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PROFITABILITY, EMPLOYMENT AND STRUCTURAL ADJUSTMENT IN FRANCE

Pentti J.K. Kouri

Jorge Braga de Macedo

Albert J. Viscio

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ABSTRACT

In this paper, we present a dynamic model which explains output, employment and energy consumption in the French manufacturing sector in terms of the expected and actual path of wage rates and energy prices in units of output. The model has two distinguishing features: First, the rate of capacity utilization is determined explicitly from profit-maximizing behavior and it is viewed as the crucial adjusting variable in the short run. Second, we assume complete lack of substitutability between capital, labor and energy inputs *ex post*.

The model is motivated by a brief discussion of French growth, focusing on the decline of profitability and employment in manufacturing, and simulated using annual data from 1950 to 1979. The wage explosion and the energy shock of the early seventies are interpreted (in a model allowing for overhead labor) in terms of changes in expected real factor prices,and their effects on the utilization and the profitability of each vintage are quantified. Aggregating over vintages, the model generates the observed decline in profitability and utilization of existing capacity.

The results of the simulation are very encouraging, and a simultaneous estimation of the model under static expectations is rejected by the data. There are two limitations of the analysis which will be relaxed in further work. Investment is exogenous and open-economy aspects only appear indirectly, say via constraints on the energy price and the price of output.

Pentti Kouri
Albert Viscio
Department of Economics
New York University
New York, N.Y. 10003
Ph: (212) 598-7516

Jorge de Macedo
Department of Economics
Princeton University
Princeton, N.J. 08544
Ph: (609) 452-6474

INTRODUCTION

In this paper, we present a dynamic model which explains output, employment and energy consumption in the French manufacturing sector in terms of the expected and actual path of wage rates and energy prices in units of output. The model has two distinguishing features: First, the rate of capacity utilization is determined explicitly from profit-maximizing behavior and it is viewed as the crucial adjusting variable in the short run. Second, we assume complete lack of substitutability between capital, labor and energy inputs *ex post*.

Accordingly, adjustment to changes in relative factor prices occurs only slowly over time, as the existing capital stock is replaced by new capital and by production techniques consistent with the new pattern of relative factor prices. The putty-clay structure of production implies that profitability of new capital, as measured, for example, by Tobin's q, can behave quite differently from the profitability of old capital, a point often emphasized in recent discussions about investment behavior. A further important implication of the putty-clay assumption is that an abrupt increase in production costs may cause a discrete reduction in the productive capacity, because old capacity can no longer be profitably operated.

The paper is organized as follows. Section I motivates the model by a brief discussion of French growth, focusing on the decline of profitability and employment in manufacturing. The basic model is developed in Section II and compared with the standard putty-putty model. We show that only in the stationary equilibrium can we represent the relationship between output and factor inputs in terms of a standard production function. We contrast this solution with the one obtained when relative factor prices are not expected to change as well as with the general case where factor prices are expected to change at different rates.

Assuming a fixed planned lifetime of each vintage, industry - wide output, employment and energy demand are derived. The model, modified to allow for overhead labor, is estimated and simulated using data on French manufacturing from 1950 to 1979 in Section III. The effects of changes in expected real factor prices on the factor proportions of new plants are quantified as well as the optimal rate of utilization and the profitability of each vintage. When utilization and profitability are aggregated across vintages, their recent decline is consistent with the decline in profitability and employment emphasized in Section I. Extensions of the analysis are pointed out in the conclusion.

I STYLIZED FACTS

The International Scene

The decade of the 1970's was a watershed in the economic development of the old industrial countries. The erosion of monetary stability from the late 1960's, the collapse of the Bretton Woods system of fixed exchange rates, the first oil shock, and the unprecedented increase in the prices of other raw materials in 1973/74 brought an end to a quarter of a century of high and stable growth at full employment. The past ten years have been characterized by slow growth, high unemployment, monetary instability, and inflation that is only now showing signs of deceleration. Most importantly, the past decade has also brought to the surface underlying long term tendencies of structural change in the world economy, caused by demographic and technological changes, the competitive challenge of Japan and of the newly industrialized countries, and the increase in the real cost of energy.

These developments in the global economy have affected Europe with particular severity. Indeed, it had not really recovered from the global recession of 1974/75 when the second oil shock and the 'dollar shock' of 1981/82 brought about the recession in the midst of which we still are. The average rate of growth of the European countries from 1973 to 1980 was only 1.6 per cent in comparison with an average growth rate of 4.6 per cent in the previous decade. The performance of the European countries after the 1974/75 recession contrasts with that of the

United States. The 1974/75 recession was more severe in the United States than it was in Europe, but from the second half of 1975 the United States experienced a strong and sustained boom supported by expansionary fiscal and monetary policies. Although Europe, too, recovered from the recession in 1976 supported by fiscal stimulus and inventory build-up, the recovery was halted and growth remained slow through the 1970's, as macroeconomic policies, particularly in Germany and France, continued to emphasize disinflation.

The differences in strategies of economic policy adopted by the United States on the one hand and Germany on the other, contributed to the depreciation of the US dollar, culminating in the 'dollar crisis' of October 1978. The depreciation of the dollar, viewed with alarm by the European goverments, helped the slowing down of inflation in Europe while it also led to a deterioration in the price and cost competitiveness and a decline in the profitability of European manufacturing.

As the boom of 1975/78 came to an end in the United States and macroeconomic policies became more concerned with inflation, the dollar stabilized and in 1979 Europe showed clear signs of recovery while inflation was still decelerating.1/ The incipient recovery was, however, soon brought to an end first by the second oil shock and then by the impact of the restrictive monetary policy adopted by the United States. As a result of slow growth and structural changes, unemployment has become a serious problem in all European countries. Indeed, the average unemployment rate of the EEC countries has increased every year since 1973, from 3 per cent in 1973 to 8 per cent in 1981, and it is still increasing.

A further important aspect of the experience of the European economies in the past ten years is the increase in government expenditure relative to GNP. The average share of total government outlays in GNP in the European countries increased from 36.5 per cent in 1970 to 45 per cent in 1978 - the last year for which we have data available. Although the tax burden increased in all countries, the increase in tax revenue has been insufficient to keep up with the growth of government expenditure. As a result, a structural deficit has emerged in the government budget in most European countries.

The French Experience

Until the Mitterand government, whose policies we do not plan to discuss in this paper, the performance of the French economy has followed the general pattern of the European countries, particularly that of Germany. From 1973 to 1981, the rate of growth of GDP was only 2.6 per cent, whereas it had been 5.4 per cent in the period 1949-73 2/. Like Germany and other European countries, France experienced an aborted recovery in 1976. Decline of growth in manufacturing has been even more abrupt: from 5.8 per cent in the post war period to only 1.7 per cent from 1973 to 1981. Behind this average decline are significant changes in the composition of industrial production. Thus, from, 1975 to 1980, the motor vehicle and transportation industry increased at an annual rate close to 19% p.a. and machinery and equipment goods increased at 14% p.a. while consumer goods, intermediate goods and consumer durables increased only at about 10% p.a. at current prices. 3/

Our focus is on the role of factor prices in explaining the aggregate decline in manufacturing, but it should be mentioned that this structural change was in large part engineered by the State. Briefly, industrial policy measures under the so-called Barre Plan consisted of sustaining heavy manufacturing (nuclear power, telecommunications and steel), encouraging high technology exports (armament, aerospace, heavy engineering and food processing) 4/ and managing an orderly contraction in traditional exports (textiles, shoes, handbags, clothing and watches). 5/

Because of slow growth and demographic developments that caused a substantial increase in labour supply, especially of women and young people, unemployment became a particularly serious problem in France in the 1970's. The rate of unemployment increased from 2.6 per cent in 1973 to close to 8 per cent in 1981.

High and increasing unemployment has however contributed little to the moderation of inflation. In terms of consumer prices, inflation has remained stubbornly above 9 per cent, averaging 10 per cent for the 1973-81 period.

Unlike in many other countries during this period, consumer prices rose faster than wholesale prices, which averaged 7.9 per cent for the same period.

Although French inflation has been higher than that of her major trading partners, 6/ there has been little change in the price and cost competitiveness of French industry from the early 1970's to 1981, because of the depreciation of the French franc, and higher than average productivity increase. 7/

As in all European countries, there has however been a substantial erosion of profitability in the manufacturing sector. According to Table 1, the share of the operating surplus in total manufacting output declined from an average of 13 per cent in period 1963-73 to an average of 9 per cent in the period 1974-79. This decline was largely the result of an increase in the share of total labour compensation from 33 per cent to 36 per cent. Despite the sharp increase in the cost of energy, its share in gross output remained around 6 per cent because of a substantial reduction in the energy intensity of manufacturing production. The same occured with other intermediate inputs, whose price did not however change substantially relative to the price of gross output. Figure 1 further illustrates the erosion of profitability in the manufacturing sector and suggests that this development started already before the first oil shock. A similar pattern can be found for other European countries, and it reflects the much discussed wage explosion of the late 1960's and the early 1970's.8/

TABLE 1

FRENCH MANUFACTURING: COST STRUCTURE

(% OF GROSS OUTPUT)

Period	(1) Labour	(2) Energy	(3) Operating Surplus	(4) Other Intermediate Inputs
1963-73	33.2	5.5	12.8	48.5
1974-79	35.7	5.7	9.3	49.3

Gross output (Q) and value added (X) in industrial subsectors (U4 + U5 + U6) from the DMS databank

Sources: (1) Total labor costs (TLC) obtained by adding the wage bill ($SALVS_i$), social security contributions by employers ($SCOCS_i$) and fringe benefits ($PSOCS_i$) for the subsectors i = U4, U5, U6 from the DMS databank.

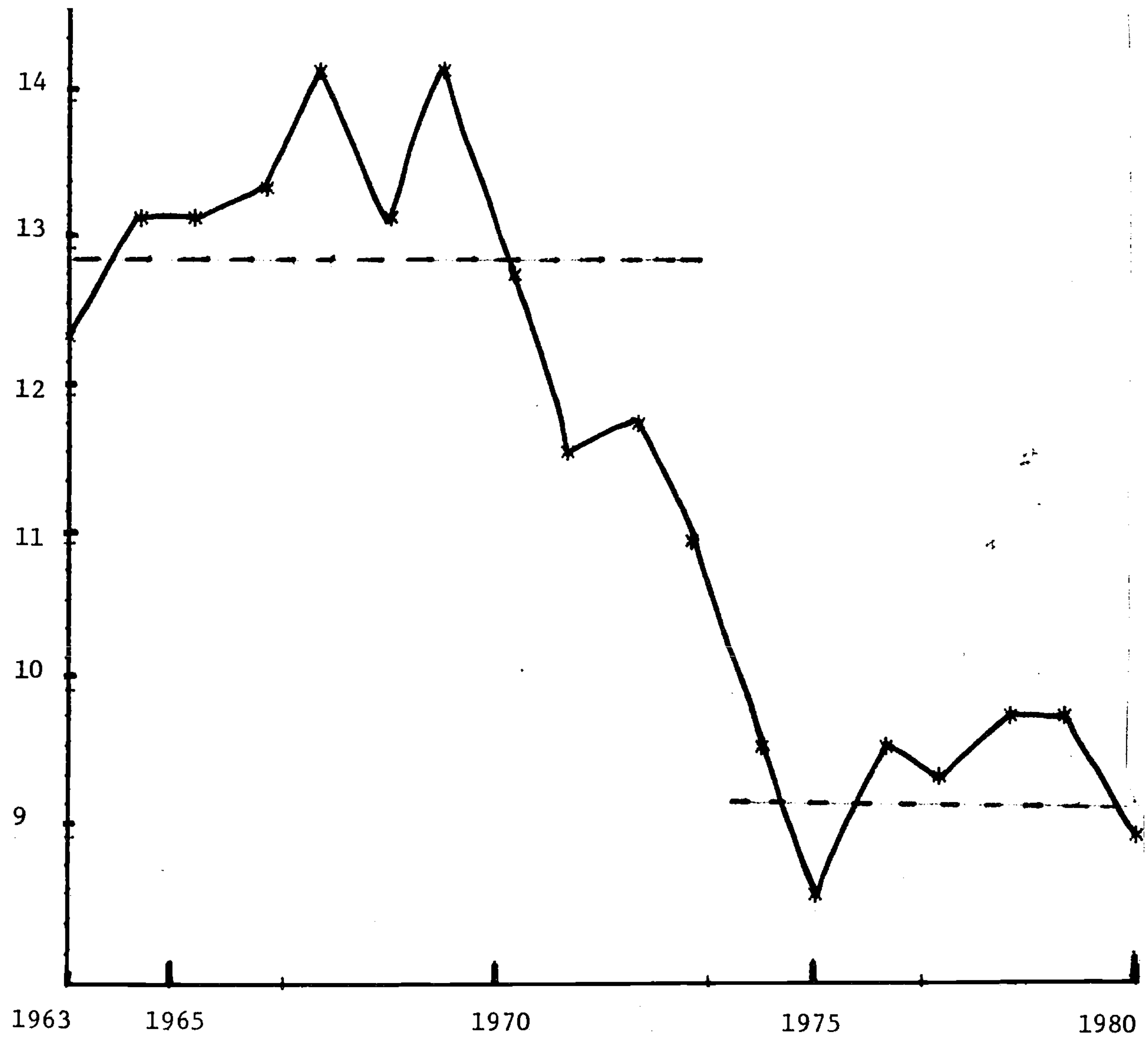
(3) Energy costs (EC) obtained by multiplying energy consumed (including refinery losses) by category by its price in francs, from UN, World Energy Supplies 1950-1974, and IEA, Energy Balance of OECD Countries 1974-78.

Note: (3) = (X-TLC)/Q
(4) = 1-(Z+EC)/Q

FIGURE 1

PROFITABILITY OF

MANUFACTURING (%)



Source: Column (2) of Table 3 and 1980 estimate.

Table 2 summarizes the evolution of the basic prices and quantities relevant to the manufacturing sector. Panel A, column (3) shows that the average rate of increase of the product wage was close to 6% throughout the period, while the real price of energy, which was constant from 1959 to 1973, increased to about 6% in the following period. This was substantially in excess of the "warranted" rates of increase implied by measured factor productivity growth, obtained from Panel B as 4% p.a. and 2% p.a. respectively. 9/ The coverse was true - particularly for energy - in the period 1959-73. Column (1) of Panel B shows that the rate of growth of output declined from 6.6% to 2.5%, while labor input, which had been constant in the period 1959-73, declined at a rate of 1.6% p.a. in 1974-79. While this is one of the crucial facts behind the French unemployment problem, it was in part due to the reduction in the length of the work week 10/. As mentioned, the increase in the real price of energy kept its use by the manufacturing sector constant in 1974-79, after an increase of over 3% p.a. in 1959-73 (column 2 of Panel B).

Using consistent figures on gross (net) capital stock and gross investment in manufacturing from SLM, 11/ we obtain annual growth rates of 5.5% (6.6%) and 8% per annum respectively over 1959-73 and a drop to 4.7 (3.9) and -2.2% in 1974-79. Similarily, survey data on capacity utilization show a drop from 84.3% for 1959-73 to 83% in 1974-79. Using variables constructed in Section III below, and reported in column (4) and (5), we see that corresponding to a drop in the rate of growth of net capital from 7% to 4%, our measure of average optimal capital utilization would have dropped from 74% to 72%. This is consistent with the excess of observed over warranted factor price growth and is, of course, the counterpart of the decline in profitability discussed above.

TABLE 2

FRENCH MANUFACTURING:

PRICE AND QUANTITIES (% p.a.)

A	(1) Total Labor Costs	(2) Wholesale Price of Energy	(3) Price of Output	(4) Product Wage (1)/(3) (w)	(5) Real price of Energy (2)/(3) (s)
1959-73	9.1	3.1	3.4	5.6	-0.2
1974-79	16.6	16.9	10.4	5.8	5.6
B	**(1) Output (X)**	**(2) Labor (N)**	**(3) Energy (E)**	**(4) Capital (K)**	**(5) Average Utilization rate (%)**
1959-73	6.6	0.5	3.4	7.0	73.9
1974-79	2.5	-1.6	0.4	3.7	71.7

Sources A (1) In mechanical and electrical industries. Includes required social security contributions, from SLM, p. 225

(2) Fuel and energy for industries wage, value-added tax excluded, from SLM, p. 219.

(3) Price of industrial goods, tax included, from IFS, line 63.

B (1) Gross output in industrial subsectors (U4 + U5 + U6), 1970 francs from SLM, p. 78.

(2) Employment in industrial subsectors times average weekly hours worked from SLM, p. 30, 33.

(3) Same as Table 1, column (2).

(5) Same as Table 5, column (2)

Note: The notation used for the series is the same as in the text and in the Data Appendix.

II THE MODEL

We view the manufacturing sector as a collection of plants of differing characteristics in terms of their production capacity, and labor and energy requirements. These three crucial features are chosen at the time a plant is built and define its vintage. We do not allow any flexibility in the choice of the production technique ex post nor do we allow any retrofitting of old plants, although such possibilities are obviously a relevant consideration. A crucial aspect of the actual behavior of firms is, in our view, the adjusting role of the utilization of capacity. In other putty-clay models, changes in utilization are, if anything, an afterthought. 12/

Our emphasis in this section is on the specification of a plant of a given vintage. Unlike standard vintage models of growth, this turns out to be the crucial building block of the model. 13/ Because we take investment as exogenous and focus on the utilization of different vintages, the analysis of aggregation over plants is left until we deal with the problem of estimating an industry-wide model in the next section.

The Basic Setup

When a plant is built, say in period t = i, the firm decides on initial investment, I_i, on the capacity of the plant and on the (effective) labor and energy requirements per unit of capacity, which remain fixed for the lifetime of the plant. A plant is closed down when the present discounted value of profits is equal to zero.

The capacity of the plant declines over its lifetime because of physical depreciation, which we assume for convenience to take place at a constant rate, δ. Then, in period t, the maximum capacity of a plant built in period i, $\bar{Z}_t^i$, is given by:

(1) $$\bar{Z}_t^i = y_i \, \bar{u} \, I_i \, (1 - \delta)^{t-i} = y_i \, \bar{u} \, K_t^i$$

Where y_i and $\bar{u}$ are defined subsequently.

Note that the maximum capacity of the plant is determined at the time it is constructed and cannot be changed thereafter. However, in each period, maximum capacity can be utilized more or less intensively, so that utilized capacity is given by:

(2) $Z_t^i = y_i \, u_t^i \, K_t^i$

Where $u_t^i/\bar{u} = \bar{Z}_t^i/Z_t^i$ is the rate of utilization of capacity of plant i on period t, relative to maximum capacity.

We assume that labor and energy inputs vary with the rate of capacity utilization:

(3) $N_t^i = a_i \, u_t^i \, K_t^i$

(4) $E_t^i = b_i \, u_t^i \, K_t^i$

The output of the plant, X_t^i, increases with capacity utilization, but at a diminishing rate. This reflects the fact that, as we approach maximum capacity utilization, input productivity declines. Capturing this feature by a very simple parametrization, ϕ, we write our output function as:

(5) $X_t^i = y_i \, \phi \, (u_t^i) \, K_t^i$

Where $\phi \, (u_t^i) = u_t^i(\bar{u} - \frac{1}{2} u_t^i)$

Note that maximum output is defined by $u_t^i = \bar{u}$.

When the plant is constructed, the firm has to decide on how to allocate its investment between capacity creation, labor saving and energy saving. For a given level of investment, the firm can increase labor or energy productivity but at the cost of a lower level of capacity. This fundamental trade-off is parametrized as:

(6) $y_i = a_i^{\alpha} b_i^{\beta}$

Where $\alpha+\beta<1$.

Substituting from (1) through (5) into (6) we can write output as a function of factor inputs and the utilization rate:

$$(7) \qquad X_t^i = \psi(u_t^i)\, N_t^{i\ \alpha}\, E_t^{i\ \beta}\, K_t^{i\ \sigma}$$

Where $\sigma = 1 - \alpha - \beta$

and $\psi(u_t^i) = u_t^{i\ 1+\sigma}\,(\bar{u} - \frac{1}{2}\, u_t^i)$

Note that, although (6) appears to be very similar to the standard production function specification, our model impose strong restrictions on the choice of N_t^i, E_t^i and u_t^i, which eliminate the apparent substitutability between labor, energy and capital inputs ex post. Note further that it is the variation of capacity utilization which allows one to discriminate between our specification and standard putty-clay models. The difference between our specification and the standard putty-clay models, where variable inputs are proportional to output, is also apparent from equation (7).

The Maximization Problem

Given total investment, I_i, the technology of the plant is chosen so as to maximize the present discounted value of expected profits. The time horizon of this optimization problem, T_i, is endogenously determined. We assume that the firm is competitive and takes both input and output prices as exogenously given. We measure factor prices in units of output and denote the product wage prevailing at time t by w_t and its expectation by $\tilde{w}_t$, where it is understood that expectations are formed at t = i, when the investment decision is made. Similarily, we denote the actual and expected real price of energy by s_t and $\tilde{s}_t$ respectively. A further simplification is that expected profits are discounted at a constant rate, r.

We now maximize the present discounted value of profits per initial investment, denoted by $\tilde{\Pi}_t^i$, subject to the technology constraint in (5).

The Lagrangian is written as:

(8) $\mathcal{L}_t^i = \tilde{\Pi}_t^i - \gamma^i \, (y_i - a_i^{\alpha} b_i^{\beta})$

Where $\tilde{\Pi}_t^i = \sum_{t=i}^{T_i} [y_i \, \phi \, (u_t^i) - a_i u_i \tilde{w}_t - b_i u_t^i \tilde{s}_t] \quad [(1 - \delta)/ \, (1 + r)]^{t-i}$

γ^i is a Lagrange multiplier

and $\tilde{w}_i = w_i$, $\tilde{s}_i = s_i$.

The cut-off point is determined by:

(8') $\tilde{\Pi}_{T_{i+1}}^i = \sum_{T_{i+1}}^{\infty} [y_i \, \phi \, (u_t^i) - a_i u_i \tilde{w}_t - b_i u_t^i \tilde{s}_t][(1 - \delta)/(1 + r)]^{t-i} \leq 0$

The optimal rate of utilization is chosen each period according to realized real factor prices, given a_i, b_i, y_i and $\bar{u}$. Thus, in any period t, we have:

(9) $\dfrac{\partial \tilde{\Pi}_t}{\partial u_t^i} = y_i \quad \phi'(u_t^i) - a_i w_t - b_i s_t = 0$

According to (9), the marginal benefit in increased output from an increase is utilization equals unit variable costs. Solving for the rate of utilization, we obtain:

(10) $u_t^i = \bar{u} \, (1 - \tilde{a}_i w_t - \tilde{b}_i s_t)$

Where $\tilde{a}_i = a_i / y_i \bar{u}$

$\tilde{b}_i = b_i / y_i \bar{u}$

Thus, given the labor and energy output ratios, $\tilde{a}_i$ and $\tilde{b}_i$, u_t^i varies with contemporaneous (realized) real factor prices since a_i, b_i and y_i are chosen at the time the plant is built and remain fixed as long as the plant operates. Given the lifetime of the plant, they are determined from the following first-order conditions:

(11) $$\frac{\partial \wp_t^i}{\partial y_i} = \sum_{t=i}^{T_i} \phi \quad (u_t^i) \; g^{t-i} - \gamma^i = 0$$

(12) $$\frac{\partial \wp_t^i}{\partial a_i} = - \sum u_t^i \tilde{w}_t \; g^{t-i} + \gamma^i \alpha (y_i / a_i) = 0$$

(13) $$\frac{\partial \wp_t^i}{\partial b_i} = - \sum u_t^i \tilde{s}_t \; g^{t-i} + \gamma^i \beta (y_i / b_i) = 0$$

Where $g = 1 - \delta/1 + r$

From (11) we see that the shadow cost of capital productivity is always equal to the present discounted value of additional output. Substituting from (11) into (12) and (13), we get:

(12') $$\alpha \sum \phi \; (u_t^i) \; g^{t-i} = \sum u_t^i \; (a_i/y_i)\tilde{w}_t \; g^{t-i}$$

(13') $$\beta \sum \phi \; (u_t^i) \; g^{t-i} = \sum u_t^i \; (b_i/y_i)\tilde{s}_t \; g^{t-i}$$

The Choice of Technology

Using (10) to substitute for u_t^i and rearranging, we express (12') and (13') as two quadratic equations in $a_i w_i$ and $b_i s_i$, with coefficients that are functions of real factor prices relative to the ones prevailing in period i:

(14) $$\tilde{a}_i^2 w_i^2 \; (2-\alpha)\mu_2 + 2\tilde{a}_i \tilde{b}_i w_i s_i \; (1-\alpha) - \tilde{b}_i^2 s_i^2 \alpha \; \nu_2 \; - 2\tilde{a}_i w_i \mu_1 + \alpha\rho = 0$$

(15) $$-\tilde{a}_i^2 w_i^2 \; \beta\mu_2 + 2\tilde{a}_i \tilde{b}_i w_i s_i \; (1-\beta) + \tilde{b}_i^2 s_i^2 \; (2-\beta)\nu_2 - 2\tilde{b}_i s_i \nu_1 + \beta\rho = 0$$

$$\mu_2 = \sum_{t=i}^{T_i} (\tilde{w}_t/w_i)^2 \; g^{t-i} / \sum_{t=i}^{T_i} (\tilde{w}_t/w_i)(\tilde{s}_t/s_i) g^{t-i}$$

$$\mu_1 = \sum (\tilde{w}_t/w_i) \; g^{t-i} / \sum \; (\tilde{w}_t/w_i)(\tilde{s}_t/s_i) \; g^{t-i}$$

$$\rho = \sum g^{t-i} / \sum (\tilde{w}_t/w_i)(\tilde{s}_t/s_i) \; g^{t-i}$$

ν_2 and ν_1 having expressions in $\tilde{s}_t/s_i$ equivalent to μ_2 and μ_1 in the numerator and the same denominator.

Equations (14) and (15) define two hyperbolas in $\tilde{a}_i w_i$, $\tilde{b}_i s_i$. 14/ There will always be one intersection in the positive quadrant associated with the optimum solution. There is, however, no analytical solution in general. In some special cases, an explicit solution can be obtained. One such case is when the relative price of the two factors is not expected to change. Then we can aggregate labor and energy inputs into a single factor. In (14) and (15), $\mu_2 = \nu_2 = 1$ and $\mu_1 = \nu_1$, so that by adding we obtain:

$$(16) \quad (\tilde{a}_i w_i + \tilde{b}_i s_i)^2 (1+\sigma) - 2\mu_1 (\tilde{a}_i w_i + \tilde{b}_i s_i) + \rho (1-\sigma) = 0$$

The negative root of (16) gives minimum variable costs: 15/

$$(17) \quad \tilde{a}_i w_i + \tilde{b}_i s_i = \frac{1}{1+\sigma} \left(\mu_1 - \sqrt{\mu_1^2 - (1-\sigma^2)\rho}\right)$$

The expression on the right-hand side of (1) captures the effect of factor price variablity on the choice of technology. Using (17) to substitute for $\tilde{b}_i s_i$ in (14) and for $\tilde{a}_i w_i$ in (15) and solving for $\tilde{a}_i$ and $\tilde{b}_i$, we get:

$$(18) \quad \tilde{a}_i = \frac{H_i \alpha / w_i}{1 + \sigma}$$

$$(19) \quad \tilde{b}_i = \frac{H_i \beta / s_i}{1 + \sigma}$$

$$\text{Where } H_i = \frac{\mu_1^2 - \rho(1+\sigma) - \mu_1 \sqrt{\mu_1^2 - \rho(1-\sigma^2)}}{-\mu_1 \sigma - \sqrt{\mu_1^2 - \rho(1-\sigma^2)}}$$

When factor prices are expected to remain constant, $\mu_1 = \rho = 1$, the square root term reduces to σ, and H=1, so that variable costs are fixed:

$$(20) \quad \tilde{a}_i w_i + \tilde{b}_i s_i = \frac{1-\sigma}{1+\sigma}$$

In this case, the planned rate of capacity utilization is also constant, and independent of factor prices. In fact, using (20) in (10), we obtain:

$$(21)\quad u_t^i = \frac{\bar{u}}{1+\sigma}\, 2\sigma$$

Recalling equation (7) above, we see that in this special case the standard production function representation applies to our specification. We can then interpret α, β and σ as the shares of labor, energy and capital costs in output.

When factor prices vary over the lifetime of the plant, the rate of utilization also varies. When the relative price of the two factors is constant, we can use (18) and (19) to substitute for $\tilde{a}_i$ and $\tilde{b}_i$ in (10) and we obtain the planned rate of utilization in period t as:

$$(22)\quad u_t^i = \frac{\bar{u}}{1+\sigma}\,(1 + \sigma - H_i v_t^i)$$

Where $v_t^i = \alpha \frac{w_t}{w_i} + \beta \frac{s_t}{s_i}$

In this case, there is no production function representation of technology which is independent of factor prices. The term in utilization in (7) now becomes:

$$(23)\quad \psi(u_t^i) = \frac{1}{2}\left(\frac{\bar{u}}{1+\sigma}\right)^{2+\sigma}(1+\sigma - H_i v_t^i)^{1+\sigma}(1+\sigma + H_i v_t^i)$$

The Life Span of the Plant

As we have noted, the planned lifetime of the plant depends on the expected time path of factor prices. The actual lifetime of the plant may of course be different to the extent that there are expectational errors. In general, the lifetime of a plant is a decreasing function of the rate of increase of factor prices. This can be seen clearly in the spread case when both factor prices increase at a constant rate, say μ. In this case, the planned shut-off date of the plant is given by setting u_t^i equal to zero in equation (22) above:

$$(24) \quad H_i(1+\mu)^{T_i} = \frac{1+\sigma}{1-\sigma}$$

Where H_i depends on μ as shown in equation (19) above.
In general, the cut-off point is determined jointly with the technology coefficients from (8'), (14) and (15).

Solution for the Plant

Our model of the plant is completely specified by equations (3), (4), (5), (6), (8'), (14) and (15). When relative factor prices are not expected to change, we can use (18) and (19) in (5) to obtain:

$$(25) \quad y_i = (UH_i)^{(1-\sigma)/\sigma} (\alpha/w_i)^{\alpha/\sigma} (\beta/s_i)^{\beta/\sigma}$$

Where $U = \frac{\bar{u}}{1+\sigma}$

Substituting for y_i in (18) and (19), we have:

$$(26) \quad a_i = (UH_i)^{1/\sigma} (\alpha/w_i)^{(1-\beta)/\sigma} (\beta/s_i)^{\beta/\sigma}$$

$$(27) \quad b_i = (UH_i)^{1/\sigma} (\alpha/w_i)^{\alpha/\sigma} (\beta/s_i)^{(1-\alpha)/\sigma}$$

Note from (26) and (27) that the choice of technology at time i depends not only on factor prices prevailing at time i but also on the time profile of factor prices relative to their initial level. This latter effect, captured by H_i, is symmetric because relative factor prices are expected to remain constant. When factor prices are expected to be constant, the first effect is ruled out and factor proportions are determined by a weighted average of prices prevailing at time i.

When a constant (common) growth rate for factor prices, μ, is expected, then an increase in μ lowers H_i and therefore increases labor and energy productivity.

We now write the solution under static expectations ($H_i = 1$) by substituting a_i, b_i and y_i in (3), (4) and (6), to yield:

$$(28) \quad X_t^i = \frac{1}{2} \; U^{1+\sigma/\sigma} (\alpha/w_i)^{\alpha/\sigma} (\beta/s_i)^{\beta/\sigma} [(1+\sigma)^2 - v_t^{i2}] \, K_t^i$$

$$(29) \quad N_t^i = U^{1/\sigma} (\alpha/w_i)^{1-\beta/\sigma} (\beta/s_i)^{\beta/\sigma} (1 + \sigma - v_t^i) \, K_t^i$$

$$(30) \quad E_t^i = U^{1/\sigma} (\alpha/w_i)^{\alpha/\sigma} (\beta/s_i)^{1-\alpha/\sigma} (1 + \sigma - v_t^i) \, K_t^i$$

In general, equation (7) above holds and it indicates the relationship between our model and the standard production function for a plant. Before proceeding with with the estimations, we discuss the aggregation of plants.

Aggregation

In any given period the manufacturing sector consists of a collection of plants with different labor and energy requirements. Those differences exist because the plants have been built in different periods, with old technologies influenced by past as well as expected current and future factor prices. It is important to note that, even with perfect foresight, different vintages would embody different technologies except in the special case when factor prices are constant. Errors in expectations add another consideration. If variable costs turn out to be higher than anticipated, labor and energy productivities of older vintages are smaller than would have been optimal with perfect foresight, and old plants will be shut-off sooner than anticipated. This is obviously an important considera- tion in view of the unanticipated increase in energy cost in the 1970's.

Because of differences between vintages, there is no aggregate production function in our model. An aggregate production function exists only in the stationary case of constant expected and actual factor prices.

A further important cause of differences between vintages is embodied technoligical progress. We can easily capture it by adding shift parameters A_i and B_i in equations (3) and (4). We also assume a fixed planned lifetime of T years for all vintages, after which the plant is scrapped. 16/ We can then write the aggregate functions as:

$$(31) \quad X_t = \sum_{i=t-T}^{t} y_i \phi(u_t^i) K_t^i ;$$

$$(32) \quad N_t = \sum_i a_i A_i u_t^i K_t^i ;$$

$$(33) \quad E_t = \sum_i b_i B_i u_t^i K_t^i .$$

III SIMULATION

To implement empirically the aggregate system in (31) through (33), we make the following simplifying assumptions. We neglect embodied technological progress (i.e. set $A_i=B_i=1$ above) but allow for labor-augumenting technological progress. We assume that the manufacturing sector faces the same product wage and real prices of energy, the same α and β coefficients and the same maximum utilization rate $\bar{u}$. In fact, we have no way of identifying $\bar{u}$, so that it would be appropriate to interpret the parameter U defined in (28) through (30) as a scale parameter. But U involves $\bar{u}$ raised to $(1+\sigma)/\sigma$ and therefore, when estimating α and β, we have to set $\bar{u} = 1$. Since actual real factor prices are not subject to choice and affect all vintages indentically, we also treat them as scale parameters and reinterpret (26) and (27) in terms of a measure of expectational errors defined as the ratio of actual to expected real factor prices, to yield, under stationary expectations:

$$(34) \quad a_i = (1+\sigma)^{-1/\sigma} (\alpha\omega_t^i)^{(1-\beta)/\sigma} (\beta\pi_t^i)^{\beta/\sigma} w_t^{-(1-\beta)/\sigma} s_t^{-\beta/\sigma}$$

$$(35) \quad b_i = (1+\sigma)^{-1/\sigma} (\alpha\omega_t^i)^{\alpha/\sigma} (\beta\pi_t^i)^{(1-\alpha)/\sigma} w_t^{-\alpha/\sigma} s_t^{-(1-\alpha)/\sigma}$$

Where $\omega_t^i = w_t/w_i$

$$\pi_t^i = s_t/s_i$$

Note that (34) and (35) are applicable when real factor prices are expected to change at the same rate because H_i does not depend on ω_t^i or π_t^i. Then, according to (18) and (19), w_i and s_i would have to be divided by H_i. When relative factor prices are expected to vary, however, we have to solve (14) and (15), given α and β, and then simulate the model.

In this Section, we introduce a feature excluded from the model in Section II for expositional convenience. This is the existence of overhead labor, which we assume to be proportional to capacity.

To equate the variables in (31) through (33) with observed gross output 17/, employment and energy demand, we define a scale parameter C_i for each of the three equations, which (since $\bar{u} = 1$) reflects the particular units in which the observed variables are measured as well as embodied technical progress. In the employment equation, another scale parameter is implicity included in the coefficient for overhead labor, n:

$$(36) \quad X_t^o = C_X X_t + \varepsilon_t^X ;$$

$$(37) \quad N_t^o = C_N N_t + nK_t + \varepsilon_t^N ;$$

$$(38) \quad E_t^o = C_E E_t + \varepsilon_t^E ;$$

Where $K_t = \sum_i K_t^i$.

To determine α, β, n and the C's in the system (36) through (38) we use a full-information maximum likelihood procedure based on K_t^i, ω_t^i and π_t^i for each vintage, then we aggregate over vintages. The estimation is carried out subject to the inequality constraints:

(i) $0 < \alpha < 1$

(ii) $0 < \beta < 1$

(iii) $0 < \sigma < 1$

The model is estimated over the period 1950 through 1979 with annual data. We use a reported (net) capital stock estimate for K_i^i, i = 1950, assume that all vintages prior to 1950 are identical and form K_t^i using gross investment in year t>i, under the assumptions that $\delta = .10$ and T = 30 years. 18/ Expectations are discounted at a rate of 10% p.a., so that g = .82.

The model is estimated under static expectations, that is to say the case when a_i and b_i are related by linear equations (18) and (19) rather than by the quadratic equation (14) and (15). The model is also simulated for the general case of equations (14) and (15) but conditional on postulated values for α and β which we take to be close to the ones reported in Table 1 above.19/ The latter simulation also includes the assumption of a constant growth of the product wage of 3% p.a. over the whole period, reflecting in part labor-augumenting technical change, and a constant expected real price of energy. 20/ The shocks of the seventies are then simulated on variants of the dynamic base case.

Estimation results for the two cases are reported in Table 3. Because of the different values of α and β, the estimates are not directly comparable. Also, for the period 1950-58 the results are less reliabe because of the greater weight of the arbitrary base value of the capital stock and of changes in the system of national accounts, which implied a different definition of the manufacturing sector. 21/ As shown in the third panel, the first-order serial correlation of the residuals is generally very high. Nevertheless, the likely misspecification of the process of capital accumulation, due to the effect of variations in depreciation rates and in scrappage as a function of changes in expected profitability, might well introduce higher-order auto-regressive errors, which are not corrected for. The existence of inequality constraints precludes explicit significance tests on the parameters α and β reported in the first panel of Table 3. Because of the constraints, there is no guarantee that the error terms to be orthogonal to the dependent variable. Therefore, the summary statistic R^2 reported in Table 3, second panel, is actually the square of the correlation coefficient between fitted and actual values. This is a good indicator of the explanatory capabilities of the model.

TABLE 3

ESTIMATION AND SIMULATION RESULTS

(t-values in parentheses)

	(1) Static Expectations	(2) Dynamic Simulation
$\tilde{w}_t$	w_i	$w_i(1.03)^t$
$\tilde{s}_t$	s_i	s_i
Parameters		
α	.060	.30*
β	.010	.05*
C_X	.006 (15.607)	.022 (2.850)
C_N	6655.4 (32.5)	3441.2 (5.9)
n	-8.34 (-4.21)	12.76 (2.21)
C_E	.003 (3.335)	.002 (12.856)
Goodness of fit		
R_X^2	.996	.980
R_N^2	.999	.998
R_E^2	.977	.993
χ^2	6044	232
Serial correlation		
ρ_X	.818 (4.405)	.948 (5.106)
ρ_N	.675 (3.633)	.893 (4.810)
ρ_E	.912 (4.910)	.778 (4.192)

Note: * Assumed values.

The scale parameters (and the coefficients of auto-correlation) have an asymptotically normal distribution: significance tests based thereon are reported in parentheses below the coefficients in the first panel of Table 3 which, again, are not directly comparable. The overall significance test of the regression has a χ^2 distribution, whose value is reported in the second panel.

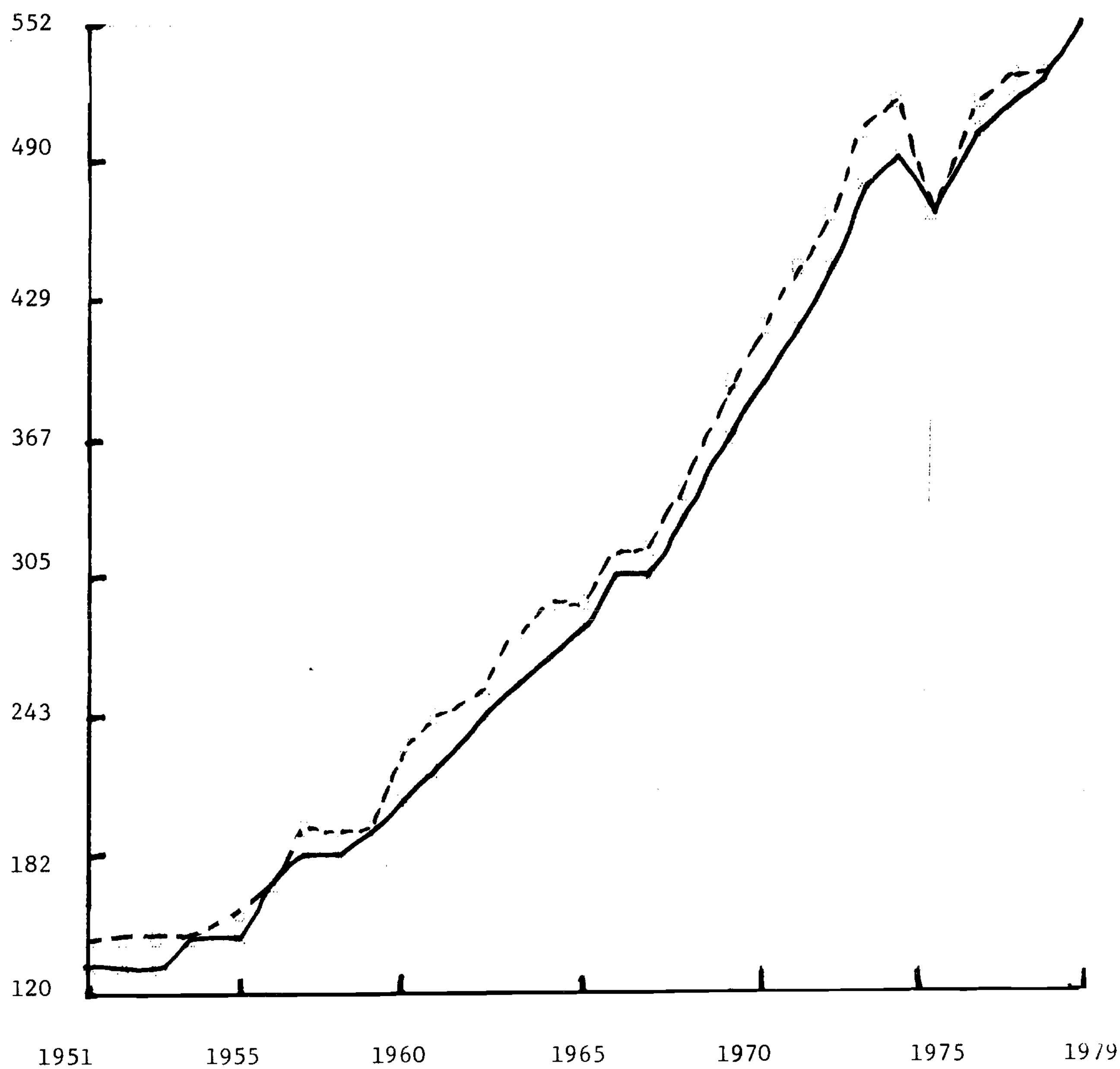
In the case of static expectations, reported in the first column, the coefficient on overhead labor has the wrong sign. To interpret the result that large expectational errors cause ω_t^i and π_t^i to vary considerably. If α and β were large, large variations in v_t^i would result, the utilization rate will be driven toward zero and could become negative. Since negative utilization leads to scrappage of the plant, the maximum likelihood values of α and β are likely to be small when the environment is characterized by large expectational errors. On the other hand, under static expectations, the standard production function representation applies so that we expect α and β to be close to the shares of labor and energy in gross output shown in Table 1. Since the values of α and β reported in Table 3 are implausibly low, even taking into account technological change, (which would justify the assumption of a constant effective wage) we conclude that static expectations do not capture the behavior of French manufacturing sector firms during the sample period.

The second column reports maximum-likelihood estimates of the scale parameters conditional upon the choice of α and β. Figures 2 through 4 plot the actual and fitted values for the three equations over the whole sample period and it is clear that the model can explain a substantial portion of the variation in output, employment and energy consumption in changes in utilization rates across vintages and suggests the usefulness of this approach. The fit is worse in the fifties, no doubt due to the greater weight of the base period

FIGURE 2

ACTUAL AND FITTED VALUES IN THE

DYNAMIC CASE: OUTPUT EQUATION (BILLION OF 1970 FRANCS)



——— actual

----- fitted

Source: 1959-79 1971 base gross output linked to 1950-59 1956 base gross output both from <u>SLM</u>.

FIGURE 3

ACTUAL AND FITTED VALUES IN

THE DYNAMIC CASE: EMPLOYMENT EQUATION (BILLION MAN-HOURS)

——— actual

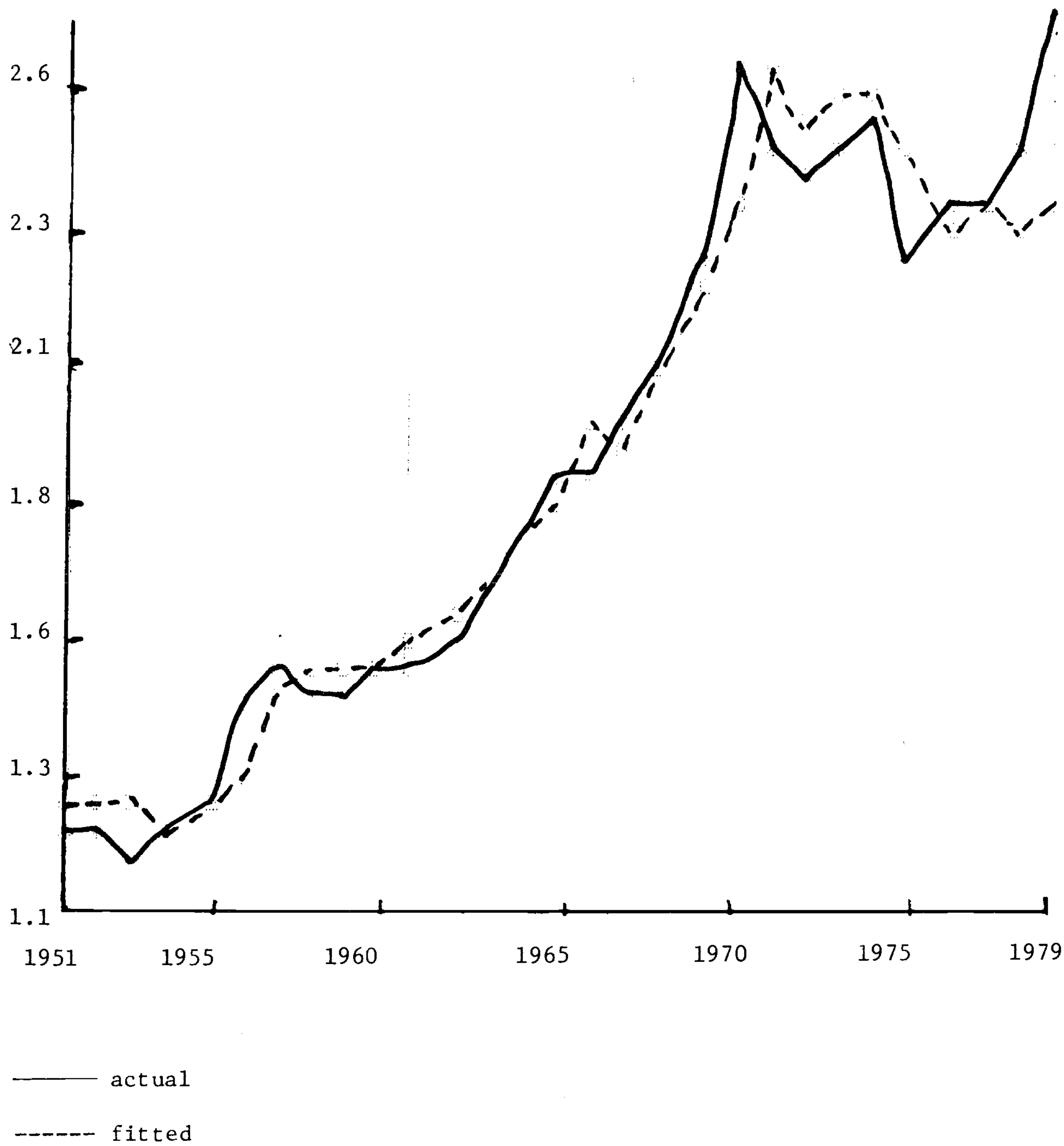
----- fitted

Source: 1959-79 1971 base employment linked to 1950-59 1956 base employment times average workweek in hours, all from SLM times 52.

FIGURE 4

ACTUAL AND FITTED VALUES IN

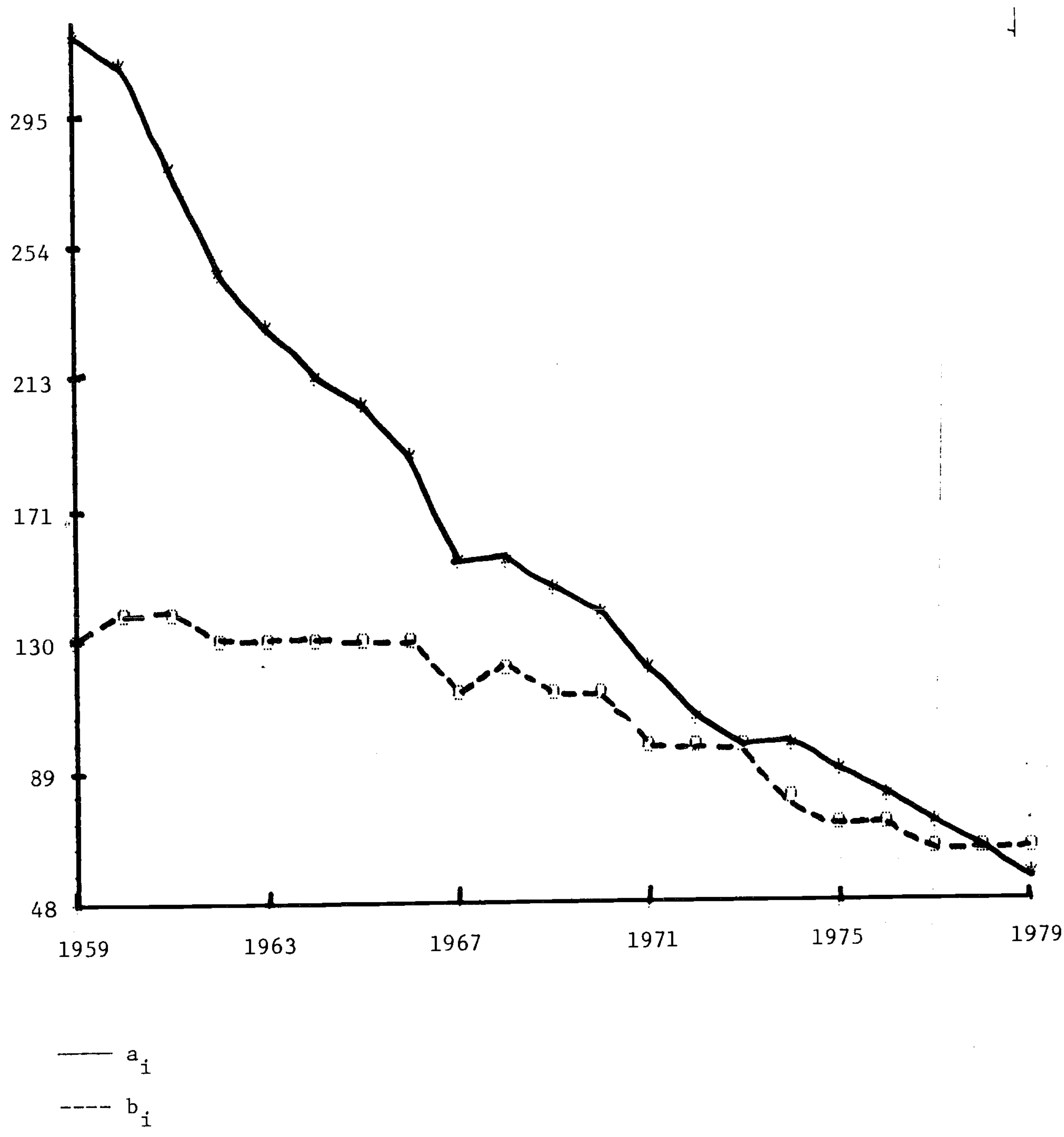
THE DYNAMIC CASE: ENERGY EQUATION (10^{15} BRITISH THERMAL UNITS)



Source: Column (2) of Table 1

FIGURE 5

FACTOR PROPORTIONS BY VINTAGE (INDEX 1973=100)



capital stock. Accordingly, Figure 5 plots index values of a_i and b_i from 1959 to 1979, with base 1973=100. There is a continuous decline in a_i whereas b is almost flat until the late sixties. Conversely, during most of the 1974-1979 period, b_i declines more than a_i. A similar pattern would obtain under static expectations, in part because we took a fairly high rate of depreciation and discount. Nevertheless, because of the expectation of a 3% increase in wages in the dynamic simulation, the values of a_i and b_i are uniformly lower than under static expectations.

<u>Changes in Factor Price Expectations</u>

In general, when there are changes in expected factor prices, there will be offsetting changes in the factor proportions of new vintages and in the utilization rate of old vintages. Specifically, differences in a_i, b_i and u_i across vintages derive from differences in α, β and γ, as well as in ω and τ. To reflect the shocks of the seventies documented in tables 1 and 2, suppose that in 1974 expectations of factor prices change. If product wages are expected to grow at 5% rather than 3% p.a., there will be a decline of 12.5% in a_i and a decline of 4% in b_i relative to the base dynamic case we have been discussing. Conversely if the real price of energy is expected to increase at 3% p.a., so that the two rates are the same, there will be an immediate decline of 14% in b_i and a decline of 1% in a_i. Suppose now that both factor price expectations change, so that wages are expected to grow at 5% and energy prices are expected to grow at 3% p.a. Then the decline for a_i is 13% and for b_i it is 17%. In all these examples, we observe negative cross-effects.

The implications of changes in factor price expectations on the utilization of the various vintages suggest that newer vintages will be more utilized than old vintages. Indeed, under static expectations (but with the assumed values of α and β), in 1979 we would find negative utilization rates of the 1950 and 1951 vintages. Utilization rates taking 1979 as the base period are shown in Figure 6. Neglecting again the observations for the early fifties, we see that the utilization of the 1959 vintage in 1979 is 58% and that an increase in expectational errors brought about by a 10% increase in the 1979 product wage leads to a drop in utilization of the 1959 vintage to 51%. For comparison, the utilization rate would have been 44% under static expectations.

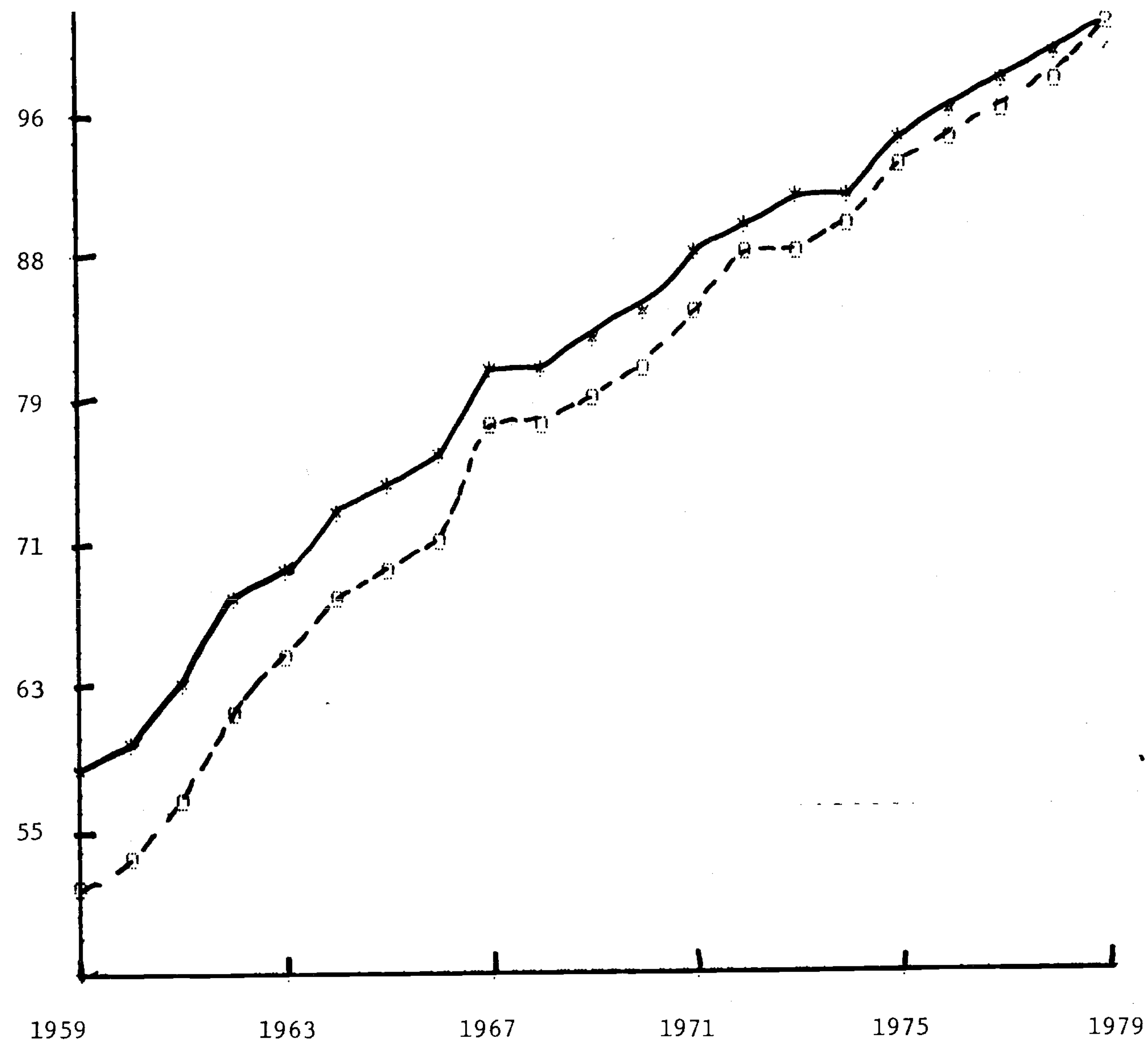
The Average Utilization Rate

A measure of average utilization of the capital stock in each year can be obtained by aggregating the utilization rate of each vintage in operation in that year. This measure, denoted by u*, is reported in Figure 7 for the base dynamic case. It shows a decline, from 76% in 1959 to 71% in 1979. The evolution mirrors the one of measures based on the output gap or survey data from the later sixties but the increase in the early sixties is not reflected in our measure, possibly because of the weight of the base period capital stock.

In Table 4, we simulate again the shocks of the seventies by showing the effects of changes in expected factor prices on u* as a proportion of the dynamic base case of column 2 of Table 3. As before, we have set the expected rate of growth of wages at 5% in column 1, the expected rate of growth of energy prices at 3% in column 2 and combine both shocks in column 3. While the year-to-year changes in a_i and b_i were negligible relative to the change in the year of the shock, the opposite holds for u*, where the impact effect is very small compared to the effect in 1979. Comparing the effect of the wage and oil shocks in Table 4, we see that the response of average utilization is much more significant in columns 1 and 3 than it is in column 2, as suggested above in the discussion of Tables 1 and 2.

FIGURE 6

UTILIZATION OF OLD VINTAGES IN 1979 (=10)



——— base case

----- 10% increase in the actual product wage in 1979

FIGURE 7

AVERAGE UTILIZATION RATE (u*)

(%)

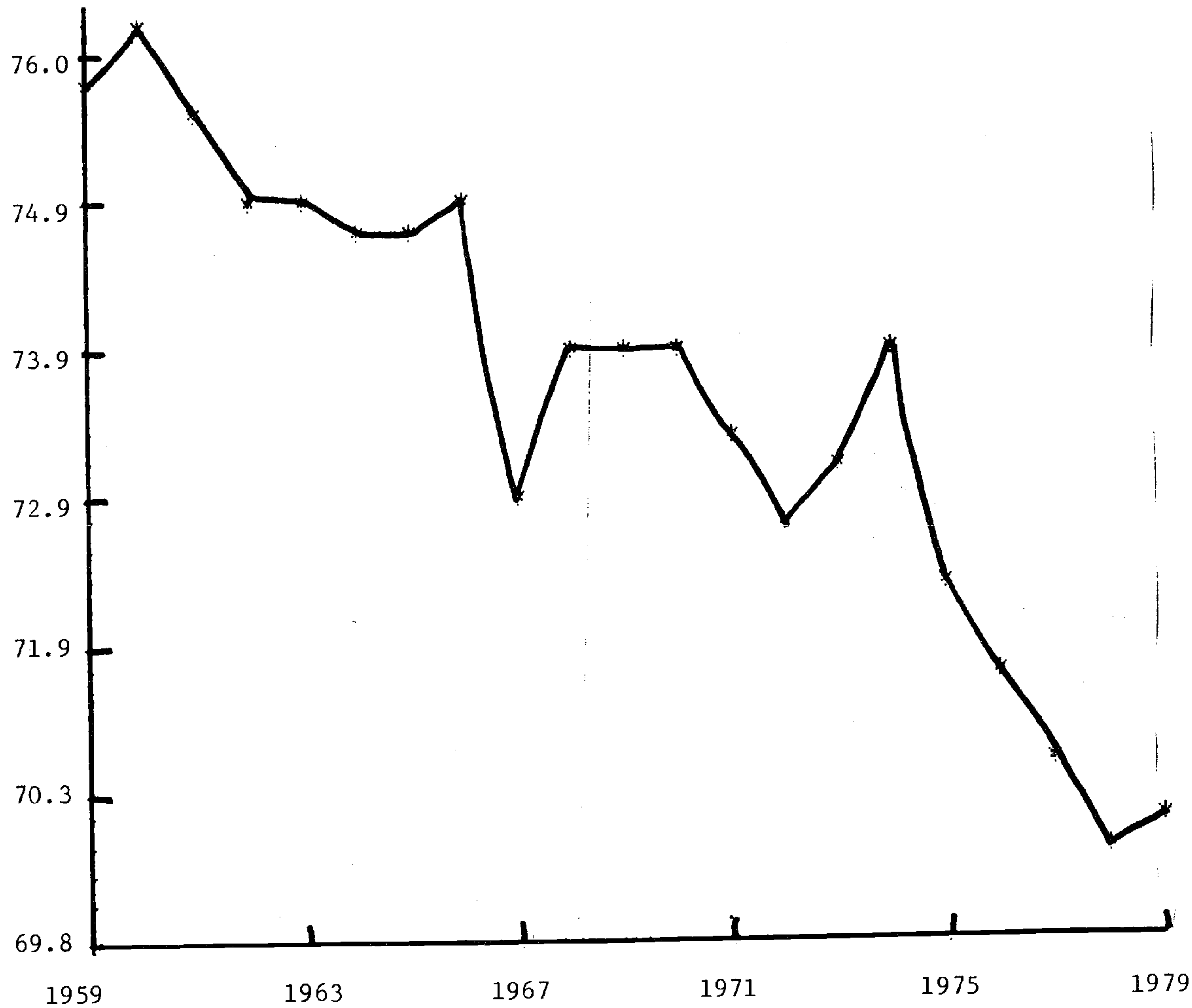


TABLE 4

AVERAGE UTILIZATION

RATES (%)

	(1) Base Case	(2) Expected Wage Increase	(3) Expected Energy Price Increase	(4) Combination
1973	73.0	0.0	0.0	0.0
1974	73.9	0.1	0.0	0.2
1975	72.2	0.7	0.4	0.9
1976	71.6	2.7	2.3	2.8
1977	71.1	3.1	2.7	3.3
1978	70.5	3.5	2.9	3.7
1979	70.6	3.5	2.8	3.7

(1) Series reported in Figure 8 ($\mu = .03$, $\nu = 0$)

(2) $\mu = .05$, $\nu = 0$ in 1973, percent over base case

(3) $\mu = .03$, $\nu = .03$ in 1973, percent over base case

(4) $\mu = .05$, $\nu = .03$ in 1973, percent over base case

Profitability

Finally, to present data on the profitability of manufacturing, we have to correct our measure of output for non-energy raw materials. Taking their share in output as constant over the period (as suggested by Table 1), we can compute profits for each vintage as a percentage of net output. In the dynamic base case, we see that, if the share is one half of gross output, then profitability declined from about 24% in 1953 to 14.5% in 1958, increased to 19.3% in 1961 and slowly declined to about 14% in the mid sixties. After a drop to 10% in 1969-70, this measure falls rapidly to 2.3% in 1975 and zero thereafter. Since the share of raw-materials also changes, we show in Table 5 the rate of profit for the share of 50% and 40%. In the latter case, profitability does decline substantially in the seventies, as suggested by Figure 1 above, but the rate of profit in 1979 is still about 5%. Note further that, measuring profits by vintage, we see that in 1979 no vintage before 1956 would be in operation and similarily that 1950 vintages would have been scrapped after 1975.

TABLE 5

PROFITABILITY OF MANUFACTURING

(as a percent of net output)

	(1) $\gamma = .5$	(2) $\gamma = .6$
1970		
1	9.8	20.7
2	8.0	19.2
3	5.6	15.7
4	5.8	16.6
5	2.3	12.2
6	0.0	9.1
7	0.0	7.1
8	0.0	6.1
9	0.0	4.7

Note: Measured as a weighted average (using gross outputs weights) of profitability by vintage defined as $(\gamma y_i \phi(u_t^i) - a_i u_t^i w_i - nw_i - b_i u_t^i s_t)/\gamma y_i \phi(u_t^i)$

CONCLUSION

The results reported in Section III have to be regarded as indicative of the usefulness of the approach defended in this paper rather than precise estimates. Our interpretation of the decline of profitability in Section I emphasized the importance of the wage explosion of the late sixties, continued into the seventies, as well as the effect of the oil shock. Since our model recognizes that it takes time to adjust factor proportions to factor price shocks and that it takes longer the lower the rate of capital formation, we were able to compare the effects of a sudden change in the price of energy to the effects of an increase in the expected rate of growth of real wages. We found that, as suggested by Figure 1, the decline in profitability started before the oil crisis, but that the energy shock was responsible for making older vintages unprofitable sooner than anticipated. The greater share of the wage bill in gross output was one reason for the stronger effect of wage growth in factor proportions but the effect of expectational errors was also found to be important in contrasting results under static expectations to the dynamic simulation of the model.

This being said, the limitations of the analysis should be borne in mind. The most serious ones are certainly the omission of investment and of the international aspects, which only appear here indirectly through the energy shock or some constraint on the price of output. These items as well as a refinement of the estimation procedure in the present set-up are in the authors' research agenda.

NOTES

1/ A "European perspective" on this period can be found in Giersch (1981).

2/ On secular French growth, see Carré, Dubois and Malinvaud (1972). The comparative perspective emerging from Maddison (1977) also suggests that France was a late starter in the process of modern economic growth. The rate of output in the later 19th century (1870-1913), 1.6% p.a., was substantially below the average of sixteen industrial countries, 2.8% p.a.. The same is true of the first half of the 20th century (1913-1949), where the French growth rate was 1.4% p.a. and the average 1.9%. After the Second World War, however, France caught up (5.3% vs. 4.8% in 1949-72) and continued above average in the seventies. In terms of manufacturing, there was a narrowing of the differential in the postwar "belle epoque" and a relative French decline in the seventies, as documented in Giersch (1981, chap 4).

3/ A detailed study of the changing structure of output in France during the fifties and sixties, as well as of the changes within manufacturing can be found in Dubois (1974). More recent accounts are in Delestré (1979) and Collet et al. (1980)

4/ There were "six sectors of the future" selected by the Committee for the Orientation and Development of Strategic Industry (CODIS): bioengineering, marine industries, robots, electronic office equipment, consumer electronics and alternative energy technologies. See Joint Economic Committee (1981, chap 2) for an insightful description of industrial and credit policy in France. Using principal components analysis, Rigal (1982) identifies three turning points during the period 1965-79. In 1969, investment was higher in food products, some equipment (mechanical, household appliances, automobile), construction and services to firms and lower in agriculture, energy (coal electricity, natural gas and water), consumption goods (leather-shoes and textile-clothing), home equipment (naval, aircraft, weapons) and transportation. In 1972, agriculture and energy continue to decline but are now joined by food products and construction; equipment and services accelerate while consumption goods pick up thanks to drugs and wood furniture. In 1978, energy and services have the higer investment ratio, while manufacturing declines, with the exceptions noted in the text.

5/ The present stance on this aspect is less sanguine but the emphasis on the high technology has, if anything, increased. According to the 1982-83 interim development plan, spending on research and development is to rise from 1.8% of GDP in 1980 to 2.5% by 1985 and in the 1982 budget, aid to industry by the Economic and Social Development Fund (FDES) is to increase by 52.4%. To what extent the managers of the newly nationalized firms will be able to find the incentives to pursue this goal remains, of course, to be seen.

6/ Historically, the single exception is the deflation of 1873-96 which was smaller in Germany (-.1% p.a.) and Italy (-.3%). In the 1920-34 period, for example, consumer price deflation (excluding Germany) was -2.2% p.a. on average when in France there was 2.1% inflation. See Schwartz (1973) and Giersch (1981, chap. 4).

7/ Griliches and Mairesse (1982, p. 6) mention a "push" type explanation for the faster productivity growth in France relative to the U.S. They present evidence against explanations of the productivity slowdown, based on the investment shortfall and on the increase in the price of raw materials, as hypothesised by Bruno (1981). They also find some effect of R & D on productivity at the firm level but not at the industry level.

8/ Comparative perspectives are provided by Nordhaus (1972), Gordon (1977) and Sachs (1979). Due to data availability, we could not present figures before

1963 in Table 1. The ratios usually reported refer to all non-financial enterprises, of which only half are manufacturing firms. There are also no series on the price of non-energy intermediate inputs and the series on the wholesale price of energy is an index (used below).

9/ A brief reference to developments since 1979 may be appropriate here. As shown in Figure 1, the operating surplus declined further in 1980 but relative shares remained in line with the average for the period since 1974, so that there was a swifter adaptation to the second oil shock than to the first. This is in large part due to a greater control over labor costs, even taking the minimum wage increase of June 1981 into account. In fact, using quarterly data on the ratio of unit labor costs to value added deflators in manufacturing relative to major trading partners, from IFS (base 1975=100) we see a decline from 104 in the first quarter to 98 in the fourth, and an increase to 99 in the first quarter of 1982. Now the labor share in French manufacturing alone declined from 102.2 to 98.6 from the first to the fourth quarter of 1981, and is provisionally put at 99.1 and 98.7 in the first two quarters of 1982.

10/ Legislation enacted in January 1982 implied a reduction of 4.5% in the legal number of hours worked per year, due to a reduction of the work week and an increase in the length of paid vacation. Note that taking into effect the length of paid vacation and the incidence of strikes on the annual average as hours worked as in Mairesse and Saglio (1971, p. 114) would lower the estimate of N in Table 2 in 1956, 1963 and above all, 1968 and 1969.

11/ We are grateful to Mr. P. Artus for this precious reference.

12/ While this is true of the exhaustive work on putty-clay of Johansen (1972, esp. p. 35), mention should be made of a sizable literature on capital utilization which concentrates on shift-work and "rhythmic input prices" e.g. Winston (1974) and (1977) and Betancourt and Clague (1981). Also, a model of utilization focusing on investment demand is in Abel (1981).

13/ See in particular Johansen (1959), Solow (1962), Solow et al. (1966) and Cass and Stiglitz (1970). Empirical implementations in a growth context are in Bliss (1965) for England, Benassy et al. (1975), Fouquet et al. (1978) and Vilares (1980) for France, Sandee (1976) for Holland and Bentzel (1979) for Sweden. Other useful references are Salter (1966), Attiyeh (1967), Johansen (1972), Isard (1973), Fuss (1977), Anderson (1981) and Bean (1981).

14/ The equation for these hyperbolas can be derived by rotating the axes by one half of an angle whose contangent is given by $(2-\alpha)\nu_2+\beta\alpha\mu_2/2(1-\alpha)$ for (14) and minus $(2-\beta)\nu_2+\beta\mu_2/2(1-\beta)$ for (15) and defining a new origin. Details are available upon request.

15/ The positive root is $\tilde{a}_i w_i + \tilde{b}_i s_i = 1$ for both equations. It implies from (10) that $u_i = 0$ and is associated with an indefinite form for H.

16/ A justification of the fixed life assumption in French manufacturing appears in Atkinson and Mairesse (1978).

17/ Strictly speaking, we should have netted out non-energy intermediate inputs, and thus adjust α and β measured relative to gross output as in Table 1. Because of the nearly fixed relative price, however, this adjustment would only affect the scale parameter. Also α only reflects the share of production labor.

18/ See Carré, Dubois and Malinvaud (1972) and Mairesse (1972) for a detailed studies of the French capital stock. See also Delestré (1979b) and SLM. Note that a lifetime of 30 years is substantially higher than the one chosen in other estimates - see Mairesse (1972 p. 59) - even without allowing for the distinction between equipment and buildings. The present combination probably allows for too little disembodied capital augmenting technical progress, which was found by Mairesse (1977) and (1978) to be important in the French case. A 5% rate of depreciation would come closer to the mark but then the series on net capital would be almost double of the corresponding series reported in SLM, whereas with a 10% depreciation, the two series are very close.

19/ Expected computing costs prevented a simultaneous estimation of α, β, n and the C's in the dynamic case but we obviously intend to perform it. The details of the estimation procedure are available upon request.

20/ See Table 2. Alternative estimates of disembodied technical progress are 4.3% in Mairesse and Saglio (1971, p. 107), 2.6% for labor and -.9% for capital in Benassy, Fouquet and Malgrange (1975, p. 35) and 2% in Mairesse (1978).

21/ From 1959 to 1979, data is based on the 1971 "enlarged system of national accounts" (SECN) and includes investment by private firms in three subsectors or "branches", intermediate goods (code U04), machines (U05) and consumption goods (U06). From 1950 to 1959, however, it is based on the 1962 system, which divides manufacturing into seven branches (denoted U06 to U12) and some national firms such as the Commissariat d'Energie Atomique are included (in U10B). To the difference in firm coverage (CEA in, some aeronautics firms out) we ahve to add the difference due to the exclusion of the deductible portion of the value-added tax. To give an example, the new investment series (without VAT was 16.3% below the old one in 1971, but, after accounting for the differences in definition, etc. the divergence was reduced to - 3.4%. The other series which are affected are employment (56 classification over 1971 classification is 1.042 in 1959) and production (similar ratio is .903 in 1959). Further details in INSEE (1978).

DATA APPENDIX

	w	s	X	N	E	K
1950	34.5	93.5	120.7	10.2	1.07	68.1
1951	31.6	80.7	130.6	10.5	1.22	70.3
1952	37.3	90.6	131.9	10.4	1.20	72.5
1953	40.6	92.5	135.3	10.1	1.14	74.3
1954	43.6	94.9	141.7	10.2	1.21	75.1
1955	46.0	93.1	150.0	10.3	1.27	76.7
1956	50.9	96.4	163.9	10.5	1.44	79.2
1957	52.7	102.5	177.9	10.8	1.51	83.2
1958	54.4	105.1	183.8	10.8	1.47	87.3
1959	54.8	109.5	188.3	10.5	1.45	91.2
1960	56.2	105.3	210.5	10.7	1.51	96.4
1961	60.4	103.6	222.4	10.8	1.53	104.1
1962	65.8	103.7	238.1	11.0	1.57	113.0
1963	69.1	100.9	256.1	11.3	1.65	121.3
1964	72.7	98.7	273.1	11.4	1.76	129.4
1965	76.2	97.0	279.4	11.2	1.85	136.7
1966	79.0	96.3	303.6	11.3	1.89	145.3
1967	89.6	103.7	311.0	11.2	1.96	154.0
1968	90.7	96.9	324.3	10.9	2.09	162.1
1969	95.1	98.1	366.9	11.2	2.30	175.2
1970	100.0	100.0	390.7	11.4	2.65	190.1
1971	108.2	106.8	413.4	11.5	2.48	206.5
1972	116.9	105.2	442.1	11.6	2.43	222.8
1973	122.7	100.9	476.1	11.7	2.47	240.4
1974	120.8	121.1	494.2	11.7	2.55	254.8
1975	134.8	126.1	465.6	11.1	2.28	263.2
1976	144.9	127.9	505.0	10.9	2.41	273.7
1977	153.9	131.5	518.3	10.8	2.40	283.2
1978	165.3	133.4	529.7	10.5	2.47	291.7
1979	171.3	138.4	549.4	10.2	2.74	297.5

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