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COMPARING PRODUCTIVITY GROWTH: AN EXPLORATION OF FRENCH AND U.S. INDUSTRIAL AND FIRM DATA

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ABSTRACT

This paper compares and analyzes the growth of productivity in the manufacturing industries and firms in France and the U.S. based on newly assembled comparable data sets in both countries. Three explanations of the recent productivity slowdown are reviewed: shortfall in physical investment, rise in materials prices, and a decline in the intensity or fecundity of R&D investment, and found not to bear on the differences in productivity growth between and within the two countries, either at the industry or the firm levels.

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Introduction

The United States, France, and many other industrial countries experienced a significant slowdown in the growth of productivity in the recent decade. This slowdown exacerbated inflationary pressures and contributed to the growing pessimism about the prospects for future economic growth. Its causes are still unclear and controversial. It makes a difference from a policy response point of view whether it was caused by insufficient investment, by rising energy and raw materials prices, or by a decline in the fecundity of R&D and the exhaustion of technological opportunities.[1]

In this paper we bring a comparative perspective to the analysis of some of these issues. To accomplish this we had to assemble and construct consistent and comparable data sets for French and United States manufacturing industries and firms. After a discussion of the respective data sets and a description of the extent of the slowdown in productivity growth in the two countries and the great variability in it, we turn to an analysis of the potential causes of such fluctuations. At the industrial level, we focus on the contribution of capital and the rise in material prices to an explanation of the observed productivity slowdown. At the firm level we look also more closely at the potential effect of R&D expenditures on productivity growth. A number of tentative conclusions close the paper.

I. Productivity Growth at the Industry Level

A. Data and Basic Facts

In this section we focus on comparing total factor productivity growth rates in manufacturing industries at the approximate 2-digit level in both France and the United States. Our industry breakdown (described in the Appendix, Table A1) is somewhat unorthodox. It is the result of trying to match the U.S. SIC classification to the French NAP classification, and was chosen primarily on the basis of the availability of the French data, and secondarily because of our interest in R&D (which led us to subdivide several industries). It differs from the usual 2-digit SIC scheme in the U.S. mainly by the separation of drugs and "parachemicals" from the other chemicals,

the aggregation of several minor industries, and the exclusion of the petroleum refining industry from manufacturing so defined.

The French estimates are based on national accounts publications, augmented by various unpublished data from the "branch" (establishment level) and "sector" (company level) accounts. The U.S. estimates were aggregated from the 4-digit SIC level detail data base constructed by Fromm et al (1979) on the basis of the Census Annual Surveys of Manufactures and National Income account based detailed deflators. Both data sets yield a gross output measure (shipments adjusted for inventory changes) in constant (1972) prices and divide inputs into three categories: labor (man-hours), capital (gross capital stock in constant prices), and purchased materials (intermediate consumption including energy inputs). With each input and output measure we associate a set of price indexes and cost shares. For each of our 15 industries, in both countries, we compute Tornquist Divisia total input indexes and use them to construct Total Factor Productivity (TFP) indexes for the 12-year period, 1967-78, and for two sub-periods: 1967-73 and 1973-78. The final results of these rather extensive computations are given in Table 1 and illustrated in Figure 1.

For the period as a whole, the rate of growth of total factor productivity was higher in France than in the U.S. and this was also true for each industry separately. The median difference was on the order of one percent per year with larger differences occurring in the "heavy" industries (primary Metals, Fabricated Metals, Machinery, and Aircraft and Boats). In both countries productivity slowed significantly in the second sub-period, though here the results are much more variable across industries. For aggregate manufacturing the deceleration was somewhat larger in the U.S. (by about .7 percent).[2]

If we divide the periods so that they are equal in length and independently constructed, i.e., if we use 1967 to 1972 as our first period, we can do an analysis of variance on the resulting 60 TFP growth numbers, using country, period and industry as classification categories. This yields the following estimates: an average TFP growth rate (in both countries across all industries) of 0.8, an average French advantage over the U.S. of 1.5 percent per year, and an average deceleration of 1.0 percent between the two periods. In terms of contribution to the total variance in TFP growth, the most important factors are country and period, with computed F statistics of 25 and 11 respectively (the .05 critical value of the F statistic with 1 and 43 degrees of freedom is about 4). Surprisingly, industrial differences contribute relatively little (the computed F = 1 constrasted to a critical $F_{.95}$ (14,43) of about 2), though individually two industries (electrical equipment and aircraft) have significantly above average TFP growth rates. This is a rather unfortunate finding from our point of view since we had hoped to find consistent and significant differences in the rate of productivity growth across industries which might have provided clues to causes of the productivity slowdown. In fact, no consistent industrial differences emerged, either within or across countries.

If we look at the numbers for the more recent subperiod in Table 1, the biggest difference between the two countries in TFP growth occurs in the chemicals (excluding drugs) industry, while the smallest are in textiles, leather, electrical equipment and drugs. It should be noted here that some of these differences may be spurious, the result of errors in the basic data. The biggest potential source of error comes from the price indexes, which could be both erroneous and improperly associated with the relevant industry output. One becomes suspicious of the numbers when one notices that in the U.S. chemicals industry capital grew by 5.7 percent per year during 1973-78, materials purchased grew at 9.6 percent, while output went up by only 3.1 percent per year. The other numbers could be wrong, but the suspicion falls on the output number and the associate price index when we note that it had the highest rate of growth of all the industrial price indexes -- 13.2 percent per year.[3] At this moment, however, we have no way of checking what are basically ingredients of the national income accounts computations. We do want to warn the reader not to place too much confidence in the various numbers; there may still be quite a bit of error left in them.[4]

Looking at Table 2, which lists the components of the TFP calculation for aggregate manufacturing, we observe that output growth in France was significantly higher in the 1967-73 period (7 vs. 4 percent) and fell by more in the 1973-78 period than in the U.S., to roughly equivalent levels (about 2 percent per year). Throughout both period, fixed capital was growing faster in France than in the U.S., at the rate of 1 to 2 percent more per year. The big puzzle is in the behavior of manhours. In the earlier period their growth is small and roughly parallel but diverges sharply during 1973-78. In France labor use declines at about -2 percent per year, while in the U.S. it rises at over 1 percent per year, in the face of a severe output growth slump.[5] There is also a divergence in the materials use story. Materials use is growing much faster in France during the first period and the drop in the second period is much sharper than in the U.S. (from over 7 to about 1 percent per year versus a drop from 3.5 to only 2.5 in the U.S.).

Looking at the price side, average output price inflation was slightly higher in France, by about 1 percent per year, but not strikingly so. This is true also of material prices, which rose slightly faster in France. The big discrepancy, however, is again in labor. Wages appear to have grown much faster in France, accelerating in the second period to a rate double that in the U.S.. While the real cost of both labor and materials remained roughly constant in the U.S. in the second period (and rose only gradually in the first), in France real labor costs were rising sharply in both periods (at a rate of 6 to 7 percent per year). This may provide a "push" type explanation for the more rapid productivity growth in France than in the U.S. though the causality is far from clear here.[6]

B. Looking for Causes of the Slowdown: Capital and Materials.

There are three potential explanations of the productivity slowdown and the shortfall of the U.S. relative to other countries in this regard which we can explore with our data: differences in investment, a differential rise in materials (and energy) prices, and different R&D policies. Those who claim that part of the productivity slowdown can be explained by a shortfall in the rate of capital investment, must have in mind a model in which the contribution of capital to output growth exceeds its factor share for some reason or other (disequilibrium, taxation, or the embodiment of technical change).[7] While capital stock was growing somewhat faster in France than in the U.S., the TFP calculations take this already into account, to a first order of approximation. One way to check on this is to take apart the TFP calculation and ask whether output growth was faster (slower) in sectors which experienced above (below) average growth in capital input.

Defining the "production function" as

$$q = \lambda + \alpha \ell + \beta c + \gamma m + e$$

where q, ℓ, c, m, and λ denote rates of growth of output, labor, capital, materials and disembodied technical change respectively; α, β, and γ are the respective input elasticicies of output, and e is a disturbance term. Approximating the relevant elasticities by their corresponding factor shares, we estimate

$$q = a_{jt} + b_1(s_\ell \ell) + b_2(s_c c) + b_3(s_m m) + e$$

where the constants (technical change terms) are allowed to differ across countries (i) and periods (t), If the TFP calculations are roughly right, the estimated b's should be around unity. If an input is in some sense "more important" than that, it should show up with a coefficient significantly above unity.

The results reported in Table 3A do not support the capital (or materials) story.[8] Only the labor coefficient exceeds unity significantly and even this result disappears when we exclude the chemicals industry with its dubious 1973-78 numbers from the U.S. equation. The capital coefficients are not significantly different from unity, either in the direct production function estimates, or the partial productivity versions, where we first treat labor and then both labor and materials as endogeneous variables, constraining their elasticities to equal their factor shares, and subtracting them from the left hand side.[9] If anything, the coefficient of capital is lower in France than in the U.S., which is exactly the opposite of what would have been needed to provide an explanation for the more rapid productivity growth in France. This is even more obvious when we try to explain cross-country differences in sectoral output growth. There, the estimated capital coefficient actually turns negative, though not significantly so; implying that output was growing faster in France than in the U.S., in industries where the relative capital growth was lower.[10]

As far as materials are concerned, while the direct coefficients are sometimes higher than unity, the differences are not statistically or economically significant. The materials story, suggested especially by Bruno (1981), is based on the notion that in the short-run their elasticity of substitution is less than unity and that a response to a sharp rise in their price is more costly to output growth than is implied by the standard formulae. This can be tested either by looking at the estimated coefficient of materials in the "production function" framework, or by substituting the real price of materials for the more endogeneous materials quantity variable.[11]

Treating materials as a separate input with an elasticity of substitution $\sigma < 1$ between itself and the aggregate of other inputs (value added, consisting of capital and labor) one can write the equation to be estimated as

$$q - \frac{\alpha}{1-\gamma}\ell = \frac{\lambda}{1-\gamma} + \frac{\beta}{1-\gamma}c - \frac{\gamma\sigma}{1-\gamma}[p_m - p_q] + e$$

where, in addition to the symbols defined above, p_m and p_q are the growth rates of materials and output prices respectively.[12] When such an equation is estimated, it yields invariably the wrong sign for the coefficient of the weighted real price of materils $[(s_m/(1-s_m)](p_m-p_q)$ implying that productivity improved in industries where real material prices rose more rapidly. This could be due to errors in the measurement of industrial output prices, since both the construction of the output variable and the real materials price variable depend on the same output price deflators. An attempt was made to get around this problem by treating $p_m - p_q$ as endogeneous and using p_m and p_ℓ (the growth rate of wage rates) as additional instruments.

This yielded a negative but not statistically significant coefficient for the real price of materials, with an estimated σ of about .2.

Actually, it is not all that surprising that we cannot get much from the materials story since the basic facts go the wrong way.[13] The growth in material use fell more sharply in France than in the U.S. and hence cannot account for the sharper productivity deceleration in the U.S.. Nor is there any evidence that real materials prices were rising more rapidly in the U.S. or accelerated more there; if anything the opposite appears to be the case. Thus, whatever explanation they may provide for the short-term timing of such movements, the rise in material prices cannot explain the persistent and increasing difference between French and U.S. productivity growth.[14]

Another way of looking at the relationships between our variables is to look at the dual price side. Treating output price as dependent, one can write.

$$p_q = -\lambda + \alpha p_\ell + \beta p_c + \gamma p_m + \varepsilon$$

where, in addition to the terms defined above, p_ℓ and p_c are rates of growth in labor and capital price indexes and ε is a disturbance. Table 3B presents the results of such regressions where, as before, factor shares replace α, β, and γ, and the estimated coefficients should be on the order of one. Estimates of a "factor price frontier" equation

$$p_c - p_q = \lambda/\beta - (\alpha/\beta)\ (p_\ell - p_q) - \gamma/\beta(p_m - p_q) + \varepsilon\ .$$

which endogeneize the price of capital (using the real return to capital as the dependent variable) are also reported in this table. In the direct price equations there is a stark contrast between U.S. and France. In the U.S. labor cost and especially materials price increases were transmitted to product prices more than proportionally, more than could have been predicted by their relative importance in total costs. In France, material price increases appear to have had less than their predicted impact on product prices. When factor price frontier equations are estimated, with the real return to capital as the dependent variable, real material prices invariably come out with the wrong sign. Somehow, the spuriousness introduced by errors in the output price deflators appears to dominate. This is another manifestation of a problem that is endemic to such data -- real factor price differences are rather small across industries within any one country, small relative to the size of transitory and erroneously measured movements in output prices.

One way of reducing the endogeneity of the right hand terms in the factor price frontier equation is to solve out both the output price and the endogeneous capital return measure from the right hand side of this equation. This leads to the estimation of "partial price equations" with $p_q - \beta p_c$ as the dependent variable, i.e.

$$p_q - \beta p_c = \lambda + \alpha p_\ell + \gamma p_m + \varepsilon$$

These equations (listed in the middle of Table 3B) also imply an above average transmission of wage and materials price changes to output prices in the U.S. relative to France. If factor prices have had a special role in this story, it has been their differential impact in the two countries. Thus, they cannot provide a unified explanation for the events in both countries.

C. The Role of R&D

We cannot really analyze the contribution of R&D to productivity growth in any detail in this section because there are no R&D time series at the industry level in France. We do have, however, French data on R&D expenditures and employment by industry for 1975 and we can use similar U.S. data (see Appendix Table 3) to investigate whether differences in productivity growth are related to differences in R&D intensity. An earlier study (Griliches and Lichtenberg, 1981) found that one can attribute only very little of the productivity showdown in the U.S. to the retardation that occurred in the growth of R&D in the late 1960's. This study utilized a more detailed industrial breakdown and showed that the relationship between TFP growth and the R&D to sales ratio did not deteriorate in the 1970's. Moreover, it indicated that the R&D to sales ratios remained relatively stable across industries between the 60's and 70's (r^2 for the correlation of R/S in 1964-68 and 1969-73 across 27 manufacturing industries was.97). Assuming a similar stability in France, we may use the 1975 data to proxy also for the unavailable earlier data.

If we combine all of our data for the two countries, two periods, and 15 industries (N = C x T x I = 60), and estimate a common R&D coefficient in the two countries, using a seemingly unrelated regression framework, we get the following equation:

$$\underset{(.31)}{TFP = .23\ DUS1} - \underset{(.37)}{1.02\ DUS2} + \underset{(.31)}{1.49\ DF1} + \underset{(.29)}{.76\ DF2} + \underset{(.09)}{.28\ R/S}$$

SEE = 1.10

where DUS1 is the U.S. constant term (average rate of TFP Growth) in the first period, and similarly for the other terms, while R/S is the ratio of company financed R&D expenditures to total sales in the respective countries.[15] The estimated R&D coefficient implies a 28 percent excess gross rate of return to R&D investment. It is excess because much of the R&D input is already counted once in the construction of labor and capital and it is gross because no allowance has been made for possible depreciation of R&D capital (see Griliches 1979 and Schankerman 1981 for a more detailed interpretation of such coefficients).

When we allow for separate country coefficients we get the following equation instead:

$$TFP = \underset{(.33)}{.30\ DUS1} - \underset{(.38)}{.94\ DUS2} + \underset{(.36)}{1.42\ DF1} + \underset{(.33)}{.68\ DF2}$$

$$+ \underset{(.12)}{.23\ R/S(US)} + \underset{(.14)}{.33\ R/S(F)}$$

SEE = 1.11

The difference between the U.S. and French coefficient is substantial but not statistically significant.

The estimated R/S coefficient for the U.S. (.23) is comparable to what we found in the earlier study. If we accept such a rate of return or even if it were twice as high, this still would not account for much of the deceleration of TFP in the U.S., since the decline in R&D to sales ratio was in fact rather small.[16] Nor can our estimates account for the differences in TFP growth between France and the U.S., since the R&D to sales ratios tend to be lower at the industry level in France than in the U.S.. We re-examine this conclusion, however, in the next section where the available micro data contain more information on firm R&D expenditures.

II. Productivity Growth at the Firm Level

A. Data and Basic Facts

In this section we examine the growth of productivity at the firm level. Because of our interest in assessing the contribution of R&D to productivity, we have been assembling data on R&D performing firms in both France and the U.S.[17] Data problems and the desire for comparable and large enough samples limited the study period to 1973-1978 and to five manufacturing industries for which we had a sufficient number of firms (at least 30) in each of the countries: Drugs, Chemicals (excluding Drugs), Electronics, Electrical Equipment (excluding Computers), and Machinery. The exact definition of these five industries in terms of the two or three digit French "NAP" or U.S. "SIC" classifications is indicated in Table 4 in the Appendix. It differs somewhat from our aggregate industry breakdown. The "parachemical" firms were brought together with the chemical firms (rather than with the drug firms) and the medical instrument firms were added to the "drug" industry. The electronics and electrical equipment firms are treated separately, and computer and (nonmedical) instrument firms have been excluded, since there were too few of them in France.

Our samples correspond best to the subtotal of the four aggregate industries (2 + 7 + 8 + 14) given separately in Table 1 of the previous section. The number of firms is relatively small (N = 185) in the French sample and only somewhat larger (N = 343) in the U.S. one, but these firms do account for about 25 and 85 percent of the total number of employees in these four aggregate industries in France and the U.S. respectively. They are not a representative sample from these industries, however. First, because we include only R&D doing firms and second, because our data cleaning efforts result in additional selection. In particular, firms which grew through major mergers have been excluded.[18]

That the use of similar selection procedures in both countries yields a much lower coverage for the French sample than the U.S. one is rather interesting. Only about a third of the French firms (in terms of the number of employees) in these industries have significant levels of R&D expenditures as against most of the firms in the U.S. This difference in the industrial structure of the two countries also accounts for the observed discrepancy between the R&D to sales ratios at the firm and industry levels in the two countries. (See the Data Sources Appendix for more details.)

In addition to constructing our samples along the same lines for both countries, we also defined and measured our main variables as similarly as possible. Output is defined as deflated sales. The industrial level of the sales deflators depends on their respective availability in the two countries (11 different price indices for the French and 25 for the U.S. data).[19] Labor is measured by the total number of employees and gross physical capital stock by the book value of gross plant adjusted for inflation (based on a rough estimate of the average age of the capital stock). An R&D capital stock variable is constructed as a weighted sum of past R&D expenditures, using a 15 percent rate of depreciation and all of the pre-1973 information on R&D that we could get for our firms.[20] Because materials purchases and labor costs are not separated for most U.S. firms (they are lumped together in the cost of goods sold item) it was not possible to treat materials as a separate factor of production and estimate a TFP index similar to that computed at the industry level. We focus, therefore, on labor productivity Q/L and on an approximate TFP measure $Q/[L^{.75} C^{.25}]$, which assumes the proportionality of materials to value added and uses constant labor and physical capital cost shares.[21] We also put more emphasis on econometric estimates of the contribution of physical investment and R&D to labor productivity growth, using a standard Cobb-Douglas production function framework to allow factor elasticities to diverge from their corresponding cost shares.

Table 4 presents means and standard deviations of the growth rates of our main variables between 1973 and 1978 and of their levels as of 1974. It also reports their weighted growth rates and compares them to the corresponding aggregate growth rates.[22] The standard deviations of the rates of growth of labor productivity are 4.9 and 3.9 percent per year in the French and U.S. samples respectively and the corresponding interquartile ranges are [-.1; 6.0] and [-1.8; 3.4]. In fact, when one looks at any histogram of individual rates of growth, or any plot of them, the scatters overlap widely across countries. This is illustrated in Figures 2 and 3 which show for both samples the histogram of q-n (labor productivity growth rate) and the plot of q-n against c-n (capital stock per employee growth rate).

Another interesting point is that the dispersion of growth rates, even though quite large in its own terms, is rather small (about a tenth) relative to the dispersion of the corresponding levels. Moreover, growth rates and levels are almost uncorrelated, GIBRAT's law holding also for productivity growth and not just for the growth in size (number of employees or sales), as it is usually formulated.[23] These two features are reflected in the long period stability of firm rankings by absolute productivity in spite of the great variability in their productivity growth rates.

Looking at the average growth rates of our variables and comparing unweighted to weighted averages, it appears that smaller firms are growing faster than larger ones in the U.S., while no such differential tendency is apparent in France. This is particularly striking when we look at the number of employees, but is also true for the growth in sales and capital. Some of this may be explained by differences in the size (and also in the range of sizes) of French and U.S. firms: the geometric means of the number of employees being 900 in France and 3000 in the U.S.[24]

Given all the discrepancies that could have arisen from the selection of our samples and the measurement of our variables, the agreement between our "micro" and "macro" numbers is rather surprising. The weighted sample means and the corresponding four industries aggregates are not that far-off. In France, the growth of R&D firms has been apparently more rapid than that for the corresponding industries as a whole, which is not surprising. Curiously, the reverse seems to be the case for the U.S., R&D firms having a somewhat lower growth in employment (although they invested more) and a lower growth of sales than the corresponding industries. We have already noted the remarkable difference between our "micro" and "macro" R&D to sales ratios. French R&D doing firms have been investing relatively more in research and development than their U.S. counterparts, but since they constitute a much smaller proportion of the totals the opposite is true for the corresponding industries taken as a whole. The unweighted and weighted average R&D to sales ratios are 4.8 and 3.7 percent respectively for the French sample, 2.6 and 2.9 percent for the U.S. sample, while the corresponding industry estimates are 2.6 and 3.0 percent respectively.[25]

In spite of such differences, comparing the 1973-78 productivity growth in the two countries yields essentially the same picture as before. Both labor and total factor productivity (based on our rough calculation with a capital share of

.25) increased much faster in France than in the U.S., by 1.5 to 2.0 percent per year.

We should, finally, remark on the comparison of productivity levels in the two countries given in Table 4 using 5 Francs for 1 dollar as an approximate rate of conversion. Though productivity growth has been more rapid in France, labor productivity levels are still below those in the U.S. by about as much as 25 percent on the average. Part of this gap may be due to differences in physical capital intensity and the scale of enterprises between the two countries.

B. Assessing the Contribution of R&D to Productivity Growth

In an attempt to assess the contribution of R&D as well as that of physical capital to productivity growth, we find it convenient to pool the French and U.S. samples together. This is not unreasonable since the standard deviations of our variables and the correlations between them are rather similar in both samples. Among different ways of handling such panel data, we chose to analyze differences in firm growth rates between 1973 and 1978. This has the advantage that the general economic situation in these two years was good in both countries, in contrast to the 1975-1976 recession years. Compared to using year to year growth rates, it also has the advantage of reducing biases due to measurement errors in the variables (diminishing the ratio of error to true variance). In doing so, we discard all the cross-sectional information in our data panel, relying only on its time series components. As we know from the literature on the econometrics of panel data and from previous work, cross sectional estimates often differ from time series estimates. In our earlier studies (see Griliches-Mairesse (1981) and Cuneo-Mairesse (1982)), they actually provide more sensible estimates of the elasticity of output with respect to R&D capital. Despite that, we do not report here on such cross-sectional estimates to keep the analysis parallel to the first section.

Let us denote by $q-n$, $c-n$ and $k-n$ the annual rate of growth between 1973 and 1978 of labor productivity, physical, and R&D capital-labor ratios respectively (dropping for simplicity the firm subscripts i); and by COU, IND, SIZ the appropriate set of dummy variables indicating whether or not firms belong to one of the two countries, one of the five industries, or one of four size groups (which we defined to control for the different range in the number of employees in the French and U.S. samples). The following types of regressions were estimated:

$$(q-n) = \beta\ (c-n) + \delta\ (k-n) + DUM + e$$

or

$$(q-n) = \beta\ COU\ (c-n) + \delta\ COU\cdot(k-n) + DUM + e$$

or

$$(q-n) = \beta\cdot(COU\cdot IND\ (c-n) + \delta\ COU\cdot IND\cdot(k-n) + DUM + e$$

where the slope coefficients are first constrained to be constant across countries and industries and then free to differ across countries and also across industries; and where DUM denotes either the set of dummy variables COU, IND, IND COU, SIZ (13 independent ones) or only the subset COU, SIZ (5 independent ones). When the full set of dummy variables is included, the regressions are based only on intracountry and intraindustry growth differences. When the industry dummies and their interactions are excluded, the regressions are based also on interindustry growth differences and are therefore more similar to those computed in the first section. To relate these regressions even more closely to the previous analysis and because we did not find evidence of a statistically signifcant contribution of k-n (the growth in R&D capital) to productivity growth, we used also an R&D intensity variable (R/S74) instead of the R&D capital measure. We used the R&D to sales ratio as of 1974 instead of a comparable 1973 ratio, so as to avoid any spurious correlation with the 1973-78 growth rate in labor productivity q-n. The substitution of R/S for k-n implies a different specification of the production function, one that assumes a constant marginal product for R&D rather than a constant elasticity across firms or industries (see Griliches-Lichtenberg, 1982).

Our main results are summarized in Table 5 which gives the estimated parameters of interest for a number of specifications we tested. Starting with the simplest analysis of variance which uses only dummy variables, we find that all the effects are statistically significant. Among the various dummy variables, the country and industry effects are most highly significant while the size effects are less so, implying a slight tendency for faster growth of productivity in larger firms. The country-industry interactions are just on the border of statistical significance.

In addition to such country and industry effects, physical capital growth also contributes significantly to the growth in labor productivity, especially when constrained to have the same average elasticity in all five industries. The evidence is weaker when different industries are considered separately. But the discrepancies in the estimated elasticities by industries and countries are not statistically significant, and we can maintain the hypothesis of a common elasticity. Given the small size of our industry subsamples, we cannot really discern differences in elasticities across industries.

In contrast to physical capital, growth in R&D capital is not significant at all, even when we impose a constant elasticity across industries. These negative results may be due to our turbulent sample period (see Griliches-Mairesse (1981)), and also to problems of measurement. Double counting of R&D related employees and R&D related capital expenditures in our actual measure of labor and physical capital stock may obscure the relation between productivity and R&D investments. In the French sample, where we can correct for some of these problems, we obtain much more sensible looking estimates, with an estimated output elasticity of R&D capital δ of about .1 (see Cuneo-Mairesse (1982)).

On the other hand, the R&D to sales ratio does turn out to contribute significantly to the explanation of the interindustry differences in productivity growth. When it is restricted, however, to the explanation of intraindustry differences, the contribution of R/S dwindles to insignificance. In the interindustry regressions, the estimated coefficient of R/S (ρ), which can be interpreted as the marginal product or gross rate of return of R&D, is .28, while in the intraindustry regressions (those containing industry dummy variables) it is only .12. Part of the discrepancy might be attributable to externalities, the fact that R&D performed by a particular firm may benefit other firms in the same industry. Unfortunately, the evidence of an intraindustry effect becomes especially weak, when we relax the constraint that the coefficient ρ be the same in the different industries. Nonetheless, to end on a positive note, it is quite encouraging that the contribution of R&D to productivity growth is confirmed by our analyses at both the industrial and the firm levels. It may even be a bit of luck that the estimated order of magnitude of the overall gross rate of return to investment in R&D comes out so close in both cases: about .25, somewhat more perhaps in France and less in the U.S.

III. Conclusions

Analyzing the French and U.S. industrial data we confirmed both the fact of faster productivity growth in France and the pervasiveness of the recent productivity slowdown. Looking at the individual industry experiences did not yield any new clues about its sources, but it did reject some old ones. Three explanations (shortfall in investment, rise in material prices, and a decline in the intensity of R&D investment) were examined and were found not to bear on the differences in productivity growth across the two countries. Industries with above (below) average growth in physical capital did not have an above (below) average growth rate of total factor productivity. Industries that experienced above average growth in the price of materials and/or had been more materials intensive, did not appear to have suffered differentially. And, while we did find some modest evidence of a positive effect of R&D on productivity, it could account for only very little of the aggregate cross-country differences, since the overall R&D investment intensities were not higher in France than in the U.S.

Looking at the individual firm data did not change these conclusions. The major impression that emerged was one of variance. At the firm level, the estimated output elasticity of physical capital is positive and statistically significant but does not exceed its factor share in either country. Thus, there is no evidence for the notion that investment in fixed assets is more important in accounting for changes in labor productivity than is already implied in the usual total factor productivity calculations. Because a much smaller proportion of firms in an industry do R&D in France than in the U.S., it turns out that the French sample is more research intensive than our U.S. one, while the reverse is true at the aggregate level for the corresponding industries. Nevertheless, the estimated R&D effects are statistically significant and of comparable magnitude at both the micro and macro levels; they cannot account, however, for much of the observed differences in productivity growth.

This is our first look at the comparative performance of manufacturing industries and firms in France and the U.S. It is obvious that we have still many unsolved problems and puzzles, both as far as data quality is concerned and in understanding the substance of what has happened. But we have made a beginning and hope that others will be encouraged to pursue such comparative studies further.

TABLE 1: TOTAL FACTOR PRODUCTIVITY GROWTH RATES IN MANUFACTURING INDUSTRIES: FRANCE AND THE UNITED STATES (percent per year)

INDUSTRY	67-78			67-73			73-78			CHANGE		
	FR	US	FR-US	FR	US	FR-US	FR	US	FR-US	FR	US	FR-US
PAPER AND ALLIED PRODUCTS	1.0	0.8	0.2	0.5	1.8	-1.3	1.5	-0.4	2.0	1.0	-2.3	3.3
CHEMICALS (EXCLUDING DRUGS)	1.5	0.3	1.2	1.8	3.7	-2.0	1.1	-3.7	4.8	-0.7	-7.5	6.8
RUBBER, MISC. PLASTIC PRODUCTS	0.9	0.1	0.8	1.0	1.9	-0.9	0.9	-2.0	2.9	-0.1	-4.0	3.9
STONE, CLAY, AND GLASS PRODUCTS	1.5	0.1	1.4	2.3	1.0	1.4	0.5	-0.9	1.4	-1.9	-1.9	0.0
PRIMARY METAL INDUSTRIES	1.0	-0.7	1.7	1.7	0.2	1.5	0.2	-1.8	2.0	-1.5	-2.0	0.5
FABRICATED METAL PRODUCTS	1.4	-0.4	1.8	1.9	0.5	1.3	0.7	-1.5	2.3	-1.1	-2.0	0.9
MACHINERY AND INSTRUMENTS	1.9	0.1	1.8	3.2	1.1	2.1	0.3	-1.2	1.5	-2.9	-2.3	-0.6
ELECTRICAL EQUIPMENT	2.6	1.9	0.7	2.9	1.7	1.2	2.3	2.1	0.2	-0.6	0.3	-0.9
AUTOMOBILE AND GROUND TRANSPOR	1.8	1.1	0.7	2.6	2.1	0.5	0.9	-0.1	1.0	-1.7	-2.1	0.5
AIRCRAFT, BOATS, AND SPACE VEH	3.4	-0.4	3.7	2.7	-0.9	3.6	4.2	0.3	3.9	1.4	1.2	0.2
TEXTILES AND APPAREL	1.4	0.8	0.6	2.0	0.9	1.1	0.7	0.7	0.0	-1.3	-0.2	-1.2
WOOD, FURNITURE, AND MISC. PRO	1.6	0.1	1.5	2.0	0.9	1.1	1.2	-0.8	2.0	-0.8	-1.7	0.9
PRINTING AND PUBLISHING	0.6	0.3	0.2	-0.4	0.7	-1.1	1.7	-0.1	1.8	2.1	-0.7	2.8
DRUGS	0.9	0.9	0.1	1.1	1.4	-0.3	0.7	0.3	0.4	-0.4	-1.1	0.7
LEATHER	1.1	-0.2	1.2	1.9	-0.4	2.3	0.1	0.1	0.0	-1.8	0.5	-2.3
AGGREGATES												
AGGREGATE MANUFACTURING	1.7	0.4	1.3	2.2	1.2	1.0	1.2	-0.5	1.7	-0.9	-1.6	0.7
SECTORS INC IN MICRO STUDY	2.0	0.8	1.2	2.5	1.8	0.7	1.4	-0.5	1.8	-1.2	-2.3	1.1
SECTORS NOT INC IN MICRO ST.	1.5	0.2	1.3	1.9	0.8	1.1	1.1	-0.5	1.6	-0.8	-1.4	0.6

Table 2.

Growth Rates of Output, Inputs, and Prices, and Levels of Factor Shares,
in
French and U.S. Manufacturing Industries, 1967 to 1978.

Variable	1967-78			1967-73			1973-78			CHANGE		
	FR	US	FR-US	FR	US	FR-US	FR	US	FR-US	FR	US	FR-US
Output	4.8	3.2	1.6	7.4	4.1	3.3	1.8	2.1	-0.3	-5.6	-2.0	-3.6
Capital	5.5	3.9	1.6	6.1	4.0	2.1	4.7	3.8	0.9	-1.4	-0.2	-1.2
Employees	0.3	0.4	-0.1	1.5	0.4	1.2	-1.1	0.4	-1.5	-2.6	0.0	-2.6
Man-hours	-0.6	1.0	-1.6	0.8	0.8	0.0	-2.2	1.2	-3.4	-3.0	0.4	3.4
Intermediate cons.	4.5	3.1	1.4	7.4	3.5	3.9	1.2	2.6	-1.4	-6.2	-0.9	-7.1
Price of output	7.1	6.0	1.1	4.6	3.5	1.0	10.2	9.0	1.3	5.6	5.5	0.1
Imputed price of capital	4.9	5.1	-0.2	5.9	4.2	1.7	3.8	6.2	-2.4	-2.1	2.0	-4.1
Price of labor (wage)	13.6	7.2	6.3	10.8	6.2	4.6	17.0	8.5	8.5	6.2	2.3	3.9
Price of interm. cons.	7.4	6.6	0.8	4.9	4.2	0.7	10.5	9.6	0.9	5.6	5.4	0.2
Share of capital in output	0.14	0.23	-0.09	0.15	0.23	-0.09	0.13	0.24	-0.10	-0.02	0.01	-0.03
Share of labor	0.31	0.27	0.05	0.31	0.28	0.03	0.31	0.25	0.06	0.00	-0.03	0.03
Share of interm. cons.	0.54	0.50	0.04	0.54	0.49	0.05	0.55	0.51	0.04	0.01	0.02	-0.01
Labor productivity (man-hours)	5.4	2.2	3.2	6.6	3.3	3.3	4.0	0.9	3.1	-2.6	-2.4	-0.2
Total factor productivity	1.7	0.4	1.3	2.2	1.2	1.0	1.2	-0.5	1.7	-1.0	-1.7	0.7

Note: Growth rates shown are percent per year. Factor shares are period geometric averages.

Table 3: Output, Productivity, and Price Growth Regressions: 15 Manufacturing Industries in U.S. and France, 1967-72, and 1973-78.

A. Primal Productivity Regressions

Dependent Variable and Country	Coefficients (standard errors) of $s_\ell \ell$	$s_c c$	$s_m m$	$[s_m/(1-s_m)](p_m-p_q)$	Residual Standard Error
I. Output q:					
U.S.	2.21 (.47)	.93 (.43)	.62 (.26)		1.21
a	1.13 (.58)	.44 (.58)	1.23 (.22)		1.20
France	1.36 (.52)	.32 (.54)	1.14 (.21)		1.18
Combined[a]	1.11 (.26)	1.08 (1.9)	1.37 (.16)		1.08
France-U.S.[a]	1.52 (.60)	-.43 (.47)	1.26 (.29)		1.24
II. Partial Productivity					
$q-s_\ell \ell$:					
U.S.		.90 (.47)	1.11 (.19)		1.33
France		.46 (.50)	1.21 (.19)		1.17
France-U.S.		-1.15 (.56)	1.25 (.17)		1.49
III. Partial Productivity					
$q-s_\ell \ell - s_m m$:					
U.S.		1.01 (.42)			1.31
France		.64 (.47)			1.17
IV. Mixed Partial Productivity					
$q[s_\ell/(1-s_m)]\ell$:					
U.S.		.92* (.23)		.64 (.25)	1.34
France		1.06* (.28)		.44 (.14)	1.46
Combined IV		.87* (.23)		-.22 (.32)	n.c.

B. Dual Price Regressions

		$s_\ell p_\ell$ or $(s_\ell/s_c)(p_m-p_q)$	$s_c p_c$	$s_m p_m$ or $(s_m/s_c)(p_m-p_q)$	Residual Standard Error
I. Output price p_q	U.S.	1.36 (.49)	.65 (.26)	1.67 (.24)	1.13
	France	.96 (.28)	.56 (.57)	.79 (.19)	1.20
II. Partial price[b] equation					
$p_q - s_c p_c$	U.S.	2.01 (.34)		1.55 (.19)	1.09
	France	.82 (.21)		.79 (.16)	1.11
III. Factor price[b] frontier					
$p_c - p_q$	U.S.	-.60 (.69)		.33 (.54)	3.99
	France	.22 (.12)		.04 (.11)	4.66

q, ℓ, c, m, and p's are rates of growth of output, labor, capital and materials and of the relevant output and input price indexes. $[x = \log X_t - \log X_{t-5})/5]$

s_k' s - average (beginning and end period) estimated factor shares of the respective inputs.

Combined equations estimated using generalized least squares, allowing a freely correlated disturbance matrix (4x4) between countries and time periods across industries. I.e., four separate equations (2 periods x 2 countries) are estimated, with the relevant coefficients constrained to be the same across equations.

All equations contain separate unconstrained country and period constant terms.

Combined IV treats $[s_m/(1-s_m)](p_m-p_q)$ as endogeneous, using $[s_m/(1-s_m)]p_m$ and $(s_m/(1-s_m)]p_\ell$ as additional instrumental variables.

a. Excludes the chemicals industry.

*. The variable here is $[s_c/(1-s_m)]c$

n.c. - not computed

b. Estimated jointly using the SUR procedure.

Table 4: Characteristics of the main variables in the French (N=185) and U.S. (N=343) samples.

Main Variables	Rates of growth of variables over 1973-78 (except R/S for which the 1974 level is given)				Levels of variables in 1974*	
	Unweighted sample means and standard deviations ( )		Weighted sample means and corresponding aggregate estimates [ ]		Unweighted sample means and deviations ( )	
	France	U.S.	France	U.S.	France	U.S.
q-n: Deflated sales per employee	3.2 (4.9)	0.7 (4.2)	3.6 [3.5]	2.2 [1.9]	25.8 (0.4)	33.5 (0.4)
c-n: Gross plant adjusted per employee	5.6 (4.9)	5.0 (6.5)	5.5 [6.9]	5.9 [3.3]	9.8 (0.5)	14.6 (0.6)
k-n: R&D capital stock per employee	5.9 (6.7)	3.7 (7.9)	5.8 -	3.6 -	3.8 (1.0)	3.0 (0.8)
n: Number of employees	.4 (4.4)	2.5 (7.1)	.8 [-.4]	.8 [1.8]	.9 (1.3)	3.0 (1.7)
TFP: Total factor productivity	1.8 (4.8)	-0.5 (4.1)	2.2 [1.8]	0.8 [1.1]		
R/S: R&D to sales ratio in 1974	4.8 (4.4)	2.6 (2.0)	3.7 [2.6]	2.9 [3.0]	-	-

* Levels of deflated sales, gross-plant adjusted, R&D capital stock are in millions of dollars. An approximate rate of 5 Francs for 1 dollar has been used to convert the French figures. Levels of numbers of employees are in thousand persons. The sample means are the geometric sample means, while the standard deviations are the log-standard deviations.

Table 5: Productivity growth differences, pooled French-U.S. sample (N = 185 + 343 = 528): Interindustry regressions (without industry dummies) and intraindustry regressions (with industry dummies, and possibly separate industry slopes).

Different Specifications France and U.S. Combined	Coefficients (standard errors) of c-n	 k-n	 R/S	Residual Standard Error
Interindustry estimates	.17 (.04)	.02 (.03)	-	4.26
	.17 (.03)	-	.28 (.06)	4.18
Intraindustry estimates	.16 (.03)	.03 (.03)	-	3.99
	.17 (.03)	- -	.12 (.06)	3.99

France and U.S. Separately		(c-n) FR	 US	R/S FR	 US	
Interindustry estimates		.19 (.06)	.16 (.04)	.31 (.07)	.19 (.11)	4.18
Intra-industry estimates, with different industry slopes	Drugs	.20 (.09)	.08 (.10)	.27 (.15)	.41 (.23)	
	Chemicals	.40 (.19)	.03 (.09)	.00 (.23)	-.19 (.36)	3.99
	Electronics	-.04 (.18)	.21 (.06)	.12 (.11)	-.06 (.19)	
	Electrical equipment	.13 (.14)	.15 (.10)	.45 (.24)	-.44 (.33)	
	Machinery	.21 (.13)	.25 (.06)	-.55 (.38)	.11 (.27)	

Figure 1

TØTAL FACTØR PRØDUCTIVITY

15 Manufacturing Industries in France and the U.S.

CØMPARISØN ACRØSS PERIØDS

(1: 1967-72, 2: 1972-78)

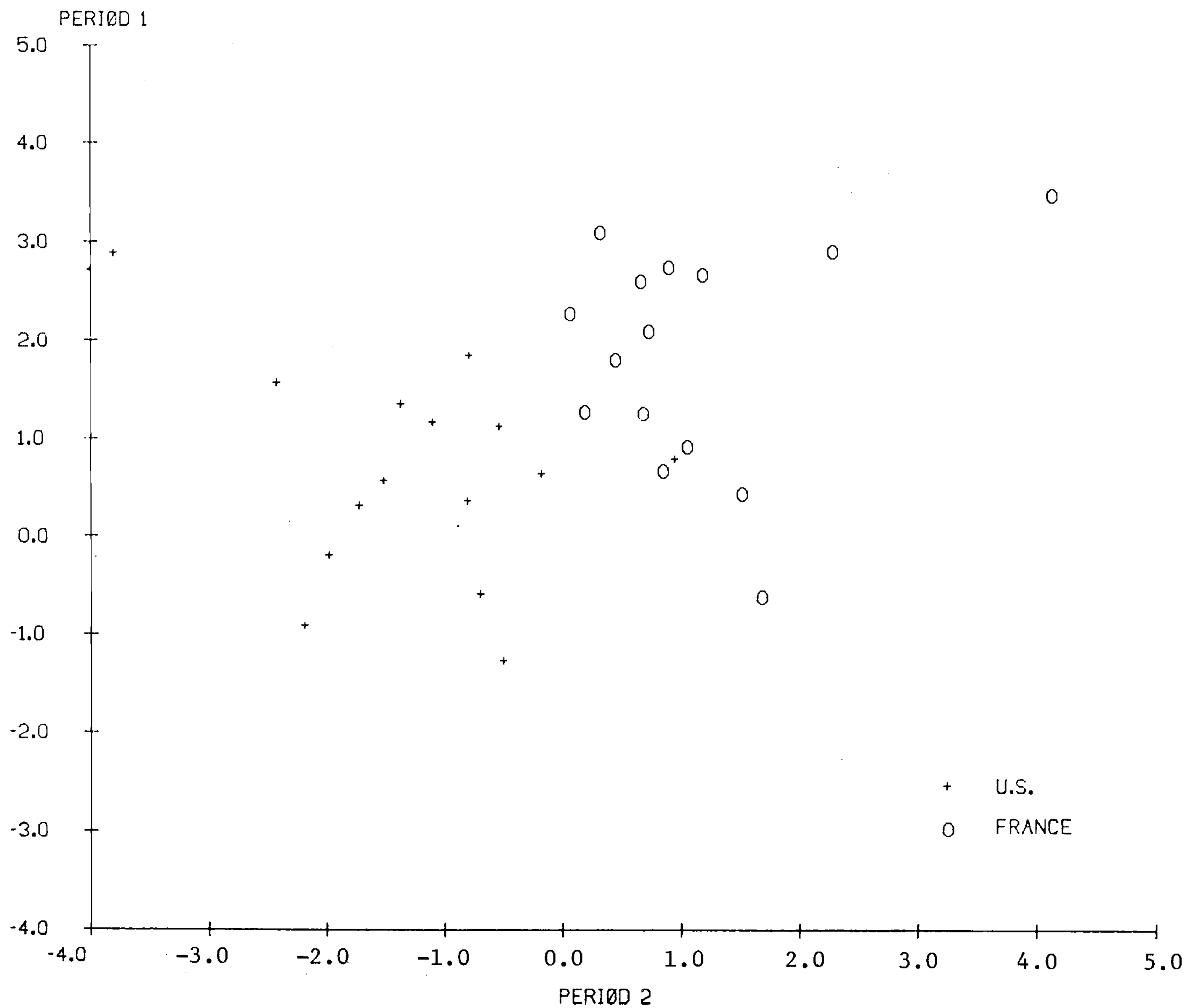


Figure 2

FREQUENCY DISTRIBUTIØN ØF DS_L

Labor Productivity Growth Rates

(French and U.S. samples, period 1973-78)

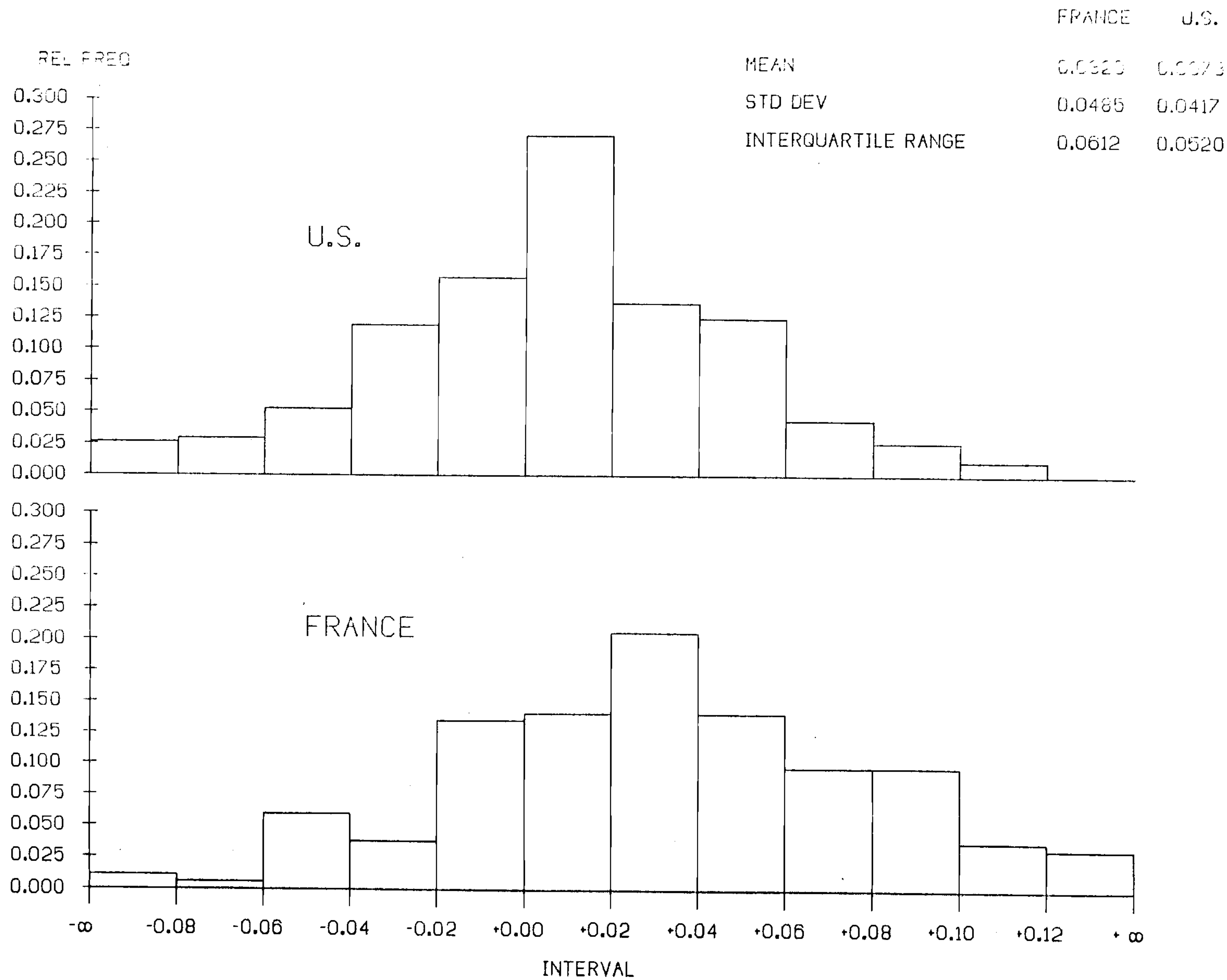
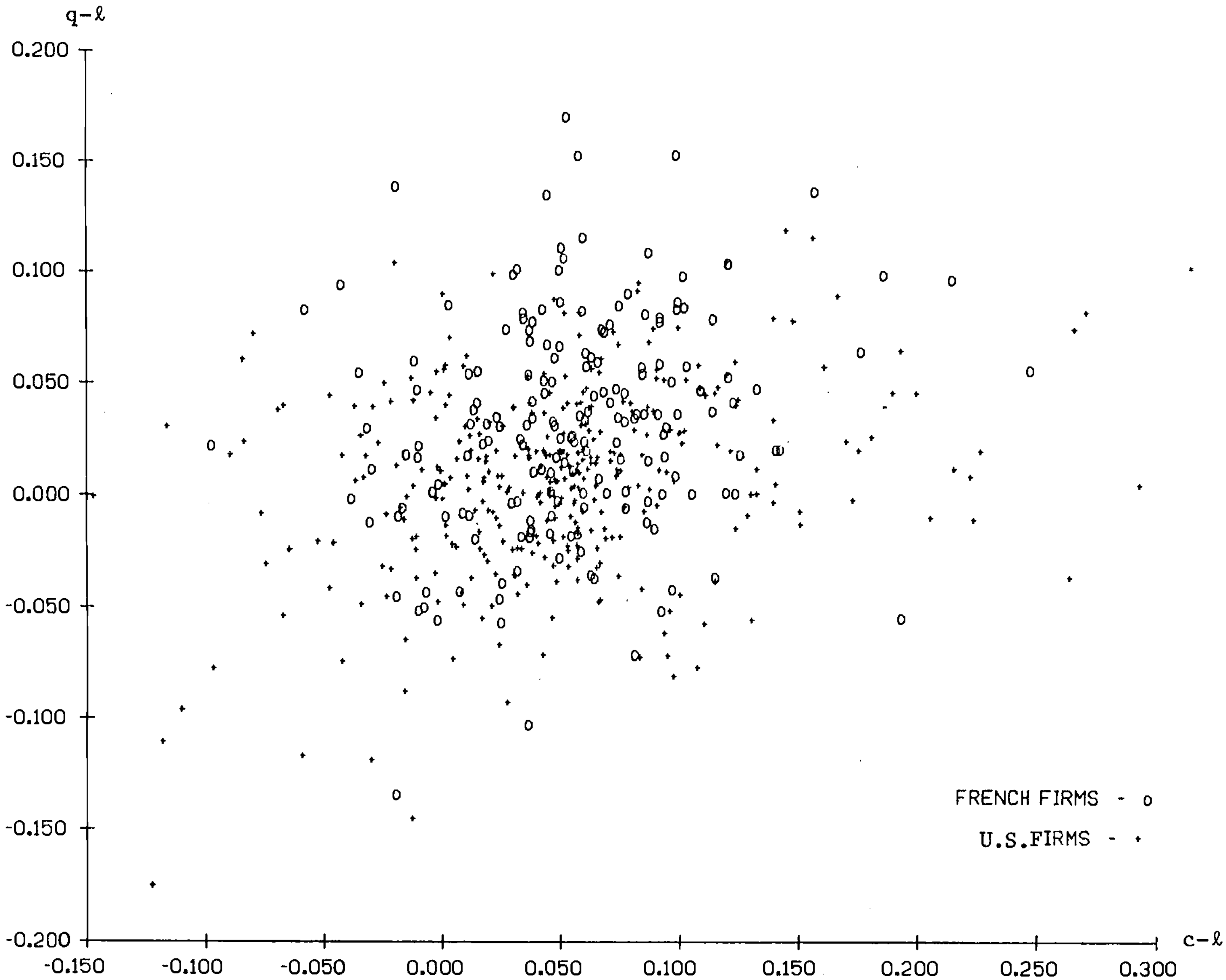


Figure 3

PLOT OF LABOR PRODUCTIVITY GROWTH RATES AGAINST

THE GROWTH IN CAPITAL-LABOR RATIOS

(French and U.S. samples, period 1973-78)



Footnotes

*Presented at the Fifth Annual International Seminar on Macroeconomics, University of Mannheim, June 20-22, 1982. This work is part of the National Bureau of Economic Research Program on Productivity and Technical Change Studies. We are indebted to the National Science Foundation (PRA79-13740, PRA81-068635, and SOC78-004279) and to the Centre National de la Recherche Scientifique (ATP 070199) for financial support, to Sumanth Addanki, Phillipe Cuneo, Bronwyn H. Hall and Alan Siu for research assistance and Martin Baily, Michael Bruno, and Robert J. Gordon for comments on the first draft of this paper.

1. See Denison, 1979 and Nordhaus, 1982, for a more detailed discussion of some of these issues.

2. This conclusion depends on the exact choice of time periods. If 1972 is chosen to divide the two time periods instead of 1973, the magnitude of the deceleration is essentially the same in both countries. The U.S. peaked more in 1973.

3. See Appendix Table A2 for this detail.

4. While there is agreement on the general outlines of the slowdown,

there remains much disagreement among various sources about its exact magnitude, especially at the more detailed industrial level. TFP estimates for manufacturing industries at the 2-digit SIC level have been computed in the U.S. by Gollup and Jorgenson (1980) through 1973 and by Kendrick and Grossman (1980) and APC, (1981)), through 1979. They vary quite a bit from each other (in the 1967-73 overlap period the correlations between these estimates and between them and ours is only on the order of 0.5). Some of the discrepancies could be explained by the use of different data bases (revised vs. unrevised, Census vs. NIPA) and some by differences in methodology (value added vs. gross output, Divisia vs. fixed weight indexes), but the size of some of them remains a puzzle. Within the confines of this paper we cannot pursue this further, but we hope to return to it in the sequel.

5. This difference is smaller if we look at employment rather than manhours.

6. These facts have been noticed before. See, for example, Sachs (1979).

7. They may be thinking primarily of the behavior of output per manhour, a measure that does not take into account the contribution of the other inputs. Some of the fluctuations in output per manhour are due to differential movements in capital and/or materials. The concept of total factor productivity attempts to allow for this by including all the major inputs in its definition of total input, weighting them in proportion to their share in total factor costs.

8. To reduce dependence, these regressions are based on a partition of the data into two non-overlapping periods: 1967-72 and 1973-78. The results are similar when other partitionings, 1967-73 or 1972-78 are used instead.

9. It makes little sense to think of input changes an exogeneous in this context of rather aggregate changes over five year periods. The regressions should be interpreted as a data summary device and not as structural estimates of the production function. The partial productivity regressions try to focus on the contribution of specific inputs by constraining the other coefficients to reasonable a priori values.

10. These results are robust to the exclusion of the chemicals industry with its possibly bad U.S. numbers from these regressions and to the use of slightly different time periods.

11. One should note that our definition of purchased materials includes also materials purchased from the same and other manufacturing industries and is not a net "outside" materials concept. The computed materials price changes understate, therefore, the true magnitude of changes in the price of "outside" materials. But the computed share of all "materials" overstates their overall importance, with the product of the two being essentially unaffected by this distinction. Let the computed p_m (rate of growth in materials prices) be $p_m = (1-d)p_q + dp_o$, where p_q and p_o are the rates of growth of the industries own price level and of outside materials prices respectively and d the share of purchases of "outside" materials in total expenditures on materials. Then the variable we use $s_m(p_m-p_q) = s_m d(p_o-p_q) = s_o(p_o-p_q)$ is the same as if we had used the "outside" definition of materials. Our conclusions should,

therefore, be robust with respect to the exact definition of "materials" and the boundaries of the various industries. (We are grateful to Michael Bruno for this remark.)

12. See Bruno (1981), equation 8.

13. Moreover, our data are not very powerful in this respect. The real price of materials varies surprising little over 5 year periods. It appears that most of the materials price changes were passed through to output prices within this length of time.

14. Most of the evidence presented in Bruno (1981) for the materials story is based on aggregate annual time series for different countries. France is not considered explicitly and the results for the U.S. are not as good as for some of the other countries.

15. The OLS estimates, although less precise, are very similar to the SUR estimates. When we use total R&D to sales ratio (or R&D employment to total employment ratio) instead of company R&D to sales ratio, we obtain rather poor and statistically insignificant estimates for the U.S. These are due mainly to one outlier, the U.S. Aircraft, boats and space vehicles industry, which had very low TFP growth rates (the lowest in the first period) and the highest total R&D to sales ratio (of which 80 percent is federally funded). When this industry is left out of the sample all estimates become comparable. Earlier work has also shown that productivity growth in the U.S. is more closely related to company R&D expenditures than to the federally financed components of total R&D.

16. The total R&D to sales ratio in U.S. manufacturing declines from about 4.4 percent in the mid 60's to 3.1 in the mid 70's. The decline is much smaller, however, for company financed R&D, from a peak of 2.2 percent in 1969 to a low of 2.0 in the mid 1970's.

17. See Griliches and Mairesse (1981) and Cuneo and Mairesse (1982) for a description of earlier work and for more detail on these data.

18. We recognized "major mergers" by large jumps in the data such as the doubling of gross plant, sales or the number of employees. This eliminated about 50 firms from the French sample and 80 from the U.S. one.

19. For the U.S. sample firm specific price indices where also computed as weighted averages of sectoral indices, the weights being obtained from the information on sales by different business segments within a company in 1978. Using such firm specific price indices did not alter our results in any significant way.

20. We were able to use R&D data as far back as 1963 for two-thirds of the French sample, and at least back to 1968 for practically all the firms of the French sample and most of the firms in the U.S. sample. We tried also alternative measures of R&D capital, retrapolating R&D series on the basis of the corresponding industry growth rates instead of using all the firm information whenever possible and adopting a 30 percent rate of depreciation. The means of such different measures differ of course appreciably (and thus the estimates exhibited in Table 4 for our main measure are only roughly indicative) but the estimated regression coefficients (elasticities) are practically unchanged.

21. Using specific country and industry cost shares of labor and physical capital (rather than .75 and .25) to compute an alternative TFP variable did not affect our results significantly.

22. Table 4 in the Appendix gives similar detail for the five industry subsamples.

23. For example, the correlation between the 1973-78 growth in labor productivity and its level in 1974 is only -0.05 and -0.07 in the French and U.S. samples respectively, while the correlation between the growth rate in employment and its level is only -0.02 and -0.15. For references to GIBRAT's law and related literature, see Marris (1979).

24. The arithmetic means of the number of employees are 2100 and 12600 in the French and U.S. samples respectively. While the growth in employment was about the same in France for firms with less than 2000 employees and for those with more than 2000 employees, in the U.S the respective growth rates were 3.6 and 1.7 percent.

25. The large difference between the unweighted and weighted ratios in France implies a difference in the R&D intensity of small and large firms: 5.1 percent in firms with less than 2000 employees, 3.8 percent for those with more than 2000 employees.

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Appendix -- Data Sources at the Industry and the Firm Level

The French industrial data come from the National Accounts data bases. Gross output, materials (intermediate consumption) and their associated price indexes and the total number of employees by industry are taken from "Le comptes de l'Industrie" - Les Collections de l'INSEE no.: C55 (1977), C76 (1979), C92 (1981). Hours of work are obtained by multiplying the average total number of employees, over the year, by the average number of hours worked per week by production workers in the same years. The latter is taken from the INSEE national accounts data bank. For a description of the methods used in constructing capital stock see J. Mairesse, "L'evaluation du capital fixe productif. Methodes et Resultats" - Les Collection de l'INSEE no.: C18-19 (1972). The numbers are taken from INSEE national accounts data bank. The share of labor in gross output is computed from the labor share in value added data, available in "Les comptes d'-entreprises par secteurs" (see Les Collection de l'INSEE, C78 (1979)) by multiplying them by $(1-s_m)$, where s_m is the share of materials in gross output. The estimates from the "sectoral" national accounts (based on firm's data) are not quite coherent with the other estimates from the "branch" national accounts (more or less based on establishments data). But at our level of industrial aggregation and for our purpose of computing TFP estimates, the possible discrepancies are negligible.

The U.S. industrial data are aggregated from the 4-digit SIC level data base constructed by the Penn-SRI-Census project (Fromm et al, 1979) and updated and extended at the NBER by Wayne Grey and Frank Lichtenberg. The basic data come from the Census Annual Surveys of Manufactures while the price series are based on the underlying detailed national income deflators. Labor input (total hours) is computed by dividing total payrolls in operating establishments by the average hourly wage rate of production workers. It can be interpreted as an estimate of total man-hours in production worker equivalent units. The capital stock data were constructed by Fawcett and Associates for Penn-SRI by perpetual inventory methods from Census sources. Output and input price indexes are based on unpublished detailed National Income deflators and tabulations. The price index of intermediate consumption was revised at the NBER by using the 1972 I-O Table and I-O sector level price indexes constructed by the Bureau of Labor Statistics. The total labor costs were revised at the NBER by adding the payrolls of Central and Auxillary Offices for Census years and interpolating in the intercensal years.

One source of discrepancies between the French and U.S. industrial data sets is that the latter are based on Census sources and not on NIPA conventions. In particular, in the U.S. Census, the notion of "materials" does not include all intermediate consumption, excluding especially purchased services. Since the capital share (s_c) is computed residually, it is somewhat too high in the U.S., perhaps by as much as a third (see the attempt at reconciliation of value added and GNP originating in the U.S. Census of Manufactures, 1977, Vol. 1, p. XXVII).

The French firm sample is the result of matching two different data sources: INSEE provided us with the balance-sheet and current account numbers (from the SUSE files) while the Ministry of Industry and Research provided the R&D numbers (from the annual survey on company R&D expenditures). The U.S. firm sample is built from the information available in the Standard and Poor's Compustat Industrial Tape. These samples are larger than the ones actually used in Griliches-Mairesse (1981) and Cuneo-Mairesse (1982). More details on the construction and cleaning of the samples, as well as on the definition and measurement of the variables can be found in these two studies.

APPENDIX TABLE 1

France-U.S. Joint Classification of Manufacturing Industries

IND	France: Niveau 40	France: Niveau 90 (NAP)	France: Name	U.S.: 2-3 digits (SIC)	U.S.: Name
1	T21	50	Papier-Carton	26	Paper and allied products
2	T11	171, 172, 43	Chimie de base. Fibres synthétiques	28 (excluding 283,284,285,289)	Chemicals (excluding drugs and pharmaceuticals)
3	T23	52, 53	Caoutchouc - Matières plastiques	30	Rubber, miscellaneous plastic products
4	T09,T10	14,15,16	Matériaux de construction - Verre	32	Stone, clay and glass products
5	T07,T08	09,10,11, 12, 13	Minerais et métaux ferreux et non-ferreux	33	Primary metal industries
6	T13	20, 21	Fonderie, travail des métaux	34	Fabricated metal products
7	T14	22,23,24, 25, 34	Construction mécanique	35,38 (less 357)	Machinery and instruments (excluding computers)
8	T15A, T15B	27,28,291, 292,30	Matériels électriques et électroniques professionnels et equipement menagers	36,357	Electrical equipment (including computers)
9	T16	311,312	Automobile et transport terrestre	37 (less 372 373, 376)	Automobile and ground transportation equipment
10	T17	26,32,33	Constructions navales et aéronautique, armement	372,373,376	Aircraft, boats and space vehicles
11	T18	441,442, 443, 47	Textile, habillement	22, 23	Textiles and apparel
12	T20	48, 49	Bois, meubles, industries diverses	24,25,39	Wood, furniture and miscellaneous products
13	T22	51	Presse, imprimerie, édition	27	Printing and publishing
14	T12	18, 19	Parachimie, pharmacie	283,284,285, 289	Drugs and parachemicals
15	T19	451,452, 46	Cuir et chaussures	31	Leather

APPENDIX TABLE 2(a).

Growth Rates of Output and Inputs, and Price of Output

	Q				K				L				M				PQ			
	1967-73		1973-78		1967-73		1973-78		1967-73		1973-78		1967-73		1973-78		1967-73		1973-78	
INDUSTRY	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US
1.	6.6	4.6	0.9	1.8	6.0	3.7	4.5	3.8	0.7	0.4	-2.9	0.4	8.3	3.3	-0.6	2.3	5.6	3.1	11.8	9.6
2.	10.0	7.3	1.4	3.1	7.3	4.2	1.8	5.7	0.4	0.4	-1.1	2.1	11.8	4.1	0.5	9.6	3.0	0.3	11.8	13.2
3.	9.2	8.8	2.5	2.0	8.2	7.7	3.0	5.6	4.3	4.7	-1.5	3.3	11.0	7.6	3.3	3.6	3.3	2.0	12.4	9.8
4.	7.8	3.7	0.7	1.7	7.6	2.3	4.7	2.5	-0.5	1.5	-3.0	1.0	9.0	3.9	0.8	3.7	5.0	4.7	11.4	9.9
5.	5.1	3.3	0.4	-1.5	4.1	2.7	4.6	1.7	-1.3	0.6	-1.7	-0.8	4.6	4.3	0.1	0.2	6.8	4.6	9.5	11.9
6.	5.2	2.4	-0.2	0.2	6.0	3.9	3.6	3.6	0.7	0.5	-3.0	1.2	4.5	2.0	-0.3	1.1	5.7	4.4	12.1	11.0
7.	8.8	4.5	0.2	2.3	8.5	5.2	7.3	5.2	1.1	1.3	-2.6	3.0	8.2	3.8	-0.3	3.0	4.2	3.5	10.9	9.9
8.	9.6	5.0	6.2	5.3	8.7	6.8	10.2	4.7	3.2	0.6	-0.6	2.0	8.5	3.3	5.1	3.3	2.3	1.8	6.3	5.6
9.	10.3	7.5	3.3	3.0	8.6	3.2	6.9	5.4	4.0	4.2	-0.1	1.3	9.2	6.1	3.0	3.0	4.5	3.3	12.7	8.6
10.	7.9	-4.7	5.9	1.1	2.3	3.2	1.9	0.0	0.3	-6.2	-1.2	0.8	7.7	-4.0	2.5	1.1	3.5	4.0	9.4	9.3
11.	5.1	3.2	-1.9	1.3	2.8	4.2	0.5	2.8	-1.8	0.7	-4.7	-1.2	5.7	2.5	-2.0	0.7	4.5	3.2	9.2	5.3
12.	7.1	4.9	1.6	1.4	5.8	4.1	5.0	4.4	0.5	2.7	-2.2	0.9	7.4	4.6	0.7	1.9	5.5	6.3	8.7	8.4
13.	4.1	2.7	3.0	2.7	6.6	3.1	2.9	1.9	1.4	0.8	-2.0	2.3	6.0	2.4	2.9	3.9	7.4	4.4	10.5	8.3
14.	9.1	5.6	4.1	4.0	8.1	5.3	7.2	3.8	1.6	1.4	0.2	2.2	11.0	4.1	3.8	4.3	2.4	2.2	9.3	7.8
15.	3.1	-2.0	-2.0	-0.2	2.6	1.9	1.7	0.6	-2.0	-2.9	-3.9	-1.2	2.7	-2.4	-1.5	0.0	5.7	5.1	11.9	6.7

NOTES :- Q, K, L, and M are output, capital stock, labor input (man-hours), and intermediate consumption respectively. Table 2(a) shows the rates of growth of these (real) quantities, and the rate of growth of PQ - the price of output.

APPENDIX TABLE 2(b).

Growth Rates of Input Prices and Average Levels of Factor Shares.

	PK				PL				PM				SL				SM			
	1967-73		1973-78		1967-73		1973-78		1967-73		1973-78		1967-73		1973-78		1967-73		1973-78	
INDUSTRY	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US	FR	US
1.	3.1	5.0	6.3	5.7	11.3	6.8	21.0	9.3	4.8	4.3	11.9	10.6	0.24	0.24	0.26	0.20	0.61	0.53	0.62	0.56
2.	7.0	4.0	5.2	5.4	12.7	6.6	20.1	9.8	1.0	3.1	12.6	10.9	0.23	0.18	0.25	0.14	0.57	0.48	0.56	0.54
3.	5.0	5.1	5.8	1.5	9.5	5.5	17.8	7.5	0.5	2.3	12.8	11.1	0.34	0.28	0.35	0.26	0.47	0.46	0.50	0.49
4.	3.5	6.7	4.5	8.3	13.3	6.7	15.9	8.3	5.0	4.3	12.5	9.8	0.34	0.30	0.33	0.27	0.44	0.42	0.47	0.45
5.	9.7	3.3	-5.5	6.1	12.5	7.1	16.4	10.4	7.3	4.5	10.1	11.0	0.20	0.24	0.21	0.22	0.67	0.60	0.68	0.62
6.	5.4	4.1	5.9	6.8	12.0	6.2	17.5	8.2	5.1	4.6	10.9	11.3	0.38	0.31	0.42	0.28	0.46	0.48	0.43	0.49
7.	2.6	3.5	0.7	6.2	10.0	6.1	16.5	8.2	7.5	4.2	10.6	10.4	0.39	0.32	0.39	0.30	0.44	0.42	0.46	0.43
8.	4.0	1.6	-1.8	6.9	8.8	5.7	13.9	8.1	3.0	3.1	8.7	7.8	0.37	0.32	0.36	0.31	0.45	0.43	0.48	0.44
9.	9.2	8.2	7.6	3.4	12.4	7.1	19.7	9.6	4.3	4.3	11.7	9.5	0.29	0.18	0.31	0.18	0.59	0.65	0.56	0.67
10.	1.4	-6.5	18.9	12.5	8.4	6.5	21.0	8.3	6.1	4.1	10.8	9.7	0.29	0.41	0.28	0.39	0.63	0.41	0.64	0.42
11.	8.5	3.9	2.9	3.4	10.2	5.5	15.0	7.6	4.3	3.5	8.7	6.2	0.31	0.26	0.31	0.25	0.57	0.55	0.59	0.56
12.	6.4	9.3	2.5	3.8	10.0	6.4	14.4	8.1	6.4	6.8	9.5	9.0	0.31	0.28	0.29	0.26	0.55	0.50	0.59	0.52
13.	4.5	4.6	7.6	9.4	10.0	6.4	15.6	6.6	5.7	4.2	11.5	8.7	0.33	0.36	0.33	0.34	0.55	0.33	0.56	0.35
14.	-0.7	2.5	4.1	6.4	7.0	6.6	13.2	8.1	3.0	3.6	10.2	10.0	0.27	0.17	0.22	0.16	0.57	0.38	0.66	0.42
15.	6.8	1.3	9.9	6.0	11.0	5.2	18.9	6.9	6.0	5.8	8.0	7.1	0.31	0.31	0.36	0.29	0.58	0.48	0.52	0.50

NOTES :- PK, PL, and PM are the price of capital (imputed), labor (the wage rate)and intermediate consumption respectively. Table 2(b) shows the rates of growth of these prices, and the average levels of SL and SM - the shares of M and L in output.

APPENDIX TABLE 3

Various Measures of R&D Intensity

Industry	R&D Percent of Sales				R&D Employees per 1000	
	Total R&D		Company R&D			
	FR	US	FR	US	FR	US
1.	0.1	0.6	0.1	0.6	0.3	0.8
2.	2.9	3.5	2.7	2.9	5.4	3.5
3.	2.0	1.7	2.0	1.1	2.5	1.4
4.	0.6	0.8	0.6	0.8	0.6	0.7
5.	0.5	0.5	0.5	0.5	1.0	0.6
6.	0.2	0.4	0.2	0.4	0.3	0.5
7.	0.8	2.0	0.8	1.2	1.0	1.0
8.	6.4	7.7	3.5	4.9	6.7	4.9
9.	2.2	3.2	2.2	2.7	2.9	2.5
10.	8.0	12.7	4.4	2.8	9.9	7.2
11.	0.1	0.1	0.1	0.1	0.0	0.1
12.	0.0	0.3	0.0	0.3	0.0	0.3
13.	0.0	0.2	0.0	0.2	0.0	0.2
14.	3.1	3.7	3.2	3.7	6.2	4.5
15.	0.0	0.1	0.0	0.1	0.0	0.0

French R-D numbers are estimated from "Le Compte Satellite de le Recherche, Methodes et series 1970-1976 " Les Collections de l"INSEE C85 (1979);

U.S. ones are estimated from NSF79.313 - Research and Development in Industries, Detailed Statistical Tables (1979).

Appendix Table 4: 1973-78 Rates of growth of the main variables by industry in the French and U.S. firm samples (1974 levels for R/S). Unweighted means and (standard deviations).

Industry / Country	DRUGS FR	DRUGS US	CHEMICALS FR	CHEMICALS US	ELECTRONICS FR	ELECTRONICS US	ELECTRICAL EQUIPMENT FR	ELECTRICAL EQUIPMENT US	MACHINERY FR	MACHINERY US
NAP: Niveau + 90-600	19 + 1811		17 + 18		291		28 + 292 + 30		22 thru 25 + 3407	
SIC: 3-4 digits	283 + 2844 + 3841 + 3843		28 (-283 - 2844)		366 + 367		36 (-366) - 367)		35 (-357)	
Subsample size	47	57	30	62	37	65	32	47	39	112
Deflated Sales per employee q-n	4.5 (4.8)	.1 (3.7)	2.2 (5.0)	1.1 (3.5)	5.4 (4.7)	3.0 (4.7)	3.2 (4.3)	.1 (4.0)	.3 (3.9)	-.5 (4.0)
Gross Plant adjusted per employee c-n	5.7 (6.2)	3.8 (5.8)	5.6 (3.7)	5.7 (5.8)	6.0 (3.6)	4.3 (8.2)	5.1 (5.0)	5.6 (6.0)	5.3 (4.9)	5.3 (6.2)
Total Factor Productivity TFP	3.0 (4.7)	-.1 (3.7)	.8 (4.8)	-.3 (3.7)	3.9 (4.7)	1.9 (4.4)	2.0 (4.3)	-.1 (4.0)	-1.0 (3.7)	-1.8 (3.6)
R&D Capital stock per employee k-n	6.5 (6.5)	3.1 (7.1)	4.4 (5.5)	3.5 (7.2)	6.1 (6.2)	3.0 (7.8)	5.0 (6.0)	4.9 (6.9)	6.9 (8.4)	4.1 (9.1)
Number of employees n	.2 (4.4)	5.5 (7.2)	.5 (3.5)	1.2 (5.9)	1.8 (4.5)	3.4 (8.2)	.6 (4.6)	-.0 (6.7)	-1.1 (4.5)	2.4 (6.5)
R&D to sales ratio in 1974 R/S	6.4 (3.9)	3.4 (2.4)	3.6 (3.3)	2.6 (1.5)	7.8 (6.0)	3.5 (2.6)	3.2 (3.0)	2.0 (1.8)	2.0 (1.7)	1.9 (1.4)

Appendix Table 5

Numbers of employees (E), in thousands, and R&D sales ratios (R/S), in percent, for the French and U.S. samples for the corresponding aggregate industries, and also for all "R&D doing firms" in the two countries*

	Samples (S)		R&D Doing Firms (R)		Corresponding Industries (I)			Coverage	
	E_S	$(R/S)_S$ %	E_R	$(R/S)_R$ %	E_I	$(R/S)_I$ %	$(RT/S)_I$ %	E_S/E_I %	E_R/E_S %
France (1974)	395	3.7	565	4.3	1550	2.6	3.3	25	35
U.S. (1976)	4250	2.9	4500	2.6	4900	2.9	4.1	85	90

* The estimates for the samples and the corresponding industries are the ones obtained in this study. The estimates for the R&D doing firms" are computed from "Le Recherche-Development dans les entreprises industrielles en 1974" (Documentation française 1977) and from "Who does R&D and who patents?" (Bound et al, 1982). Numbers of employees are in thousands, R&D sales ratios in percent. RT/S refers to ratio of total R&D performed in the industry (whether company or public financed), while R/S refers only to company financed R&D. These estimates are only indicative, and can be misleading for a number of reasons. First, they are not strictly comparable, since computers and nonmedical instruments are not included in our samples, while they are part of the corresponding industries. This explains specifically why $(R/S)_I$ appears to be higher than $(R/S)_S$ and $(R/S)_R$ in the U.S. Second, they are not strictly comparable also due to the conglomerateness and the importance of foreign activities of many of our firms, particularly in the U.S., while the industry level numbers are establishment based and cover only domestic activities. This results in a severe overestimation of the coverage ratios in the U.S., but is not enough to change the finding that the proportion of R&D doing firms in the industries considered is much less in France than in the U.S. Third, the cutoff point between R&D and non-R&D doing firms seems somewhat higher in France than in the U.S. This is not enough, however, to account for the finding that R&D doing firms appear to do relatively more R&D in proportion to their sales in France than in the U.S. Fourth, the picture differs across industries, the coverage and the R&D sales ratios being both much less for machinery than for drugs and chemicals or for electronics and electrical equipment.