demand elasticities

w.r.t. / sub period		Retail hog price	Veal price	Income
1955-66	SR LR	- .15 - .21	.16 .21	.45 .59
1967-73	SR LR	- .64 - .84	nega- tive	.42 .55

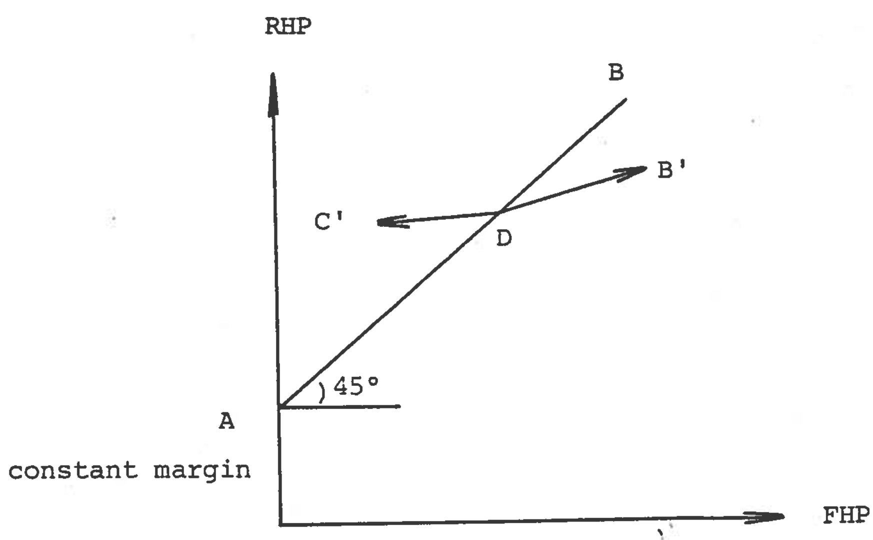
The change of structure is accepted on the face of the F test (calculated $F_{8,59} = 23$, table $F_{8,59} = 2.1$). This change contribute to explain why the adjustement coefficient was 0.56 in the estimation over the whole period, while subperiods estimates are over 0.70. The main evidence is the apparent 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 as a surprise. Perhaps the exclusion of undeclared slaughter which has been decreasing sharply over the period, has something to do with it. Marketed consumption increased faster than total consumption, so that the opposite trends to prices may overestimate, the price elasticity.

We turn now to the margin equation (3.4). It is a well known fact that farm prices fluctuate more than retail prices, so we expect that the slope parameter of FHP would be less than one in the short run. The estimate 0.30 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 one 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 0.25, and it is tempting to accept the model of variable margins in the short run but constant in the long run.

Following many authors [12, 24] marketing costs and production were introduced in the equation to get closer to the underlying reduced form. Wages in the food industry seem to play a positive role in the retail price a result consistent with theory, but the t value was low (0.65). The time coefficient was still negative as technical progress in marketing implies, but its level of significance decreased further (t = 0.56 vs 0.76). These two effects contributed to maintain margins almost constant in real terms in the long run. The production variable was also not significant 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 heard that retailers are responsible for nonsymmetric transmission of farm price increases and decreases. If this hypothesis were true, it would mean that retailers have some market power relatively to consumers in the short run which allows them to resist price declines at farm level. In the long run however competition would still work and with the help of inflation, real margins would still follow costs, since equation (3.4) implies 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 $B_t.FHP_t$. Regressions were run for whole pork and for the subset fresh pork, the less processed part of the carcass.

(1955-1973, 75 observations) whole pork

$$(3.10) \quad RHP_t = 1.18 + \underset{(2.2)}{0.12}\ SP_t + \underset{(2.2)}{0.13}\ SU_t - \underset{(1.4)}{0.08}\ FA_t - \underset{(.4)}{0.0009}\ t + \underset{(5.9)}{0.29}\ FHP_t - \underset{(.66)}{0.0066}\ B_t.FHP_t + \underset{(10.7)}{0.77}\ RHP_{t-1}$$

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

(1955-1973, 75 observations) Fresh pork 1/

$$(3.11) \quad RHP^f_t = - \underset{(1.1)}{.07} + \underset{(1.1)}{.013}\ SP_t + \underset{(2.3)}{.026}\ SU_t - \underset{(1.8)}{.02}\ FA_t + \underset{(2.5)}{.0006}\ t + \underset{(4.7)}{.040}\ FHP_t - \underset{(1.7)}{0.003}\ B_t.FHP_t + \underset{(16.1)}{.85}\ RHP^f_{t-1}$$

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

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.

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).

Splitting the margin behavior into two parts seems justified by the reduction of serial correlation 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 is insufficient for useful policy analysis. Elasticities with respect to price and income (respectively 4.3 and 9.9) are high as usual in trade equations.

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

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

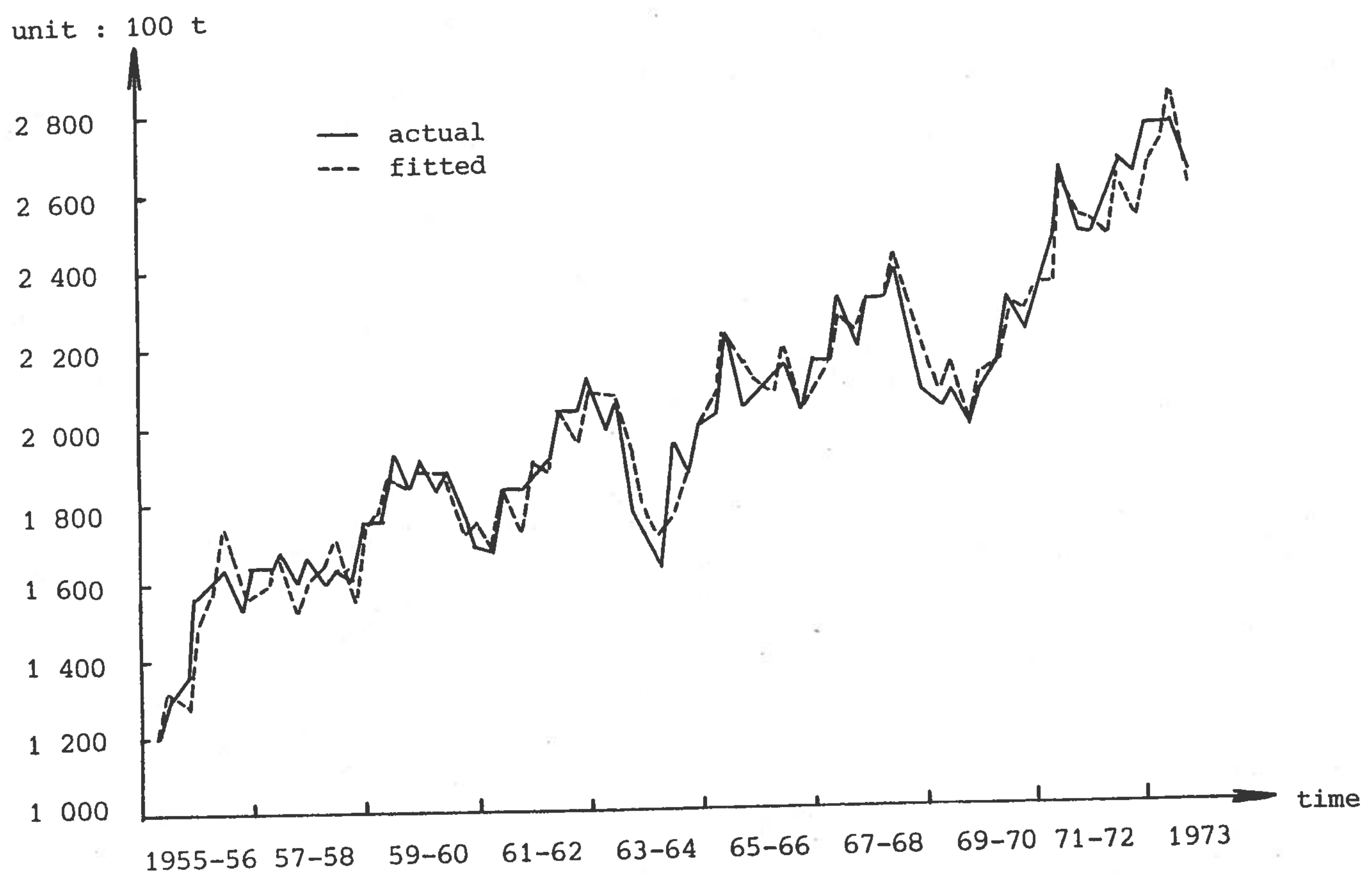


Figure 3.12 - Actual and fitted values : feeder pig price (eq. 3.2)

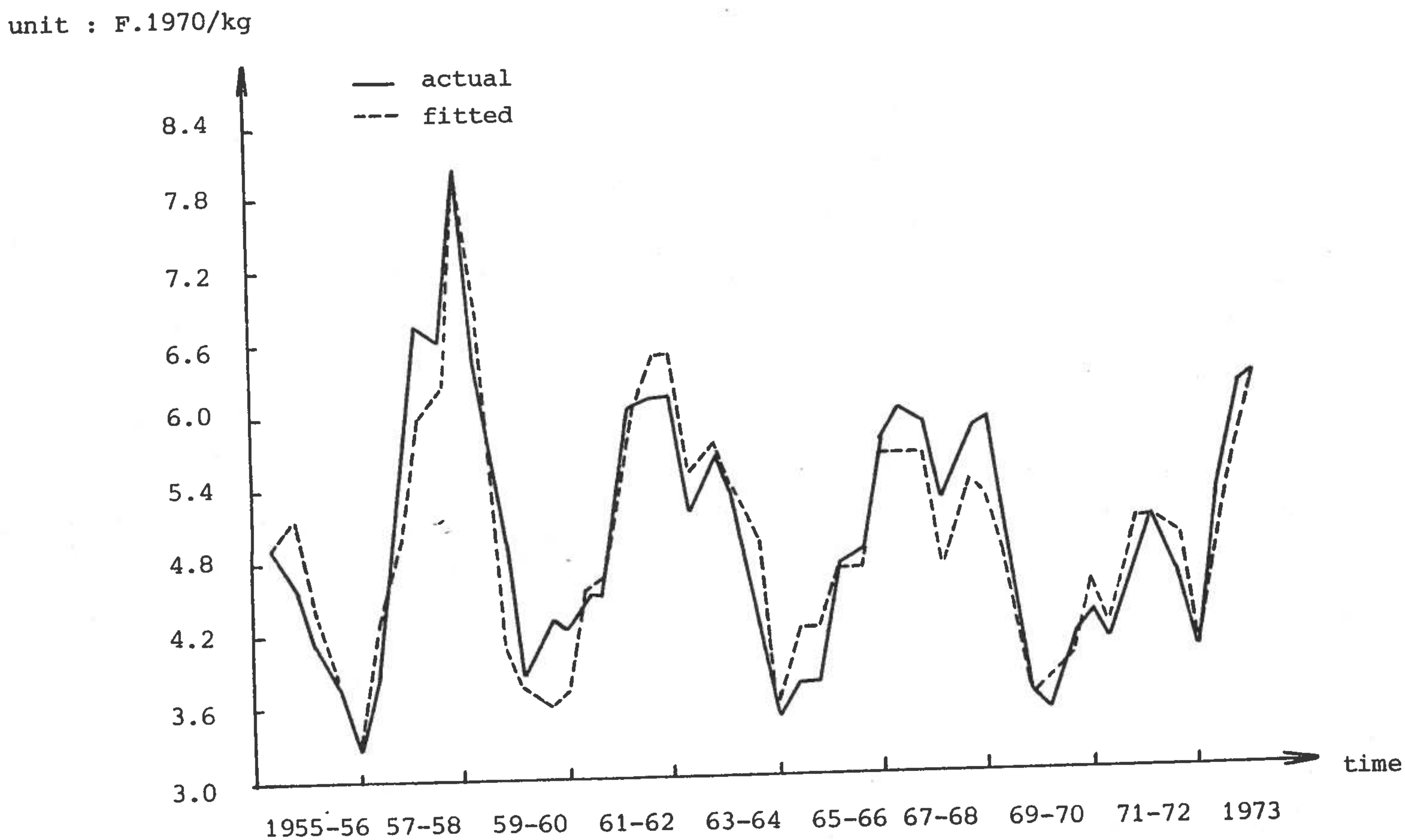


Figure 3.13 - Actual and fitted values : demand (eq. 3.3)

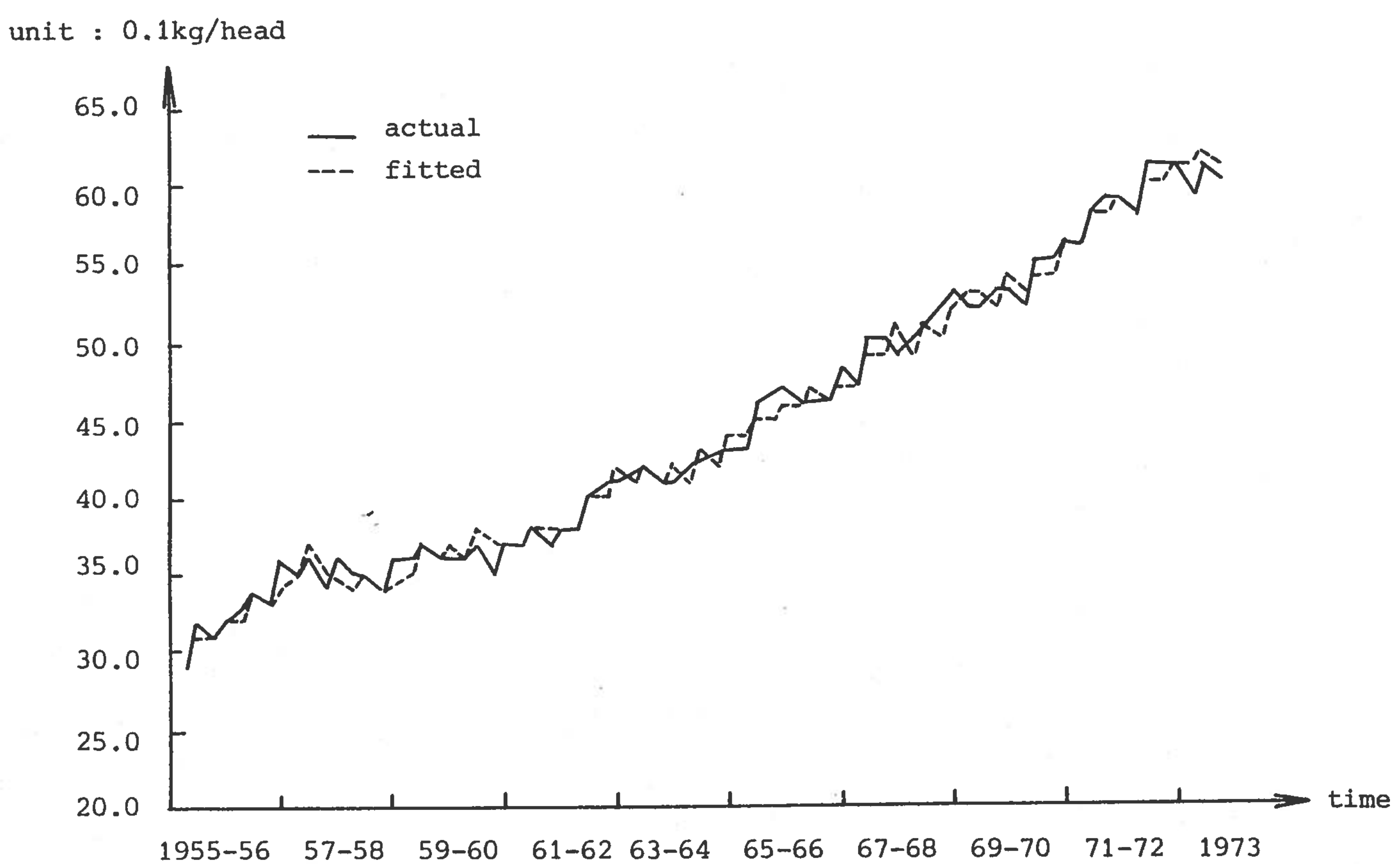


Figure 3.14 - Actual and fitted values : farm retail relation (eq. 3.4)

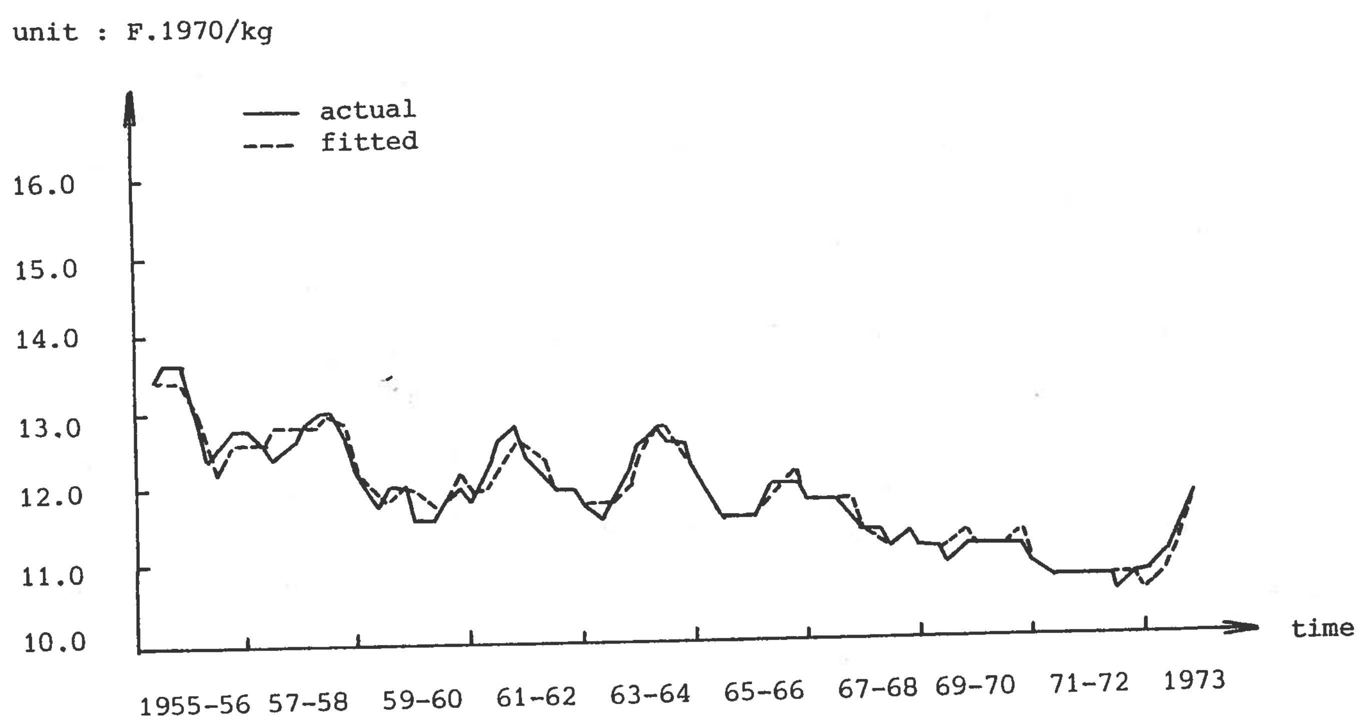
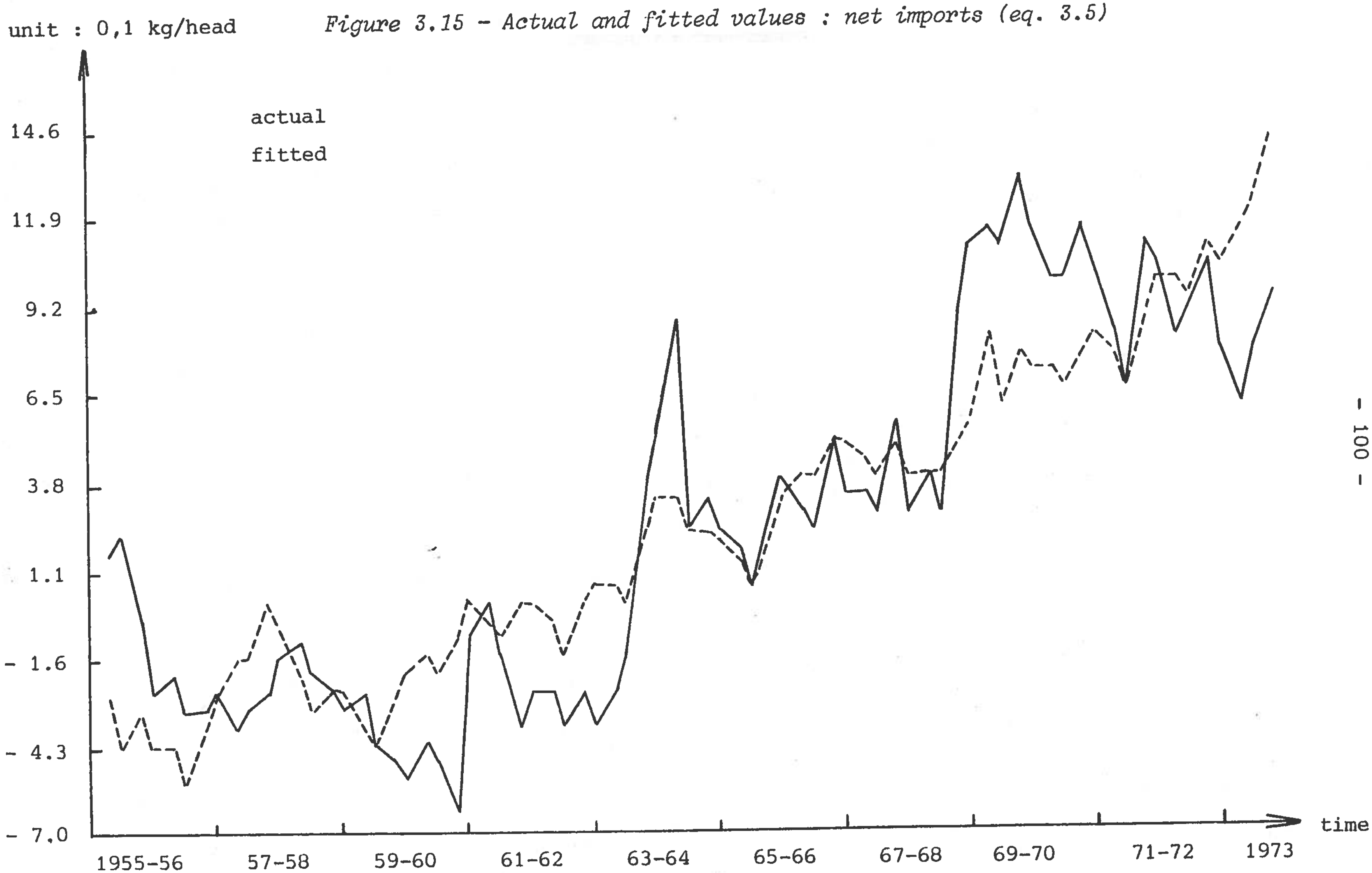


Figure 3.15 - Actual and fitted values : net imports (eq. 3.5)



32 - Preliminary work on the supply part of the model

This section is meant to justify the specification used 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.

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

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 for w. But breeding decisions may be made on sows at various stages with corresponding different production lags. If the main decision would bear on very young sows, 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 expects 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 the use of 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 makes 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} (0.80). One also notes that OLS estimates gives larger current price effect than 2 SLS as a result of simultaneous bias.

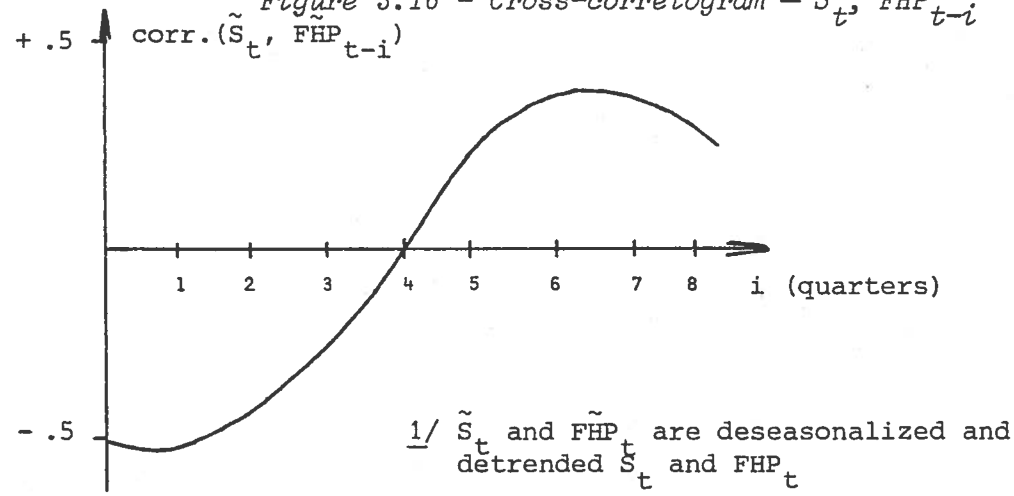
Preliminary work of estimation was used on monthly data using Almon polynomial constraints [2] and Shiller's smoothness prior [48] (Fig. 3.18). They tend to confirm the dominant role of the fifth quarter but suggests that the reaction spreads over quarters t-4 and t-6. Shiller's method gave a flatter curve, which may be due to the prior information fed in. In the quarterly model, it is useless to use the polynomial approach since with 3 points (4, 5, 6) we have no constraint 1/ 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 $WPGP_{t-5}$ (weighted feeder pig price) 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.

1/ Using a quadratic polynomial constrained to have roots in t-3 and t-7, would make it too flat relative to the hump implied by monthly results on Fig 3.18.

Figure 3.16 - Cross-correlogram $\underline{1/}\tilde{S}_t$, $\tilde{FHP}_{t-i}$



$\underline{1/}$ $\tilde{S}_t$ and $\tilde{FHP}_t$ are deseasonalized and detrended S_t and FHP_t

Figure 3.17 - Unconstrained regression

Log $S_t = a + \Sigma a_i$ *Log* FHP_{t-i}

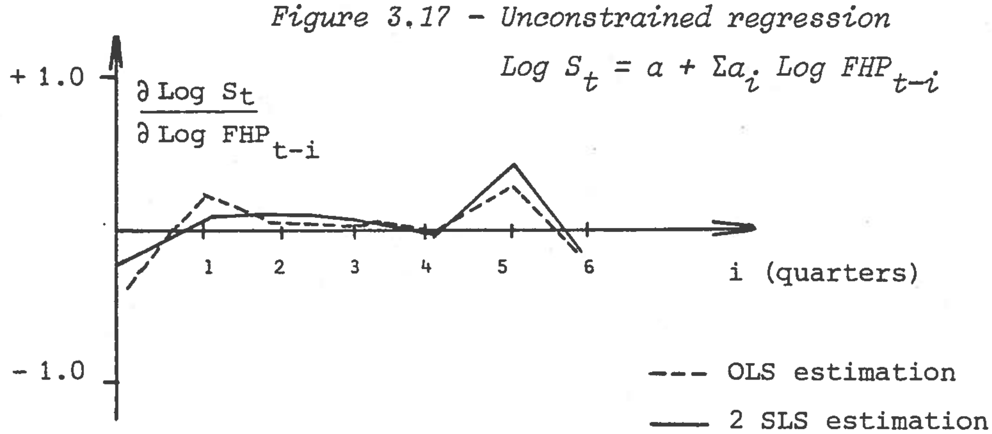
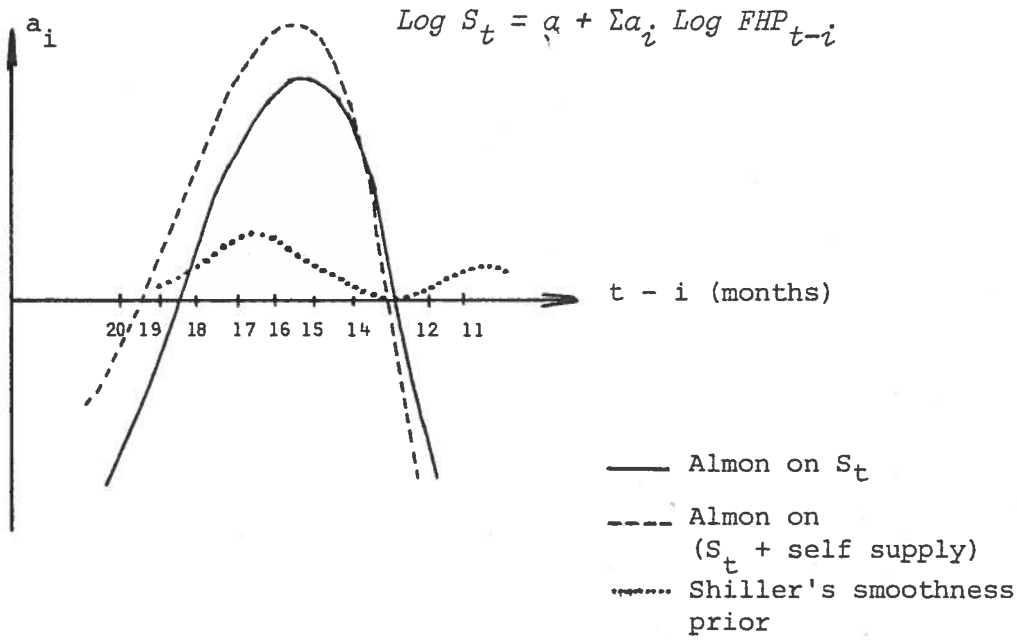


Figure 3.18 - Constrained regression

Log $S_t = a + \Sigma a_i$ *Log* FHP_{t-i}



(1955-1973, 75 observations 2 SLS)

(3.12)
$$QS_t = \text{constant} + \text{seasonals} + \underset{(9.6)}{.73}\, QS_{t-1} + \underset{(3.6)}{4.1}\, t + \underset{(1.6)}{18.3}\, PGP_{t-5} - \underset{(1.1)}{18.1}\, \hat{PGP}_t$$

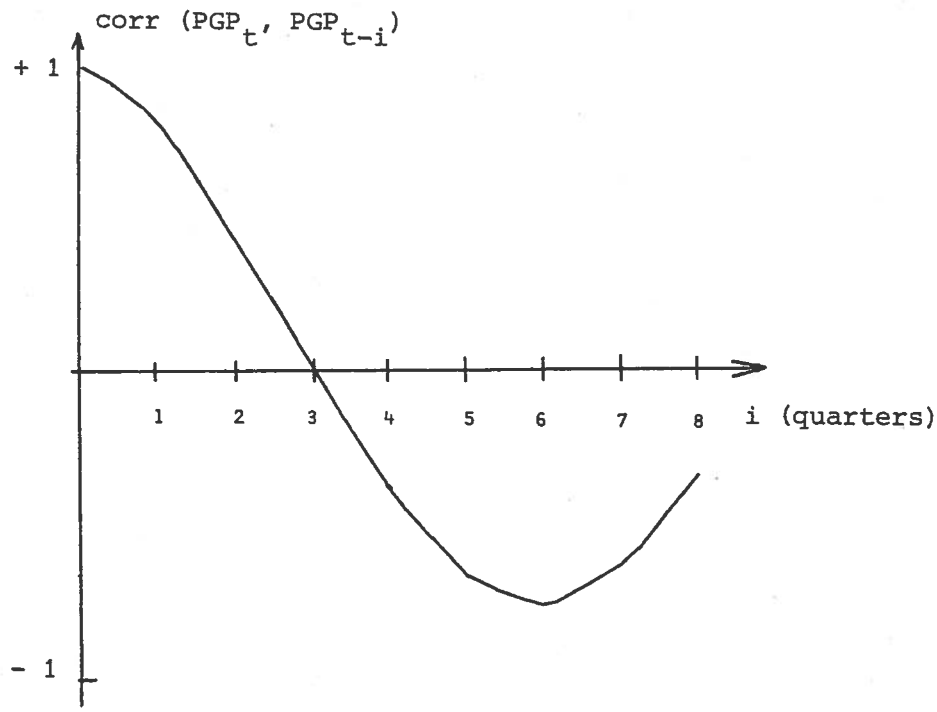
$R^2 = .96 \quad h = 2.1$

(3.13)
$$QS_t = \text{constant} + \text{seasonals} + \underset{(9.5)}{.74}\, QS_{t-1} + \underset{(3.5)}{4.0}\, t + \underset{(1.9)}{26.7}\, WPGP_{t-5} - \underset{(.5)}{9.8}\, \hat{PGP}_t$$

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

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 of feeder pig price



Simultaneity or recursiveness

One of the arguments made in Chap 2 was that a recursive model would lead to overestimated apparent supply elasticity σ_1. This is illustrated by equations (3.13) and (3.14) where total weight (QS_t) is the dependent variable, and by (3.15) and (3.16) with numbers (S_t) as dependent variable.

Recursive, dependent variable in weight, QS_t

(3.14) $$QS_t = \text{constant} + \text{seasonals} + \underset{(12.7)}{0.77}\, QS_{t-1} + \underset{(3.6)}{3.7}\, t + \underset{(4.3)}{33.1}\, WPGP_{t-5}$$

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

Recursive, dependent variable in heads, S_t

(3.15) $$S_t = \text{constant} + \text{seasonals} + \underset{(13.5)}{0.78}\, S_{t-1} + \underset{(3.7)}{4.9}\, t + \underset{(5.0)}{48}\, WPGP_{t-5}$$

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

Simultaneous, dependent variable in heads, S_t

(3.16) $$S_t = \text{constant} + \text{seasonals} + \underset{(4.0)}{0.71}\, S_{t-1} + \underset{(3.7)}{5.9}\, t + \underset{(1.4)}{26}\, WPGP_{t-5} - \underset{(1.4)}{34}\, PGP_t$$

$R^2 = .97 \quad h = 2.2$

The apparent supply elasticities estimates (σ_1) are given in Table 3.15 - for the four specifications at mean values.

Table 3.15 - Estimates of Long-Run apparent supply elasticities σ_1 for different specificiations

Dependent variable	Specification	
	recursive	simultaneous
weight	0.70	0.52
numbers	0.83	0.34

As expected, recursive models give substantially higher estimates than simultaneous models do. The OLS estimate $\hat{\hat{\sigma}}_1 = 0.83$ derived from (3.15) where the dependent variable is the number of heads marketed, yields the highest value for σ_1. OLS estimate $\hat{\sigma}_1 = 0.70$ derived from equation (3.14) where weight is used as dependent variable gives a smaller value for σ_1, because of the offsetting role played by current price on average weight. These results are in agreement with the analysis of biases made in Chap. 2.

An estimate of the elasticity (σ_0'') of average weight w. r. t. current hog price was derived from equation (3.17) below.

(1955-1973, 75 observations, 2SLS)

$$W_t = .73 + \underset{(46.6)}{} 0.0019\, \underset{(.56)}{SP_t} - \underset{(2.9)}{0.009}\, SU_t + \underset{(1.3)}{0.004}\, FA_t \tag{3.17}$$

$$- \underset{(2.9)}{0.002}\, t + \underset{(3.5)}{0.009}\, \widehat{FHP}_t$$

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

Where W_t is the average weight of hogs marketed. The estimate of σ''_0 is 0.06. Now, following the concepts defined in Chap. 2, we could derive estimates of true supply elasticity both in numbers ($\sigma = \sigma_1 + \sigma'_0$) and in weight ($\sigma_Q = \sigma_1 + \sigma'_0 + \sigma''_0 = \sigma_1 + \sigma_0$), from equations (3.13) and (3.16). It is clear however that the parameters of lagged and current price in (3.13) and (3.16) are not consistent with the theory developped earlier : equation (3.16) would yield a negative value for σ by summing algebraicly 26 and - 34. Similarly equation (3.13) would give a very small estimate of σ, namely 0.33.

In Chap. 2, it was shown that the magnitude of lagged price parameter should be m times the magnitude of the current price coefficient according to equation (2.7). This is not verified. The current price effect is too high 1/. Possible explanations were suggested previously : improper specification of the lag structure, socalled demand effect and high collinearity due to the regularity of the price cycle. Using simultaneous equations methods in hog supply, without checking results with a priori information, may be a worse procedure than simple OLS on recursive supply equations. They give biased estimates but with a much smaller variance.

One way out of the difficulty, is to introduce explicitly the constraint $\sigma_1 = - m\, \sigma'_0$ in the estimation procedure. Taking m = 5 which is an order of mangitude for the number of pigs saved per sow, the following result was obtained :

(1955-1973, 75 observations)

(3.18)
$$S_t = \text{constant} + \text{seasonals} + \underset{(13.1)}{0.76}\, S_{t-1} + \underset{(3.9)}{5.2}\, t + \underset{(5.1)}{8.6}\,(5\ WPGP_{t-5} - \widehat{PGP}_t)$$

$R^2 = 0.967$ $\quad d = 1.66$ $\quad h = 1.7$

1/ In Tryfos results, the negative current price effect also seems quite high relative to the inventory elasticity.

We now have estimates for all the parameters defined in Chap. 2. Although we have to keep in mind the a priori information fed in the estimation procedure, it is interesting to verify the arguments advanced in Chap. 2. Consistent estimates are collected in Table 3.16.

Table 3.16 - Consistent 1/ estimates of σ_1, σ_0', σ_0'', σ, σ_Q

$\tilde{\sigma}_1$	$\tilde{\sigma}_0'$	$\tilde{\sigma} = \tilde{\sigma}_1 + \tilde{\sigma}_0'$	$\tilde{\sigma}_0''$	$\tilde{\sigma}_0$	$\tilde{\sigma}_Q = \tilde{\sigma}_1 + \tilde{\sigma}_0$
0.68	- 0.13	0.55	0.06	- 0.07	0.61

The point estimates in Tables 3.15 and 3.16 are in agreement with the expected ranking described in Chap. 2, namely

$$\text{plim}\ \hat{\hat{\sigma}}_1 > \text{plim}\ \hat{\sigma}_1 > \sigma_1 > \sigma_Q > \sigma$$

$$\hat{\hat{\sigma}}_1 > \hat{\sigma}_1 > \tilde{\sigma}_1 > \tilde{\sigma}_Q > \tilde{\sigma} \qquad (3.19)$$

$$0.83 > 0.70 > 0.68 > 0.61 > 0.55$$

The results also imply that the overall current price effect σ_0 is negative, but smaller than the estimate drived from uncronstrained 2SLS in (3.13) i.e. $\sigma_0 = - 0.07$ instead of - 0.19. This suggests to set a constraint in the equation in weight (3.13). But, we do not have a priori information on the parameter corresponding to m = 5 in equation (3.18). Table 3.16 suggests that after

1/ The estimates are consistent provided that the constraint imposed is appropriate.

desagregating the sales equation in weight into an equation in numbers and an equation in average weight, a value of 10 might be appropriate. This will be done later, with a check based on the predictive ability of the model.

To summarize the results the folowing statements may be proposed :

- There exist a small overall negative current price effect on sales measured in weight, in spite of the positive response of average weight to prices.
- The biases resulting from specification errors have the direction announced in Chap. 2 eg. supply elasticity is overestimated.
- It is difficult beacuse of collinearity and lag structure specification to get independent estimates of lagged and current price coefficients.
- It seems that unconstrained 2SLS may lead to larger errors than OLS with a recursive sales equation, because of the large variance of the estimates.
- Data on inventories would be necessary to give a more complete verification of the analysis presented in Chap. 2.

33 - Structural changes and supply elasticity

Many commentators have written that 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 costs to be covered and the action of producers' associations would stabilize supply.

Irwin [28] 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 [54] 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 $\Sigma\omega_i\varepsilon_{ip}$, where ω_i are the input elasticities of output and ε_{ip} the demand elasticities of input with respect ot output price [Griliches, 16]. Assuming further that factors are paid at their marginal product, the ω_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 mentioned before, the use of purchased inputs has increased a good deal in hog production recently and one may expect an increased supply elasticity contrary to the widrspread opinion. Tweeten and Quance did not find clearcut evidence that supply elasticity had changed over time, but they were dealing with aggregate farm supply.

Dean and Heady [10] 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 changes in breeding, feeding and facilities, which shift the production function and flatten the marginal cost curve.

A self-contained analysis of possible effects of structural changes on supply elasticity is needed. For now the question is 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 out the test : first the simultaneity, second the short period of observation on structural changes in the industry (1966). I have taken the easy way out by working with a recursive model since there is a linear relation between true elasticity σ and marketed elasticity σ_1. I have split the sample period at the 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].

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

(1955-1966, 48 observations)

$$QS_t = \underset{(2.1)}{246} + \underset{(4.3)}{121}\ SP_t - \underset{(2.3)}{67}\ SU_t + \underset{(2.4)}{69}\ FA_t + \underset{(3.4)}{4.9}\ t$$

$$+ \underset{(4.3)}{35}\ WPGP_{t-5} + \underset{(7.8)}{.66}\ QS_{t-1}$$

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

(1967-1973, 27 observations)

$$QS_t = \underset{(1.1)}{206} + \underset{(1.4)}{52}\ SP_t - \underset{(4.4)}{164}\ SU_t - \underset{(.3)}{12}\ FA_t + \underset{(2.4)}{6.8}\ t$$

$$+ \underset{(2.2)}{41}\ WPGP_{t-5} + \underset{(8.9)}{.81}\ QS_{t-1}$$

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

Using also the error sum of squares of the equation estimated on years 1955-1973, an F test is constructed [29, p. 199] with 7 and 61 degrees of freedom. Computed $F_{7,\ 61}$ is 0.5 compared to the 2.2 value of the table. Structural change cannot be accepted on this basis. The supply slope has increased from 35 to 41. But it is not so for short-run supply elasticity 1/ at mean values respectively 0.10 and 0.08, the decreasing ratio $\frac{P}{S}$ overcompensates the increasing supply slope. However if one compares the long-run elasticities in the two subperiods the order is reversed since adjustment speed appears to be smaller in the more recent years,

1/ With respect to feeder pigs price.

respectively (0.29 and 0.43). A similar result was obtained previously on monthly data, with a specification of the equation in logarithms. This overall evidence tends to suggest a slight increase of the long-run supply elasticity over time. The opposite ranking short-run and long-run estimates is consistent with both the fixed factor specialization argument of Irwin which works more for the short-run and the increased share of purchased inputs arguments which would work in the long-run (acquisition of new facilities, etc...).

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 noticeably in the recent years and this works in the direction of stagilization. If one computes long-run elasticities of supply 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 the hog cycle remains quite unstable around equilibrium. They also suggest that the linear model is not sufficient to account for the stability conditions, since they imply an explosive cycle.

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Chapter 4

WEFARE ANALYSIS OF THE HOG CYCLE IN FRANCE

Farm prices are well known for their instability. In most cases the wide swings of prices are due to disturbances on the supply side. Two kinds of disturbances may be distinguished : random and cyclical.

In spite of technical progress, agriculture remains a biological process subject to randomness. To cope with this sort of fluctuations, agricultural policy is limited to curative devices i.e. measures designed to weaken the consequences on producers and consumers.

Cyclical fluctuations originating in the supply side of a commodity market, are not due to causes exogenous to market mechanism. On the contrary production lags and decentralization of decision making lead to a built-in feed-back which generates commodity cycles.

In both types of disturbing factors, prices and quantity fluctuations disrupt the effort of producers and consumers to reach equilibrium. Welfare losses are expected to result from these price distortions. In the case of random causes the welfare losses are due to forces external to the market system. In the case of cyclical fluctuations, welfare losses are generated by the decentralized market system itself. Therefore, free competition is not able to reach optimal allocation of resources in the case of cyclical commodities. It is one more example where regulations are needed to help free market to reach Pareto optimum.

The welfare aspects of price instability have been extensively studied in the literature, but mainly random fluctuations have received noticeable attention 1/. Only recently Heifner and Man have considered the case of a cyclical commodity, in a paper discussing research on market instability [23].

In this chapter, first I evaluate the aggregate welfare loss due to fluctuations in a simple cobweb framework. I also develop a cost-benefit analysis of stabilization of a cyclical commodity in this particular case. Then, I deal with distribution effects of fluctuations on producers, consumers and the marketing sector. Marketing margin behavior is discussed in this context. Finally I try to extend the approach to a real life case (the hog market) on the basis of the model estimated in Chap. 3.

1 - Aggregate welfare loss in a simple cobweb

Distortion between supply and demand prices is widely considered as a discrepancy from optimality under general conditions and can be used as a measure of the marginal welfare loss [Harberger, 18].

1/ Most references are given in Turnowsky [53] and need not be repeated here.

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 : $Q_t = \alpha_0 + \alpha_1 P_t$

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

This simple model generates a stationary cycle of prices and quantities moving from the point (P_m, Q_M) to the point (P_M, Q_m) on Fig. 4.1.

Following Harberger, the welfare loss associated with the observed point (P_m, Q_M) is the area included between supply and demand curves, and the vertical line drawn at Q_M; in the linear case this area is given by

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

Using the symmetry of the cycle we have

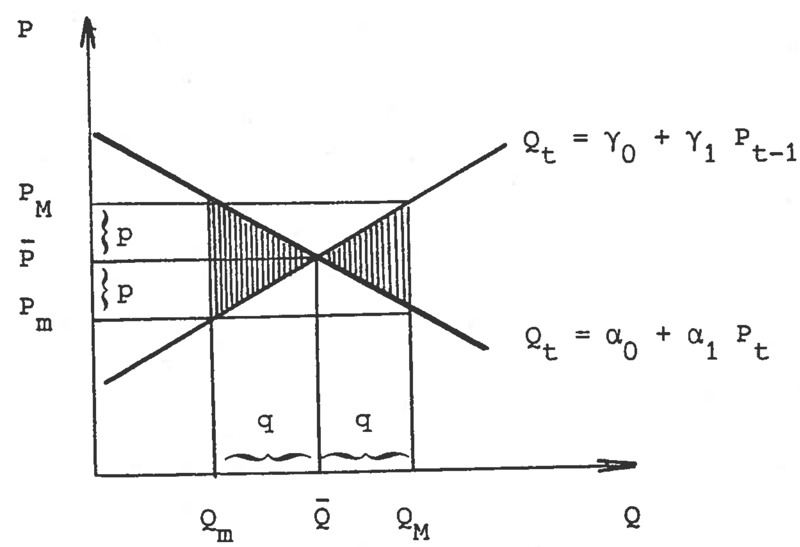
$$(P_M - P_m) = 2 \ (P_M - \bar{P})$$

Define the absolute deviations of price and quantity from equilibrium by p and q

$$p = (P_M - \bar{P}) = - \ (P_m - \bar{P})$$

$$q = (Q_M - \bar{Q}) = - \ (Q_m - \bar{Q})$$

Figure 4.1 - Symmetrical stationary cobweb



Using the symmetry again the welfare loss for a complete cycle is

(4.3) $$L = 2\ pq$$

This loss can be written in term of price or quantity deviation alone together with the common parameter γ. We have

$$q = (Q_M - \bar{Q}) = \gamma_1\ (P_M - \bar{P}) = \gamma p$$

and

(4.4) $$L = 2\ pq = 2\gamma p^2 = 2\ \frac{q^2}{\gamma}$$

Considering the point (P_m, Q_M) and excess supply $(Q_M - \bar{Q}) = q$, a simple benefit-cost analysis of stabilization consists in comparing the present value of the welfare loss if the cycle goes on, to the cost of disposing of the excess supply q, which feeds the cycle. If the cycle goes indefinitely, the present value of the welfare loss is the limit of:

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

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

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

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

This condition can be written in terms of relative price deviations:

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

A sufficient condition for (4.6) to be satisfied is that $p/\bar{P} \geqslant \rho$. If the relative magnitude of price fluctuations around equilibrium price is at least equal to the chosen discount rate, it would be worth to use the extreme policy of destroying excess supply, in the case of a stationary symmetrical cobweb. If the walue of ρ is about 10%, stabilization would be justified for cyclical commodities whose price fluctuates by more than 10% around the trend.

One could study more flexible policies using buffer stocks or funds, which are more relevant in the general case where random fluctuations are 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 and consumer surpluses. These concepts are widely used and widely criticized in the literature [9]. I make only few remarks in order to justify 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 surplus, 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 consumers's total expenditures. The aggregation over consumers is certainly more questionable, since we run into distribution problems, and it is difficult to accept the assumption of optimal distribution of income.

On the producer side two main aspects are to be considered. First there is the distinction between the producer surplus and the rent to the factors [9]. 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 long-run marginal cost curve or to the short-run one ? If 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 short-run marginal cost curve, which is more relevant to the use of producer surplus than is the long-run cost curve [9]. The aggregation problem remains unsolved on the production side too, and one should certainly try to analyze which firms are more likely to be affected by price fluctuations.

In the description of distribution effects we evaluate the welfare changes on producers and consumers when we move from a fluctuating market to a stabilized market. In other words we measure the welfare gains from stabilization (which are in the same time losses resulting from fluctuations), on Fig 4.2 built on the same model (4.1) and (4.2).

Stabilization means a gain of (a + b) in consumer surplus from the point (P_M, Q_m) to ($\bar{P}$, $\bar{Q}$) and a loss of (c + d + e) when moving from (P_m, Q_M) to ($\bar{P}$, $\bar{Q}$).

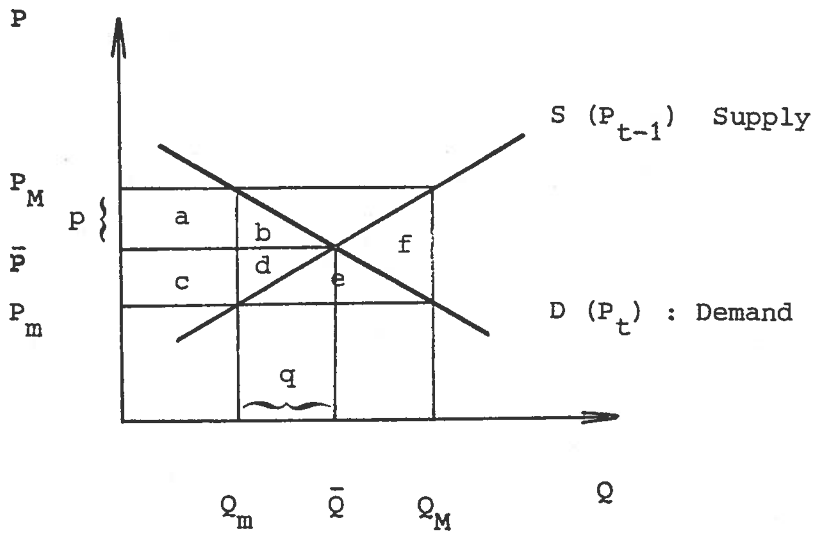
$\Delta CS = -(c + d + e) + a + b = -e$, by using symmetry (b = d).

In terms of absolute deviations p and q,

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

Consumers lose from price stabilization. This is a known result when the source of fluctuation is on the supply side [Waugh, 56].

Figure 4.2 - Distribution effects



For producers the effect of price stabilization at $\bar{P}$ is

$$\Delta PS = (c + d + e + f) - (a - d) = 2\,d + f + e$$
$$= (b + d) + e + f$$

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

Producers gain from stabilization when disturbances originate in the supply [9]. With price at P_m, producers lose more than the strict producer surplus variation from $(\bar{P}, \bar{Q})$ 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 given by supply price.

This loss [1/] amounts to area e + f.

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

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

By the compensation principle, it would therefore be worthwile for 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 (denoted by P') is identical to farm price (P). I shall assume hovever that quantities [2/] are the same at retail and farm level : $Q' = Q$.

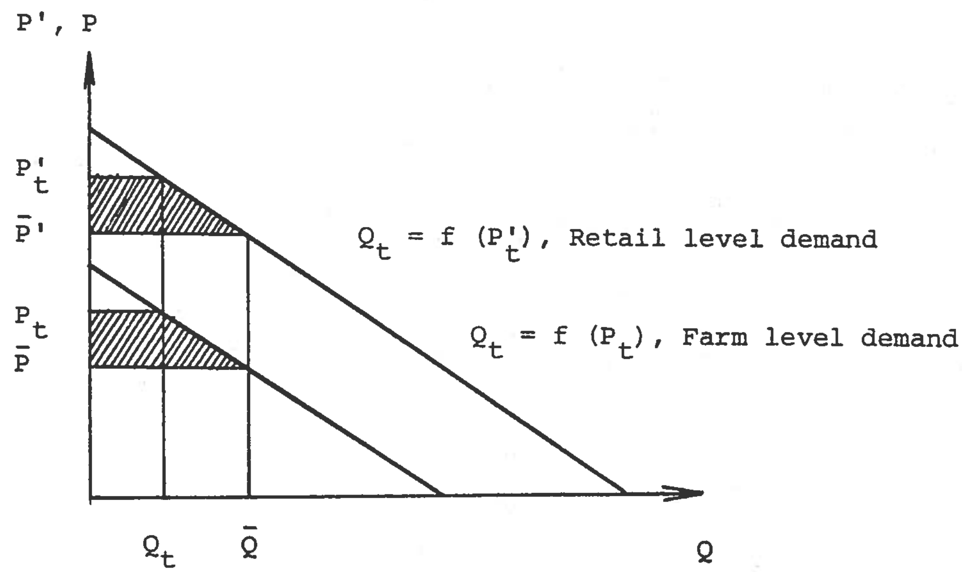
1 - Constant margins $P' = P + \bar{M}$

The variation of consumer surplus is the same at farm and retail level (Fig 4.3). No further distribution effects are generated by the marketing sector.

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 [15].

Figure 4.3 - Constant margin and consumer surplus



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

where dCS' is the change in consumer surplus observed at retail and dCS is the changed observed at the farm level, i.e. with a demand using farm price.

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

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

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

$$dCS' = (1 + \alpha)\ dCS$$

Because price variations are amplified, we expect 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 margin case.

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

- Consumers lose from stabilized prices, in a whole cylce:

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

- Marketing firms gain from price stabilization 1/:

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

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 2c in Fig 4.4 b)

- Producers gain the same ammount as before, 3pq

1/Assuming zero marginal cost in marketing, see p. 134.

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

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

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

Figure 4.4 - Proportional margins

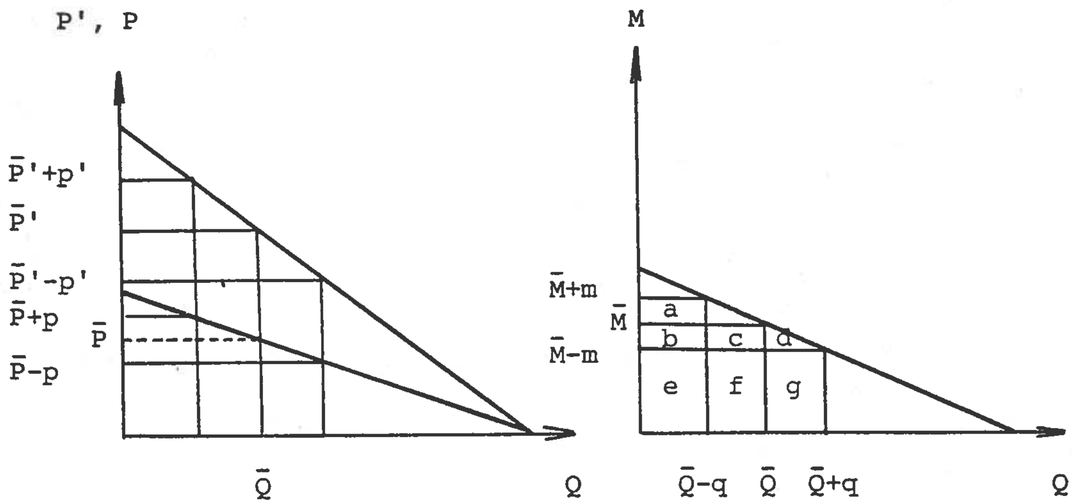


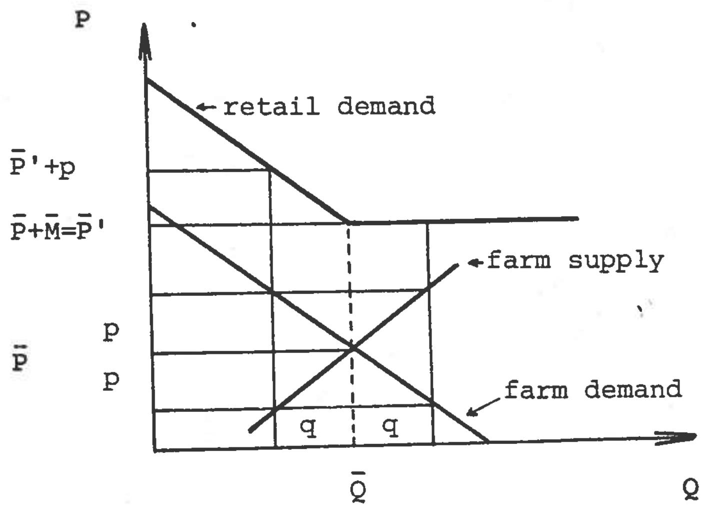
Figure 4.4 a *Figure 4.4 b*

It turns out that proportional margins associated with symmetrical fluctuations benefit consumers more than constant margins. Furthermore marketing firms lose (αpq) from strict proportional margins on a cyclical commodity, and they lose more than the extra gain from fluctuation (αpq) accruing to consumers. These results suggests that strict proportional margins create a welfare loss and that they are not necessarily associated with market power since marketing firms do not benefit from them, in the case of symmetrically reversible price fluctuations [Ruttan, 44].

3 - Non reversibility of retail price fluctuations

Casual observation of prices at different marketing levels shows the contrast between wide reversible farm prices and much more stable retail food prices. The two previous models do not stick very close to reality, at least in the short-run. One interesting assumption to consider is the nonreversibility 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. This could be called the strict ratchet effect.

Figure 4.5 - Nonreversibility of retail prices



In the stationary cobweb again this means :

$$p' = \begin{cases} p \text{ when } P > \bar{P} & \text{i.e. } \Delta M = 0 \\ 0 \text{ when } P < \bar{P} & \text{i.e. } \Delta M = \bar{P}' - (\bar{P} - p) - (\bar{P}' - P) \end{cases}$$

$$\Delta M = p$$

Marketing firms will clearly benefit in such a situation from price fluctuations. Consumers will suffer surplus losses but no surplus gain will accrue to them. In the previous particular case, the welfare effect of stabilization will be:

$$(4.15) \qquad \Delta CS' = Qp - \frac{1}{2} pq > 0$$

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

$$\Delta MS = - Qp - pq < 0$$

In this case consumer gain from the stabilization of a cyclical commodity while marketing firms lose. Moreover, marketing firms lose 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 cases are conceivable however, with intermediate kinds of distribution effects.

In the analysis described above, the relationship between marketing margins and marketing cost is neglected. If marginal cost in marketing is increasing around $\bar{Q}$, then the situation is comparable to the producers' case if margins are proportional. 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, see Appendix 4.3).

32 - A first application to the hog market

The stationary cobweb presented above would fit better an annual crop than a continuous production like hogs. Transactions occur each day and all the intermediary points between peaks and troughs are observed. Surplus deviations from equilibrium must be evaluated at each time unit. Such an evaluation is made below in the context of a quarterly model.

321 - 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 and feed prices shift the supply curve, and so is it for income and prices of substitutes on the demand side. It seems intuitively appealing to assume the existence of a moving equilibrium going through the actual peaks and troughs and displaced only by exogenous variables. Samuelson [46, p. 320] has warned that there is a lot of arbitrariness in the concept of moving equilibrium; it is 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". Even if income and technical progress may be considered as smooth shifters, and may be expressed as simple function of time, it is not the case 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 to determine a smooth path as an approximation to a moving equilibrium conditioned by exogenous variables. It is a rough extension of the simple stationary model described by equations (4.1) and (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 the case. Samuelson [46, p. 323] advises proceeding by successive approximations of the path $\bar{P}(t)$ and feed them in (4.1'), which could be written as :

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

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

There was not enough time to set up a routine for this iterative procedure. But the solution given by (4.19) was used as a first try. The results were rather bad with the reason probably coming more from the estimated structure of the model than from the approximation made. In particular the net import equation seemed to be one 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 inadequate 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 period, 1955-1973. Samuelson [46, p. 322] quotes Moore's suggestion 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 extention of this method is to regress each of the endogenous variables on all the truly exogenous variables of the model, excluding predetermined variables which create the cycles. All cyclical and seasonal movements are eliminated and we get a path corresponding to the slow effects of income, prices of substitutes and time, on the endogenous variables of the model (production, demand, imports, farm and retail prices). The time series of actual path and "estimated equilibrium path" are shown on Fig 4.9 - 4.12. Of course this particular estimated reduced form has an important shortcoming. Nothing constrains the method to yield equilibrium values rigorously consistent with all the structural equations of the model, in particular no balance of supply and demand is imposed 1/.

322 Expressions for the surplus variations

Assuming we have correctly determined equilibrium paths, we have to define first the deviations of the various agents'surplus,

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

relative 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 price, retail prices and marketing margin.

ΔPS_t, ΔCS_t, ΔMS_t, ΔIS_t are the deviations of surplus from 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 time t of this variable. Lower case letters denotealgebraic deviations from equilibrium values:

$$s_t = S_t - \bar{S}_t,\ p_t = P_t - \bar{P}_t,\ \ldots$$

The formulae are given for the linear case only. They are illustrated by Fig 4.6 which corresponds to an increase of domestic supply at time t due to a price level at time t-5 higher than equilibrium price $\bar{P}$. The same algebraic formulae apply to a decrease of domestic supply. Fig 4.6 is built as follows. Domestic supply function $S(P_{t-5})$, domestic demand $D(P_t)$ and import $I(P_t)$ are given. Stationary 1/ equilibrium ($\bar{P}$, $\bar{S}$, $\bar{D}$, $\bar{I}$) is determined by equating excess demand

$$ED(P_{t-5}, P_t) = D(P_t) - S(P_{t-5})$$

and imports

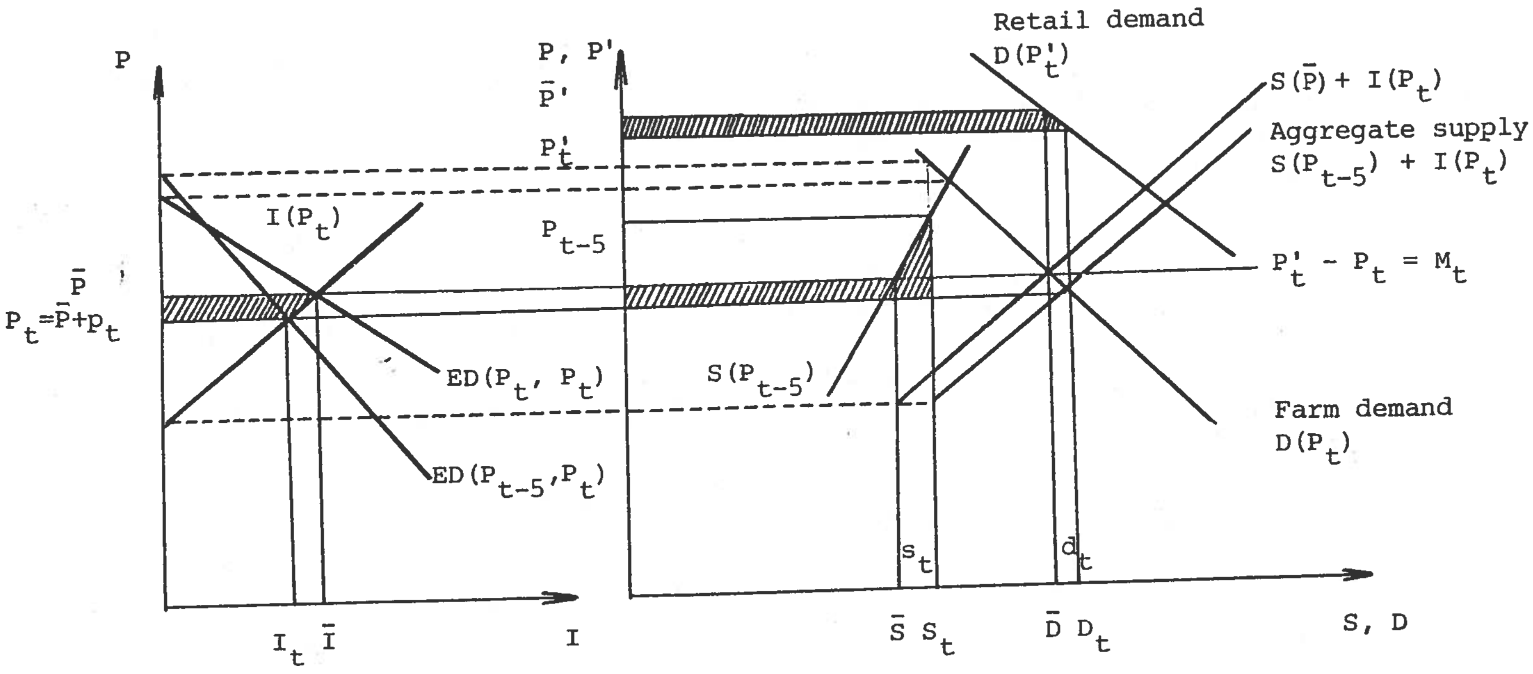
$$I(P_t)$$

with the assumption

$$P_{t-5} = P_t$$

1/Market equilibrium is stationary on Fig 4.6 because shifters are not considered in the illustration.

Figure 4.6 - Surplus deviations in the complete model



In particular equilibrium price $\bar{P}$ is the price which satisfies the relation

$$ED(\bar{P}, \bar{P}) = I(\bar{P})$$

this point is the intersection between excess demand $ED(P_t, P_t)$ and $I(P_t)$ on the left part of Fig 4.6.

When price P_{t-5} is higher than $\bar{P}$, domestic supply is predetermined at the level $S(P_{t-5})$ and aggregate supply $S(P_{t-5}) + I(P_t)$ shifts to the right 1/. Market equilibrium at time t will occur at a lower price P_t (price variation p_t is therefore negative in the formulae below).

(a) Producers

Given the specification of the supply of pork 2/ 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 3/

The same line of reasoning is used as in the simple static case. Producers lose 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).

1/ and excess demand shifts and rotates.

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

3/ Partial adjustment is skipped over here (Appendix 4.2).

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

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

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

(b) Consumers

(4.22) $$\Delta CS'_t = - D_t p'_t + \frac{1}{2} p'_t d_t$$

ΔCS_t is positive when p_t is negative, in the case of constant or proportional margins.

(c) Marketing firms

I have made the assumption that total cost is constant over the quantity range and surplus variation is defined as revenue variation of marketing firms 1/.

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

(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 behavior of the margin.

1/ It may have been better to assume rising marginal cost as in appendix 4.3 and the formula : $\Delta MS_t = D_t m_t - \frac{1}{2} d_t m_t$ which is more consistent with the distribution of consumer surplus at farm level $\Delta CS_t = - p_t D_t + \frac{1}{2} p_t d_t$ between consumers $\Delta CS'_t$ and the marketing sector ΔMS_t by $\Delta CS_t = \Delta CS'_t + \Delta MS_t$.

(d) 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 is not a hog producer surplus because this supply curve depends on current prices which are related to export cost and exchange rate rather than to production cost. It is not a surplus accruing to foreing hog producers but to exporters.

The algebraic sum over agents of surplus variations at farm level 1/ gives a net social loss, by a similar expression to the symmetrical cobweb one.

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

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

using (4.21)

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

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

Marketed equilibrium implies

(i) $I_t + S_t = D_t$ (actual path)

(ii) $\bar{I}_t + \bar{S}_t = \bar{D}_t$ (moving equilibrium path)

and therefore $i_t + s_t = d_t$. After simplification the expression for

1/ Using the formula of the previous footnote for ΔMS_t, we could use the sum $\Delta MS_t + \Delta CS'_t$ instead of ΔCS_t.

for the welfare loss is

$$(4.24) \qquad \Delta W_t = \frac{1}{2} (P_t - P_{t-5}) \; s_t < 0$$

Equation (4.24), similar to pq in the stationary cobweb, shows that the welfare loss will be negative, whenever the market is out of equilibrium. However the formulae of surplus variations and their signs are valid in the context of Fig 4.6 where desequilibrium is due to the domestic hog cycle only. If random disturbances occur on supply or demand or if the import equation shifts, the coherence of surplus formulae no longer exists. For example if import equation shifts to the left because of a random shock, we may have $s_t > 0$, $P_t - P_{t-5} \gtrless 0$ and therefore $\Delta W_t > 0$, although a discrepancy between supply price P_{t-5} and demand price P_t implies a welfare loss. Moreover since the moving equilibrium paths $\bar{I}_t$, $\bar{S}_t$, $\bar{D}_t$ have been estimated independently, equality (ii) is not always verified. In order to appreciate the balance of welfare effect due the domestic cycle, it seems appropriate to choose a "clear-cutcycle", i.e. a period where $(P_t - P_{t-5}) \; s_t$ is negative. Looking at Table 4.1, the time series of net social loss ΔW_t, computed according to (4.24), shows negative values in almost all quarters. This is an encouraging fact for the applicability of the surplus formulae (4.21) - (4.24).

323 Results

Given the limitations mentioned previously the numerical results are meant only as an indication of the importance of price fluctuations from the viewpoint of efficiency and distribution.

In view of the shortcomings of the method, the search for an approximation of the welfare effects may proceed in two different way. (1) Use the formulae giving the balance of various

effects for a complete symmetrical cycle, and evaluate the results in percentage of 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 result 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 stationary cobweb

The balance of the effects for a complete cycle depends only on the product of deviations, pq. In a complete cycle producers would lose a fraction 3 pq/2 $\bar{P}\bar{Q}$ of the equilibrium cash receipts. Looking at the price time series of hog prices (Fig 4.11) the magnitude of the relative price deviation p/$\bar{P}$ goes from 10% to 20%. The time series of production (Fig 4.9) exhibits fluctuations around the trend ranging from 5% to 10%. Producers loss in a complete cycle would lie in the range 0.75% to 3% of the average cash receipt. This loss looks small relative to cash value of production. But in terms of net income or profit margin accruing to farmers which is only a few percentage points of cash value, the welfare loss is far from being negligible.

Consumption (Fig 4.10) fluctuates much less than production and the same is true for retail prices (Fig 4.12). This is due to the stabilizing role of imports and to the behavior of marketing margin. Percentage variation is less than 5% for quantities consumed and less than 10% for prices. The welfare gain of consumers in a complete cycle would then be less than 0.5% of the average pork expenditure.

As to the marketing sector, the results of Chap. 3 on the margin equation suggested that margin is quite variable in the short-run, but in the long-run a nearly constant margin seems to prevail. This suggest large distribution effects played by the marketing sector in the short-run; in the long run the distribution effects almost cancel, except that a small ratchet effect seems to exist on fresh pork which means a transfer of surplus from consumers to the marketing sector. This transfer is certainly small in view of the small slope differential of the margin between farm price increases and decreases 1/.

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

The period chosen to illustrate the numerical results includes the three years 1962, 1963, 1964 (observations 29 to 40, 12 quarters) 2/. One way to check the "clear cut face" of the cycle is 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 ΔPS_S has reached the maximum of + 244 millions francs (MF) and the minimum of - 192 MF for quarters spring 1962 (Table 4.1) and fall 1963 respectively; at that time the average cash value of hogs was 1,000 MF for a quarter. Price fluctuations certainly had 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 receipts for the 12 quarters.

1/ Looking at equation (3.11) the asymmetry of price transmission is reflected by a slope smaller by 7.5% for price decreases than for price increases.

2/ Underlined in Table 4.1.

Table 4.1 - Time series of surplus deviations (100,000 Francs, 1970 basis) quarterly, 1955 (I) to 1973 (III). Read by row from left to right.

1) Net social loss: W_t (equat. 4.24)

-165	22	76	-7	-42	-71	5		6	16
-43	9	-20	-	5	-59	-58	-231	-29	-88
5	12	-4	-15	-46	6	6		-11	-107
-29	-102	-21	9	-165	-259	-350	1	-5	8
11	-207	-2	-	-93	28	-66	6	-	-58
-10	-68	-64	-93		-17	-65	-50	-128	-42
-23	7	21	46	-15	-87			2	6
6	-6	35	57	-2					

2) Producers' surplus: ΔPS_t (equat. 4.21)

1048	121	-237	-711	-1063	-1133	-385	-515	-233	106
1282	1341	1591	265	446	-552	-570	-1385	-309	-910
-93	-226	336	411	535	-91	837	491	-296	-1919
-1352	-1709	-772	-194	1535	2447	2071	-837	180	-865
-1138	-1919	-111	284	1092	800	1447	1167	727	-585
-734	-1043	-1094	-1406	67	362	-502	83	652	901
994	172	-229	-1156	-1405	-1410	-505	-512	-634	-857
-512	-106	835	1544	2014					

3) Consumers' surplus: ΔCS_t (equat. 4.22)

-709	-826	-1041	-72	719	297	12	164	373	887
346	-42	-663	-627	-189	462	987	706	448	999
1103	741	517	673	-109	-781	-1164	-701	-151	271
161	477	735	435	-631	-1244	-1758	-1547	-1634	-721
227	573	411	350	-319	-454	-525	-464	-447	-173
-15	330	195	587	195	286	1094	559	33	-141
-239	-363	-283	422	805	900	474	356	781	835
401	348	-6	-807	-2590					

4) Marketing' surplus (see p. 140)

Table 4.1 (continued)

4) Marketing' surplus: ΔMS_t (equat. 4.23)

-1107	876	946	678	446	965	175	947	190	-710
-1900	-825	-701	536	-603	351	-222	783	-191	-223
-1059	-442	-1516	-1236	-898	779	-252	-144	86	1517
1157	1103	-313	103	-1391	-1803	-967	2507	1239	1619
688	1749	-385	-316	-847	-370	-1320	-751	-771	1071
1291	604	1142	972	-287	-287	-922	-787	-1009	-1235
-1553	482	694	1078	1038	1038	642	558	-182	624
637	60	-1487	-1409						

The consumers seem to have successively gained about 200 MF and lost about 750 MF over this three year cycle. The balance is a loss of about 550 MF which accounts for about 2% of consumer expenditure on pork over the period. During the same period 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 (4.24) 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 not large, 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 + 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.

Conclusion to chapter four

Both direct method and stationary cobweb approach indicate that the hog cycle generates a welfare loss measured by the discrepancy between supply and demand prices. The order of magnitude of this loss is about 1% of the gross value of production. Although small at first glance, this loss is large enough to justify an extreme stabilizing policy (destruction of excess supply) if discount rate is about 10% or smaller.

Producers are more affected by the cycle than any other group of economic agents in the long-run. Over the whole 1955-1973 period they seem to have lost in surplus 0.5% of the total cash receipts. This small number is less small when related to the profit margin or to net income derived from hog production (which is only a few percentage points of gross product).

Welfare gains of consumers and marketing sector seem to be rather negligible in the long-run although their existence is confirmed.

These results seem to argue for considering price cycle as a minor problem in the economy. However, in the short-run the welfare position of some agents is affected by a considerable amount (Fig 4.13). Under certain circumstances, this may by more than 20% from equilibrium and by using quarterly data we have underestimated price fluctuations to a considerable extent. The conflicts of interest between economic agents at successive levels of the industry are exaggerated by price fluctuations and create violent tensions in the social group. This is an extension of the dimension of the problem which may deserve some attention.

Other extensions of the evaluation of the social cost of fluctuations are needed because the analysis in terms of surplus does not cover the whole scope of the problem. As an example the small ratchet effect exhibited by retail fresh pork price, indicates that farm price fluctuations do participate in the inflation process, at least to a small extent.

Another aspect of price instability goes beyond the static approach of surpluses. The risk created by price uncertainty may limit the investment rate and create trade deficit; it may also slow down the rate of technical progress and therefore prevent production costs from reaching the minimum level made possible by available technology.

Welfare loss evaluation is one step toward policy. Stabilizing schemes should be analysed for a more complete assessment of feasible policy actions.

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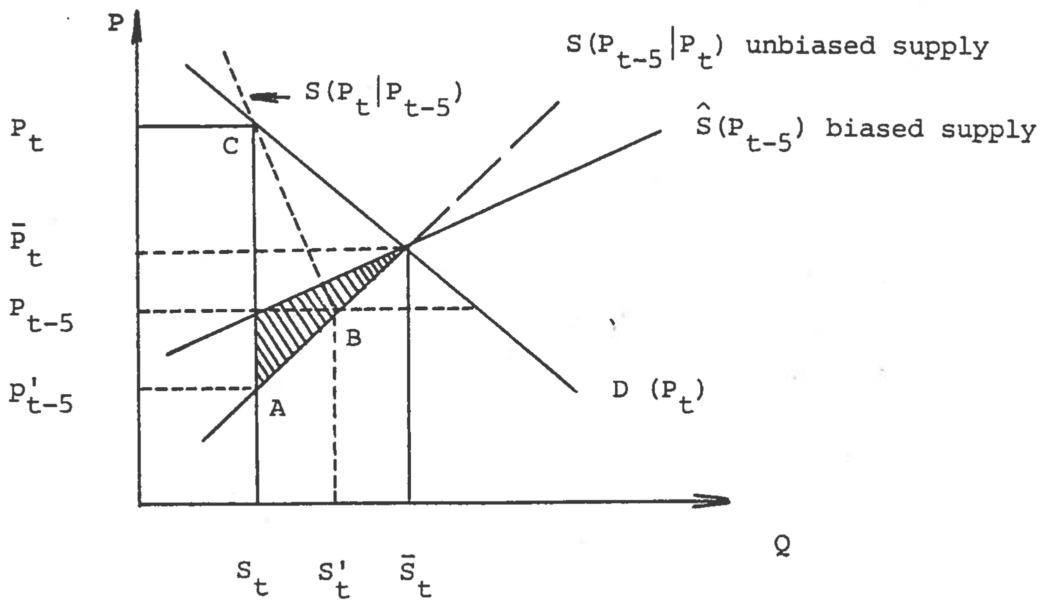
Appendix 4.0

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 argued 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 than the biased one $\hat{S}(P_{t-5})$ 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) on 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 corresponds to equation $S\ (P_t|P_{t-5})$

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

This yields after simplification:

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

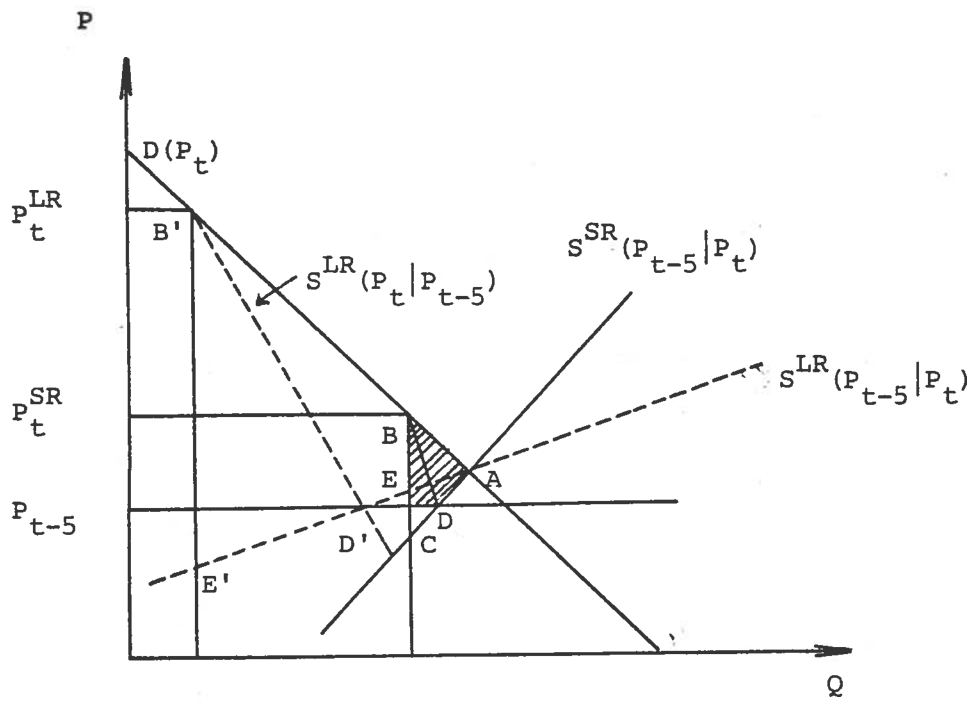
As the ratio η_0/η_1 is approximately minus one tenth, then social loss would be increased by 10%.

4.2 Implication of partial adjustment and adaptive expectations (with current price effect) Fig 4.8

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

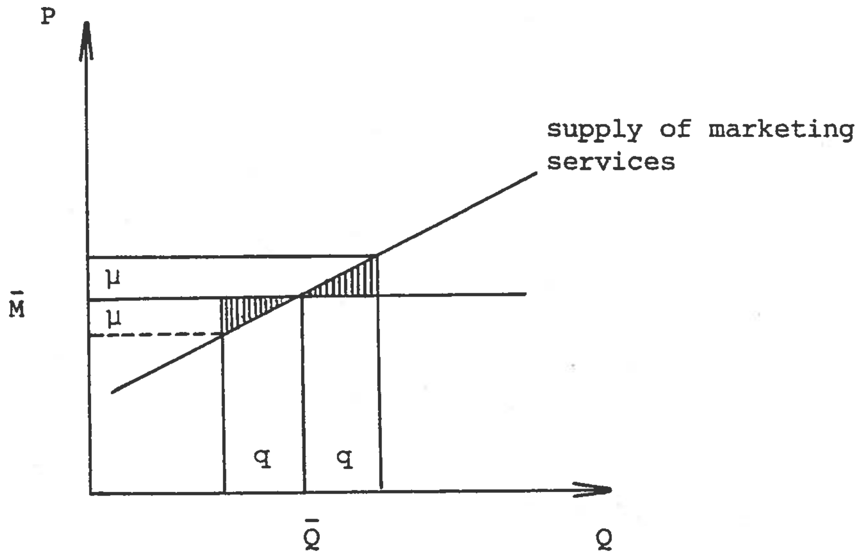
The autoregressive model implies that producers move along S^{SR} instead of S^{LR}. The result is smaller price variation from P_t^{LR} to P_t^{SR}, and a smaller welfare loss from area AE'B' to AEB assuming that it is adaptive expectations which induce caution and that the supply curve reflecting marginal cost is S^{LR}. If we assume

Figure 4.8 - Slow adjustment and welfare effects



Note : BD, and B'D' represent current price effect

Figure 4.9 - Constant margins and welfare losses



partial adjustment however, it is more correct to relate 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 naîve expectations. Partial adjustment also implies 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 to be steeper than the long-run curve AD'.

4.3 Rising marginal cost in marketing

Suppose that marginal cost in the marketing sector 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, $q\mu$ (Fig 4.9). Therefore there seems to be an argument for margins to vary in opposite direction to farm prices, which is actually the case. However wide margin fluctuations do not seem to be closely related to marginal cost change, especially if we note that relative variation of quantities $q/\bar{Q}$ is generally small, and thant marketing margin fluctuate widely.

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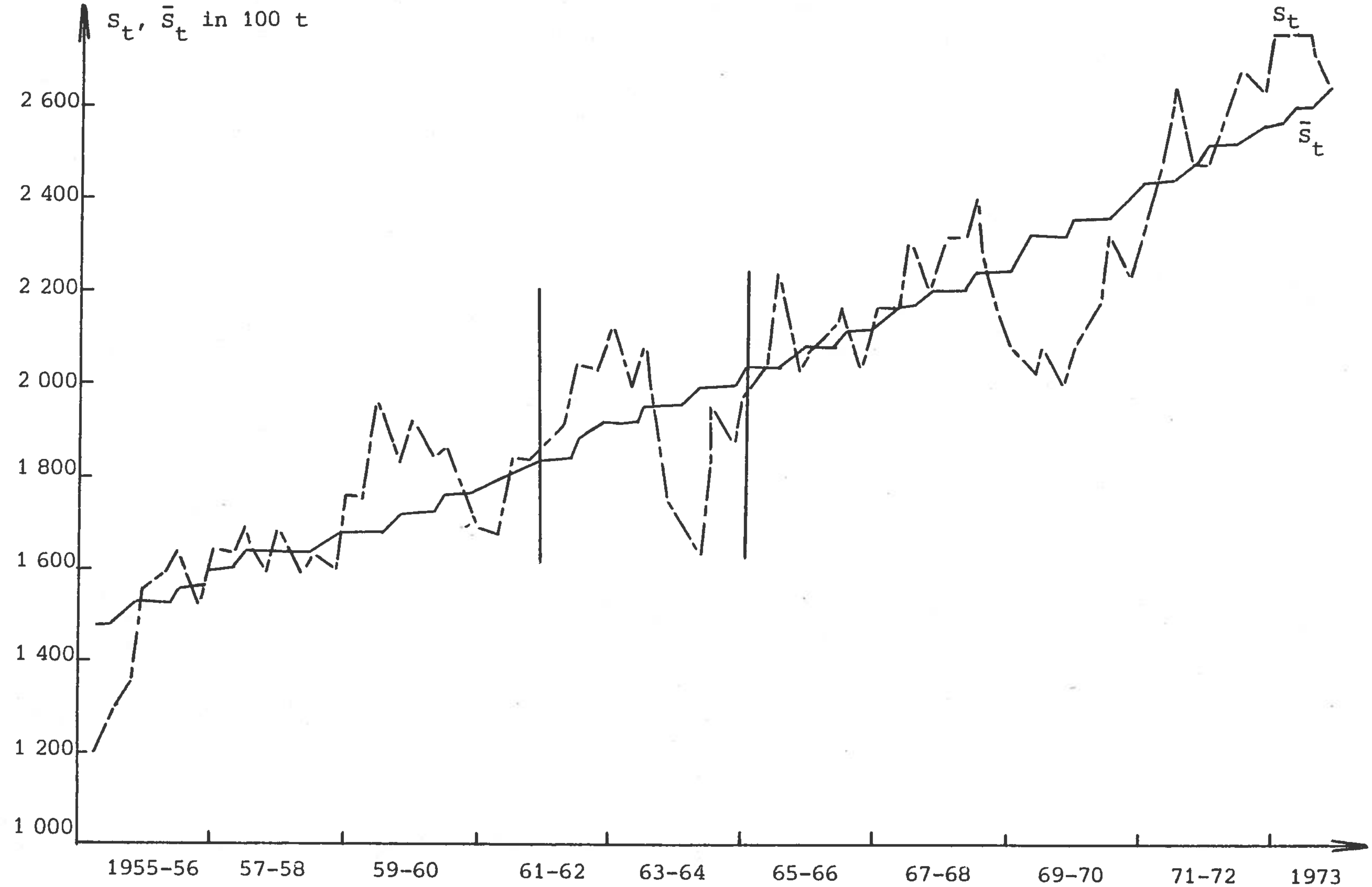
Figure 4.10 - Equilibrium path $\bar{S}_t$ production



Equilibrium path was determined as explained in section 321 of Chap. 4

Figure 4.11 - Equilibrium path : $\bar{D}_t$: consumption

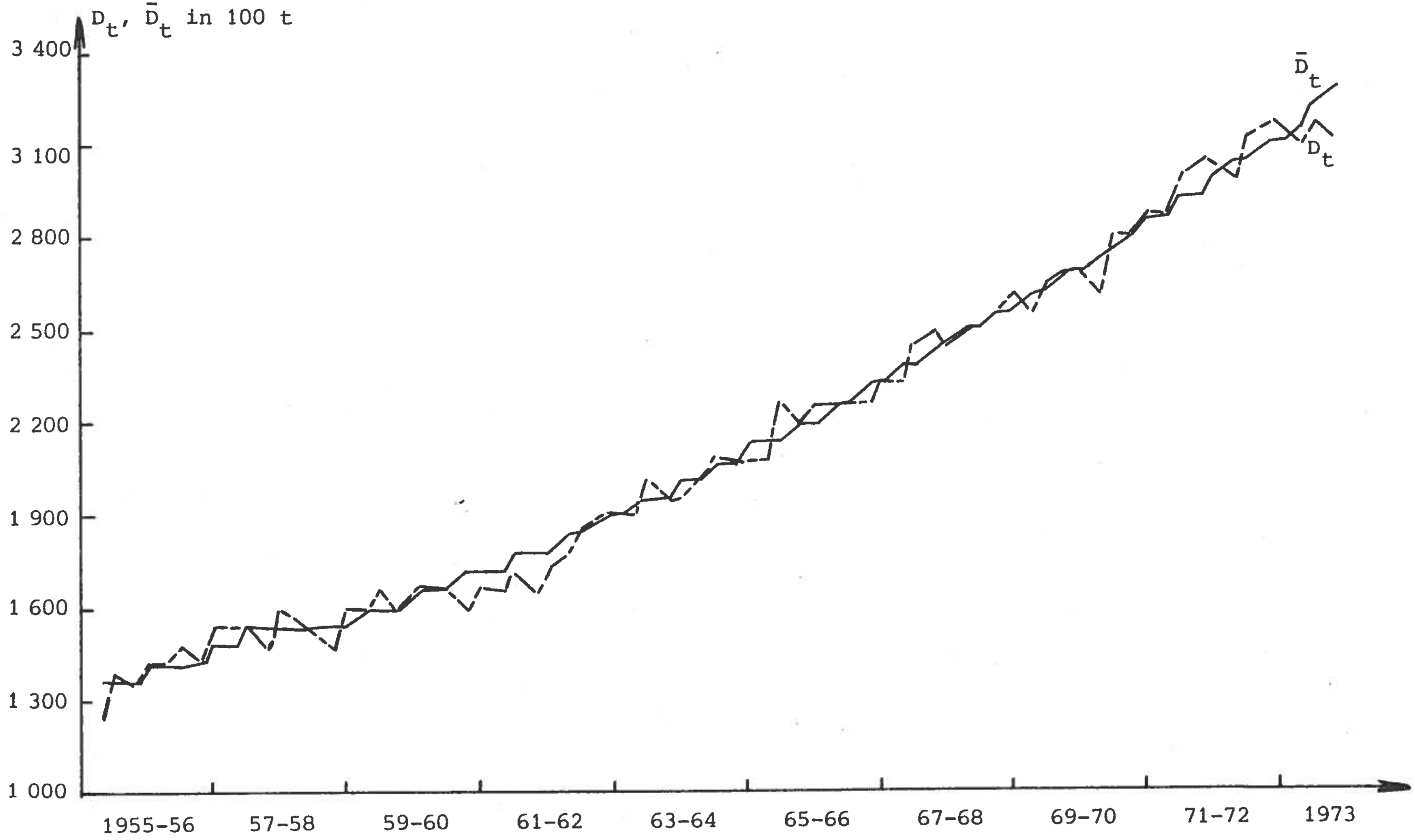


Figure 4.12 - Equilibrium path : P_t = farm price

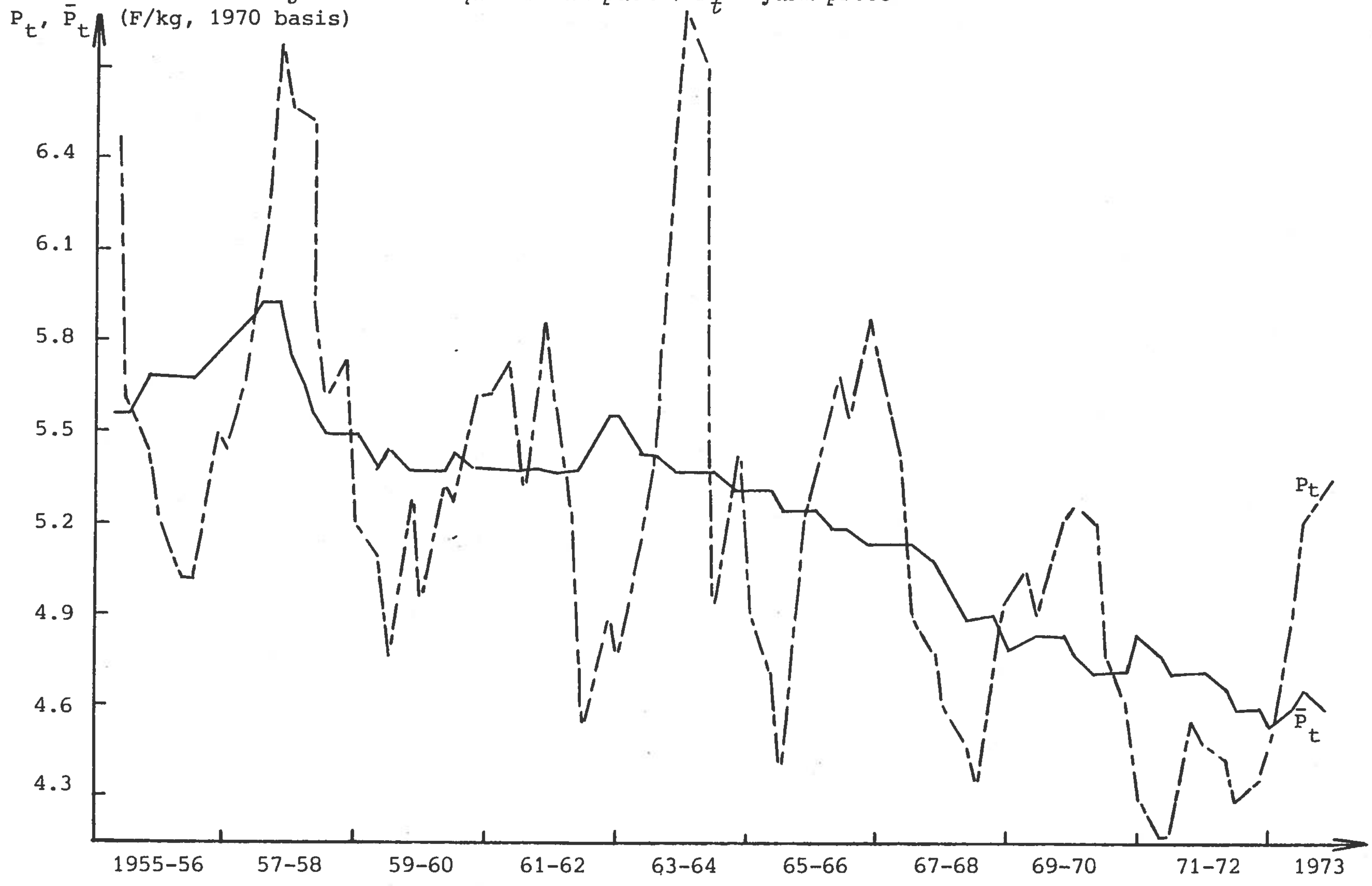


Figure 4. 13 - Equilibrium path : P'_t = retail price

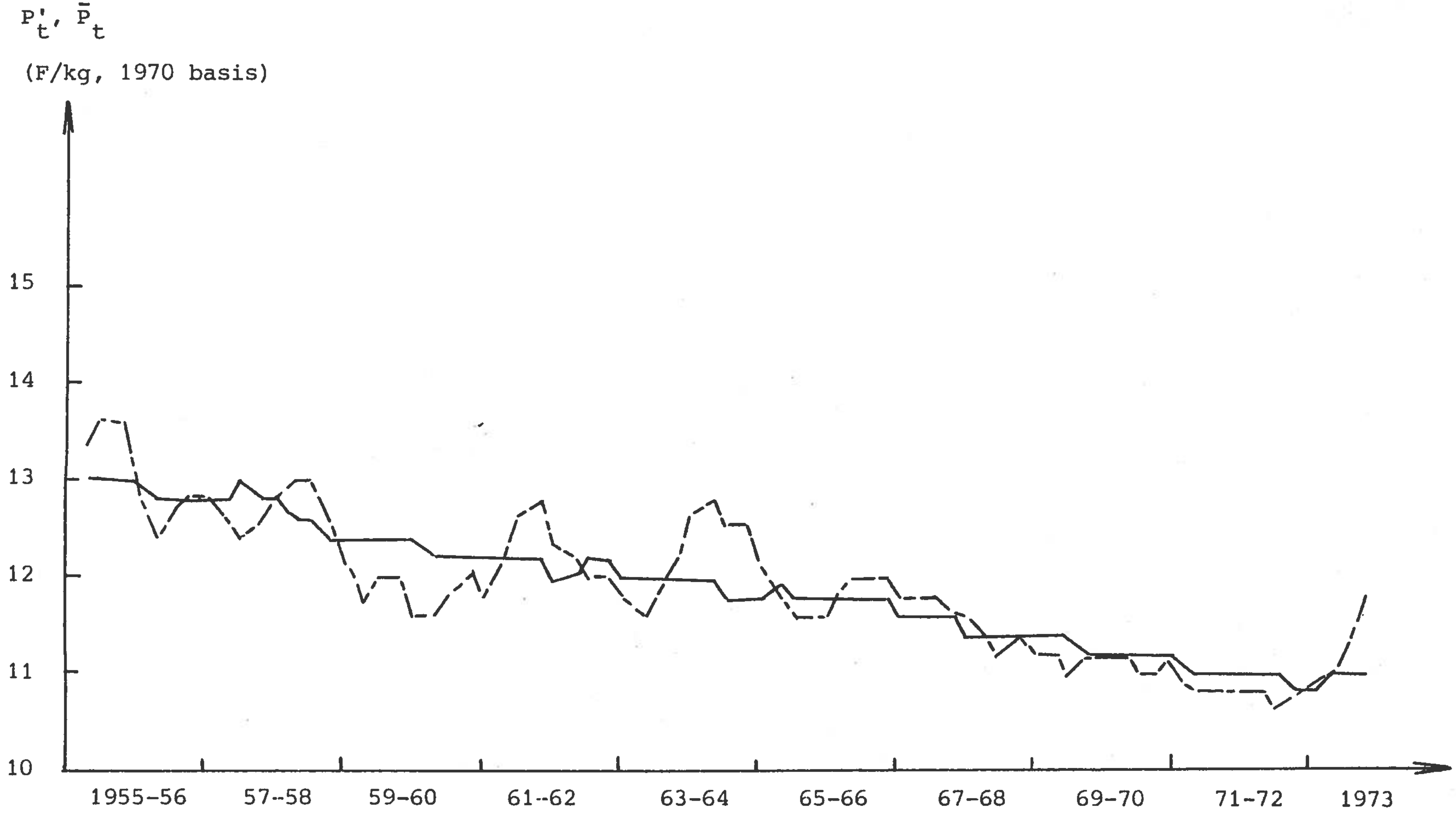
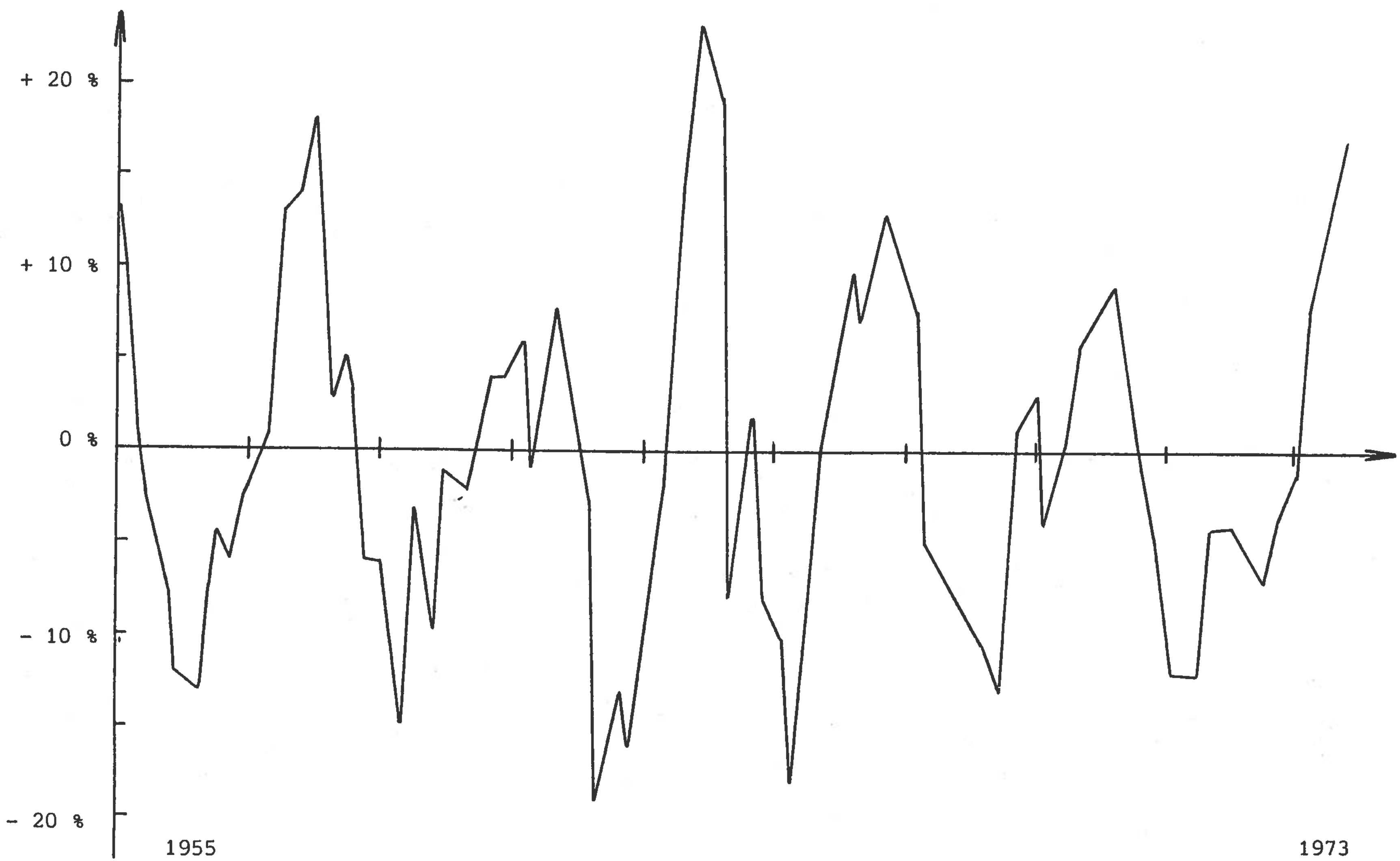


Figure 4.14 - Producers surplus variation as a % of equilibrium receipt $(\bar{P}_t \cdot \bar{Q}_t)$



CONCLUSION

The simplicity of the theories advanced to explain the hog cycle namely the 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 obtained suggest also that the bias on the supply elasticity may be far from negligible. The great variability of specification of published models prevents a clear cut exogenous illustration of the question raised.

This observation led to an investigation of 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 a *a priori* basis. This choice combined with assuming away simultaneity may lead to severe errors in the estimates of supply elasticity. The lack of data on inventories made it impossible to illustrate this particular point and other studies are different in too many ways to confirm or contradict.

The complete model fo the hog market in France provides an acceptable representation of the subsector, as far as fit and expected behavior are concerned. The feeder pig 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 basis of the results. On the demand side, price and income are still important factors, but substitution effects have been observed only for veal meat. Farm-retail price transmission is slow in the short-run, but real margins turn out to be approximately 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 foreign trade aspects of the hog market have neither been fully explained, nor 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.

Because 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 small on the efficiency point of view. Distribution effects are more important, Quite large in the short-run they may and do indeed creat acute tensions between economic agents involved. In the long-run however they cancel almost exactly but the producers seem to lose from them, although a rather small amount.

At the end of this research effort, I have the impression I 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. Much remains to be done to explore fully the policy use of the model.

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APPENDIX I

DATA series 1953(1)-1973(3) Quaterly
(read on sows from left to right)

QS_t = quantities of hogs marketed (100 metric tons)

1278	1320	1214	1366	1317	1254	1201	1305	1192	1288
1364	1540	1610	1656	1506	1636	1638	1670	1597	1662
1593	1647	1615	1755	1750	1956	1848	1932	1840	1884
1752	1693	1667	1824	1850	1872	1908	2058	2029	2106
2006	2985	1769	1710	1625	1971	1888	2011	2924	2230
2045	2094	2122	2179	2029	2165	2147	2329	2219	2310
2313	2399	2151	2070	2033	2070	2017	2974	2143	2319
2241	2323	2474	2635	2482	2492	2588	2674	2621	2766
2775	2761	2626							

Source: [49].

D_t = consumption of pork per head (0.1 kg)

29.2	29.9	27.6	30.6	29.7	28.9	27.9	30.5	29.3	32.0
30.9	32.2	33.4	33.9	32.8	35.7	35.3	35.6	33.7	36.0
34.9	35.0	33.5	36.2	36.2	37.1	36.0	36.4	36.4	37.3
35.0	37.1	36.6	38.2	36.7	37.7	38.3	40.1	40.5	40.8
39.8	42.1	40.6	41.3	42.2	42.9	42.5	43.6	43.3	46.1
44.7	46.6	45.8	46.4	46.2	47.5	46.6	49.5	50.3	49.0
50.3	50.6	51.6	52.5	51.6	52.1	52.8	52.6	51.9	55.3
55.3	56.0	56.3	58.2	59.0	58.9	58.1	60.5	60.9	61.1
59.4	60.6	59.7							

Source: derived form [49].

M_t = net imports per head (0.1 kg)

-.94	-1.15	-.89	-1.43	-1.17	-.46	-.07	.09	1.53	2.15
-.74	-2.63	-2.03	-3.18	-3.02	-2.57	-3.50	-3.08	-2.64	-1.77
-1.13	-2.12	-2.86	-3.12	-2.71	-4.35	-5.01	-5.11	-4.14	-5.06
-6.20	-1.03	-.17	-1.72	-3.59	-2.83	-2.84	-3.84	-2.83	-3.90
-2.61	-1.65	3.54	5.64	8.39	2.03	3.37	2.02	1.60	.57
2.79	3.58	2.51	1.95	4.98	3.51	3.10	2.46	5.57	2.47
3.86	2.64	8.69	10.81	11.09	10.93	12.79	11.53	9.57	9.53
11.16	10.40	7.89	6.70	10.62	10.42	7.90	8.73	10.28	7.81
6.02	7.54	9.45							

Source: derived from [49].

N_t = population (10^6 heads)

42.36	42.43	42.50	42.57	42.63	42.72	42.81	42.89	42.98	43.06
43.13	43.19	43.25	43.32	43.34	43.53	43.64	43.75	43.88	44.00
44.13	44.25	44.37	44.49	44.61	44.73	44.84	44.95	45.07	45.18
45.30	45.42	45.55	45.67	45.90	46.12	46.35	46.58	46.83	47.08
47.33	47.59	47.72	47.86	48.00	48.14	48.26	48.38	48.51	48.63
48.73	48.83	48.93	49.03	49.13	49.23	49.33	49.43	49.53	49.62
49.72	49.81	49.91	50.01	50.12	50.22	50.33	50.44	50.56	50.67
50.79	50.91	51.04	51.16	51.27	51.39	51.50	51.61	51.72	51.83
51.94	52.05	52.15							

Source: Bulletin mensuel de la Statistique; INSEE

PSI_t = Public storage increase (10^2 tons)

0	0	0	0	0	0	0	0	0	0
0	34	77	49	-49	-31	-56	-23	0	0
0	0	1	4	12	98	7	65	11	-31
-117	-41	-11	0	0	0	0	10	-3	-1
-4	-1	0	0	0	0	0	0	1	13
0	-7	0	0	0	0	0	0	0	0
5	6	7	-15	0	0	0	0	0	0
0	0	0	1	0	-1	0	0	0	0
0	0	0							

Source: Direct from SIBEV: the bady in charge of Public storage.

PGP_t = Feeder pig price F/kg deflated

0.	0.	0.	0.	5.84	7.09	7.00	6.93	7.47	7.00
5.55	4.17	4.23	3.32	4.48	4.41	5.51	6.25	6.53	6.43
6.50	6.44	5.42	4.12	3.86	4.03	4.05	4.36	4.50	5.23
5.91	5.54	6.09	6.22	6.04	4.91	4.58	4.02	3.56	3.26
3.88	5.22	6.71	6.62	8.02	6.39	5.01	3.80	4.35	4.19
4.38	4.47	6.01	6.13	6.08	5.12	5.66	5.22	4.20	3.44
3.72	3.68	4.64	4.75	5.72	5.96	5.84	5.27	5.71	5.86
5.04	3.57	3.52	4.04	4.36	4.02	4.65	5.05	4.52	3.90
5.02	6.08	6.18							

Source: Statistique agricole: supplément série étude n$_o$ 56, Nov. 1969
Note de conjoncture du Ministère de l'Agriculture - production porcine -

FHP_t = Farm hog price (francs/kg, deflated)

3.27	5.35	5.68	5.28	5.86	6.43	6.62	6.21	6.44	5.64
5.44	5.20	5.00	5.00	5.49	5.45	5.70	5.99	6.74	6.56
6.53	5.64	5.75	5.75	5.08	4.79	5.25	4.93	5.31	5.27
5.59	5.62	5.71	5.71	5.85	5.62	5.21	4.52	4.87	4.75
5.08	5.35	6.31	6.31	6.71	4.95	5.43	4.90	4.74	4.44
5.20	5.38	5.70	5.70	5.87	5.66	5.46	4.92	4.77	4.60
4.45	4.35	4.91	4.91	5.95	4.89	5.19	5.23	5.17	4.78
4.62	4.31	4.20	4.20	4.53	4.49	4.39	4.29	4.37	4.47
4.87	5.18	5.34	5.34						

Source: Bulletin mensuel de statistique agricole, Ministère de l'Agriculture

This time series of index was converted into a price series by using the actual farm hog price in 1970.

RHP_t = Retail pork price index (deflated)

1.12	1.13	1.19	1.14	1.13	1.17	1.22	1.20	1.20	1.20
1.22	1.15	1.10	1.13	1.14	1.13	1.12	1.10	1.12	1.13
1.16	1.15	1.12	1.08	1.05	1.06	1.08	1.04	1.03	1.05
1.06	1.05	1.09	1.12	1.14	1.11	1.08	1.06	1.07	1.03
1.04	1.05	1.09	1.12	1.14	1.13	1.13	1.09	1.05	1.03
1.04	1.04	1.06	1.06	1.06	1.06	1.06	1.05	1.03	1.02
1.01	1.00	1.01	1.00	.99	.99	1.00	1.00	1.00	1.00
.99	.98	.96	.95	.97	.97	.95	.95	.96	.96
.97	1.00	1.04							

Source: direct INSEE

This series was multiplied by 11.89, which was an estimate of actual retail pork price in 1970, in order to get RHP_t

VP_t = Retail veal price index deflated

.81	.82	.78	.80	.81	.82	.79	.71	.73	.76
.78	.77	.77	.79	.81	.80	.81	.86	.90	.86
.86	.87	.89	.88	.88	.92	.94	.90	.89	.91
.88	.88	.91	.91	.90	.89	.93	.94	.92	.90
.90	.92	.93	.92	.92	.92	.95	.95	.96	.97
.96	.98	.98	.97	.98	1.00	.99	.99	.99	.98
.98	.98	.99	.98	.98	.98	.98	.98	.97	.98
.99	.99	.99	1.00	1.01	1.00	1.01	1.01	1.02	1.02
1.03	1.97	1.13							

Source: Bulletin mensuel de la Statistique, INSEE

$N_t.REV_t.CPI_t$ = Disposable income in current (million) francs

2543	2565	2593	2650	2716	2777	2835	2900	2977	3042
3117	3207	3260	3323	3411	3494	3595	3710	3835	3931
4030	4140	4255	4347	4420	4520	4610	4743	4875	4995
5120	5220	5300	5389	5564	5739	5899	6140	6410	6610
6765	6940	7087	7264	7389	7540	7665	7815	7942	8092
8242	8416	8533	8733	8883	9058	9279	9529	9678	9878
10000	10259	10510	10760	11850	11560	11906	12250	12540	12940
13340	13840	14190	14565	15063	15463	15787	16240	16740	17240
17773	18525	19155							

Source: Direct from INSEE

EPI_t = Feed price index (deflated)

-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
149.0	146.4	144.6	145.4	145.2	144.5	147.5	148.8	150.1	150.8
149.8	147.7	145.3	143.6	142.6	141.4	141.3	140.4	140.9	140.6
140.9	141.1	140.9	140.0	140.1	139.6	138.6	137.5	136.6	134.2
138.7	138.7	137.2	134.8	132.9	130.8	134.5	133.2	132.9	134.4
135.8	137.0	136.6	134.7	133.8	133.1	132.7	131.7	131.5	134.7
146.8	152.7	162.7							

Source : Bulletin mensuel de Statistique, INSEE

CPI_t = Consumer price index (1970 basis)

.50	.50	.49	.48	.49	.49	.49	.49	.50	.50
.49	.50	.51	.51	.51	.51	.51	.51	.52	.55
.59	.60	.61	.61	.63	.63	.64	.65	.66	.66
.66	.67	.67	.67	.68	.69	.70	.71	.72	.73
.74	.75	.76	.77	.77	.78	.78	.79	.79	.80
.80	.81	.81	.82	.83	.83	.84	.84	.85	.86
.87	.88	.89	.80	.92	.93	.94	.96	.97	.99
1.00	1.01	1.92	1.04	1.06	1.07	1.08	1.10	1.12	1.14
1.15	1.18	1.21							

Source: Bulletin mensuel de Statistique.

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Agri. Econ. Res.: Agricultural Economics Research
AER: American Economic Review
AJAE: American Journal of Agricultural Economics
EDCC: Economic Development and Cultural Change
EJ: Economic Journal
Food. Res. Inst. Studies: Food Research Institute Studies
JAE: Journal of Agricultural Economics
JEL: Journal of Economic Litterature
JFE: Journal of Farm Economics
JPE: Journal of Political Economy
QJE: Quarterly Journal of Economics
RES: Review of Economics and Statistics

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