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A 4-Digit SIC Level U.S. Manufacturing Study

SUSANA GARCIA CERVERO

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Skill differentials in the long and in the short run. A 4-digit SIC level U.S. manufacturing study

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Abstract

During the last decade, labour economists have shown an increasing interest in explaining the behaviour of skill wage differentials as well as the evolution of the corresponding inputs' shares. Most tend to focus on the long run evolution of such variables, few on their short run fluctuations, none on both. They also tend to consider only one of the two main forces traditionally given as explanations of the behaviour of the skill shares differentials: capital skill complementarity and biased technical progress. This paper studies this behaviour both in the long run and in the short run allowing for both of these causes to act jointly. The results strongly suggest the existence of capital-skill complementarity and the incapability of the Solow Residual to approach technology at business cycle frequencies. These findings seem to challenge most papers on Real Business Cycles.

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1 Introduction

In recent years, an overwhelming number of papers in the field of labour economics have tried to explain the observed upwards trend in skill differentials (Blackburn et al. 1989, Bound and Johnson 1989, Katz and Murphy 1991, Blau and Kahn 1994, Juhn 1994 among others). They mainly focus on the phenomenon from a long run perspective. Very few treat the phenomenon from a short run perspective, i.e. try to work out the reasons for the skill differentials' behaviour at a business cycle frequency. None of them carry out the analysis from both perspectives in order to compare the outcomes. The main goal of this paper is to attempt to cover this gap. Furthermore, most of the studies ignore the role of materials as another factor of production, focusing only on different categories of workers. Here, I also include materials in order to study to what extent the results are affected and how far the inclusion of the new input will shed new light on the analysis.

In a panel data framework, there are two factors which explain this observed upwards trend in the skill differentials; a shift in the demand for labour across industries and a shift in the skill composition of labour demand within each industry. The main reasons proposed to explain the latter shift are possible complementarity of physical capital and skilled labour, and technical progress biased towards skilled labour. A recurring feature in the labour economics literature is that these explanations are never distinguished. Either only capital intensity or only technology are considered, or some sort of embodied technical progress measure is introduced into the regression. In both cases, it is impossible to discriminate between them and quantify their relative contribution to movements of skill differentials'. Here, I consider both capital skill complementarity and biased technical progress, allowing for the data to discriminate between them. In computational terms, this implies that both Solow's residual (proxying technology) and capital intensity will be considered in the regression analysis. This analysis will first be framed in terms of simple comparative statics, which will be called the cost function approach. In a second step, an alternative macroeconomic approach characterized by the existence of adjustment costs will be used in order to compare both approaches.

The remainder of the paper is organized as follows. Section 2 briefly describes the data base used in the empirical analysis. Section 3 documents the observed patterns of the main variables involved in the analysis. Section 4 tries to identify the reasons for the patterns described in the previous section, and introduces new material that will be used in further sections. Section 5 presents the microeconomic foundations by deriving the main econometric expression of the paper. Section 6 goes beyond econometrics by analyzing the economic framework in which the econometric expressions have been derived. Sections 7 and 8 present and discuss the empirical evidence supporting the two approaches of the analysis: the cost function approach and the alternative macroeconomic approach. Finally, Section 9 draws the main conclusions.

2 Data description

Most of the data used in this paper were obtained from a large data set developed by Wayne Gray at the NBER, which covers 449 U.S. 4-digit SIC level manufacturing industries, during the period 1958-1984. The main source of this data set is the Annual Survey of Manufacturers (ASM), conducted by the U.S. Census Bureau. Gross output is computed as the value of shipments plus inventory change. Total intermediate inputs include both materials and energy although excluding purchased services. Therefore they are slightly underestimated. Data on capital refers to both structures and equipment. These data are based on estimates from a joint project by the University of Pennsylvania, the Census Bureau, the SRI Inc., and from the Bureau of Industrial Economics of the Commerce Department. This data set permits the computation of Solow residuals (see section 4.1) distinguishing two different labour inputs: production workers' hours and the number of non production workers[1]. Production workers are defined as "workers engaged in fabricating, processing, assembling, inspecting and other manufacturing". Non-production workers are defined as "personnel, including those engaged in supervision, installation and servicing of own product, sales, delivery, professional, technological, administrative. etc". However, Gray's data on labour compensation do not include Social Security benefits and the pay of employees in auxiliary units, which account for as much as 10% of total employees[2]. This implies that the compensation of labour is underestimated. Therefore if we compute the Solow residuals from Gray's data, we would be underestimating the shares of labour and overestimating the Solow residuals, thus introducing a potential bias in the results. Fortunately, good data on labour compensation can be obtained by using 2 digit figures from U.S. National Income and Production Accounts (NIPA). Thus, the 4 digit SIC data were corrected using the 2 digit NIPA features and assuming that the

[1] Unfortunately, data on non-production workers hours are not available.

[2] The categories production and non-production workers apply only to operating plants.

distribution of the errors was the same in both series.

3 Changes in the structure of manufacturing industry employment: moving towards non-production labour.

Several authors have documented the upward trend in the ratio of non-production employment to total employment in U.S. manufacturing (Berman et alia 1993). In this section, I will present similar evidence enlarging the analysis to three factors of production: non-production labour, production labour and materials. Together, these three will constitute the total variable cost since we will assume that capital can be treated as a fixed factor.

Table 1 reports long term aggregate changes in the relative shares of non-production labour in manufacturing employment during the period 1958-1984. The figures make it clear that, over the whole period, the nature of employment shifted considerably away from production towards non-production labour. The magnitude of the shift is large (of the order of a 0.77% annual rate of change). A similar pattern appears for the share of non-production wage bill over total wage bill which rose from 0.321 in 1958 to 0.382 in 1989. This implies an annual rate of change of 0.70%. Both series have been plotted in Figure 1. These changes in the wage bill share will roughly reflect changes in the relative skill levels. However, the non-production/production relative wage (i.e. the ratio of non-production workers' wages to production workers' wages), plotted in Figure 2, is more volatile than the evolution in the share of non-production wage bill. In fact, there is only a slight increasing trend from 1958 until the first oil crisis, then, during both oil crises, the relative wage tends to decrease, so that the final effect over the whole period is a very slight increase.

When materials cost enter the analysis, this violent upward trend in the non-production workers share smooths considerably. Looking at Figure 2, one can picture the greatly increasing role of the material cost in total variable cost. The series present a strong upward movement until 1970, followed by a pronounced break during the seventies, possibly because of the oil crises. It reaches its minimum value around 1980, to start a new period of increase while the economy recuperates. Therefore, although there is an apparent move away from production labour towards non-production labour, the same cannot be said in relation to materials cost. Here we will focus on the first phenomenon

Year	Series 1	Series 2	Series 3	Series 4
1958	0.238	1.502	0.321	0.094
1963	0.239	1.523	0.324	0.0978
1968	0.243	1.542	0.331	0.104
1973	0.241	1.545	0.329	0.100
1978	0.255	1.517	0.342	0.086
1984	0.288	1.523	0.382	0.090
ARC	0.77%	0.04%	0.70%	-0.16%

Table 1: Series 1: share of non-production employment in total employment. Series 2: relative wages non-production/production workers. Section 3: Share of non-production wage bill in total wage bill. Series 4: non-production workers share over total variable cost. ARC stands for annualized rate of change

without ignoring the role of material inputs in variable cost.

This move towards non-production labour can be interpreted as a skill upgrading phenomenon. Berman et al.(1993) determined how the classification between production and non-production workers can be mapped into educational and occupational categories, concluding (in line with the work by S. Machin 1994 for U.K manufacturing) that an important component of skill upgrading is the shift away from blue collar or production labour towards white collar or non-production labour. The next step consists of analyzing the relations between the production inputs as well as quantifying possible reasons that might explain the observed upward patterns in non-production workers shares of both total wage bill and total employment.

4 Why do we move away from production labour?

The erratic behaviour of the relative wage non-production/production workers (Figure 2) doesn't explain by itself the impressive upward movement in the non-production workers' share. At least during the period under study, it can be said that the main cause of such a trend is the behaviour of the employment levels. Moreover, under a strict microeconomic approach, since the relative wage has increased over the period as a whole, one would expect substitution effect working in the opposite direction, moving away from non-production labour towards production labour.

In the U.S. literature, several possible explanations have been proposed to explain shifts in the relative demand non-production/production labour. Two main lines of thought can be distinguished. One asserts that it is mainly due to product demand shifts that affect industries with a different share of production workers. We will be dealing with a force that acts *across* industries, such as the rise of import competition in the U.S. manufacturing industry or the increase in the Defense Department procurement[3]. The second is that skill upgrading has occurred due to skill biased technical progress. This argument refers to within-industry changes. Another reason that would also operate in the same framework is a possible capital-skill complementarity, in the sense that physical capital seems to be more complementary (or less substitute) with skilled labour (non-production workers) than with unskilled labour (production workers). It is thus convenient to distinguish the forces that work by shifting the derived demand for labour across industries from those that shift the skill composition of labour demand within each industry. The standard method is to decompose aggregate changes in the structure of employment into within-industry and between-industry components of the total change. Berman et al. 1993 computed the decomposition and concluded that the within-industry component is by far the most important: it accounts for about 70% of the increase in the relative share of non-production labour.

The literature which focuses on such intra-industry forces, when trying to explain the phenomenon has never considered jointly the two issues of capital skill complementarity and biased technical progress. This avoids the possibility of discriminating between them and of quantifying their relative contribution to the pattern. Here, both will be included in the analysis. This literature also tends to ignore the role of materials in production. We have already noted the relative importance of materials cost in total variable cost. In order to have a more complete view of the empirical evidence it seems therefore appropriate to include them in the analysis.

[3]The increasing international competition that US manufacturing has faced over the last decades has been said to operate by shifting the relative demand for labour across industries because the US has typically imported goods that are less skilled labour intensive and exported goods that are more skilled labour intensive.

4.1 Biased technological progress and how to proxy technology: the Solow residual

The concept of disembodied technological progress is associated with the growth literature. As it is well known, assuming the existence of exogenous technical progress has been an easy way of dealing with economic growth from a neoclassical perspective. This approach simply consists of attaching an exogenous and constant rate of growth to the economy as a whole and it basically means shifts in the production function over time. The relevant concept for our analysis is that of *neutrality of technical progress*, which implies that, along the balanced growth paths, factors' shares remain constant. This is so because the marginal productivities of all inputs increase at the same rate over time. When the factor shares do not remain constant over time but present a systematic pattern which favours a specific factor, we say that technical progress is *biased towards* such a factor. Similarly, if such a pattern systematically does not favour a factor, technical progress is said to be *biased against* this factor.

The question of how to proxy technical progress is a very tricky one. Empirical literature on growth, as well as labour market studies, tend to proxy using variables that are plausibly correlated with productivity growth, such as investment in computers and R&D expenditures. The problem of proxying this way is that it is not attached to the disembodied technical progress concept, but to the embodied one[4]. If we want to consider both hypothesis of capital skill complementarity and biased technical progress, we should not proxy technology through any sort of investment measure. The reason is that more investment implies more stock of capital to be combined with the other factors of production, so that some capital-skill complementarity effect would also be captured. That is why technical progress will be proxied via Solow residuals.

Total factor productivity or Solow residual (henceforth SR) is defined as the part of output growth not explained by growth in inputs. Let us assume a production function for each industry of the form,

$$Y_t = F(N_{pt}, N_{npt}, K_t, M_t, \theta_t) \tag{1}$$

where N_{pt} represents the production labour, N_{npt} the non-production labour, K_t physical capital, M_t materials and θ_t is some sort of technology index. Under

[4]Disembodied technical change stems from a reorganization of the factors of production, with a constant quality of inputs. By contrast, when technical change is embodied it is caused by changes in the quality of capital and also possibly of other inputs into the production process.

perfect competition and constant returns to scale in all factors of production Solow residuals take the form:

$$SR_t = \Delta ln\theta_t = \Delta lnY_t - \alpha_{npt}\Delta lnN_{npt} - \alpha_p\Delta lnN_{pt} - \alpha_k\Delta lnK_t - \alpha_m\Delta lnM_t \quad (2)$$

where α_{np} is the factor share earned by the non-production workers, α_p is the factor share earned by production workers, α_k is the factor share which remunerates the capital services and α_m is materials factor share. The accuracy of the SR calculations depends on accurate calculation of growth in all factors of production. It also requires that competitive assumptions hold, so that factors are paid their marginal products and the growth of a given factor affects output in proportion to its income share. Perfect competition together with constant returns imply that there are no pure profits, so that capital's share is observable as a residual. Thus, when both hypotheses are assumed, we can substitute α_k for $1 - \alpha_{np} - \alpha_p - \alpha_m$. That is the way how the SR will be calculated further on in the paper.

Aggregate total factor productivity data are often considered weak because capital stocks and some parts of output are felt to be poorly measured. In our case, SR will be computed at 4-digits industry level with a relatively reliable database on physical capital. Besides constant returns to scale, it is implicitly assumed that the qualities of the output produced with the technology under study have not experienced important changes over time. Otherwise, productivity gains or losses cannot be correctly identified with existing indexes of TFP and the SR would not be proxying the notion of "disembodied technical progress". Regarding the assumption of perfect competition, its relaxation will be considered in section 6.

4.2 Changes in the returns to skill

If we assume that there are, at least, two different kinds of labour depending on the level of skill or education jointly with competitive labour markets, then higher wages associated with higher level of education or skills correspond to the greater productivity of that labour.

Let us imagine a world with neutral technical progress and exogenous labour supply, so that it is fixed and independent of agents' decisions. The neutral technical progress hypothesis implies that the relative marginal productivities of inputs do not depend on the technical progress index. If perfect competition holds, firms will demand labour until they equate marginal productivity to its wage. The key feature here is that the ratio of marginal productivities (or relative labour demand) is unaffected by technical progress. Thus, as time passes and the economy grows at an exogenous constant rate, the relative demand, relative wages and relative employment levels will stay constant *for ever*. As a consequence, the relative shares will also stay constant *for ever and ever*.

Data on long run movements of returns to education or skills in US and other countries (Kutz et al 1993, Machin 1993, Mincer 1991, Juhn 1994, Berman et al 1993) do not indicate a sensitive reduction in such rates of return. This absence of a long term downward trend in the profitability of education or skills has been justified by long term growth in the demand for educated labour. Such a phenomenon would be possible if we allow for biased technical change or if there is some sort of capital skill complementarity. In the latter case, as the capital is accumulated, the demand for more skilled or educated people will increase, causing also an upward pattern in the shares of more educated or skilled workers.

Both explanations for the long run upwards trend in returns to skill or education are compatible. A different issue is whether such reasons play a similar role both in the short run and in the long run[5]. This issue constitutes an indirect method of determining whether the forces causing business cycles are of the same nature as those causing long run growth (as Real Business Cycles economists claim). Here the long-run relation among the variables involved will be captured by computing the between-industry estimator, while at cyclical frequencies, this relation will be captured through the within industry estimator. Finally, both will be compared through the Hausman test. If the RBC school is right, when the forces causing the movement in the skill differentials are analyzed, we should find that the regressors which turn out to be significant when the between-industry estimates are computed are roughly the same as those which appeared to be significant when the within-industry estimates are obtained. In this context, SR plays a very important role, since technological shocks are the key feature in the RBC model (the driving force behind cyclical fluctuations) and productivity shocks are always proxied with SR. An expansion/depression will correspond to a period of increase/decrease of the SR (an effect that should be captured through the within-industry estimator). Underlying these forces which act at cyclical frequencies, there is also a long run growth (permanent productivity shock) which should correspond

[5]A detailed description of exogenous shocks likely to have caused such movements in the US skill wage differentials, is found in Mincer (1991)

to a continuous increase of the SR (and that should be captured through the between-industry estimator and random effects estimator)[6].

5 Explaining the behaviour of non-production workers "share"

As mentioned above, we will assume that, over the time horizons we are working with, capital can be treated as a fixed factor while the other inputs should be treated as variable. The econometric specification that will be estimated further on can easily be derived from a translog cost function which expresses the expenditures on variable inputs as a function of the variable input prices, the level of output (Y_t), and the quantities of the fixed factor (K_t). We will also introduce a technological progress indicator θ_t. The translog cost function can be interpreted as a second-order Taylor's approximation in logarithms to an arbitrary cost function. The dual cost function approach is particularly accurate if industries are reasonably competitive and if data are disagregated, since in such a case it is more likely than prices rather than quantities are exogenous. The variable inputs in our variable cost function are the number of non-production workers N_{np}, number of production workers N_p and materials M. Their respective prices are denoted by W_{np}, W_p and W_m. Thus, the total variable cost function will be $TVC = N_{np}W_{np} + N_pW_p + MW_m$.

We can obtain an equation for the variable input we are interested in based on the translog variable cost function, by using Shephard's Lemma and obtaining the corresponding FOC's for the cost minimization problem[7]. The corresponding FOC's for the three variable inputs will turn out to be

$$\frac{\delta ln(TVC)}{\delta ln(W_{np})} = \frac{N_{np}W_{np}}{TVC} = s_{np} = \alpha_{np} + \beta_{npnp}ln(W_{np}) + \beta_{npp}ln(W_p) + \qquad (3)$$
$$+\beta_{npm}ln(W_m) + \beta_{npK}ln(K) + \beta_{npY}ln(Y) + \beta_{npt}ln(\theta_{npt})$$

[6]Nevertheless, as we will see, the idea of SR as exogenous technological shock is suspiciously incompatible with its procyclical nature. Here, empirical evidence has been found to be fully compatible with previous literature on SR which has proved it to be significantly correlated with demand variables such as military expenditure (Hall, 1988), monetary aggregates (Evans 1992) and government consumption (Burnside et alia 1993)

[7]As capital is treated as a fixed (and exogenous) factor, there is no FOC attached to it

$$\frac{\delta ln(TVC)}{\delta ln(W_p)} = \frac{N_p W_p}{TVC} = s_p = \alpha_p + \beta_{pnp} ln(W_{np}) + \beta_{pp} ln(W_p) + \tag{4}$$
$$+\beta_{pm} ln(W_m) + \beta_{pK} ln(K) + \beta_{pY} ln(Y) + \beta_{pt} ln(\theta_{pt})$$

$$\frac{\delta ln(TVC)}{\delta ln(W_m)} = \frac{MW_m}{TVC} = s_m = \alpha_m + \beta_{mnp} ln(W_{np}) + \beta_{mp} ln(W_p) + \tag{5}$$
$$+\beta_{mm} ln(W_m) + \beta_{mK} ln(K) + \beta_{My} ln(Y) + \beta_{mt} ln(\theta_{mt})$$

We will call s_{np}, s_p and s_m the share of non-production workers wage bill, share of production workers wage bill and share of materials in total variable cost. We can simplify the analysis by focusing on two out of these three equations in order to study the behaviour of the input shares. I have chosen to study equations (3) and (5).

For a cost function to be well behaved, among other things it has to be homogeneous of degree one in prices, given Y. Assuming a well behaved cost function plus constant returns to scale imply the following set of restrictions

$$\begin{aligned} \beta_{npnp} + \beta_{npp} + \beta_{npm} = 0, &\quad \beta_{npk} = -\beta_{npy} = \beta_{np} \\ \beta_{pnp} + \beta_{pp} + \beta_{pm} = 0, &\quad \beta_{Pk} = -\beta_{Py} = \beta_p \\ \beta_{mnp} + \beta_{mp} + \beta_{mm} = 0, &\quad \beta_{Mk} = -\beta_{My} = \beta_m \end{aligned} \tag{6}$$

Introducing such restrictions into equations (3) and (5), taking first differences and appending an error term ϵ give changes in the share equations as follows

$$\Delta s_{np} = \beta_{npnp} \Delta ln(W_{np}/W_p) + \beta_{npm} \Delta ln(W_m/W_p) + \\ \beta_{np} \Delta ln(K/Y) + \beta_{npt} \Delta ln(\theta) + \epsilon_{np} \tag{7}$$

$$\Delta s_m = \beta_{mnp} \Delta ln(W_{np}/W_p) + \beta_{mm} \Delta ln(W_m/W_p) + \\ \beta_{mp} \Delta ln(K/Y) + \beta_{mt} \Delta ln(\theta) + \epsilon_p \tag{8}$$

We will proxy technical progress via Solow residuals as was shown in equation (2). These are very useful devices for empirically analyzing changes in factor cost shares over time. Changes in the wage bill share will reflect changes in relative skill levels. The direction of the substitution bias will depend on whether the elasticity of substitution is above or below one. An elasticity below one implies that the change in the wage bill overstates changes in the relative demand for non-production labour (wages constant), while an elasticity above one implies the opposite. A brief summary of the interpretation of the coefficients is presented in Table 2.

These two equations will be estimated via SUR. The analysis will also be replicated when materials are excluded from the study so that total variable cost is replaced by the total wage bill $TWB = N_{np}w_{np} + N_p w_p$. Applying the same procedure as before, BLU estimators can be obtain by running OLS on the following uniequational model

$$\Delta s_{np} = \beta_{npnp}\Delta ln(W_{np}/W_p) + \beta_{np}\Delta ln(K/Y) + \beta_{npt}\Delta ln(\theta) + \epsilon_{np} \quad (9)$$

where here s_{np} stands for $\frac{\delta ln(VC)}{\delta ln(W_{np})} = \frac{N_{np}W_{np}}{N_{np}W_{np}+N_pW_p}$

Unfortunately, there are two basic features which produce noise in the time series behaviour of the data. The first one is the fact that the sample is redrawn every five years, which tends to introduce jumps in the series at five year intervals. The second one (Siegel and Griliches, 1992) relates to the tendency for firms to migrate from one industry to another. A possible way to minimize such behaviour is to weight the data by some measure of industry size. I choose to weight them by the industry's share in total manufacturing payroll averaged over the corresponding periods: 1958-1973, 1974-1984, as well as over the whole sample 1958-1984. Doing so implies that the dependent variable aggregates to within-industry changes.

6 Economics beneath econometrics

Before calculating the different estimators and studying the results, it is appropriate to interpret the economic framework in which all the empirical results will be obtained. It should be recalled that all the econometric equations have been derived from the FOC's of a static cost minimization problem. We have also assumed competitive markets and constant returns to scale. To base an econometric expression on such a FOC means that there are no adjustment costs and therefore we reach the long run equilibrium automatically. Thus,

Regressor	positive sign	negative sign
β_{npnp}	Elasticity of substitution between production and non-production workers below one	Elasticity of substitution between production and non-production workers above one
$\beta_{npnp} - \beta_{npm}$	Elasticity of substitution between non-production workers and materials below one	Elasticity of substitution between non-production workers and materials above one
β_{mm}	Elasticity of substitution between production workers and materials below one	Elasticity of substitution between production workers and materials above one
β_{np}	Capital skill complementarity	Capital skill substitutability
β_{npt}	Technical progress biased towards non-production workers	Technical progress biased against non-production workers
β_{mt}	Technical progress biased towards materials	Technical progress biased against materials

Table 2: Economic interpretation of the coefficients

there is no theoretical difference between the short run and the long run. We are working in first differences because we are interested in capturing the relation between the variables at cyclical frequencies, but, as we are *always* at the long run optimum, these relations should also hold as the time horizon changes. Implicit also in this economic approach is the assumption of exogeneity of the rate of growth of the relative wages at industry level. Let us call this the *cost function approach.*

Now, let us look at the graphics and the rates of change of the main variables involved in the analysis. It seems as if there is some sort of volatility ranking among the factors of production. In decreasing order the ranking is the following: materials, production workers, non-production workers and capital. For this reason materials, as well as SR, are found to be highly procyclical, while capital intensity is clearly countercyclical. The existence of adjustment costs (which act in such a way that the long run equilibrium is not reached automatically) may be the reason why some factors tend to react more than others to the cyclical fluctuations of output[8]. This would explain why materials are so strongly procyclical, why firms tend to lay off production labour rather than non-production labour during the recessions and therefore why the rate of unemployment for unskilled workers is higher than for skilled ones. In this scenario, we would be oscillating around some target employment levels instead of staying continuously in equilibrium. Dynamics would be introduced into the model, in comparison to the cost function approach which is strictly static. Moreover, the distinction between cyclical fluctuations and trend would now recover its sense. In the long run, we would tend to some sequence of equilibria that might never be reached in the short run, while inputs would fluctuate in inverse proportion to their adjustment costs during periods of non-equilibrium. Firms would react to shocks by rearranging the labour utilization intensity and only in the long run would the new optimum level of labour be reached. In the meantime, the comovements of variables would be explained by slow or quick responses to demand fluctuations. This would be some sort of *alternative macroeconomic approach.*

Neither of these approaches establish a casual relation, in the sense that although both try to explain the mechanism through which the forces cause changes in the share differential dynamics, neither claim to explain how and what are the primary causes. Neither of them are implemented in a broader

[8]Empirical work by Pfann and Verspagen (1989) for the Dutch manufacturing sector has found these adjustment costs to be non-quadratic so that this asymmetry allows for different speeds of adjustment during recessions and upturns.

benchmark theory which explains the nature and causes of economic fluctuations and long-run growth, as RBC school claims to do.

7 Empirical evidence: cost function approach

7.1 Long run and between-industry estimators

In order to study the long run relations among the variables in the regression, I have run the equivalent regression with the industries' means. That is, we calculate the change over the whole period of each variable and for each industry and obtain their respective means before running the regression. In other words, we run the regression with the means of the first differences (eq. 7, 8 and 9). The exercise yields the between industry estimators, the values of which are presented in Tables 3, 4 and 5. The regression has been run both for the whole period and for the subperiods 1958-1974 and 1974-1984 in order to see to what extent evidence of structural break can be found.

The results of Tables 3 and 4 seem to support the capital skill complementarity hypothesis, since the corresponding coefficients have a positive and significant sign, both with respect to total wage bill and total variable cost (eq 7 and eq. 9). Similarly, Table 5 supports the existence of a substitutability relation between materials and capital in the long run, since, in this case, the coefficient is negative and significant (eq 8). With respect to the elasticity of substitution between non-production workers and production workers, these signs indicate an elasticity of substitution between inputs of less than one. The same holds true in relation to the elasticity of substitution between non-production workers and materials. There is strong evidence supporting biased technological change towards non-production workers with respect to total variable cost and weaker evidence of biased technical progress with respect to total wage bill. Evidence of technical change biased against materials (Table 5) can be found by taken into account the sign of the SR coefficient, though these do not appear to be significant.

Even though there does not seem to be definitive evidence of a structural break between the two subperiods, the relative change in the magnitude of the SR coefficient in Table 4, should be pointed out. Due to the impact of both oil crises, the relative importance of the SR decreases sensibly from the first subperiod to the second. This reflects a quicker rate of decrease in the dependent variable than in the SR, which is consistent with the decrease in wages relative to the price of materials that took place in the States during the post oil crises period. Finally note the gain in the goodness of fit when materials are included in the regression (R^2 values increases from 0.10 to 0.37 for the whole period). Although the dependent variable is different in each equation (share of non-production workers over total wage bill and over total variable cost), the result shows the cost of ignoring materials as another factor of production.

7.2 Short run and within-industry estimators

Tables 6, 7 and 8 show the values of the within-industry estimators corresponding to equations 9, 7 and 8 respectively. As data have been first differenced, we are capturing the year to year dynamics, so that the estimators inform us about the forces affecting the dependent variable at cyclical fluctuations.

Estimated values present strong evidence supporting the capital-skill complementarity hypothesis in equations 9 and 7 (Tables 6 and 7). Again, there is strong evidence of substitutability between capital and materials. In contrast to Tables 4 and 5, relative wages seem to play a more important role in the long run than in the short run (since the absolute values of the corresponding coefficients are higher in the case of the between-industry estimates). The difference is surprising since one would expect that, although we can accept production and non-production labour as well as non-production labour and materials to be substitutes in the long run, they should not respond rapidly to the change in relative wages. This means prices have bigger effects on quantities in the short run. In contrast to Table 3, in Table 6 the SR coefficients appear to be significant and negative at cyclical frequencies both for the whole period and the first subperiod, which is clearly inconsistent with the *cost function approach.* According to it, we should have found the same results both in the long run (between-industry estimators) and in the short run (within-industry estimators). There is evidence of the two components of the SR, a strong cyclical component (captured in the within-industry estimator) and a non-cyclical component, highly attached to the notion of technological progress (captured in the between-industry estimator). In Table 6, it is the linkage between the dependent variable and the cyclical component of the SR what is captured by the estimates. Moreover, this result can be easily interpreted in the light of the existence of asymmetric adjustment costs between production and non-production workers. During expansions, the SR grows, and firms react by increasing the relative demand for production/non-production labour, which makes the shares of non-production labour decrease.

When materials are introduced into the analysis, two more elements should be considered. The first one is the fact that results point at an elasticity of substitution between materials and non-production workers below one. The second concerns the signs of the SR coefficient, which coincide with those in the between-industry case. This would lead us to conclude that, when SUR estimation is performed in order to get the within- industry point estimates, we are rather capturing the linkage between the non-cyclical component of the SR and the dependent variables (Tables 7 and 8)[9]. Still, as the only difference between Table 6 on one hand, and Tables 7 and 8 on the other is the introduction of materials, the question of whether the price of materials (including energy) are mismeasured arises, especially since the oil crises might have favoured this missmeasurement. An standard way of checking such missmeasurement consists of estimating by instrumental variables. This will be done from an alternative macroeconomic approach in Section 8.

7.3 Medium run and random effects estimators

Hitherto, we have obtained the fixed effects estimators (within-industry) and the between-industry estimators in order to compare the forces causing the behaviour in the skill differentials both at cyclical frequencies and in the long run. The exercise is also an indirect way of testing the validity of the *cost function approach* and to study the robustness of the change in the time horizon. An alternative and simple way of testing this is to run a Hausman test once the random effects estimators have been computed. The random effects' estimators are constructed by weighing the between and within-industry estimators so it could be said that they are considering both the long and the short run. Therefore, when comparing fixed and random effects, if the above approach is correct, we should accept that both estimators are not significantly different. However, as the fixed effects estimates and the between-industry estimates are very close to each other when materials are taken into account (Tables 4 and 7, 5 and 8), there is no point in computing the random effects estimates in these

[9]It should be noted that, although the presented results have been obtained by estimating with SUR, the equivalent OLS fixed effects estimates are very close to the previous ones because the contemporaneous covariance between the two equations is very close to zero. This implies that, when the alternative macroeconomic approach is studied in Section 8, the instrumental variables/fixed effects estimates can be compared with the within-industry/SUR estimates.

two cases. Thus, running a Hausman test only makes sense when the dependent variable is the share of the non-production workers over total wage bill. The results are presented in Table 9.

Under the null hypothesis, the random effects estimator is efficient, while under the alternative, only the fixed effects estimator is consistent. Therefore, if the null is rejected, it would mean there is some difference between the long and the short run and thus the behaviour of the dependent variable is not caused by the same forces both at cyclical frequencies and in the long run. In other words, it would mean that the ***cost function approach*** is not fully able to explain the behaviour of the dependent variable when different time horizons are considered.

The results are very close to the fixed effects estimators, the main difference being the absolute value of the SR coefficients, higher for the fixed effects estimates, both for the whole period and the first subperiod. Apparently, the high cyclical component of the SR (captured by the fixed effects estimates) is dominating the effect of its non-cyclical component (between-industry estimates) when the random effects estimates are computed. In other words, the random effects estimates are "tricked" by the strong cyclical component of the SR. It is only when the between-industry estimator is computed and the time horizon enlarges, that the SR recovers its capability to proxy technology.

8 Empirical evidence: alternative macroeconomic approach

The same regressions were re-estimated including additional variables. The reason it is done this way is because a comparison of the extended model and the parsimonious OLS estimators allows us to test whether a possible omitted variable problem is producing biased results and, therefore, making the original econometric model misspecified. On one hand, it is possible to admit that aggregate demand shocks are partly causing the observed pattern in the share under study at cyclical frequencies. On the other, the existence of adjustment costs might also be causing a misspecification of the model. Under adjustment costs, firms are not able to readjust automatically and hence, over a period of time, they are operating outside our FOC[10].

[10]Or, equivalently, they would be operating on a different FOC, coming from a dynamic optimization problem with adjustment costs.

The implications of adjustment costs could be as follows. In the long-run, equilibrium level of employment is hardly affected insofar as the adjustment costs depend mainly on changes in employment (the between-industry estimators should stay the same). At cyclical frequencies (in the short run), adjustment costs have to be amortised, so that the marginal product equals the factor price plus the amortised costs of adjustment. This means that the factor price is underestimating its corresponding marginal product. Thus, our dependent variable will be missmeasured and OLS results may lead to false predictions. The within-industry estimators could be significantly different depending on the role played by the adjustment costs. Allowing for adjustment costs alters the speed of adjustment to a new equilibrium level and is therefore important for understanding the short-run dynamics of the dependent variables (within-industry estimators). The existence of different adjustment costs of production and non-production labour will make the dependent variables move in a different way after a shock than in the case of absence of adjustment cost.

Intuitively, one would expect that adjustment costs will be higher the greater the skill of workers. Clearly, training costs will be very low for unskilled labour, for the firm's expenditure on training will be very small. Empirical findings by Palm and Pfann (1993), using aggregate data from the Netherlands and UK, and Bresson et alia (1991) using firm-level data from France, among others, show that adjustment of unskilled workers is generally faster than that of skilled workers.

Indeed, restricting the analysis to our FOCs means that the only relevant relation between the dependent variable and the regressors is "short run responses". This is particularly restricting because it is reasonable to suppose that the effects of the regressors on the dependent variable will not merely be contemporaneous. Sometimes it may sometimes be optimal for a firm to operate "off" its production function and retain excess labour during contractions. In summary, the absence of dynamics in the model may be a misspecification of the model inherent in the *cost function approach*

In an effort to focus even more on the cyclical aspect of the Solow Residuals (to increase the omitted variable bias) I have instrumented both the rate of growth of capital intensity and the SR with three variables: the rate of growth of real gross national product, the rate of growth of civilian unemployment rate and the rate of growth of the Department of Commerce's business cycle coincident indicator (COIN) [11]. All of them fulfil the requirement of being correlated with the regressors. Relative wage non- production/production workers has been

[11] Data on the coincident indicator were obtained from the United States National Govern-

instrumented with itself. For equations 8 and 9, two more instruments have been used: the rate of change of the relative wage materials/production workers (instrumenting itself) and the rate of change of the oil price. Again, fixed effects are also included.

If aggregate demand shocks (and cyclical indicators in general) have no significant impact on the dependent variable and there are no adjustment costs, the model will be well-specified and the original regressors should be statistically sufficient with respect to the dependent variable. In this case, we would find that the instrumental variables estimates and the OLS estimates are not significantly different. If they are found to be different during a specific subperiod, this would be due to the asymmetric role of such shocks in explaining the first difference of the shares. Results are presented in Tables 10, 11 and 12.

Comparing these results with those of Table 6 we can observe how the IV estimates take lower values for the rate of change of capital intensity and the rate of change of relative wages. On the contrary, SR coefficients present higher absolute values with a negative sign. Again, this should be interpreted as evidence supporting the existence of adjustment costs. Here it is clear that the cyclical component of the SR is driving its linkage with the dependent variable. In fact, similar evidence can be found in Tables 11 and 12 for the first subperiod, where the point estimates tend also to be higher than in the fixed effects case, because the cyclical component of the SR is captured. Unfortunately, the IV estimator is less efficient than the OLS estimator and the high standard errors make precise inference difficult.

This exercise shows the relevance of the cyclical component of the SR and indicates the undesirability of ignoring the cycle when dealing with this regressor. The standard way of ascertain whether the specified model suffers from an omitted variable problem is to enlarge the set of regressors with possible omitted variables and test their significance This has been done by introducing one of the instrumental variables into the regression (the coincident business cycle indicator) and testing its significance. The literature normally deals with the existence of adjustment costs by introducing lagged values of the regressors into the equation. Nevertheless, this would not be a proper way of studying them in this case because, as we are working with a moving average model, we might (unintentionally) introduce some dynamics into the model. Enlarging our fixed effects equation with lagged regressors would not lead to any economic

ment Series, data on GNP were obtained from the OECD Quarterly Accounts, data on oil prices correspond to those in Hall (1988). Finally, data on unemployment were obtained from the Annual Report to the President interpretation of the coefficients. Thus, only one alternative specification of the three equations, introducing contemporaneous values of the rate of change of the coincident indicator has been estimated. As this final specification clearly encompasses the original one, a progress test have been run in order to know whether the subsequent reductions are appropriate. The results are fairly illuminating: in 9 out of 9 cases the null hypothesis of model reduction from the largest model to the original econometric specification was rejected. Results are presented in Tables 13, 14 and 15.

Table 13 can also be interpreted in the light of adjustment costs. The negative sign of the rate of growth of the coincident indicator shows how the cycle does not favour the share of non-production workers over total wage bill. During recessions (decreasing coincident indicator) firms will get rid of more production workers than non-production workers (or, alternatively, they will find it optimal to hoard non-production labour), so that the share of non-production labour will increase. Periods of downturns will favour skilled workers in relative terms while expansions will favour unskilled workers.

The signs of the rates of growth of the coincident indicator in Table 14 follow the same line. The cycle again does not favour the share of non-production workers over total variable cost. This is fully consistent with the ranking of inputs according to its degree of variability suggested in Section 6. When a shock takes place, production workers are the inputs with which firms tend to adjust in order to reach the new equilibrium by changing its "level". The level of the non-production workers attached to higher skilled labour presents less variability because it is profitable for the firms to "hoard" them and to react to shocks by acting on its intensive margin rather than on the extensive one. In other words, the cost of adjusting the level of production workers is almost neglectable in comparison with the cost of adjusting the level of non-production labour. Table 15, on the contrary, does not seem to support the existence of adjustment costs (or rather, the non-existence of adjustment costs with respect to the level of materials). This striking result might be caused by some miss-measurement error derived from the impact of both oil crises. Indeed, taken into account the result when the IV estimates were computed (Table 12), nothing conclusive can be said. With respect to the sign of the SR coefficients in these two last tables (Table 14 and 15), we can infer that it is the non-cyclical component of the SR what has been captured (perhaps the oil shock).

9 Concluding remarks

Given the results presented in Sections 7 and 8, we can draw the following conclusions. First, there is strong evidence supporting the capital-skill complementarity hypothesis, as well as a substitution relation between materials and capital. This applies both to the long and to the short run. The result is also consistent with previous works by Griliches (1969), Berndt et al. (1992) and Mincer (1989) inter alia. In any case, the effects of capital-skill complementarity and biased technical progress are confounded as new vintages of capital contain new technology. Hence, this empirical fact could also be reflecting the skill bias of embodied technical progress.

Secondly, there is no empirical evidence supporting the existence of biased technological progress favouring the share of non-production workers with respect to the total wage bill at cyclical frequencies. On the contrary, when the time horizon enlarges (and the between-industry estimates are computed), such empirical evidence is found. When materials are included into the analysis, evidence of biased technical progress towards skilled labour and against materials is obtained, both at cyclical frequencies and in the long run. This leads to the third conclusion of the paper: the behaviour of the SR when the alternative macroeconomic approach is presented (IV and extended model) makes it clear that, at cyclical frequencies, the feature which links the SR with the dependent variable is the cycle. The cycle itself (due probably to the existence of adjustment costs), affects the dependent variable, although in the long run (between-industry estimator) this effect vanishes. Therefore, by ignoring the business cycle and the existence of adjustment costs, the cost function approach would lead to wrong predictions, e.g. technical change biased against non-production workers at cyclical frequencies.

The inconsistent result which is found when the between-industry estimates and the fixed effects estimates are computed, in the case of the non-production workers share over total wage bill, suggests the need for searching for new economic insights from an alternative approach. This has been done by computing the IV estimates as well as the expended model/fixed effects estimates. The new results point to the key role played by the SR. As suggested above, the third conclusion of the paper clearly deals with the incapability of the SR to proxy technology at cyclical frequencies because of the existence of adjustment costs.

Those findings are not entirely consistent with previous literature on

Labour Economics. This may be due to the fact that, on the whole, these papers proxy technology via dummies normally attached to some sort of investment (computers, R&D expenditure). Thus, they are capturing a composite of capital intensity and embodied technical progress while, at the same time, they do not take into account the existence for adjustment costs.

This suggests that the cost function approach should be properly modified in order to explain fully both trends (between estimators, random effects) and cyclical fluctuations (within-estimators, extended model). The neglect of adjustment costs and the possible existence of imperfect markets appear to have invalidated this approach, opening new lines of research dealing with the alternative macroeconomic approach.

Regressors	OLS 1958-1984	1958-1973	1974-1984
Constant	0.0012	0.00044	0.0026
Student t	7.79*	2.21*	11.23*
$\Delta ln(K/Y)$	0.0076	0.010	0.029
Student t	1.51	2.06*	4.65*
$\Delta ln(W_{np}/W_p)$	0.093	0.061	0.082
Student t	6.52*	4.46*	7.87*
SR	0.023	0.018	0.0059
Student t	2.72*	1.61	0.61
R^2	0.10	0.05	0.17
DW	1.82	2	1.8

Table 3: BETWEEN-INDUSTRY estimators-Dependent variable: first difference of the share of non-production workers wage bill over total wage bill. Estimations were performed with PCGIVE 7.0

Regressors	1958-1984	1958-1973	1974-1984
Constant	-0.00009	-0.0001	0.0001
Student t	-4.25*	-4.62*	10.95*
$\Delta ln(K/Y)$	0.032	0.032	0.033
Student t	10.17*	9.60*	5.73*
$\Delta ln(W_{np}/W_p)$	0.054	0.048	0.49
Student t	4.79*	4.72*	5.73*
$\Delta ln(W_m/W_p)$	-0.028	-0.027	0.014
Student t	-4.53*	-3.53*	-4.94*
SR	0.026	0.024	0.014
Student t	4.91*	3.48*	3.11*
R^2	0.37	0.28	0.31
DW	1.96	1.93	2.14

Table 4: BETWEEN-INDUSTRY estimators-Dependent variable: first difference of the share of non-production workers wage bill over total variable cost. Estimations were performed with PCGIVE 7.0

Regressors	1958-1984	1958-1973	1974-1984
Constant	0.0002	0.00027	0.00035
Student t	6.84*	4.81*	7.80*
$\Delta ln(K/Y)$	-0.055	-0.053	-0.036
Student t	-9.34*	-8.76*	-7.49*
$\Delta ln(W_{np}/W_p)$	-0.018	-0.039	-0.018
Student t	-0.89	-2.13*	-1.35
$\Delta ln(W_m/W_p)$	0.027	0.047	0.056
Student t	2.36*	3.41*	5.44*
SR	-0.008	0.009	-0.001
Student t	-0.87	0.69	-0.17
R^2	0.21	0.21	0.18
DW	1.60	1.85	1.53

Table 5: BETWEEN-INDUSTRY estimator-Dependent variable: first difference of the materials share over total variable cost. Estimations were performed with PCGIVE 7.0

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.141	0.106	0.204
Student t	26.98*	14.41*	29.72*
$\Delta ln(W_{np}/W_p)$	0.215	0.211	0.238
Student t	38.03*	29.39*	25.39*
SR	-0.070	-0.106	0.033
Student t	-6.12*	-5.88*	2.59*

Table 6: FIXED EFFECTS/OLS-Dependent variable: first difference of non-production workers share over total wage bill. Estimations were performed with LIMDEP.

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.048	0.0477	0.050
Student t	46.11*	32.68*	34.27*
$\Delta ln(W_{np}/W_p)$	0.028	0.024	0.037
Student t	23.44*	16.26*	18.28*
$\Delta ln(W_m/W_p)$	-0.025	-0.029	-0.015
Student t	-12.98*	-11.65*	-5.26*
SR	0.014	0.014	0.201
Student t	6.00*	3.94*	6.76*
DW	2.19	2.20	2.20

Table 7: WITHIN-INDUSTRY/SURE-Dependent variable: first difference of non-production workers share over total variable cost. Estimations were performed with LIMDEP

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	-0.088	-0.103	-0.068
Student t	-55.14*	-46.27*	-32.01*
$\Delta ln(W_{np}/W_p)$	-0.021	-0.0212	-0.182
Student t	-11.42*	-9.13*	-6.12*
$\Delta ln(W_m/W_p)$	0.106	0.118	0.075
Student t	35.9*	30.24*	18.21*
SR	-0.055	-0.087	-0.036
Student t	-15.58*	-15.36*	-8.47*
DW	2.17	2.17	2.28

Table 8: WITHIN-INDUSTRY/SURE-Dependent variable: first difference of the materials share over total variable cost. Estimations were performed with LIMDEP.

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.144	0.109	0.203
Student t	28.36*	15.30*	30.28*
$\Delta ln(W_{np}/W_p)$	0.215	0.211	0.237
Student t	38.02*	29.40*	25.41*
SR	-0.049	-0.091	0.038
Student t	-4.55*	-5.29*	3.10*
Constant	-0.0008	0.0005	0.0010
Student t	5.97*	3.13*	5.28*
Hausman Test	reject Ho	reject Ho	reject Ho

Table 9: RANDOM EFFECTS-Dependent variable: first difference of non-production workers share over total wage bill. Estimations were performed with LIMDEP

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.053	0.079	0.075
Student t	2.30*	4.01*	4.37*
$\Delta ln(W_{np}/W_p)$	0.063	0.054	0.084
Student t	22.07*	18.75*	?20.69*
SR	-0.0159	-0.053	-0.106
Student t	-2.32*	-0.92	-2.18*
DW	2.21	2.25	2.33

Table 10: FIXED EFFECTS / INSTRUMENTAL VARIABLES estimator-Dependent variable: first difference of the share of non-production workers share over total wage bill. Estimations were performed with PCGIVE 7.0

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.086	-0.012	0.083
Student t	3.67*	-0.682	6.38*
$\Delta ln(W_{np}/W_p)$	0.025	0.044	0.033
Student t	4.36*	10.56*	6.62*
$\Delta ln(W_m/W_p)$	-0.021	-0.080	-0.011
Student t	-1.44	-8.47*	-1.07
SR	0.085	-0.262	0.084
Student t	1.06	-4.45*	1.95
DW	2.14	2.26	2.24

Table 11: FIXED EFFECTS / INSTRUMENTAL VARIABLES estimator- Dependent variable: first difference of the non-production workers share over total variable cost. Estimations were performed with PCGIVE 7.0

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	-0.082	0.090	-0.111
Student t	-2.36*	-2.58*	-4.90*
$\Delta ln(W_{np}/W_p)$	-0.012	-0.057	0.0095
Student t	-1.46	-7.38*	-1.08
$\Delta ln(W_m/W_p)$	0.079	0.204	0.014
Student t	3.65*	11.49*	0.83
SR	-0.126	0.522	-0.246
Student t	-1.05	4.73*	-3.20*
DW	2.19	2.25	2.21

Table 12: FIXED EFFECTS / INSTRUMENTAL VARIABLES estimator- Dependent variable: first difference of the materials share over total variable cost. Estimations were performed with PCGIVE 7.0

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.117	0.088	0.176
Student t	21.53*	11.18*	22.20*
$\Delta ln(W_{np}/W_p)$	0.221	0.217	0.246
Student t	38.72*	29.22*	24.72*
SR	-0.065	-0.105	0.0134
Student t	-5.64*	-5.52*	0.92
COIN	-0.075	-0.088	-0.060
Student t	-17.18	-11.39*	-11.06*

Table 13: EXTENDED MODEL/FIXED EFFECTS-Dependent variable: first difference of non-production workers share over total wage bill. Estimations were performed with LIMDEP.

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	0.046	0.046	0.045
Student t	41.06*	29.08*	27.13*
$\Delta ln(W_{np}/W_p)$	0.029	0.025	0.038
Student t	23.14*	15.64*	16.80*
$\Delta ln(W_m/W_p)$	-0.026	-0.031	-0.015
Student t	-13.12*	-11.36*	-4.94*
SR	0.014	0.015	0.0.18
Student t	5.82*	3.81*	5.83*
COIN	-0.0068	-0.0070	-0.0073
Student t	-7.59	-4.61	-6.38

Table 14: EXTENDED MODEL/FIXED EFFECTS estimator-Dependent variable: first difference of non-production workers share over total variable cost. Estimations were performed with LIMDEP

Regressors	1958-1984	1958-1973	1974-1984
$\Delta ln(K/Y)$	-0.091	-0.106	-0.068
Student t	-53.12*	-46.27?*	-32.01?*
$\Delta ln(W_{np}/W_p)$	-0.020	-0.020	-0.014
Student t	-10.33*	-8.03*	-4.58*
$\Delta ln(W_m/W_p)$	0.104	0.115	0.725
Student t	33.84*	27.65*	16.04*
SR	-0.055	-0.0867	-0.030
Student t	-14.95*	-14.27*	-6.87*
COIN	-0.009	-0.011	-0.005
Student t	-6.93*	-4.72*	-3.50*

Table 15: EXTENDED MODEL/FIXED EFFECTS estimator-Dependent variable: first difference of the materials share over total variable cost. Estimations were performed with PCGIVE 7.0

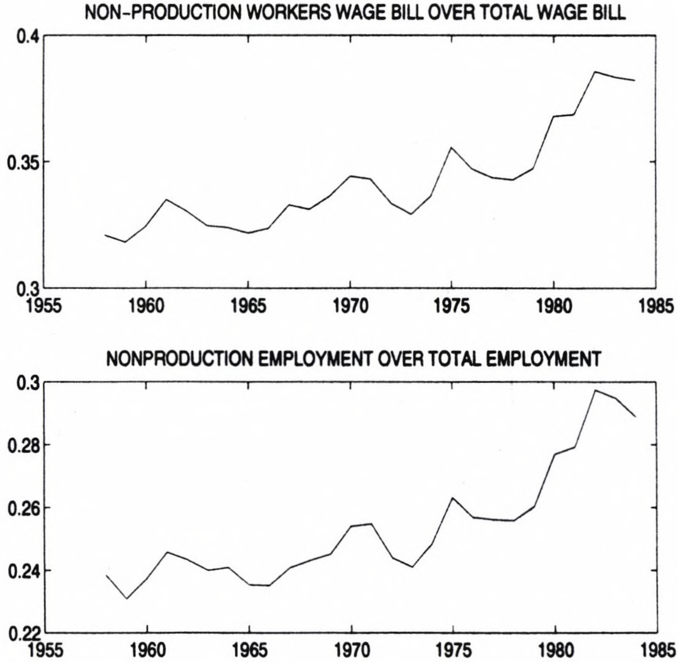

Figure 1: Variables are expressed in levels

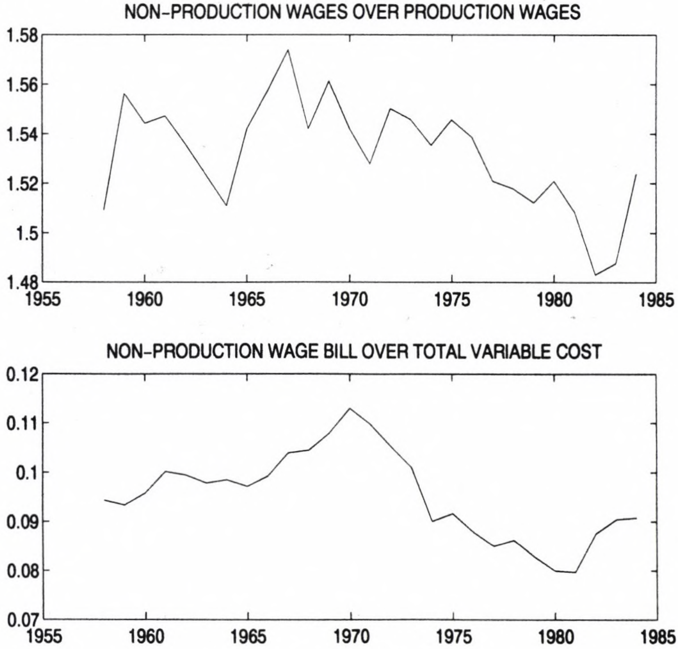

Figure 2: Variables are expressed in levels

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