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ABSTRACT

In Kouri, Macedo and Viscio (1982), we applied a vintage model of supply to data from the French manufacturing sector. The model was, however, solved with a particular parametrization (Cobb Douglas production function and a quadratic adjustment function). Also, no fixed factors were allowed for in the theoretical treatment, even though fixed labor was found to be significant in the application to France. The treatment of technological progress was equally restrictive.

Here we solve in Section I the general case of N variable factors and $\bar{N}$ fixed factors with embodied and disembodied technological progress. It turns out to be simpler than the combination of a Cobb-Douglas production function with a quadratic adjustment function, thus suggesting a manageable framework for the analysis of profitability and employment in industrial countries. The model is simulated in Section II using previously unavailable data on a subsector of French manufacturing from 1959 to 1980. The empirical results confirm the importance of vintage effects.

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Introduction

Prior to 1973, stability in prices and expanding demand masked the difference among production techniques and the way in which these differences were related to economic performance. Following the energy price shock, though, a period of sharp inflation and prolonged recession clearly highlighted the importance of vintage differences.

A key element of the vintage approach is the time path of investment. Firms construct plants with long useful lives when measured on an engineering basis but only those plants which can operate profitably will be used. Unexpected increases in factor prices can lead to economic obsolescence if existing efficiencies of inputs such as labor and energy cease to be appropriate at the new prices. Plant closings are the final recognition of this obsolescence. The severity of the plant closings in the 1970's can be explained in this manner.

Reported utilization rates in many industries are currently overstating the present level of unused capacity. The issue is not just measuring excess capacity, but identifying usable capacity. Thus, in many industrial countries, the smokestack industries have been plagued with idle capacity. Nevertheless, investment is required to maintain usable capacity. The profitability of an investment can be seen most easily in countries not burdened with old technology that lowers the average rate of return. Both Korea and Japan have been very successful competing in world markets by applying modern, efficient production techniques in smokestack industries.

The steel industry provides a good example of the importance of vintage differences: between 1974 and 1978, eighteen percent of the blast furnaces in the United States have been scrapped. Producing steel in a blast furnace requires over twenty-six million btu's of energy per ton of output, almost three times more than the mini mills which use electric arc furnaces and continuous casting. The intermediate input requirement is also different because electric arc furnaces use scrap steel as a feed stock while blast furnaces are traditional smelters. The advantage of the newer mini mills goes beyond energy and materials and translates into a large difference in profitability. Capital costs for a blast furnace process are about $2000 per ton per year of capacity, almost seven times higher than the corresponding figure for a mini mill. Although asset size is not an exact representation of the production process, it is indicative of the profitability of the newer technology: in 1982 US steel firms with less than $25 million assets had a profit of $30 million while firms over $25 million registered losses of over $800 million.

Electric utilities in the US provide another example of how vintage cost curves affect production. The first, and unexpected, decline in electricity demand took place in 1982. There is a long lead time for planning and construction of new generating capacity, so that new plants are continuing to come on stream despite the slower growth of demand in the past few years. The distribution of plant utilization clearly showed the expensive plants--in this case oil-fired generators--are underutilized while coal-fired plants are still being built. One New England utility ran an oil-fired plant at two percent capacity, using it for peak-loading only. Currently, about ten percent of the oil-fired capacity on the East Coast is planned to be converted to coal. Past fuel choice is a major determinant of current operating costs and these costs determine utilization rates.

Other industries are heavily investing in predominantly cost savings rather than in increasing output capacity. Almost all recent investment in the US paper and pulp industry has been to reduce labor and energy costs. Very little new capacity has been created. Current capacity utilization rates reported for this industry are over 98 percent. Partly as a result of this shift in investment, the profitability of the industry has completely turned around from its trough.

The performance of industry has shown that adjustment of production techniques to changing condition is slow. Improved efficiency is made at the margin, as new facilities are built. Old capacity can be a hindrance to new investment. International competition favors those newly industrializing countries where the most appropriate technology can be deployed. Since the most profitable plants will be utilized more intensively, the decline of profitability in the industrialized West and newly emerging patterns of international trade can also be explained by difference in vintage characteristics. Indeed, foreign direct investment is attracted to countries and sectors with a low rate of return on old capital but a high rate of return on new capital. Strategic considerations relating to trade policy notwithstanding, substantial Japanese investment in the US auto industry in recent years can be explained along these lines. The implication is that the traditional measures of return to capital which equates the productivity of old and new capital may be seriously misleading in the prediction of international capital flows.

Even though the international repercussions of vintage differences are an important issue for future research, it can be agreed that, in the words of Fabbri (1984) foreign penetration forces "a portion of business' net investment to be siphoned into 'slenderizing' existing plant."

This view, which has been used in recent analytical work by Malinvaud (1983), also underlies the model of Faini and Schiantarelli (1984), tested using data for the Italian industrial sector. Earlier contributions to this way of thinking can be found in Kouri, Macedo and Viscio (1982), where a vintage model of supply is applied to the French manufacturing sector. The model is, however, solved with a particular parametrization and no fixed factors were allowed for in the theoretical treatment, even though fixed labor was found to be significant in the application to France. The treatment of technological progress is also restrictive.

We now solve the general case of N variable factors and $\bar{N}$ fixed factors with embodied and disembodied technological progress in Section I and simulate the model using previously unavailable data on a subsector of French manufacturing from 1959 to 1980 in Section II. While many of the considerations mentioned above are not yet fully reflected in the model presented here, they do provide a motivation for the approach. Moreover, they are intended to outline a research agenda.

I The Model

Think of an industry as a collection of plants, characterized by their capacity, unit input requirements, and flexibility (ratio of fixed to variable costs). These characteristics are chosen at the time of construction, and they cannot be changed *ex post*. Plant characteristics do, however, vary over the life span of the plant because of depreciation, learning by doing, and disembodied technological progress.

Time is divided into discrete production periods, during which the stock of capital remains fixed. The flow of capital services during the period is the product of the stock of capital at the beginning of the period and the time of its active use, or the rate of utilization. The level of employment is similarly fixed during the production period, while labor input can vary.

Once a plant has been constructed, there are two levels of choice: firstly, whether or not the plant should be operated, shut down temporarily, or permanently scrapped; and secondly, if it is operated, what the rate of utilization of capacity should be. We assume that there is a maximum capacity *ex post*, and that output increases at a diminishing rate as that maximum is approached. The actual rate of utilization is determined by short run profit maximization.

We assume that the capacity of the plant, and the technology coefficients, are chosen at the time of construction so as to maximize the present discounted value of profits over the lifetime of the plant. Factor prices as well as the price of output are exogenously given to the firm. Total investment is also given exogenously in each period, and the decision is on how it is allocated between capacity creation, labor saving, energy saving, and so forth. This decision determines dynamic supply and factor demand schedules, which are functions of the time path of investment, and of output prices and factor costs, both actual and expected at the time of construction. We sketch in the conclusion a procedure to make investment endogenous.

In general, there is no simple production function representation of the supply side, nor can the economy be described in terms of a representative plant. Plants of different vintage differ because of changes in prices and costs, and because of embodied technological progress. The model is able to characterize these differences in a manageable way, and also capable of assessing their quantitative significance.

The model is first derived for the case of N variable factors and compared to the standard putty-putty model. Fixed factors are introduced next.

1. N variable factors

Consider a single plant built in period i with an initial investment I_i. Output during the production period t, $X_{i,t}$, is given by:

(1) $$X_{i,t} = q^k_{i,t}\, y_i\, \phi(u_{i,t})\, I_i$$

where $u_{i,t}$ = the rate of utilization

y_i = the output-capital ratio chosen at the time of construction

$q^k_{i,t}$ = a productivity coefficient capturing the effects of depreciation, learning by doing and technological progress

The only inputs in the production process are variable factors. Factor j input requirement in production period t, $Z^j_{i,t}$, is given by:

(2) $$Z^j_{i,t} = q^{a^j}_{i,t}\, a^j_i\, u_{i,t}\, I_i \qquad j = 1, \ldots, N$$

where a^j_i = input j-capital ratio chosen at the time of construction

$q^{a^j}_{i,t}$ = productivity coefficient capturing the effect of depreciation, learning by doing and technological progress on input j

To reduce the number of the parameters, we assume that the productivity of a given plant is a function of time (disembodied technological progress), year of construction (embodied technological progress), and age (learning by doing and depreciation). Then $q^{k}_{i,t}$ and $q^{a^j}_{i,t}$ are products of three parameters:

$$(1') \qquad q^{k}_{i,t} = {}^{1}q^{k}_{t} \; {}^{2}q^{k}_{i} \; \delta(t - i)$$

$$(2') \qquad q^{a^j}_{i,t} = {}^{1}q^{a^j}_{t} \; {}^{2}q^{a^j}_{i} \; \delta(t-i)$$

where ${}^{1}q^{k}_{t}$ and ${}^{1}q^{a^j}_{t}$ measure disembodied technological progress,

${}^{2}q^{k}_{i}$ and ${}^{2}q^{a^j}_{i}$ measure embodied technological progress;

and $\delta(t - i)$ measures the effect of age (learning and depreciation).

The first term applies to all vintages equally; the last two terms are a source of difference between vintages.

Variable costs and profits (in units of output) add up to the value of output each period:

$$(3) \qquad X_{i,t} = VC_{i,t} + \Pi_{i,t}$$

where $VC_{i,t} = \sum_{j=1}^{N} Z^{j}_{i,t} \, w^{j}_{i,t}$

$w^{j}_{i,t}$ = the price of input j in units of output

and $\Pi_{i,t}$ = profits in units of output

Finally, technology is defined by:

$$(4) \qquad y_i = F(a_i^1, a_i^2, \ldots, a_i^N, 1)$$

where $F(\{a_i\},1)$ is a standard neoclassical production function, with marginal products defined as F_j and F_k.

A useful benchmark is provided by the case where y_i and a_i^j can be chosen every production period: technology is putty-putty. Then, substituting from equations (1) and (2) into (4) we express output as:

$$(5) \qquad X_{i,t} = F(\{q_{i,t}^{n^j} \frac{\phi(u_{i,t})}{u_{i,t}} Z_{i,t}^j\}; q_{i,t}^k \phi(u_{i,t}) I_i)$$

where $q_{i,t}^{n^j} = q_{i,t}^k / q_{i,t}^{a^j}$ captures the effect of j factor-augmenting technological progress

Substituting (5) in (3) and maximizing profits, we find that the rate of utilization should be chosen every period so as to maximize output. This optimally chosen rate of utilization, $u_{i,t}^*$, which can be called the normal rate, satisfies:

$$(6) \qquad \frac{\varepsilon(u_{i,t}^*)}{1-\varepsilon(u_{i,t}^*)} = \frac{VC_{i,t}}{\Pi_{i,t}}$$

where ε is the elasticity of the capacity utilization function assumed to have a unique maximum, $\bar{u}$.

As an example, consider the following parametrization:

$$(7) \qquad y_i = \prod_{j=1}^{N} (a_i^j)^{\alpha_j}$$

where $\sum_{j=1}^{N} \alpha = 1 - \sigma$

$$(8) \qquad \phi(u_{i,t}) = u_{i,t}(\bar{u} - \frac{1}{2} u_{i,t})$$

Then (6) implies that the optimal rate of capacity utilization is constant and given by equation (21) in Kouri, Macedo and Viscio (1982), reproduced below:

$$(9) \qquad u_i^* = \frac{2\sigma}{1+\sigma} \bar{u}.$$

Except for the Cobb-Douglas case, u_i^* is a function of the capital intensity of production and therefore of factor prices and technology coefficients.

In the putty-putty case, the plant is always operated at the normal rate. We can therefore solve u_i^* out of equation (5) to obtain a conventional production function:

$$(10) \qquad X_{i,t} = G(\{q_{i,t}^{n^j} \ Z_{i,t}^j\}, q_{i,t}^k \ I_i)$$

Thus the concepts of capacity and capacity utilization play no role in a putty-putty model of production. Equation (10) shows that there is no maximum capacity. Output can always be increased by employing more labor. Similarly, there is no role for expected future factor prices.

In contrast, with putty-clay technology, expectations about the future become important in determining the optimal choice of technology since decisions made at the time of construction cannot be revised. We denote by a_i^j and y_i the technology coefficients chosen in period i for a plant of vintage i. The expected time path of the product wage is denoted by $\{\tilde{w}_{i,t}\}$ and that of the productivity coefficients by $\{\tilde{q}_{i,t}^{n^j}\}$ and $\{\tilde{q}_{i,t}^k\}$. Given expectations, the firm chooses a_i^j and y_i so as to maximize the expected present discounted value of profits over the planned lifetime of the plant:

$$(11) \qquad V_{i,i} = \max \sum_{t=i}^{T_i} \tilde{\Pi}_{i,t} (1 + R_{i,t})^{-t},$$

where $\tilde{\Pi}_{i,t} = [\tilde{q}^{k}_{i,t}\, y_i\, \phi(\tilde{u}_{i,t}) - \sum_{j=1}^{N} \tilde{q}^{aj}_{i,t}\, a^j_i\, \tilde{u}_{i,t}\, \tilde{w}^j_{i,t}]\, I_i$

is the expected profit in period t

and $R_{i,t}$ is the appropriate t-period market rate of capitalization prevailing in period i.

The maximization problem in (11) is subject to the technology constaint given by (4). The choice variables are a^j_i and y_i. In addition, the optimal solution implies optimal planned rates of utilization, denoted by $\tilde{u}_{i,t}$ for each period. These are conditional on expectations prevailing in period i. The utilization rate must obviously be non-negative: this is an additional constraint of the maximization problem.

The optimal plan must satisfy the following first-order conditions:

$$(12) \qquad \tilde{q}^{k}_{i,t}\, \phi'(\tilde{u}_{i,t})\, y_i = \sum_{j=1}^{N} a^j_i\, \tilde{q}^{aj}_{i,t}\, \tilde{u}_{i,t}\, \tilde{w}^j_{i,t}$$

for $t = i, \ldots, T_i$; and

$$(13) \qquad \{\sum_{t=i}^{T_i} \tilde{q}^{k}_{i,t}\, \phi(\tilde{u}_{i,t})(1+R_{i,t})^{-t}\} F_j(a^j_i, 1) = \sum_{t=i}^{T_i} \tilde{q}^{aj}_{i,t}\, \tilde{u}_{i,t}\, \tilde{w}^j_{i,t}(1+R_{i,t})^{-t}$$

These equations may not have a positive solution for $u_{i,t}$ in some periods when the unit factor cost is very high. In that case, the optimal policy is to set $u_{i,t}$ equal to zero. Since there are no fixed costs, the plant is never shut down permanently except when $u_{i,t}$ is nonpositive for all t after some period T_i. The planned life span of the plant is therefore such that $\tilde{\Pi}_{i,t}$ is nonnegative for all t greater than T_i.

Equations (12) and (13) determine a_i^j and y_i as functions of the expected time paths of factor prices and productivity coefficients in period i:

$$(14) \qquad a_i^j = \psi_a^j\,(\{\tilde{w}^j_{i,t}\},\ \{\tilde{q}^k_{i,t}\},\ \{\tilde{q}^{a^j}_{i,t}\},\ \{R_{i,t}\})$$

$$(15) \qquad y_i = \psi_y(\{\tilde{w}^j_{i,t}\},\ \{\tilde{q}^k_{i,t}\},\ \{\tilde{q}^{a^j}_{i,t}\},\ \{R_{i,t}\})$$

where $\quad t = i,\ i + 1,\ \ldots,\ T_i$,

and $\quad j = 1,\ \ldots,\ N$.

The optimal program also entails an optimal time path for $\tilde{u}_{i,t}$:

$$(16) \qquad \tilde{u}_{i,t} = \psi_u(\{\tilde{w}^j_{i,t}\},\ \{\tilde{q}^k_{i,t}\},\ \{\tilde{q}^{a^j}_{i,t}\},\ \{R_{i,t}\})$$

In general, the functions denoted by ψ_a^j, ψ_y and ψ_u have no closed form representation. Using the parametrization in (7) and (8) above with labor and energy as variable factors, Kouri, Macedo and Viscio (1982) present an explicit solution for the case of static expectations as well as for the case where there are no expected changes in relative factor prices. Macedo (1983) presents an explicit solution for the case where relative factor prices are expected to vary.

Once the plant has been constructed, the only flexibility is the choice of the rate of utilization. For a plant of vintage i the actual rate of utilization in period t, $u_{i,t}$ is determined by:

$$(17) \qquad q^{k}_{i,t}\ \phi'(u_{i,t})\ y_i = \sum_{j=1}^{N} a^{j}_{i}\ q^{a^j}_{i,t}\ u_{i,t}\ w^{j}_{t}$$

if $\qquad \Pi_{i,t} = [q^{k}_{i,t}\ y_i\ \phi(u_{i,t}) - \sum_{j=1}^{N} q^{a^j}_{i,t}\ a^{j}_{i}\ u_{i,t}\ w^{j}_{t}]\ I_i > 0$

or $\qquad u_{i,t} = 0$

if $\qquad \Pi_{i,t} \leq 0$

Comparing equations (17) and (12), it is seen that the actual rate of utilization is equal to the planned ex ante rate of utilization, $\tilde{u}_{i,t}$, only if expectations concerning $w^{j}_{i,t}$, $q^{k}_{i,t}$ and $q^{a^j}_{i,t}$ turn out to be correct. Indeed, the only difference is that (17) is expressed in terms of realized productivities and input costs rather than in terms of their expected values (denoted by a tilde over the variable).

It is convenient to write the rate of utilization as a function of the ratio of technology coefficients and effective unit input costs:

$$(18) \qquad u_{i,t} = \max\ \{\rho[a^{j}_{i}/y_i)\ w^{j}_{t}/q^{n^j}_{i,t}],\ 0\}$$

where $\qquad a^{j}_{i}$ and y_i are determined by equations (14) and (15).

The aggregate supply function can now be written by summing over plants of all vintages in operation, to yield:

$$(19) \qquad X_t = \sum_{i=T_t}^{t} q^{k}_{i,t}\ y_i\ \phi(u_{i,t})\ I_i,$$

where $\qquad u_{i,t}$ is determined by (18)

$\qquad y_i$ is determined by (15)

and $\qquad T_t$ is the year of construction of the oldest plant still in operation in period t.

The aggregate input demand functions are similarly obtained by summation across vintages. They are given by:

$$Z_t^j = \sum_{i=T_t}^{t} q_{i,t}^{a^j} a_i^j u_{i,t} I_i, \tag{20}$$

and $u_{i,t}$ by equation (18)

where a_i^j is determined by equation (14)

2. Fixed Factors and Economic Obsolescence

When all costs, apart from sunk capital costs, are variable, there is never any reason for plants to be shut down since it does not cost anything to keep them alive. The situation changes when it is costly to keep a plant alive. To integrate this feature into the model, denote the $\bar{N}$ fixed factors by $\bar{Z}^j$ and their prices by $\bar{w}^j$. The associated productivity coefficients are denoted by $\bar{a}^j$ and $\bar{q}^{a^j}$. By their very nature, fixed input requirements do not change over the lifetime of the plant. They are proportional to initial investment:

$$\bar{Z}_{i,t}^j = \bar{q}_{i,t}^{a^j} \bar{a}^j I_i \qquad \text{for } j = 1, \ldots, \bar{N}, \tag{21}$$

The rest of the model remains basically unchanged, but now the firm has one more choice with respect to a plant already built (with given y_i, a_i^j and $\bar{a}_i^j$). The choices are: (a) to produce, (b) not to produce but still keep the plant alive; and (c) to shut the plant down.

If the plant continues to produce, the rate of utilization is chosen so as to maximize $X_{i,t} - VC_{i,t}$. The relevant first-order condition is exactly the same as before and given by equation (12) above. We denote the rate of profit associated to this choice by ${}^{1}\Pi_{i,t}$:

(22) $$ {}^{1}\Pi_{i,t} = X_{i,t} - VC_{i,t} - FC_{i,t} $$

where $$ FC_{i,t} = \sum_{j=1}^{\bar{N}} \bar{Z}^{j}_{i,t} \, \bar{w}^{j}_{t} $$, fixed cost of keeping plant in operation

The second choice is not to produce, but still keep the plant alive. The rate of loss ${}^{2}\Pi_{i,t}$ is then:

(23) $$ {}^{2}\Pi_{i,t} = - FC_{i,t} $$

The second choice dominates the first if $X_{i,t} - VC_{i,t}$ is negative.

We denote by $\Pi_{i,t}$ the maximum of ${}^{1}\Pi_{i,t}$ and ${}^{2}\Pi_{i,t}$:

(24) $$ \Pi_{i,t} = \max \{{}^{1}\Pi_{i,t}, {}^{2}\Pi_{i,t}\}. $$

The third alternative is to shut the plant down. This is optimal if $V_{i,t}$ is negative where $V_{i,t}$ is given by:

(25) $$ V_{i,t} = \max_{T} \sum_{\tau=t}^{T} \tilde{\Pi}_{i,\tau} \, (1 + R_{i,T})^{-\tau} $$

We can now give a complete characterization of the supply side as far as existing plants are concerned:

(1) Compute $\{{}^{1}\tilde{\Pi}_{i,t}\}$, $\{{}^{2}\tilde{\Pi}_{i,t}\}$ and $\{\tilde{\Pi}_{i,t}\}$ for all plants still in operation. From these compute $V_{i,t}$.

(2) Shut down all plants for which $V_{i,t}$ is negative.

(3) If $V_{i,t}$ is positive there are two choices:

(i) If ${}^{2}\Pi_{i,t}$ is greater than ${}^{1}\Pi_{i,t}$, set production equal to zero.

(ii) If ${}^{1}\Pi_{i,t}$ is greater than ${}^{2}\Pi_{i,t}$ the rate of utilization is determined by equation (17) above.

Total output is then simply the sum of outputs of all active plants. The total demands for variable inputs are the sums of input requirements of all active plants. Finally, the total demands for variable inputs are the sums of fixed input requirements of all plants that are alive.

The problem of technology choice at the time of construction also changes when there are fixed factors. Technology is now defined by:

(4') $$y_i = F(a_i^j,\ \bar{a}_i^j,\ 1),$$

where F( ) is a standard neoclassical production function.

When technology is putty-putty, adapting the notation in (5), output is expressed as:

(5') $$X_{i,t} = F[\{q_{i,t}^{n^j} \frac{\phi(u_{i,t})}{u_{i,t}} Z_{i,t}^{j}\};\{\bar{q}_{i,t}^{n^j}\phi(u_{i,t})\ Z_{i,t}^{-j}\};q_{i,t}^{k}\ (u_{i,t})I_i]$$

As before, the normal rate of utilization is obtained from (5') by maximizing $X_{i,t}$ with respect to $u_{i,t}$. It satisfies an equation like (6) above, but allowing for fixed costs:

(6') $$\frac{\varepsilon\ (u_{i,t}^{*})}{1 - \varepsilon(u_{i,t}^{*})} = \frac{VC_{i,t}}{\Pi_{i,t} + FC_{i,t}}$$

In the case of putty-clay technology, the coefficients y_i, a_i^j, $\bar{a}_i^j$ as well as the planned lifetime $\tilde{T}_{i,i}$ and the planned rates of utilization $\tilde{u}_{i,t}$ are chosen so as to maximize the present discounted value of expected profits as given by (11) above.

We now solve this problem in two stages. First we solve:

$$(26) \qquad V_{i,i}\,(T_{i,i}) = \max \sum_{t=i}^{T_{i,i}} \tilde{\Pi}_{i,t}\,(1 + R_{i,t})^{-t}$$

Then we choose $T_{i,i}$ so as to maximize $V_{i,i}$:

$$(27) \qquad V_{i,i} = \max_{T_{i,i}} V_{i,i}\,(T_{i,i})$$

The first order conditions of the maximization problem are given by (12) if ${}^1\tilde{\Pi}_{i,t} > {}^2\tilde{\Pi}_{i,t}$, and by $\tilde{u}_{i,t} = 0$ if ${}^1\tilde{\Pi}_{i,t} < {}^2\tilde{\Pi}_{i,t}$.

The a_i^j coefficients must satisfy (13) and the $\bar{a}_i^j$ coefficients must satisfy its equivalent for fixed factors, written as:

$$(28) \qquad \{\sum_{t=i}^{T_{i,i}} \tilde{q}_{i,t}^{k}\,\phi(\tilde{u}_{i,t})(1 + R_{i,t})^{-t}\}\,F_j\,(a_i^j,\,\bar{a}_i^j,\,1) =$$

$$\sum_{t=i}^{T_{i,i}} \bar{q}_i^{a^j}\,\tilde{\bar{w}}_{i,t}^{j}\,(1 + R_{i,t})^{-t} \qquad \text{for } j = N+1,\ \ldots,\ N + \bar{N}$$

These four equations determine $V_{i,i}$, y_i, a_i^j and $\bar{a}_i^j$ as functions of $\{\tilde{w}_t\}$, $\{\tilde{\bar{w}}_t\}$, $\{\tilde{q}_t^k\}$, $\{\tilde{q}_t^{a^j}\}$, $\{\tilde{\bar{q}}^{a^j}\}$, $\{R_t\}$ and the lifespan of the plant $T_{i,i}$. They also imply an optimal time path for $\tilde{u}_{i,t}$, as in (16) above. The final step is to iterate on $T_{i,i}$ to obtain the maximum maximorum of $V_{i,i}$. The associated values of y_i, a_i^j and $\bar{a}_i^j$ are the optimal choices of technology at the time of construction.

III. Simulation Results for France

The model presented in the previous section has been simulated for the French intermediate goods manufacturing sector (branch U04). The purpose of this exercise is to study the behavior of the model and to measure its ability to replicate the historical evolution of output and factor demands in a particular subsector of French manufacturing.

The basic series are reported in the Data Appendix. The data on output, materials and energy consumption are expressed in billions of 1970 francs, series (1) through (3) in the Appendix. The series for labor was obtained as follows. First, by multiplying employment by average hours worked in the subsector and the number of weeks in one year, we obtain series (4) in the Appendix, expressed in billions of man-hours per year. We then use total labor compensation in the subsector (wages, employees' social security contributions and fringe benefits) for the base year 1970 and divide it by the man-hours series to obtain the wage rate in the year. The adjustment coefficient comes out to 10.37 francs per man-hour.

In the simulation, a number of assumptions need to be made concerning expectations about productivity and factor prices in units of output. These are listed in Table 1. As mentioned by Mairesse and Dormont (1985), at this level of disaggregation nominal prices of factors in manufacturing probably introduce a bias in the results. In part as a consequence, they are inclined to neglect their importance. These difficulties notwithstanding, we interpret our results as supporting a view where both expected and actual factor prices play a crucial role, as emphasized in Macedo (1985).

The prices of output, materials and energy are reported in the Data Appendix, series (6) through 8, while series (9) therein reports the wage in units of output. By multiplying this series by series (6), it is easy to see that labor compensation increases by more than energy, reaching 400 in 1980 from the base 100 in 1970. This implies a growth

Table 1
Assumptions

Technological Progress: (per annum)

${}^{1}q^{k} = .002$

${}^{1}q^{\ell} = .005$

${}^{1}q^{m} = {}^{1}q^{e} = 0$

${}^{2}q^{k} = .01$

${}^{2}q^{\ell} = .01$

${}^{2}q^{m} = {}^{2}q^{e} = .005$

Expectations: (rates of increase per year)

	1959-73	1974-80
nominal wages	.09	.13
prices of output, materials and energy	.03	.08

$\bar{u} = 1 \quad \delta = .05 \quad R = .10$

rate of about 5% p.a. for the product wage. Note that this is the expectations assumption of Table 1 for the period 1974-1980.

Aggregate values for output, employment, energy consumption, and intermediate goods consumption generated by the model (denoted by $S_{i,t}$) are obtained by summing across vintages in each year. These values differ from historical data (denoted by $A_{i,t}$) by a scale parameter β_i. The model's simulated values are then regressed against actual values, as a four-equation system, after allowing for first-order autocorrelation in the error term:

(29) $$S_{i,t} = \beta_i A_{i,t} + \nu_{i,t}$$

where $$\nu_{i,t} = \rho_i \nu_{i,t-1} + \mu_{i,t}$$

The estimated values of β_i and ρ_i are reported in Table 2. The coefficient of autocorrelation is particularly high in the energy equation, where the standard error is also highest. The employment equation, on the other hand, shows no autocorrelation.

From the simulated values thus obtained, a dynamic simulation (denoted by $DS_{i,t}$) is run using 1959 actual values as a base and adjusting the values as:

(30) $$DS_{i,t} = \rho_i DS_{i,t-1} + \beta_i(S_{i,t} - \rho_i S_{i,t-1})$$

The dynamic simulations are reported in the Data Appendix, series (10) through (12). A plot of the fitted versus actual values (Graphs 1 through 3) shows that the model is able to capture the evolution of output and factor demands. Note that the fitted output series is off in the first year but it follows the actual series consistently. The graph of intermediate inputs is not shown because it replicates almost exactly

Table 2

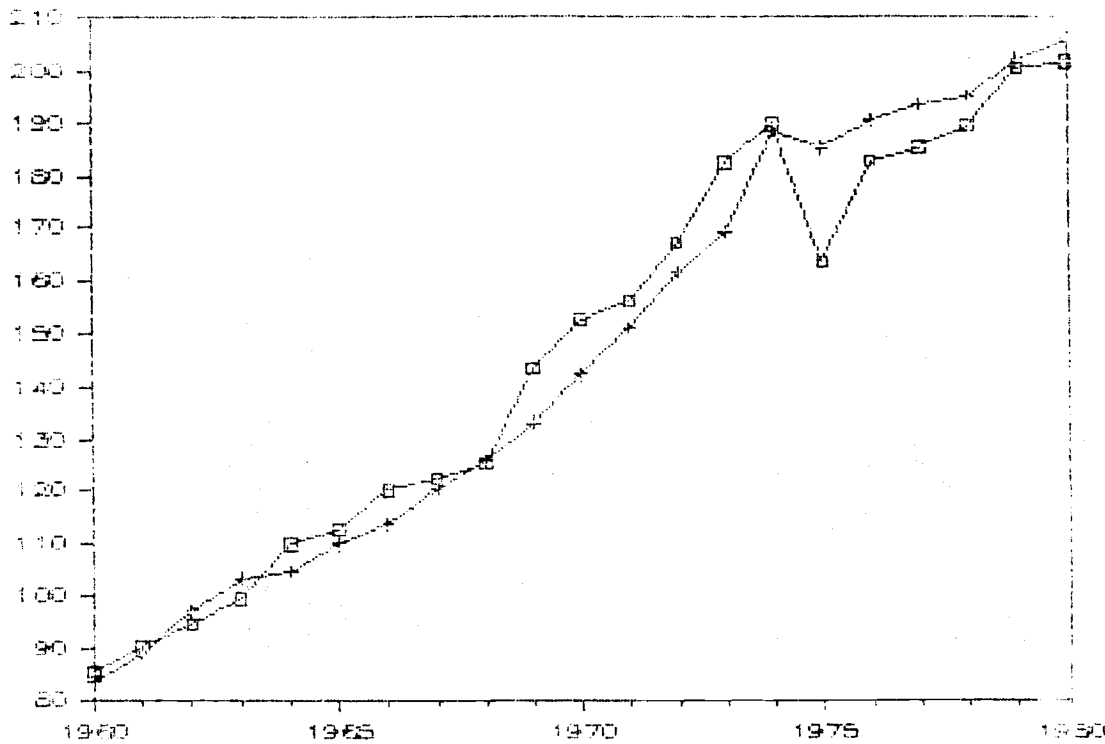
Model Results

Equation	Coefficient	Standard Error	Coefficient of Auto Correlation
Output	9.36	.024	0.46
Employment	10.24	.038	0.0
Energy	9.34	.462	0.85
Materials	8.95	.027	0.46

Graph 1

Output

(billions of 1970 francs)



__________Actual

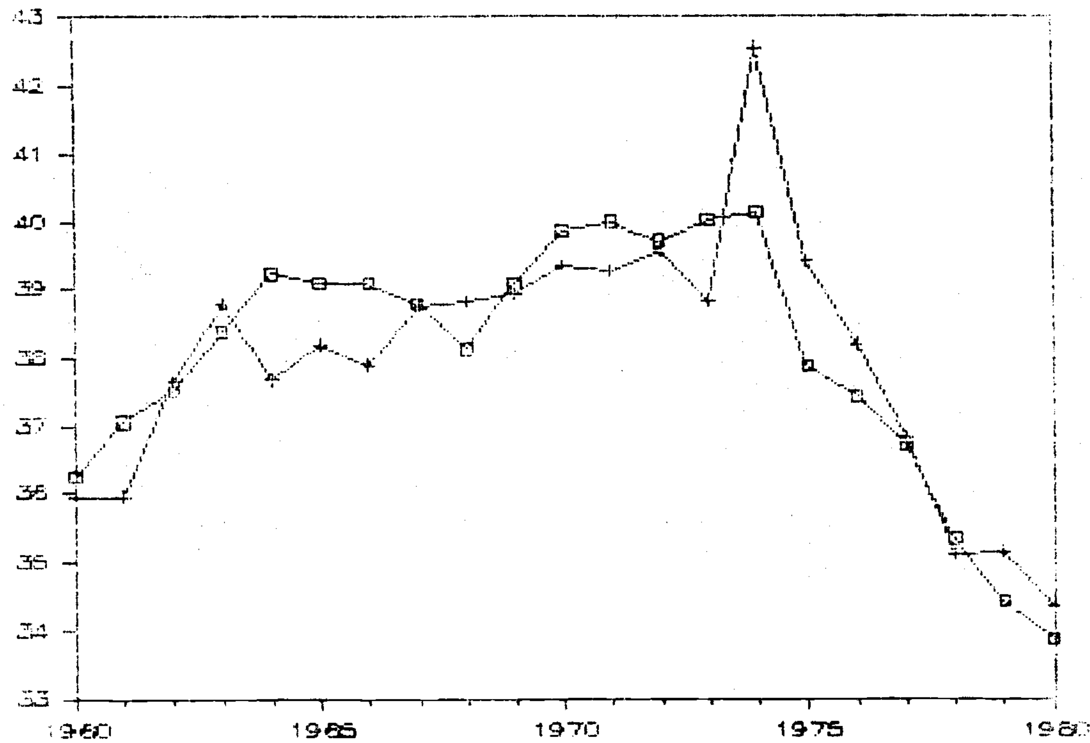
+++++++++Fitted

Source: Series (1) and (10) in Data Appendix.

Graph 2

Employment

(billions of 1970 francs)



_______Actual

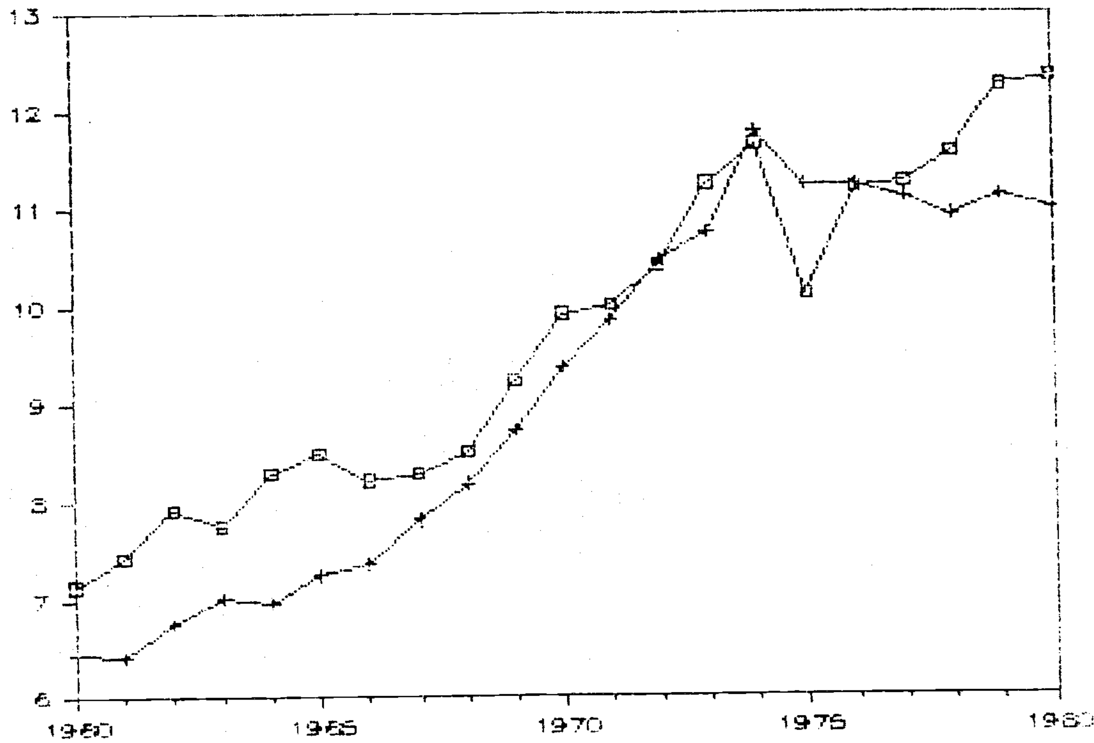
+++++++Fitted

Source: Series (4) times 10.37 and Series (13) in Data Appendix.

Graph 3

Energy

(billions of 1970 francs)



________Actual

+++++++Fitted

Source: Series (3) and (12) in Data Appendix.

the one for output: series (6) and (7) in the Data Appendix show how close prices were during the sample period. This implies that working with value-added is a good approximation, as argued in Kouri, Macedo and Viscio (1982, note 12).

The putty-clay aspect of the model can be seen in the changes in the technology parameters in Table 3. The evolution of a_V and b_V shows that, when factor prices are increasing, firms will economize by increasing the efficiency of that factor. In response to a 50% increase in wages, the labor-capital ratio declined by about 20% from 1970 to 1980. Note that the unit requirement for intermediate materials increases over this period. The increase in materials cost combined with embodied technological progress (which decreases wage costs) accounts for the relative stability in the coefficient of output, y.

Both utilization and profits (operating surplus) decline over time in each vintage, see table 4. From 1959 to 1980, for example, the profit of that vintage falls to one-half of its initial value, while utilization falls to one-fourth. The decline in profitability due to age of a vintage is caused by two factors: the physical depreciation of the initial investment which reduces output, but not fixed costs; and factors costs rising above expectation, which lowers utilization rates. This is clear after 1974, where utilization in 1980 is lower than for the 1973 vintage, and the profit rate is higher.

Measures of profitability are reported in Table 5. The return on sales (or rate of profit) and the return on assets. The latter is computed as aggregate operating surplus divided by aggregate capital stock. A downward drift in rates of return is evident. The decline is due to costs increasing faster than revenues. The lower initial

Table 3

Technology Parameters

	a_V $*10^2$	a_F $*10^4$	b_V $*10^2$	b_F $*10^4$	c $*10^2$	y $*10^2$
1959	11.4	2.5	1.9	0.4	17.2	38.8
1960	11.4	2.4	2.0	0.4	17.2	38.5
1961	10.8	2.4	2.1	0.4	16.9	38.2
1962	10.4	2.2	2.2	0.4	17.6	38.5
1963	10.3	2.2	2.3	0.5	18.1	38.8
1964	9.8	2.1	2.3	0.5	17.7	38.2
1965	9.5	2.0	2.4	0.5	18.1	38.4
1966	9.3	2.1	2.3	0.5	18.1	38.3
1967	9.0	1.9	2.5	0.5	18.8	38.6
1968	8.6	1.8	2.6	0.5	19.3	38.7
1969	8.2	1.8	2.7	0.5	19.7	38.7
1970	8.0	1.7	2.7	0.5	19.9	38.7
1971	7.6	1.6	2.5	0.5	20.4	38.6
1972	7.3	1.6	2.5	0.5	21.0	38.7
1973	6.6	0.8	2.3	0.5	20.7	37.8
1974	7.7	0.9	2.2	0.2	21.3	38.8
1975	6.8	0.8	2.0	0.2	22.1	38.4
1976	6.5	0.7	2.0	0.2	22.5	38.4
1977	6.3	0.8	2.0	0.2	23.0	38.4
1978	6.0	0.7	2.0	0.2	23.4	38.4
1979	6.2	0.8	2.0	0.2	24.0	38.8
1980	6.3	0.8	1.8	0.2	24.1	38.9
Memo: Shares in production (%):	24.5	.5	6.9	.1	50.0	

Table 4

Utilization and Profits by Age of Plant

(Selected Vintages)

		1959	1966	1973	'74	'75	'76	'77	'78	'79	'80
	t(years)	1	8	15	16	17	18	19	20	21	22
1959	u(%)	36.1	27.8	17.5	20.0	16.3	13.9	12.0	9.7	9.4	8.5
	Π(%)	21.8	17.0	12.0	12.0	11.9	11.9	11.8	11.8	11.7	11.0
	t		1	8	9	10	11	12	13	14	15
1966	u		36.0	29.6	30.9	28.6	27.7	26.9	25.6	24.0	23.8
	Π		22.8	19.3	19.3	19.3	19.2	19.2	19.2	19.2	19.2
	t			1	2	3	4	5	6	7	8
1973	u			37.2	37.7	26.6	35.6	34.8	33.9	33.7	32.6
	Π			22.8	21.8	21.0	20.4	19.6	19.5	18.7	18.7
	t				1	2	3	4	5	6	7
1974	u				37.3	36.0	35.9	34.0	33.0	32.8	31.8
	Π				22.8	22.1	21.5	20.9	20.7	20.0	20.0
	t					1	2	3	4	5	6
1975	u					37.2	36.3	35.6	34.7	34.5	33.5
	Π					22.8	22.3	21.7	21.5	20.8	20.8
	t						1	2	3	4	5
1976	u						37.2	36.6	35.8	35.0	34.5
	Π						22.8	22.3	22.1	21.4	21.4
	t							1	2	3	4
1977	u							37.2	36.5	36.3	35.3
	Π							22.8	22.6	21.9	21.9
	t								1	2	3
1978	u								37.2	37.0	36.0
	Π								22.8	22.1	22.1
	t									1	2
1979	u									37.3	36.3
	Π									22.8	22.1
	t										1
1980	u										37.3
	Π										22.8

Table 5

Rates of Return (%)

	(1) On Sales	(2) On Assets
1959	21.8	23.3
1960	21.0	21.9
1961	19.9	20.1
1962	20.0	20.3
1963	19.9	20.2
1964	18.7	18.4
1965	18.6	18.3
1966	18.0	17.4
1967	18.3	17.8
1968	18.1	17.7
1969	17.9	17.4
1970	17.7	17.2
1971	17.4	16.8
1972	17.5	17.0
1973	17.4	16.7
1974	18.6	19.1
1975	17.8	17.6
1976	17.6	17.3
1977	17.6	17.1
1978	17.5	16.8
1979	17.8	17.5
1980	17.7	17.4

(1) Π_t / X_t

(2) $\Pi_t / \sum_{i=\tau}^{t} I_i \, \delta^{\tau - i}$

utilization places the firm on a lower portion of the marginal cost curve, but profitability is still not fully recovered. Note that the profit of a 1980 vintage is 23%, whereas the average rate is only 18%.

The shift in labor demand can be seen in Chart 4 where the demand for labor in 1973 and in 1980 is aggregated across vintages. Both demand curves are almost coincident despite the larger capacity in 1980. However, recall from table 3 that the coefficient of labor has been declining considerably since 1973. The shift in the demand for labor can also be seen by comparing employment of 36 billion francs (at the base wage of unit in 1970) for a real wage of 120 in 1973 and 32 billion francs for a real wage of 160 in 1980 (see Appendix Table 1).

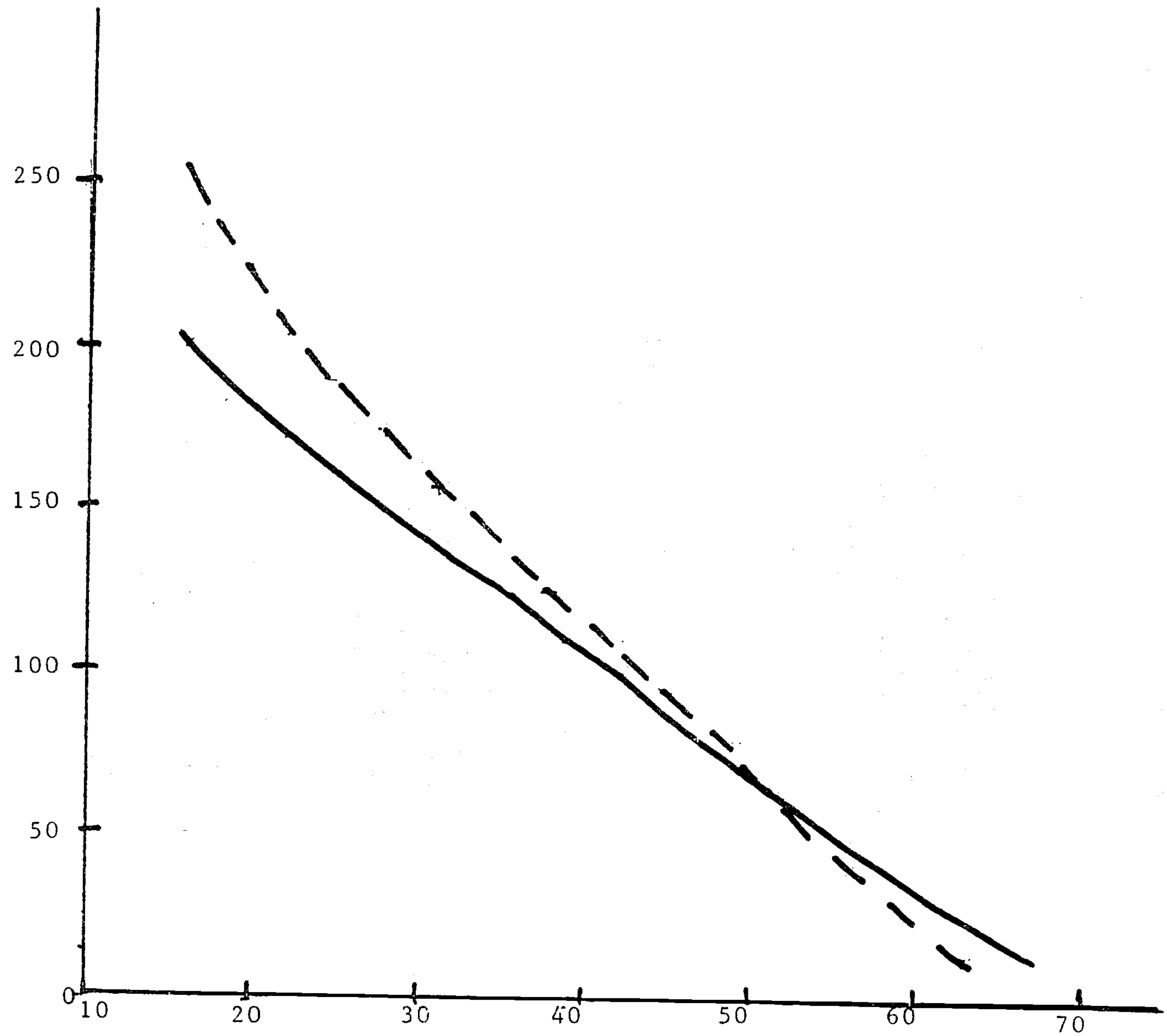
The shift in output supply curves reported in Chart 5 shows less elasticity in 1973 than in 1979. Moreover, despite greater capacity, higher cost shifted the supply curve sharply to the left between the two years. From a supply of 172 billion francs at a price of 110 in 1973, we go to a supply of 200 billion francs at a price of 220 in 1979 (see Appendix Table 2).

Conclusion

The vintage model of supply is able to address issues of profitability and factor demands from the perspective of profit maximization of the firm. Despite the uncertainty as to the appropriate values for expectations and technological progress, the model was able to roughly capture the behavior of a subsector of manufacturing in France. This may be an indication that severe measurement problems need not obscure the relevance of factor prices in explaining the decline of employment and profitability in French manufacturing during the seventies.

Chart 4

Labor Demand Curves



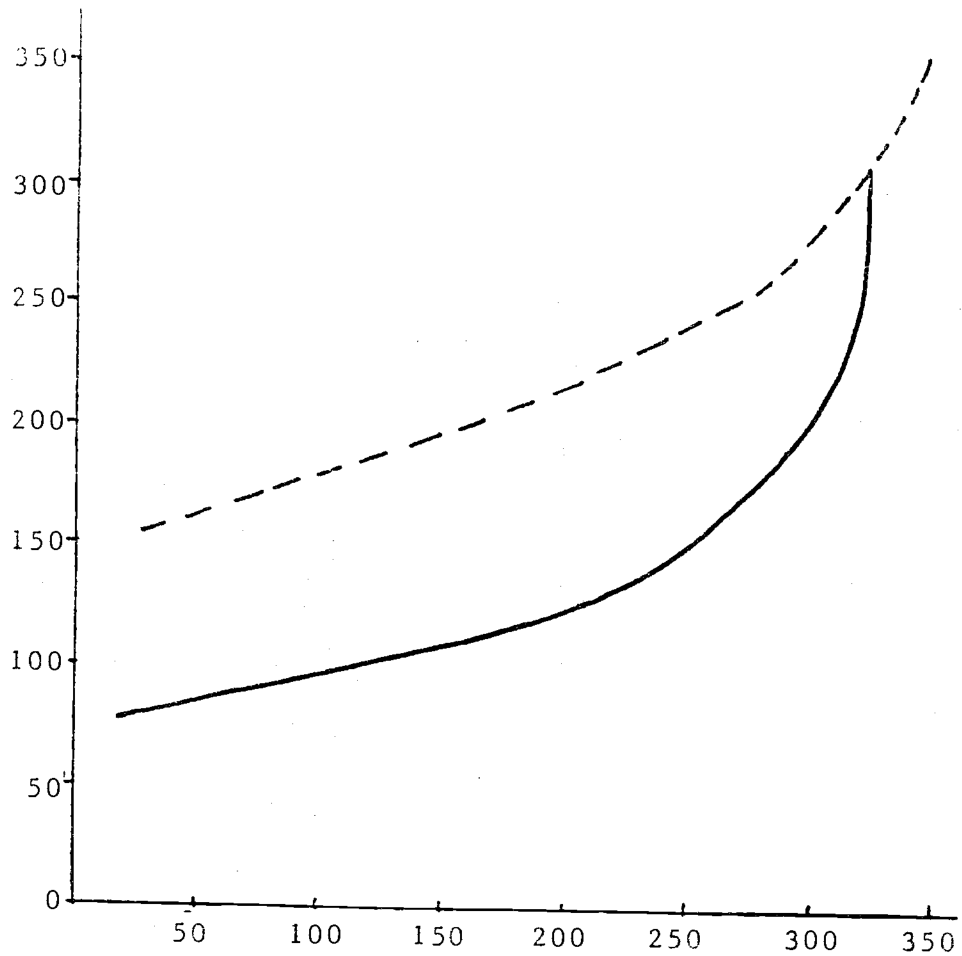
_______ 1973 vintage

------- 1980 vintage

Source: Appendix Table 1

Chart 5

Output Supply Curves



_______ 1973 vintage

------- 1979 vintage

Source: Appendix Table 2

We have argued in this paper that the differentiation between old and new capital by profitability is essential in assessing the "surplus" capacity in many of the industrialized countries. The premature obsolescence of old capital by rising factor costs has both hindered the productive capacity and improved the profit potential for new investment relative to the average rate of return across vintages. Moreover, higher factor costs require a propor-tionately greater amount of gross investment to yield an equivalent output capacity as cost savings investment increases.

The results are, nevertheless, quite tentative and only purport to illustrate the workings of the model. Aside from a more satisfactory treatment of demand, along the lines of Malinvaud (1983) for example, further work remains to be done in parametrizing individual countries and industries.

In addition, the question of whether a plant should be built in the first place must be answered. We merely sketch the argument here. Associated with each investment program inherited from the past, there is an investment plan for the future which, given the price of investment goods, determines the expected supply curves. By netting out the investment cost from the gross value of the firm, one obtains a sequence of expected net values of the firm. The rule is then to increase investment until the ratio of net value to its replacement cost (marginal q) is greater than one. This in turn determines investment and depreciation in each period.

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Appendix Table 1
Labor Demand Curves

1973		1980	
Price	Quantity	Price	Quantity
12	66.5	15	62.7
24	63.1	31	59.3
37	59.6	47	55.8
49	56.2	63	52.3
61	52.8	79	48.9
74	49.3	95	45.4
86	45.9	111	41.9
100	42.5	127	38.4
111	39.1	143	35.0
123	35.6	159	31.5
136	32.2	175	28.0
148	28.7	190	24.6
161	25.3	206	22.2
173	21.9	222	20.1
185	18.5	238	18.1
198	16.4	254	16.2

Note: Computed by using equation (30) in the text with $A_{i,t-1}$ instead of $DS_{i,t-1}$ on a particular vintage and varying the product wage.

Appendix Table 2

Output Supply Curves

1973 price	1973 quantity	1979 price	1979 quantity
79	23.2	154	28.1
91	74.8	176	93.1
102	129.3	198	151.9
114	171.6	220	205.3
125	202.9	242	246.0
137	226.7	264	277.0
148	245.2	286	301.1
159	260.0	308	320.2
171	271.7	330	335.7
182	281.4	354	348.3
194	289.5		
205	301.9		
217	306.8		
228	311.0		
240	314.6		
251	317.8		
263	320.6		
274	323.0		
286	325.2		
297	327.1		

Note: Computed by using equation (30) in the text with $A_{i,t-1}$ instead of $DS_{i,t-1}$ and varying the price of output.

DATA APPENDIX

	(1) Output	(2) Materials	(3) Energy	(4) Labor
1959	75.0	32.0	6.5	3.40
1960	85.3	44.7	7.1	3.50
1961	90.6	46.2	7.4	3.57
1962	94.5	48.4	7.9	3.62
1963	99.3	50.8	7.8	3.70
1964	110.0	54.7	8.3	3.78
1965	112.6	55.2	8.5	3.77
1966	120.0	58.3	8.2	3.77
1967	122.4	59.1	8.3	3.74
1968	125.1	60.4	8.5	3.68
1969	143.5	70.3	9.2	3.77
1970	152.7	73.5	9.9	3.84
1971	156.2	75.2	10.0	3.86
1972	167.1	81.5	10.4	3.83
1973	182.7	89.0	11.3	3.86
1974	189.8	93.6	11.6	3.87
1975	163.8	79.3	10.1	3.65
1976	182.8	88.6	11.2	3.61
1977	185.4	88.3	11.3	3.54
1978	189.3	89.8	11.6	3.41
1979	200.6	96.3	12.3	3.32
1980	201.9	96.9	12.4	3.27

(1) PRRZB4/10^3
(2) CIZ4 - CIZ34/10^3
(3) CIZ34/10^3
(4) EMPTB4 * DH4 * 52/10^6
Source: DMS Data Bank.

DATA APPENDIX (cont'd.)

	(5) Investment	(6) Price of Output	(7) Price of Materials	(8) Price of Energy	(9) Product Wage
1959	80.5	75.7	72.8	88.7	50.1
1960	7.8	77.0	75.1	86.9	53.5
1961	9.5	78.0	77.5	86.8	57.7
1962	10.5	79.5	77.7	87.6	61.8
1963	10.1	81.5	79.6	86.9	64.9
1964	10.0	82.5	82.6	89.1	69.3
1965	10.4	86.7	83.6	88.3	73.3
1966	11.3	84.0	85.1	92.8	76.7
1967	11.0	84.7	84.8	86.7	82.2
1968	11.7	88.2	87.6	88.6	88.5
1969	14.2	91.2	90.5	90.3	95.2
1970	16.4	100.0	100.0	100.0	100.0
1971	17.6	103.3	102.1	115.6	107.7
1972	17.9	105.4	102.9	117.2	116.5
1973	17.3	114.2	113.0	120.9	124.0
1974	15.8	151.7	152.4	176.2	112.1
1975	12.9	161.1	157.2	203.8	129.3
1976	16.8	171.8	167.5	217.8	139.3
1977	13.9	184.0	178.8	242.7	147.3
1978	13.4	195.3	189.2	257.1	157.9
1979	13.0	220.2	214.2	295.8	159.1
1980	13.8	251.3	247.6	380.5	158.9

(5) Base Value in 1959: KBZB4 + KMZB4
Series: IBLZB4 + IMLZB4
(6) Price of output: PRORB4/PRRZB4
(7) Prices of materials: (CIB4 - CI34)/(CIZ4 - CIZ34)
(8) Price of energy: CI34/CIZ34
(9) Product Wage: (SALVS4 + PSOCS4 + CSOCS4)/(4) divided by (6)
Source: DMS Data Bank.

DATA APPENDIX (cont'd.)

	(10) Output	(11) Materials	(12) Energy	(13) Labor
1960	83.2	42.7	6.5	35.9
1961	88.6	44.8	6.4	36.0
1962	96.8	48.7	6.7	37.7
1963	102.9	51.7	7.0	38.8
1964	104.3	51.7	7.0	37.7
1965	109.6	54.0	7.3	38.2
1966	113.2	55.2	7.4	37.9
1967	119.9	58.4	7.8	38.7
1968	125.3	60.8	8.2	38.8
1969	132.6	64.2	8.7	38.9
1970	141.8	68.3	9.4	39.4
1971	150.6	72.4	9.9	39.3
1972	161.3	77.7	10.5	39.6
1973	168.6	81.1	10.8	38.8
1974	187.9	91.1	11.8	42.6
1975	184.6	89.1	11.2	39.4
1976	190.0	91.7	11.2	38.2
1977	192.9	93.2	11.1	36.8
1978	194.3	94.0	10.9	35.1
1979	201.6	97.9	11.1	35.2
1980	253.6	99.5	11.0	34.3

Source: Computed as in equation (30).