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Explaining Movements in the Labor Share*

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Abstract

In this paper we study the evolution of the labor share in the OECD. We show it is essentially related to the capital-output ratio; that this relationship is shifted by factors like the price of imported materials or capital-augmenting technological progress; and that discrepancies between the marginal product of labor and the real wage –due to, e.g., labor adjustment costs or union wage bargaining– cause departures from it. We also estimate the model with panel data on 13 industries and 12 countries for 1972-93, finding evidence in favor of the model.

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KEY WORDS: Labor share, capital-output ratio.

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1 Introduction

In this paper we explore the factors driving the observed movements in the labor share in OECD countries. Until recently, the labor share did not often generate an interest among neoclassical economists, partly because its constancy has been taken as a granted "stylized fact of growth".[1] On the other hand, the labor share is very much present in the political debate as a measure of how the "benefits of growth" are shared between labor and capital. For example, its decline since the mid-1980s is often used by unions in Europe as an argument against policies of wage moderation, and by governments in order to justify increased taxation of profits. Moreover, contrary to economists' presumptions, there have been considerable medium-run movements in the labor share over a period of 35 years, as shown in Figures 1 to 4 for several countries. For these reasons, it is important to understand the determinants of the labor share, which is the purpose of this paper.

It is striking to find that there are large cross-country differences in the behavior of the labor share.[2] Figures 1 to 4 illustrate this fact. The UK exhibits the closest approximation to the "growth stylized fact", with the labor share experiencing large short-run fluctuations around a stable level.[3] In the US it undergoes sizable short-run fluctuations around a mild downward trend, becoming essentially flat in the 1980s. In Japan, on the contrary, it experiences a sharp rise, slowing down considerably after 1975. The picture for continental Europe is typically hump-shaped, with the labor share going up and then down. But actual country experiences are heterogeneous: in Germany and France the labor share peaks in the early 1980s, while in other countries like Italy, the Netherlands, and Spain it does so in the mid-1970s.[4]

From a cross-country perspective, it should be noted that these large differences across countries take place even though they are relatively similar from a technological point of view. Table 1 shows the evolution of the labor share in the business sector of 12 OECD countries for 1970 to 1990.[5] As evidenced by the first three columns, the labor share has not converged among these countries during the 1980s (the standard deviation has actually increased). In 1990, some countries like Finland

[1] The concept was introduced in 1821 by David Ricardo. Recently Blanchard (1997,1998), Caballero and Hammour (1998), Acemoglu (2003), and Blanchard and Giavazzi (2003) have examined various aspects of the labor share. On the other hand, Galí and Gertler (1999) have used the labor share as a measure of marginal costs in New Keynesian Phillips curves. See Batini *et al.* (2000) for other references.

[2] The measure shown in the graphs includes an imputed labor remuneration for the self-employed on the basis of the average wage.

[3] The graphs show the variable up to 1995, while our analysis in Section 3, due to data availability, only goes up to 1993.

[4] de Serres *et al.* (2002) argue that part of the hump is due to sectoral shifts, but with their adjusted data the hump is still there for most countries within our sample period, and also in our data when we construct a fixed-weights aggregate. In any event, our empirical analysis is performed on industry data. For the non-constancy of the labor share see also Jones (2003).

[5] Later years would show similar patterns. Again, our sectoral data in Section 3 stop in 1993.

or Sweden showed labor shares around 72%, while others like France, Germany or Italy had values around 62%.

TABLE 1. THE LABOR SHARE AND REAL WAGES IN 12 OECD COUNTRIES

	Labor share				Real wage
	Levels			Changes	Changes
	1970	1980	1990	1970-90	1970-90
United States	69.7	68.3	66.5	-3.3	0.4
Canada	66.9	62.0	64.9	-2.0	1.3
Japan	57.5	69.1	68.0	10.5	3.5
Germany	64.1	68.7	62.1	-2.0	2.0
France	67.6	71.7	62.4	-5.2	2.2
Italy	67.1	64.0	62.6	-4.5	2.1
Australia	64.8	65.9	62.9	-1.9	1.2
Netherlands	68.0	69.5	59.2	-8.8	1.8
Belgium	61.6	71.6	64.0	2.4	2.9
Norway	68.4	66.4	63.9	-4.5	2.2
Sweden	69.7	73.6	72.6	2.9	1.6
Finland	68.6	69.6	72.3	3.7	3.5
Mean	66.2	68.4	65.1	-1.1	2.1
Standard deviation	3.6	3.3	4.1	5.2	0.9

Note.– All variables in percentages. The labor share corresponds to the business sector, the real wage is the real compensation per employed person in the private sector. It includes an imputed labor remuneration for the self-employed on the basis of the average wage. Source: *OECD Economic Outlook* Statistics on Microcomputer Diskette.

In the policy debate, movements in the labor share are often interpreted as changes in real wages. It is for example usually heard that because the labor share is currently low in Europe, there is no real wage problem. But this is clearly mistaken, since it all depends on the elasticity of labor demand. The last two columns of Table 1 suggest that the correlation between changes in wages and changes in the labor share is not tight (in other words, labor productivity behaves differently across countries). For example, from 1970 to 1990 France had one of the sharpest drops in the labor share and an above-average increase in the average real wage, while Sweden had one of the largest increases in the labor share and one of the lowest increases in real wages.[6] Thus, a more systematic exploration of the determinants of the labor share is warranted.

What can we learn from analyzing the labor share? It provides a compact way of looking at labor demand which directly controls for the role of factors such as wages, labor-embodied technical progress, and capital (or, alternatively, real interest rates). We shall show that, as long as labor is paid its marginal product, there should be a one-for-one relationship between the labor share and the capital-output ratio, which we label the *share-capital schedule*. As long as that condition holds –and it must in long-run equilibrium–, changes in any of those three factors will generate changes of both the labor share and the capital-output ratio along that schedule. Any change in the labor share which shows up as a *deviation* from that relationship must arise from a shift in labor demand which is not due to real wages, capital accumulation, or labor-augmenting technical progress, and therefore has to be explained by other factors. We study the role of factors which displace the schedule, such as changes in the price of imported materials or capital-augmenting technical progress, and those which put the economy off the schedule, by changing the gap between the shadow marginal cost of labor and the wage, such as changes in markups of prices over marginal costs, union bargaining power, or labor adjustment costs.

We also analyze the empirical performance of the model, using panel data on a sample of 13 industries in 12 OECD countries, over the period 1972-93. We estimate the relationship between the labor share and a number of its presumed determinants according to the model. In our estimation we follow Arellano and Bover's (1995) proposal of a system estimator for panel data. We find evidence in favor of an empirical relationship between the labor share and the capital-output ratio, e.g. the share-capital relationship, but also significant shifts of the labor share coming from capital-augmenting technical progress and, less clearly, the real price of oil, and from factors which create a wedge between the shadow marginal cost of labor and the wage, like labor adjustment costs and, marginally, union bargaining power.

The paper is structured as follows. Section 2 presents a model of the determination of the labor share. After introducing the stripped-down model, which yields the key relationship between the labor share and the capital-output ratio, we show how the relaxation of various assumptions may affect such a relationship. Section 3 presents empirical evidence on the performance of the model on international panel data. Section 4 contains our conclusions.

2 Theory

We start by sorting out, from an analytical point of view, the various factors which may explain variations in the labor share.

[6] The correlation coefficient between labor share changes and real wage changes over the period 1970-90 across these 12 countries is 0.59.

2.1 The labor share and the capital-output ratio

When trying to explain variations in the labor share we need to depart from the usual assumption of a Cobb-Douglas production function. We show that under the assumptions of constant returns to scale and labor embodied technical progress, there are strong restrictions on the behavior of the labor share, in the sense that there should be a one-for-one relationship between it and the capital-output ratio. We then explore how this relationship shifts if there is capital-augmenting technical progress and we end the subsection showing the results for a constant elasticity of substitution production function.

Proposition 1 *Consider an industry indexed by i. Assume it has a constant returns to scale, differentiable production function by which output, Y_i, is produced with two factors of production, capital, K_i, and labor, L_i. Assume there is labor-augmenting technical progress, B_i: $Y_i = F(K_i, B_iL_i)$. Then, under the assumption that labor is paid its marginal product, there exists a unique function g such that:*

$$s_{Li} = g(k_i) \tag{1}$$

where $s_{Li} \equiv w_iL_i/(p_iY_i)$ is the labor share in industry i, with w_i denoting the wage and p_i the product price, and $k_i \equiv K_i/Y_i$ is the capital-output ratio.

PROOF. Let us use the constant returns property to rewrite the production function as $Y_i = K_if(B_iL_i/K_i) = K_if(l_i)$, where $l \equiv B_iL_i/K_i$. In equilibrium we have:

$$\frac{w_i}{p_i} = B_if'(l_i) \tag{2}$$

where the prime denotes the first derivative, implying that the labor share is equal to:

$$s_{Li} = \frac{B_iL_if'(l_i)}{K_if(l_i)} = \frac{l_if'(l_i)}{f(l_i)} \tag{3}$$

The capital-output ratio is then equal to:

$$k_i = \frac{1}{f(l_i)} \tag{4}$$

As $f(.)$ is monotonic, Equation (4) defines a one-to-one relationship between l_i and k_i, which can be written $l_i = h(k_i) = f^{-1}(1/k_i)$. Substituting into (3), we find that

$$s_{Li} = k_ih(k_i)f'(h(k_i)), \tag{5}$$

which defines s_{Li} as a sole function of k_i. Q.E.D.

Proposition 1 tells us that even if the production function is not Cobb-Douglas, there is a stable relationship between the labor share and an observable variable, the capital-output ratio. From now on, we shall refer to this relationship as the *share-capital* (SK) schedule (or curve). This relationship is unaltered by changes in factor prices –e.g. wages or interest rates– or quantities, or in labor-augmenting technical progress. That is to say, any change in the labor share which is triggered by those factors will be along that schedule, so that they cannot explain any deviation from the SK relationship, i.e. any residual in equation (1).

Note that equations (1) and (3) capture essentially the same relationship, but equation (1) is simpler to estimate, since it does not require the computation of l_i, which itself requires us to compute labor-augmenting technical progress, B_i. Our aim is thus to decompose changes in the labor share between those explained by the capital-output ratio –due to changes in factor prices and labor-augmenting technical progress– and those explained by the residual –i.e., due to other factors discussed below.

It is worth noting that the response of the labor share, s_{Li}, to the capital-output ratio, k_i, is related to the elasticity of substitution in the production function between labor and capital. The latter is defined as (see Varian, 1984, p. 70):

$$\sigma_i = \frac{d(K_i/L_i)}{d(r/w)} \frac{r/w}{K_i/L_i},$$

where K_i/L_i is the cost-minimizing input mix and r/w the relative cost of capital. With the production function in Proposition 1 we find that

$$\sigma_i = \frac{f'(l_i)}{l_i f''(l_i)} \left[1 - \frac{l_i f'(l_i)}{f(l_i)} \right].$$

where the double prime denotes second derivatives. As is well known, for a Cobb-Douglas production function, $f(l_i) = (l_i)^{\alpha}$, we have $\sigma_i = -1$. Equations (3) and (4) imply that

$$\frac{ds_{Li}}{dk_i} = -f(l_i) + l_i f'(l_i) - \frac{l_i f(l_i) f''(l_i)}{f'(l_i)} = -(1+\sigma_i) f(l_i) \frac{l_i f''(l_i)}{f'(l_i)} = -\frac{1+\sigma_i}{k_i \eta_i},$$

where $\eta_i = f'(l_i)/(l_i f''(l_i)) < 0$ is the elasticity of labor demand with respect to wages, holding capital constant. Thus, a positive coefficient in a regression of s_{Li} on k_i indicates an elasticity of substitution σ_i lower than one in absolute value, and vice-versa. In other words, a strong complementarity between labor and capital means that an increase in the capital-output ratio is associated with a larger labor share.

Proposition 1 will however not hold under capital-augmenting technical progress. In this case we have $Y_i = F(A_i K_i, B_i L_i)$, and the relationship between s_{Li} and k_i is no longer stable. We can check that

$$s_{Li} = A_i k_i g(A_i k_i) f'(g(A_i k_i)), \tag{6}$$

is the expression for the labor share instead of (5). Clearly, changes in A_i now shift the SK relationship. The assumption of labor-augmenting technical progress is standard in macroeconomics, since it is compatible with a balanced long-term growth path, but the possibility of having capital-augmenting technical progress must be considered as well.

Under capital-augmenting technical progress productivity shifts do affect the SK curve, but in a way which, if it can be measured, implies a strong restriction. As A_i always multiplies k_i in (6), we must have:

$$k_i \frac{\mathrm{d} \ln s_{Li}}{\mathrm{d} k_i} = A_i \frac{\mathrm{d} \ln s_{Li}}{\mathrm{d} A_i}.$$

This is a restriction with respect to the regression coefficients of s_{Li} on k_i and A_i. It may be difficult to test, as A_i is often measured by an index, and as that index will aggregate labor-augmenting with capital-augmenting technical change. However, one corollary of the restriction is that the effects of A_i and k_i on s_{Li} should have the same sign.[7] Therefore, if A_i shifts SK but violates that condition, it is neither labor- nor capital-augmenting. In such a case, we can just write $Y_i = K_i f(l_i, A_i)$, and the inclusion of A, or some measure of it, in a regression of s_{Li} on k_i will yield the following coefficients:

$$\begin{aligned} \frac{d \ln s_{Li}}{d k_i} &= -\frac{f}{k_i f'_{l_i}} \left(\frac{1}{l_i} - \frac{f'_{l_i}}{f} + \frac{f''_{l_i l_i}}{f'_{l_i}} \right), \\ \frac{d \ln s_{Li}}{d A_i} &= -\frac{f'_{A_i}}{l_i f'_{l_i}} - \frac{f'_{A_i} f''_{l_i l_i}}{(f'_{l_i})^2} + \frac{f''_{A_i l_i}}{f'_{l_i}}. \end{aligned}$$

An interesting implication of these formulae is that, given that $f'_{l_i} > 0$ and $f'_{A_i} > 0$, in order to have $\frac{d \ln s_{Li}}{d k_i} > 0$ and $\frac{d \ln s_{Li}}{d A_i} < 0$, which is the case in some of our estimates below, we must have

$$\frac{f''_{A_i l_i}}{f'_{A_i}} < \frac{1}{l_i} + \frac{f''_{l_i l_i}}{f'_{l_i}} < \frac{f'_{l_i}}{f},$$

which makes it more likely (though by no means necessary) that technical progress is "labor-harming", i.e. reduces the marginal product of labor, $f''_{A_i l_i} < 0$.[8]

To illustrate Proposition 1 more concretely, let us consider what happens when the production function has a constant elasticity of substitution (CES):

$$Y_i = (\alpha (A_i K_i)^{\varepsilon} + (1-\alpha)(B_i L_i)^{\varepsilon})^{1/\varepsilon} \tag{7}$$

where A, B and ε are technological parameters.

[7] This implication only depends on A_i being multiplicative in k_i, and therefore it will still be valid if there are other factors of production.

[8] It can be shown that if A_i is capital augmenting, then $K_i(\partial Y_i / \partial K_i) = A_i(\partial Y_i / \partial K_i)$, or equivalently: $A_i f'_{A_i} + l_i f'_{l_i} = f$. Differentiating with respect to l, we see that the following must also hold: $A_i f''_{A_i l_i} + l_i f''_{l_i l_i} = 0$. Consequently, $f''_{A_i l_i} > 0$, implying that capital-augmenting technical progress cannot be labor-harming.

Then the labor share is equal to:

$$s_{Li} = \frac{(1-\alpha)(B_i L_i)^{\varepsilon}}{\alpha (A_i K_i)^{\varepsilon} + (1-\alpha)(B_i L_i)^{\varepsilon}}. \tag{8}$$

Note that when ε goes to zero, the production function converges to a Cobb-Douglas one, $Y_i = (A_i K_i)^{\alpha}(B_i L_i)^{1-\alpha}$, and the labor share converges accordingly to $s_{Li} = 1-\alpha$. Next, the capital-output ratio is simply equal to:

$$k_i = \left(\frac{K_i^{\varepsilon}}{\alpha (A_i K_i)^{\varepsilon} + (1-\alpha)(B_i L_i)^{\varepsilon}} \right)^{1/\varepsilon} \tag{9}$$

from equations (8) and (9) we have (where k is such that $s_L \in [0,1]$):[9]

$$s_{Li} = 1 - \alpha (A k_i)^{\varepsilon} \tag{10}$$

We therefore see that the relationship between s_{Li} and k_i is very simple in this case. It is monotonic in k_i, either increasing or decreasing depending on the sign of ε: if labor and capital are substitutes ($\varepsilon < 0$), a lower capital intensity will increase the labor share, and conversely if they are complements ($\varepsilon > 0$); in the Cobb-Douglas case, $\varepsilon = 0$ and $s_{Li} = 1-\alpha$. For more general production functions, the relationship need not be monotonic, so that the labor share can go up and then down as some variable driving changes in k_i (such as real wages or interest rates) varies.

2.2 Deviations from a stable *SK* relationship

We now analyze the factors that generate deviations from this relationship. To do so, let us define more precisely the SK curve in equation (1), as a relationship between $k = 1/f(l)$ and $\eta \equiv l f'(l)/f(l)$, the employment elasticity of output.[10] Then the economy is on the SK curve in the (k, s_L) plane if and only if $s_L = \eta$, i.e. the marginal product of labor is equal to the real wage. We shall distinguish between two types of deviations, depending on whether they cause shifts *of* the SK curve, i.e. shifts in the $g(.)$ function in equation (1), or movements *off* it, i.e. increases in the difference between s_L and η.

First, as discussed in the previous subsection, factors such as capital-augmenting technical progress, A, will shift the SK curve if they are not constant. Secondly, there are factors which create a wedge between the real wage and the marginal product of labor. While they do not affect the relationship between η and k, they create a gap between s_L and η. These factors therefore do not shift the SK curve, but put the economy off that schedule in the (k, s_L) plane. These two sources of movements are illustrated in Figure 5. Let us now discuss each type of deviation in detail.

[9] The first-order condition with respect to capital implies $s_{K_i} = \alpha(A_i k_i)^{\varepsilon}$. One could thus derive (10) directly from it. But our proof is slightly different, because, as in Proposition 1, we assume that labor, but not necessarily capital, is paid its marginal product.

[10] For ease of notation, we dispense with industry subindices until the end of this Section.

2.3 Non-neutralities in the aggregate production function

We first discuss deviations which shift the SK schedule by changing the aggregate production function in a non-labor-augmenting way.[11] For instance, what happens if there are imported raw materials whose price fluctuates? Unless very restrictive conditions hold, these fluctuations will shift the SK schedule, in a direction which will depend on the characteristics of the production function. Let us assume that we have $Y = F(K, BL, M)$, where M denotes imported raw materials (say oil), with price q. This can be rewritten as $Y = Kf(l, m)$, with $l \equiv BL/K$, as above, and $m \equiv M/K$. L and M are set so as to maximize profits. The first order conditions are (where f'_n denotes the first derivative with respect to the n-th argument):

$$Bf'_1(l, m) = \frac{w}{p}; \qquad f'_2(l, m) = \frac{q}{p} \tag{11}$$

Value added is defined as (see Bruno and Sachs 1985, Appendix 2B, for a discussion): $\tilde{Y} \equiv Y - (q/p)M$, and the SK curve is now a relationship between $\widetilde{s}_L$, the share of labor in value added given by $\widetilde{s}_L \equiv wL/(p\tilde{Y})$, and $\tilde{k} \equiv K/\widetilde{Y}$, the capital-value added ratio. We now have, instead of (4):

$$\tilde{k} = \frac{1}{f(l, m) - \frac{q}{p}m} \tag{12}$$

implying:

$$\widetilde{s}_L = \frac{lf'_1(l, m)}{\tilde{k}} \tag{13}$$

Equations (11) and (12) now define l and m as functions of $\tilde{k}$ and q/p. Plugging these into equation (13) we get a relationship where $\widetilde{s}_L$ is a function not only of $\tilde{k}$ but also of q/p. Let us examine the implications of this extension for both the elasticity of substitution and the impact of changes in q/p on $\widetilde{s}_L$.

We can now recall the Allen elasticity of substitution between K and L as:

$$\sigma_{KL} = \frac{\partial(K/L)}{\partial(r/w)} \frac{r/w}{K/L},$$

where the derivative is taken holding q constant (N.B.: we normalize p to 1). We therefore get:

$$\sigma_{KL} = \frac{f'_1}{l\left(f''_{11} - \left(f''_{12}\right)^2 / f''_{22}\right)} \left[1 - \frac{lf'_1}{f - mf_2}\right].$$

The response of $\tilde{s}_L$ on $\tilde{k}$ holding q constant is equal to:

$$\begin{aligned} \frac{\partial \tilde{s}_L}{\partial \tilde{k}} &= lf'_1 - (f - qm) - lf''_{11}(f - qm)/f'_1 + \frac{l\left(f''_{12}\right)^2}{f''_{22}f'_1}(f - qm) \\ &= -(1 + \sigma_{KL})l(f - qm)\left[\frac{f''_{11}}{f'_1} - \frac{\left(f''_{12}\right)^2}{f'_1 f''_{22}}\right] = -\frac{(1 + \sigma_{KL})}{\tilde{k}\eta}, \end{aligned} \tag{14}$$

[11] In Bentolila and Saint-Paul (2001) we provide an analysis of the SK schedule with skilled and unskilled labor in production. This breakdown is however not available in the database used below.

where $\eta = \frac{f_1'}{l\left(f_{11}''-\left(f_{12}''\right)^2/f_{22}''\right)} < 0$ is the elasticity of l with respect to w, holding q constant. In Section 3 we will compute σ_{KL}, using our estimates and relying on external estimates of η.

To grasp the effects at work when q/p increases, we can differentiate equations (11) to (13), to get the change in the labor share holding $\tilde{k}$ constant:

$$\frac{d\widetilde{s}_L}{d(q/p)} = \frac{1}{\tilde{k}}\left(m + \frac{lf_{12}''}{f_{22}''} + \frac{lm}{f_1' f_{22}''}\left(f_{11}''f_{22}'' - (f_{12}'')^2\right)\right) \tag{15}$$

where $f_{11}''f_{22}'' - (f_{12}'')^2 > 0$ is the Hessian of the production function.

The first term in the brackets of (15) is positive; it is due to the fact that to maintain a constant ratio between capital and value added as materials prices rise, the labor-capital ratio must rise, which pushes the labor share upwards. The second term is typically negative as long as imported materials increase the marginal product of labor. It measures the fact that given l, imports fall when q/p increases, which reduces the marginal product of labor and therefore wages and the labor share. The third term is also negative. It captures the fall in wages induced by the required increase in the labor capital ratio (taking into account the indirect effect of the induced effect on m). Thus, the price of raw materials shifts the SK schedule in an ambiguous direction.

To illustrate this, let us look again at the CES case. Assume the production function:

$$Y = \left((AK)^\varepsilon + (BL)^\varepsilon + (CM)^\varepsilon\right)^{1/\varepsilon}$$

where A, B, C, and ε are the technological parameters. The labor share is then:[12]

$$\widetilde{s}_L = 1 - (A/C)^\varepsilon \left(C^{\frac{\varepsilon}{\varepsilon-1}} - (q/p)^{\frac{\varepsilon}{\varepsilon-1}}\right)^{\varepsilon-1} \tilde{k}^\varepsilon \tag{16}$$

We can thus in principle take into account the impact of changes in the price of imported materials on the labor share by estimating (16) or a linearized variant of it. Note that the SK schedule will shift upwards when q/p rises if and only if $\varepsilon > 0$. The more labor is a substitute for capital ($\varepsilon < 0$), the lower the wage fall required to increase l so as to maintain $\tilde{k}$ constant when imported materials fall, and the larger the increase in the labor share.

[12] The first-order condition for profit maximization with respect to M is: $\left((AK)^\varepsilon + (BL)^\varepsilon + (CM)^\varepsilon\right)^{1/\varepsilon-1} C^\varepsilon M^{\varepsilon-1} = q/p$. This equation can be solved for M, yielding: $M = C^{-1}\left((q/p)^{\varepsilon/(\varepsilon-1)}/\left(C^{\varepsilon/(\varepsilon-1)} - (q/p)^{\varepsilon/(\varepsilon-1)}\right)\right)^{1/\varepsilon}\left((AK)^\varepsilon + (BL)^\varepsilon\right)^{1/\varepsilon}$. Given the definition of value added we have: $\widetilde{Y} = C^{-1}\left((AK)^\varepsilon + (BL)^\varepsilon\right)^{1/\varepsilon}\left(C^{\varepsilon/(\varepsilon-1)} - (q/p)^{\varepsilon/(\varepsilon-1)}\right)^{\frac{\varepsilon-1}{\varepsilon}}$.

The last term in parentheses is decreasing in q/p and captures the effect of the price of materials on total factor productivity defined in terms of value added; it is multiplicative in output. The second equation defines a functional form similar to equation (7) so that by making the appropriate substitutions in equation (10) we obtain equation (16).

2.4 Differences between the marginal product of labor and the real wage

We now turn to those factors that put the economy off the SK curve by generating a gap between the marginal product of labor and the real wage. We consider three of them: product market power, union bargaining, and labor adjustment costs.

2.4.1 Variations in the markup

Assume firms are imperfectly competitive, so that there is a markup μ of prices on marginal costs. Accordingly, the optimality condition (2) should be replaced with:

$$\frac{\partial F}{\partial L} = Bf'(l) = \mu \frac{w}{p}$$

so that we now have:

$$s_L = \mu^{-1} \frac{lf'(l)}{f(l)} = \mu^{-1} \eta$$

implying a relationship such as $s_L = \mu^{-1} g(k)$. Clearly, if the markup is constant, there should still be a stable relationship between s_L and k. However, variations in the markup will affect that relationship and will show up in the residual. For example, if markups are countercyclical, the labor share will tend to be procyclical once we have controlled for k.

Note that the above relationships are actually used by macroeconomists in order to *compute* the markup (see Hall, 1990, Rotemberg and Woodford, 1991 and 1992, and Bénabou, 1992). From our point of view, this is unfortunate: many deviations of the labor share from the predicted SK schedule may be due to factors other than the markup. Ideally, one would want to correlate these deviations with direct measures of the markup. In their survey on the cyclical behavior of markups, Rotemberg and Woodford (1999) actually discuss various sources of deviation. For instance, they allow for materials in the production function, but assume that they are a fixed proportion of aggregate output.[13]

Recall now Figure 5, which summarizes the discussion up to this point. It depicts the SK curve in the (k, s_L) plane, showing that increases in wages imply movements along the curve, but changes in the price of materials cause shifts of the curve itself, while variations in the markup put the economy off the schedule.

2.4.2 Bargaining

Another source of deviations from the SK curve is the existence of bargaining between firms and workers. Indeed, increases in the labor share are customarily

[13] They also mention other deviations ignored here, like overhead labor, fixed costs in production, increasing marginal wages, or variable effort. However, their paper's focus is on the cyclicality of the markup, rather than on the shifts in labor demand as ours.

interpreted as increases in workers' bargaining power, and it is often hastily concluded that employment consequently has to decline. The issue is more complicated, though, because everything depends on what bargaining model is assumed.

Right-to-manage Under this model, firms and unions first bargain over wages and then firms set employment unilaterally, taking wages as given. This model is widely seen as a good description of how bargaining actually takes place in many countries (see Layard *et al.*, 1991, ch. 2). But then, because firms are wage takers when setting employment, the marginal product equation (2) remains valid, and so does Proposition 1. Under this model, changes in the bargaining power of workers may move the labor share, but along the SK curve, not away from it, in a direction which depends on the elasticity of substitution between labor and capital (see equation (10) for the CES case). More specifically, an increase in workers' bargaining power creates a wage push that increases k as firms substitute capital for labor. But the labor share may rise or fall depending on the slope of the SK curve (i.e. the elasticity of substitution between labor and capital), and the relationship between k and s_L is unaffected.[14]

Efficient bargaining If, on the other hand, firms and workers bargain over both wages and employment, they will set employment in an efficient way, implying that the marginal product of labor is equal to its real opportunity cost ($\bar{w}/p$):

$$Bf'(l) = \frac{\bar{w}}{p}$$

In the short run, an increase in the bargaining power of workers affects the labor share but is not reflected in employment. In the long-run, adjustment of the capital stock indeed implies that changes in the bargaining power of workers also affects employment.

How does efficient bargaining affect the position of the economy in the (k, s_L) plane? In a simple Nash bargaining model the wage is a weighted average of the *average* product of labor and its opportunity cost, with the weight on the former being equal to workers' bargaining power, θ (see Blanchard and Fischer, 1989, ch. 9):

$$\frac{w}{p} = \theta \frac{Bf(l)}{l} + (1-\theta)\frac{\bar{w}}{p}$$

This in turns implies that $w/p = \theta\,(Bf(l)/l) + (1-\theta)Bf'(l)$, hence (recalling the definitions of s_L and l):

$$s_L = \theta + (1-\theta)\frac{lf'(l)}{f(l)} = \theta + (1-\theta)\eta = \theta + (1-\theta)g(k)$$

[14] We have assumed that bargaining over wages takes place after the capital stock is determined. Our conclusions would be unaffected if instead the capital stock was determined by the firm after wage setting, or even if bargaining took place over the capital stock, as long as employment is determined by profit maximization given wages.

This is a well-defined relationship between the labor share and the capital-output ratio. It has the same properties as the SK curve, but is above it, reflecting that workers are paid more than their marginal product. As $\eta < 1$, an increase in workers' bargaining power shifts that relationship upwards, putting the economy further off the SK curve: the labor share tends to increase given the capital-output ratio. The latter is unchanged, as it is pinned down by the equality between marginal product and the alternative wage. Thus the labor share unambiguously increases. Increases in workers' bargaining power reduce the sensitivity of the labor share to the capital-output ratio according to this relationship. For example, in the CES case we get:

$$s_L = 1 - (1 - \theta) (Ak)^{\varepsilon}$$

2.4.3 Labor adjustment costs

We now consider how the introduction of labor adjustment costs alters the SK relationship. This is of interest for analyzing European countries, whose regulation imposes high hiring and firing costs. Adjustment costs affect the behavior of the labor share for two reasons. First, the labor share is no longer equal to wages divided by value added. Labor costs now consist of two parts: wage costs and non-wage adjustment costs. The adjustment costs will enter the labor share if they are a resource cost which uses labor –for example if new hires have to be recruited by an employment agency, or if they have to be trained by the firm's existing workforce, thus diverting it from direct productive activity. They will also enter the labor share if they are payments from the firm to the worker, as is the case for severance payments. Other components of firing costs such as court and arbitration procedures will have a strong labor cost component.

Second, adjustment costs create a gap between the marginal revenue product of labor and the wage, which is no longer equal to the relevant marginal cost of labor. More precisely, the marginal cost now includes three terms: the current wage, the current marginal adjustment cost generated by an extra unit of labor, and the *shadow* expected future marginal adjustment costs generated by that unit. Let us discuss the latter two in turn.

The second component will push the marginal cost of labor above the wage when the firm is hiring and below it when it is firing. More specifically, if we assume that real labor adjustment costs are a convex function $AC(\Delta L)$, where ΔL is the change in employment, and if the future is neglected (say because the discount rate tends to infinity), we have that $Bf'(l) = w + AC'(\Delta L)$, where $AC'(\Delta L) > 0$ if $\Delta L > 0$ and $AC'(\Delta L) < 0$ if $\Delta L < 0$ (see, e.g., Bentolila and Bertola, 1990). If adjustment costs are not part of the labor costs included in the labor share, this implies that $s_L > g(k)$ if $\Delta L < 0$ and $s_L < g(k)$ if $\Delta L > 0$, thus suggesting that we should add a decreasing function of the change in employment to our explanatory variables. In Appendix A we show that this intuition is roughly valid as well when we take into account that adjustment costs also enter labor costs.

As to the shadow expected future marginal adjustment costs, they depend, among other things, on the degree of uncertainty. Higher uncertainty might be expected to increase the likelihood that a worker be fired, thus increasing the shadow cost of labor and pushing the economy further below the SK curve. But this is not unambiguous: as in the case of investment (see Nickell, 1977), an increase in uncertainty may well increase incentives to hire.

Empirically, the preceding arguments indicate that both taking current adjustment costs into account in the labor share and taking marginal adjustment costs –current and future– into account in the marginal cost of labor, should lead to adding a decreasing function of ΔL and a function of perceived uncertainty, σ_t, as explanatory variables for the labor share, i.e.: $s_{Lt} = f(k_t, \Delta L_t, \sigma_t)$, where it is likely that $f_2'(.) < 0$, $f_3'(.) \lesseqgtr 0$.

3 Evidence

We now investigate empirically the factors driving the evolution of the labor share in 12 OECD countries and 13 sectors over the period 1972-1993, following our model. Data availability precludes our analyzing all the variables which are relevant according to the model. We focus on three sources of variation: movements along the SK relationship –i.e., shocks whose effect on s_L is entirely mediated by k, such as changes in the prices of capital and labor, and labor-augmenting technical progress–; two shifters of the SK curve, namely capital-augmenting technical progress and changes in the price of raw materials; and two sources of movements off the SK schedule, namely changes in union bargaining power and labor adjustment costs. We start by documenting a few stylized facts present in the data, we then discuss the equation to be estimated and the econometric techniques used, and we finally show the empirical results.

3.1 Stylized facts

The SK schedule is a technological relationship, and so it is more appropriate to investigate it at the industry than at the country level. Therefore, we use industry data from the OECD International Sectoral Data Base (ISDB), which includes information on output, employment, capital, total factor productivity, and factor shares for 12 OECD countries over the period 1970-93, disaggregated at the 1- or 2-digit level.[15] The set of industries analyzed does not span the whole economy, excluding agriculture, but comes close to doing so. Appendix B provides details on the database.

Our key variables are the labor share, s_L, and the capital-output ratio, k. s_L is defined as the share of labor in nominal value added net of indirect taxes and k is the

[15] The database covers the period 1960-95, but disaggregated data on a sufficient scale for most variables are available only for 1970-93. The OECD has not produced this database beyond 1995.

ratio of the real capital stock to real value added. In other words, they correspond to $\widetilde{s}_L$ and $\widetilde{k}$, as defined in the theory section, although we will omit the $\sim$ symbol for simplicity. The standard labor share is measured as the fraction of value added that goes to the remuneration of employees. However, part of the remuneration of the self-employed is a return to labor rather than to capital. Gollin (2002) discusses the bias implicit in ignoring this fact and discusses three alternative methods of imputing that part. Here we follow his preferred method, namely imputing the self-employed labor income equal to the average wage earned by employees.

TABLE 2. DESCRIPTIVE STATISTICS OF THE MAIN VARIABLES
(All observations in the sample; 1972-93)

	Mean	Standard deviation	Minimum	Maximum
Labor share	67.8	18.8	2.4	141.8
Capital-output ratio	3.5	4.2	0.3	49.1
Real price of oil	30.1	16.4	5.4	96.2
Total factor productivity	93.2	16.2	24.5	236.5
Employment growth rate	-0.5	4.4	-22.3	18.2
Labor conflict rate	0.9	1.2	0.0	6.5

Note.– The labor share and the employment growth rate are percentages, total factor productivity is an index (1990=100 in each industry-country unit), and the remaining variables are ratios. The data correspond to an unbalanced panel of 13 industries and 12 countries. Total number of observations: 2457. Source: OECD International Sectoral Data Base (ISDB). See definitions of variables and number of observations by country, year, and industry in Table A1.

Table 2 presents the overall statistics of these two variables for all industries, countries, and years in the sample.[16] Table 3 shows 1972-93 averages (the period used in the econometric estimates) for s_L and k by industry and country. For countries, averages for the whole business sector are shown as well; the differences between databases are small, except in a few cases, and they stem from the absence of data for a few sectors. As expected, given the technological determinants of the labor share, within our sample both variables vary more widely across industries than across countries: the range for the labor share, for example, goes from 35% in Electricity, Gas, and Water to 85% in Construction.

[16] Due to imputation for the self-employed, in 62 of the 2457 observations the labor share exceeds 1, which explains the maximum value in the Table.

TABLE 3. DESCRIPTIVE STATISTICS OF THE LABOR SHARE AND THE CAPITAL-OUTPUT RATIO BY INDUSTRY AND BY COUNTRY (1972-93)

Industry	s_L	k	Country	s_L	k	s_L	k
	ISDB Sample			ISDB Sample		Business Sector	
Mining	50.6	3.9	U. States	69.7	2.7	67.1	1.4
Food	64.0	2.0	Canada	66.2	3.7	63.8	1.4
Textiles	82.5	2.1	Japan	62.8	2.5	68.8	2.1
Paper	71.6	3.0	Germany	69.0	2.6	65.8	2.7
Chemicals	59.1	3.4	France	67.0	2.8	67.3	2.7
Non-metallic minerals	71.1	2.8	Italy	62.3	2.6	64.8	2.7
Basic metal	70.2	4.8	Australia	70.4	4.7	65.7	3.2
Machinery	77.1	1.7	Netherlands	46.9	3.2	65.2	2.3
Electricity, Gas & W.	34.9	8.8	Belgium	70.3	2.6	67.9	2.5
Construction	84.6	0.8	Norway	70.5	6.5	65.9	4.0
Trade	80.5	1.4	Sweden	74.8	3.8	70.5	2.5
Transport & Comm.	65.9	7.9	Finland	66.1	5.1	72.0	3.6
Social services	69.1	1.7					

Note.- s_L: Labor share (in percentages), k: Capital-output ratio. The labor share measure includes an imputed remuneration of the self-employed on the basis of the average wage. Sources. ISDB Sample: OECD International Sectoral Data Base (ISDB) (Number of observations by country, year, and industry appear in Table A1). Business sector: *OECD Economic Outlook* Statistics on Microcomputer Diskette.

3.2 Empirical specification

For empirical purposes, we do not restrict the functional form of the labor share to the one derived for a specific production function like the CES, but rather assume a more general multiplicative form:

$$s_{L,ijt} = g(k_{ijt}, S_{ijt})h(X_{ijt}) \tag{17}$$

where the subindices denote industries ($i = 1, ..., 13$), countries ($j = 1, ..., 12$), and time ($t = 1972, ..., 1993$).[17] Here $g(k_{ijt}, S_{ijt})$ captures the SK schedule, which is affected by S. Following Section 2.3, and given data limitations, in our empirical specification S contains the national real price of imported oil, q_{jt}/p_{jt}, and a measure of total factor productivity (TFP_{ijt}), meant to capture capital-augmenting technical progress.

[17] The data start in 1970, but we lose two years due to the dating at t–2 of instrumental variables.

On the other hand, $h(X_{ijt})$ captures discrepancies between the marginal product of labor and the wage –wage bargaining, adjustment costs, etc.– which may move the economy off the SK relationship. Following Section 2.4, X_{ijt} includes two variables. First, the effect of current labor adjustment costs is captured through the industry net growth rate of the number of employees ($\Delta \ln n_{ijt}$). We also tried to capture the effect of future expected adjustment costs through several industry-specific measures of uncertainty, which came out with the expected sign but were not statistically significant.[18] Second, the effect of workers' bargaining power (θ), which would matter in an efficient bargains setup, is captured by the number of labor conflicts nationwide, normalized by the number of employees in the preceding year. This variable is measured as a country-specific, backward-looking 5-year moving average and it is denoted by $\widetilde{lcr}_{jt}$.[19] Neither of the latter two variables is very well measured from the point of view of the theory. Lastly, we are missing a measure for variations in price-cost markups, which are very hard to come by (see, e.g., Batini *et al.*, 2000, in a related setting).

Again for empirical purposes, we impose further structure by assuming that the functions $g(.)$ and $h(.)$ in equation (17) are also multiplicative, i.e.:

$$g(k_{ijt}, S_{ijt}) = A_{ijt}^{\beta_0} (d_i k_{ijt})^{\beta_{1i}} \left(d_i \frac{q_{jt}}{p_{jt}} \right)^{\beta_{2i}} \tag{18}$$

$$h(X_{ijt}) = \exp \left(\sum_{m=3}^{5} \beta_m x_{ijt}^m \right) \tag{19}$$

where $A_{ijt} = TFP_{ijt}$, $X_{ijt} = (\Delta \ln n_{ijt}, \widetilde{lcr}_{jt}, v_{ijt})$, and v_{ijt} is a residual term (so that $\beta_5 \equiv 1$). Note that the coefficients on $\ln k_{ijt}$ and $\ln(q_{jt}/p_{jt})$ are allowed to vary by industry through interactions with industry dummies ($d_i = 1$ for industry i, and 0 otherwise). Now substitute equations (18) and (19) into (17) and take logs, arriving at the basic estimated equation:

$$\ln s_{L,ijt} = \beta_0 \ln TFP_{ijt} + \sum_i \beta_{1i} d_i \ln k_{ijt} + \sum_i \beta_{2i} d_i \ln(q_{jt}/p_{jt}) + \beta_3 \Delta \ln n_{ijt} + \beta_4 \widetilde{lcr}_{jt} + v_{ijt} \tag{20}$$

3.3 Econometric methods

Equation (20) is estimated using panel data techniques, both in levels and first differences, where individual units of observation are industry-country pairs. We treat right-hand side variables as potentially endogenous and characterize such endogeneity through the following specification of the error:

$$v_{ijt} = \delta_{ij} + \epsilon_{ijt}$$

[18] More specifically, we tried with the backward-looking 5-year moving average of the standard deviation of the growth rate of industry output ($\widetilde{\sigma}_{ijt}$).

[19] We also tried the the number of workers involved and work-days lost due to conflicts, and centered moving averages. The empirical results were scarcely sensitive to these variations.

The term δ_{ij} is an industry-country specific effect potentially correlated with the explanatory variables. ϵ_{ijt} is a period-specific individual shock that represents expectational and possibly measurement errors, but may also capture unobservable variables, such as markups. Our instrumental variables should therefore not be significantly correlated with these potential error components.

With respect to ϵ_{ijt}, we treat the labor share, the capital-output ratio, the real price of oil, the total factor productivity index, and the employment net growth rate as potentially endogenous, and two variables constructed as backward-looking moving averages as predetermined, namely the labor conflict rate and the industry uncertainty measure discussed above.[20] We therefore use as instrumental variables for the equations estimated in first differences, which are free of the δ_{ij}, contemporaneous or lagged values of the latter, plus lags of the total factor productivity index, the rate of change of employment, and the real capital stock. Since differencing induces a first-order moving average of the residuals, we use the second, rather than first, lagged values for the endogenous variables.

With respect to δ_{ij}, we also assume that the correlation between some of the regressors and the fixed effects is constant over time. This assumption only requires stationarity in mean of the regressors given the effects and it can be tested through the overidentifying restrictions.[21] It is useful because it allows us to use lagged first differences as instruments for the errors in levels. Thus, for the equations estimated in levels, apart from first differences of the predetermined variables, we use as instruments the lagged first differences of the total factor productivity index, the rate of change of employment, the capital-output ratio and the real price of imported oil –the latter two interacted with industry dummies.[22]

It should be noted that, since the regression error term includes measurement error and possibly product market competition, identification may be in question if these sources are not truly constant (fixed effects) and show some persistence.

Our joint estimation in levels and first differences is carried out using Arellano and Bover's (1995) *system estimator*, which is shown to yield potentially large efficiency gains vis-à-vis the pure first-difference estimator (see also Blundell and Bond, 1998).[23] Algebraically, it can be expressed as follows. For simplicity, let us first rewrite equation (20) in the form:[24]

$$y_{ijt} = \beta' x_{ijt} + v_{ijt} \tag{21}$$

where $y_{ijt} = \ln s_{L,ijt}$, $x_{ijt} = \left(\ln TFP_{ijt}, d_i \ln k_{ijt}, d_i \ln(q_{jt}/p_{jt}), \Delta \ln n_{ijt}, \widetilde{lcr}_{jt}\right)$, and β

[20] Note that by construction we expect the TFP measure to be contemporaneously correlated with the labor share (see Appendix B).

[21] The stationarity requirement precludes the use of the capital stock as an instrument here.

[22] We cannot use industry interactions in the equations estimated in differences as well, due to lack of degrees of freedom.

[23] We use the dynamic panel data program DPD99, which implements the system estimator as an extension of the Generalized Method of Moments (GMM) procedure of Arellano and Bond (1991).

[24] See Arellano and Bond (1998) and Arellano (2003), Section 8.5, for further details.

is the parameter vector. The number of industry-country units is 121. The panel is unbalanced, with some observations missing either at the beginning or the end of the sample period (see Table A1), so that $t = 1, ..., T_{ij}$, where $12 \leq T_{ij} \leq 22$ is the number of periods available on the ij-th unit. The v_{ijt} are assumed to be independently distributed across units with zero mean, but arbitrary forms of heteroskedasticity across units and time are allowed. The identification assumptions are as follows. If there is a variable, say Z^L_{ijt}, satisfying the condition $E(Z^L_{ijt}\epsilon_{ijt}) = 0$ and we can assume that $E(Z^L_{ijt}\delta_{ij})$ does not depend on t, then we have $E(\Delta Z^L_{ijt}v_{ijt}) = 0$, i.e. ΔZ^L_{ijt} is a valid instrument for equation (21). Note that it would not make sense to include fixed effects in the estimation of this equation; that would be tantamount to including them twice (and, indeed, estimates of the fixed effects could be obtained from the estimation that we perform). Similarly, for the equation estimated in first differences, $\Delta y_{ijt} = \beta' \Delta x_{ijt} + \Delta v_{ijt}$, $E(Z^D_{ijt}\Delta v_{ijt}) = 0$ implies that Z^D_{ijt} is a valid instrument.

The specification is checked by means of the Sargan statistic (ST), a test of overidentifying restrictions for the validity of the instrument set, which is distributed as a χ^2 with degrees of freedom equal to the number of instrumental variables minus the number of parameters. We also report a statistic for the absence of second-order serial correlation in the first-differenced residuals, $\widehat{v}_{kt} - \widehat{v}_{k,t-1}$, labeled m_2. This is based on the standardized average residual autocovariances, which are asymptotically $N(0, 1)$ variables under the null of no autocorrelation, and should not be significantly different from zero if the residuals in levels are serially uncorrelated (note that, due to differencing, first-order autocorrelation is expected ex-ante).

3.4 Empirical results

Table 4 gives the estimates of our basic specification, equation (20). Industry capital-output ratios are jointly very significant (p-value: 0.00), which indicates departures from the Cobb-Douglas production function. The coefficients are either positive or negative, suggesting that labor and capital are either complements or substitutes depending on the industry, a finding which may depend on the (unobserved) industry shares of skilled labor. However, the t-ratios, which in this case test for the difference vis-à-vis the Social Services sector, indicate that industry coefficients for k are not statistically significant from each other.

As a check of the results, we use the estimated coefficients to compute industry-specific measures of the elasticity of substitution between K and L, σ_{KL}. From equation (20), we compute it as: $\sigma_{KL} = -(1 + \frac{\partial \tilde{s}_L}{\partial \tilde{k}} \tilde{k}\eta) = -(1 + \frac{\partial \ln \tilde{s}_L}{\partial \ln \tilde{k}} \tilde{s}_L \eta) < 0$. For this purpose we need an estimate of η, the elasticity of the labor demand with respect to the wage holding the real price of oil constant. Wage elasticity estimates abound but, as shown by Hamermesh (1993), they depend strongly on the specificities of the particular studies. Thus it seems better to use a ballpark estimate taken from Hamermesh's (1993, p. 92) summary of nearly 70 studies. The overall range is (–0.15, –0.75), with an average of –0.39. Table 4 shows our estimates for $-\sigma_{KL}$

Table 4. Estimation of Labor Share Equation
Dependent variable: ln $s_{L,ijt}$

	$Coeff.$	t-$ratio$	$-\sigma_{KL}$	$Coeff.$	t-$ratio$
Total factor productivity ($\ln TFP_{ijt}$)	-1.12	(3.21)			
Employment change ($\Delta \ln n_{ijt}$)	-1.41	(1.90)			
Labor conflict rate ($\widetilde{lcr}_{jt}$)	-7.02	(1.96)			
	Capital/Output			Real oil price	
Industry	$d_i(\ln k_{ijt})$			$d_i \ln(q_{jt}/p_{jt})$	
Mining	-1.22	(1.07)	1.24	1.49	(0.67)
Food	-0.44	(0.99)	1.11	-0.04	(0.18)
Textiles	0.17	(0.65)	0.94	-0.15	(0.79)
Paper	-0.10	(0.81)	1.03	-0.07	(0.38)
Chemicals	-1.99	(1.19)	1.46	0.37	(0.58)
Non-metallic minerals	-0.36	(0.94)	1.10	-0.05	(0.22)
Basic metal	-0.42	(1.05)	1.12	0.05	(0.21)
Machinery	0.16	(0.65)	0.95	-0.09	(0.50)
Elec., Gas, and Water	-0.47	(0.98)	1.06	0.01	(0.09)
Construction	0.43	(0.47)	0.86	-0.02	(0.09)
Trade	-0.13	(0.81)	1.04	-0.06	(0.29)
Transport and Communications	0.19	(0.64)	0.95	-0.25	(0.66)
Social services	1.26	(0.73)	0.66	-0.01	(0.02)
Joint significance (p-value)	0.00			0.05	
Specification checks	p-value	d.f.			
$Sargan$	0.60	6			
m_2	0.30				

No. of observations: 2457, no. of industry-country units: 121, Period: 1972-93. Method: Instrumental variables, system estimator. Two-step estimates of coefficients and t-ratios (in parenthesis) are robust to residual heteroskedasticity and autocorrelation. For sectoral capital and real price of oil t-ratios represent tests of the coefficient's difference vis-à-vis the Social Services sector. Instruments: (a) Levels: $\Delta\widetilde{lcr}_{jt}$, $\Delta\widetilde{lcr}_{j,t-2}$, $\Delta\widetilde{\sigma}_{ijt-1}$, $\Delta \widetilde{TFP}_{ij,t-2}$, $\Delta^2 \ln n_{ij,t-2}$, $\Delta\left(d_i ln\ k_{ij,t-2}\right)$, and $\Delta\left(d_i \ln(q_{j,t-2}/p_{j,t-2})\right)$. (b) Differences: $\widetilde{lcr}_{jt}$, $\widetilde{lcr}_{j,t-2}$, $\widetilde{\sigma}_{ijt-1}$, $TFP_{ij,t-2}$, $\Delta \ln n_{ij,t-2}$, and $\ln K_{ij,t-2}$. Legend: d_i=industry dummies and $\widetilde{\sigma}_{ijt}$=backward-looking 5-year moving average of the standard deviation of the growth rate of industry output.

using the latter value, which in 5 out of 13 cases are below 1, varying across sectors from 0.66 to 1.24. Nevertheless, only the elasticity for the Food sector (1.11) is significantly different from 1 (Cobb-Douglas) at the 5% level.

The first shifter of the SK relationship, the real oil price, is also significant, attracting negative coefficients (except for four industries) and thus resolving the theoretical ambiguity. Like for k, however, differences across sectors are not statistically significant.

As for total factor productivity, meant to capture the effect of capital-augmenting, or more generally not labor-augmenting, technical progress on the labor share, the estimated coefficient is negative, but we cannot interpret the magnitude, since the variable is measured as an index. Given the way the TFP measure is constructed, we also estimated the equation with a linear trend as an alternative, finding qualitatively similar results (see Bentolila and Saint-Paul, 2001). As pointed out above, if total factor productivity is strictly capital augmenting, it should come out with the same sign as the capital/output ratio. This is the case for most sectors, but not all, suggesting that a more complex effect of productivity on the production function may be at work.

Turning to movements off the SK curve, in Table 4 the variable capturing the effects of labor adjustment costs, namely the employment growth rate, shows the expected negative sign, as does the labor conflict rate, both being significant. The diagnostic statistics do not indicate problems with the specification.[25]

The lack of significance of industry-specific coefficients on the capital-labor ratio and the real oil price, which is most likely due to the relatively small number of observations, leads us to reestimate the equation without those interactions. We obtain the following results (t-ratios in parentheses):

$$\ln s_{L,ijt} = -\underset{(2.65)}{0.26} - \underset{(2.29)}{0.42} \ln TFP_{ijt} - \underset{(2.67)}{0.23} \ln k_{ijt} + \underset{(0.30)}{0.01} \ln(q_{jt}/p_{jt}) - \underset{(2.79)}{1.99} \Delta \ln n_{ijt} - \underset{(1.84)}{2.34} \widetilde{lcr}_{jt}$$

$$Sargan \text{ (}p\text{-value)} = 0.09 \text{ (d.f.=6)}; \; m_2 \text{ (}p\text{-value)} = 0.36.$$

The coefficient for the capital-output ratio implies a capital-labor elasticity of 1.06 (at η=–0.39), which is statistically different from the Cobb-Douglas value of 1 at the 1% level. This result lies in between those found by other researchers. On the one hand, there is a long literature finding elasticities significantly below 1, from 0.3 (Lucas, 1969) to 0.76 (Kalt, 1978). Antràs (2003) provides a survey and points out that ignoring the possibility of technological change biases the estimate towards 1. His own estimates, for instance his two-stage least squares estimates for a CES production function and exponential labor- and capital-augmenting technological change, fall in the interval (0.46,0.83). On the other hand, Papageorgiou and coauthors, who also use a CES production and capture technological progress through trends, provide many estimates, most of which are above 1 (e.g. –without

[25] We tried variations in the instrument set, not shown for brevity, obtaining very similar results.

including measures for human capital– 1.54 in Masanjala and Papageorgiou, 2003, or 1.24 in Duffy and Papageorgiou, 2000). Our estimates in Table 4 are in between the results in these two sets of studies, which are however not readily comparable to ours, since they use aggregate data for many countries, rather than industry data for high-income countries as we do. Moreover, our computed elasticities depend on positing an external value for η, so that we cannot in fact provide direct estimates of σ_{KL}.

Given that the theoretical model suggests potential non-linearities in the elasticity of the labor share with respect to the capital-output ratio, and given that we find both positive and negative coefficients in our specification with industry dummy interactions, we tried to capture this effect by adding a term in the squared log capital-labor ratio in the equation without industry dummy interactions. The coefficient turned out, however, not to be significant (t-ratio: 1.2).

Coming back to our estimates, we still get a negative coefficient for the real oil price, but it is insignificant, both economically and statistically. Total factor productivity is again negative and very significant.[26] This suggests that allowing for capital-augmenting technological progress in both theoretical and empirical models is indicated.

Changes in employment are significant and the estimated coefficient implies that, at an employment growth rate of, say, 1% p.a., a 1 percentage point increase in that rate reduces the labor share by 0.02%, which is small. This would mean that current labor adjustment costs move the economy off the SK curve, though we have not found a role for future expected labor adjustment costs –probably due to the low quality of our proxy for this variable. Lastly, the labor conflict rate is again negative but significant only at the 7% level. Taking this as a result of non-significance, a straightforward interpretation would be that wage bargains are not efficient, with the right-to-manage model, say, being a more appropriate description of reality.[27]

In sum, we have tested our model of the determination of the labor share. The results confirm that a share-capital schedule exists, that capital-augmenting technical progress shifts it (as well as the real price of oil, when its effects are allowed to vary by industry), and that there are significant deviations from it due to gaps between the marginal product of labor and the wage, arising from labor adjustment costs and, possibly, workers' wage bargaining power.[28]

[26] Both in this specification and in the one with industry specific interactions, including time dummies as regressors strongly reduced the significance of TFP.

[27] Alternatively, if one took the negative sign at face value, one interpretation could rely on delayed responses to wage pushes (see Caballero and Hammour, 1998).

[28] In Bentolila and Saint-Paul (2001) we apply the SK model its empirical estimates to disentangle the sources of unemployment in West Germany and the US, through the concept of wage gaps (the difference between wages and the marginal product of labor). We find sizable labor demand shifts in both countries, especially in Germany, where they seem to be related to labor adjustment costs.

4 Conclusions

In this paper we show that movements in the labor share can be fruitfully decomposed into movements along a technology-determined curve –the share-capital (SK) curve–, shifts of this locus, and deviations from it. Movements along the SK curve capture changes in factor prices such as wage pushes and changes in real interest rates, as well as the contribution of labor-augmenting technical progress. The curve is itself shifted by factors such as non-labor embodied technical progress or changes in the price of imported materials. Lastly, other sources of variation of the labor share are represented by movements off the SK curve, and are accounted for by deviations from marginal cost pricing such as changes in markups, labor adjustment costs, and changes in workers' bargaining power.

We analyze the performance of the model empirically, using data on a panel of 13 industries in 12 OECD countries, over the period 1972-93, by estimating the relationship between the labor share and the capital-output ratio, controlling for variables intended to capture some of the factors mentioned above. In the estimation we follow Arellano and Bover's (1995) system estimator for panel data, i.e. a generalized method of moments estimator with instrumental variables which exploits the information contained in the relationship between the variables in both levels and first differences.

We find a significant relationship between the two key variables, i.e. evidence of an SK schedule. There is also evidence of movements in the labor share due to either shifts of the SK schedule, arising from total factor productivity and –less clearly– changes in the real price of oil, and of movements off such schedule, arising from labor adjustment costs and, much less obviously, from workers' wage bargaining power.

Colophon

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Appendix A
The labor share with labor adjustment costs

We wish to show that the labor share is a decreasing function of the change in employment when adjustment costs are part of the labor share. In this case we have (where L_{-1} denotes lagged employment):

$$\begin{aligned} s_L &= \frac{wL + AC(\Delta L)}{F(K, BL)} = \frac{Bf'(l)L - AC'(\Delta L)L + AC(\Delta L)}{F(K, BL)} \\ &= g(k) + \frac{AC(\Delta L) - AC'(\Delta L)(L_{-1} + \Delta L)}{F(K, B(L_{-1} + \Delta L))} \end{aligned}$$

The last term's derivative with respect to ΔL has the same sign as its numerator: $-AC''(\Delta L)F(K, BL)L - [AC(\Delta L) - AC'(\Delta L)L]Bf'(l)$. This is clearly negative if $\Delta L \leq 0$. Assume, to the contrary, that $\Delta L > 0$. Then this term is negative if and only if

$$AC''(\Delta L) > -\frac{AC(\Delta L)}{L^2}\frac{lf'(l)}{f(l)} + \frac{AC'(\Delta L)}{L}\frac{lf'(l)}{f(l)}$$

A sufficient condition for that to hold is $AC''(\Delta L)L/AC'(\Delta L) > lf'(l)/f(l)$. For $AC(\Delta L)$ quadratic in ΔL this is equivalent to $L/\Delta L > g(k)$, which is extremely plausible as $g(k) < 1$ and ΔL is likely to be smaller than L.

Appendix B
Data sources and definitions of variables

The variables we use in the estimation are constructed from the OECD International Sectoral Data Base (ISDB) 1996, documented in OECD (1996). It covers the period 1960-95, but disaggregated data on a sufficient scale for most variables are only available for 1970-93. The variables we use –which have both country and year variation except for the real oil price and the labor conflict rate, which only vary by country– are as follows (original ISDB variables denoted by their own acronyms in capital letters):

Labor share: $s_L = WSSS\ (ET/EE)/(GDP\ (1 - IND))$.
Capital-output ratio: $k = KTVD/GDPD$.
Total factor productivity: $TFP = (GDPD/(ET^{\alpha}KTVD^{1-\alpha})/TFP_0$.
Real oil price: q/p= Nominal oil price/GDP deflator= $(PO \times ER)/(GDP/GDPV)$.
Labor conflict rate: lcr = Number of labor conflicts (strikes+lock-outs)/Number of employees in the preceding year (Source: CEP-OECD Data Set, documented in Bell and Dryden, 1996).

where:

• ET = Total employment.
• EE = Number of employees.
• ER = Exchange rate vis-à-vis the dollar (Market rate/Par or Central rate, period average. Source: International Monetary Fund, *International Financial Statistics*, IFS).
• GDP = Value added at market prices, current prices, national currency.
• $GDPD$ = Value added at market prices, at 1990 prices and 1990 Purchasing Power Parities (PPP). (US dollars).
• $GDPV$ = Value added at market prices, at 1990 prices, national currency.
• IND = Ratio of net indirect taxes to value added.
• $KTVD$ = Gross capital stock, at 1990 prices and 1990 PPP (US dollars).
• PO = Price of oil in dollars (Source: IFS).
• $TFP_0 = TFP$, 1990 value.
• $WSSS$ = Compensation of employees, at current prices, national currency.
• α = Standardized labor share weight, not corrected for indirect taxation.

The sectoral breakdown used distinguishes between 13 industries. The number of observations available for the econometric estimation by country, year, and industry are shown in Table A1.

Table A1. Number of Observations Available for Econometric Estimation By Country, Year, and Industry

Country	No.	Year	No.	Year	No.
United States	286	1972	44	1984	131
Canada	250	1973	79	1985	131
Japan	221	1974	79	1986	131
Germany	286	1975	79	1987	131
France	169	1976	83	1988	131
Italy	175	1977	113	1989	131
Australia	72	1978	113	1990	131
Netherlands	52	1979	129	1991	131
Belgium	232	1980	129	1992	103
Norway	220	1981	129	1993	70
Sweden	273	1982	129		
Finland	221	1983	130		

Industry	ISIC code	No.
Mining and quarrying	2	146
Food, beverages and tobacco	31	193
Textiles, wearing apparel and leather products	32	193
Paper, paper products, printing and publishing	34	172
Chemicals, petroleum, coal, rubber and plastic	35	172
Non-met. mineral products excl. petrol. and coal	36	173
Basic metal industries	37	193
Fabricated metal prods., machinery and equipment	38	193
Electricity, gas and water	4	224
Construction	5	224
Wholesale and retail trade	61+62	177
Transport, storage and communications	7	211
Community, social and personal services	9	186

Total no. of observations: 2457.

References

Acemoglu, D. (2003), "Labor- and Capital-Augmenting Technical Change", *Journal of the European Economic Association* 1, forthcoming.

Antràs, P. (2003), "Is the U.S. Aggregate Production Function Cobb-Douglas? New Estimates of the Elasticity of Substitution", mimeo, MIT.

Arellano, M. (2003), *Panel Data Econometrics*, Oxford, Oxford University Press.

— and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *Review of Economic Studies* 58, pp. 277-297.

— and — (1998), "Dynamic Panel Data Estimation using DPD98 for GAUSS", mimeo, CEMFI (ftp://ftp.cemfi.es/pdf/papers/ma/dpd98.pdf).

— and O. Bover (1995), "Another Look at the Instrumental-Variable Estimation of Error-Components Models", *Journal of Econometrics* 68, pp. 29-52.

Batini, N., B. Jackson, and S. Nickell (2000), "Inflation Dynamics and the Labour Share in the UK", External MPC Unit Discussion Paper no. 2, Bank of England (http://www.bankofengland.co.uk/mpc/extmpcpaper0002.pdf).

Bell, B. and N. Dryden (1996), "The CEP-OECD Data Set (1950-1992)", mimeo, Centre for Economic Performance, London School of Economics.

Bénabou, R. (1992), "Inflation and Markups: Theories and Evidence from the Retail Trade Sector", *European Economic Review* 36, pp. 566-574.

Bentolila, S. and G. Bertola (1990), "Firing Costs and Labour Demand: How Bad is Eurosclerosis?", *Review of Economic Studies* 57, pp. 381-402.

Bentolila, S. and G. Saint-Paul (2001), "Explaining Movements in the Labor Share", mimeo (ftp://ftp.cemfi.es/pdf/papers/sb/share_2001.pdf).

Blanchard, O. (1997), "The Medium Run", *Brookings Papers on Economic Activity*, 2, pp. 89-158.

— (1998), "Revisiting European Unemployment: Unemployment, Capital Accumulation and Factor Prices", NBER Working Paper no. 6566.

— and S. Fischer (1989), *Lectures on Macroeconomics*, Cambridge, Mass., The MIT Press.

— and F. Giavazzi (2003), "Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets", *Quarterly Journal of Economics*, forthcoming.

Blundell, R. and S. Bond (1998), "Initial Conditions and Moment Conditions in Dynamic Panel Data Models", *Journal of Econometrics* 87, pp. 115-143.

Bruno, M. and J. Sachs (1985), *Economics of Worldwide Stagflation*, Cambridge, Mass., Harvard University Press.

Caballero, R. and M. Hammour (1998), "Jobless Growth: Appropiability, Factor Substitution, and Unemployment", *Carnegie-Rochester Conference on Public Policy* 48, pp. 51-94.

de Serres, A., S. Scarpetta, and C. de la Maisonneuve (2002), "Sectoral Shifts in Europe and the United States: How They Affect Aggregate and The Properties of Wage Equations", OECD Economics Department, Working Paper 326 (http://appli1.oecd.org/olis/2002doc.nsf/linkto/eco-wkp(2002)12/$FILE/JT0 0123916.PDF).

Duffy, J. and C. Papageorgiou (2000), "A Cross-Country Empirical Investigation of the Aggregate Production Function Specification", *Journal of Economic Growth* 5, 83-116.

Galí, J. and M. Gertler (1999), "Inflation Dynamics: A Structural Econometric Analysis", *Journal of Monetary Economics* 44, 195-222.

Gollin, D. (2002), "Getting Income Shares Right", *Journal of Political Economy* 110, 458-474.

Hall, R. (1990), "Invariance Properties of Solow's Productivity Residual", in P. Diamond and O. Blanchard, eds., *Growth/Productivity/Unemployment*: *Essays to Celebrate Bob Solow's Birthday*, Cambridge, Mass., The MIT Press.

Hamermesh, D. (1993), *Labor Demand*, Princeton, Princeton University Press.

Jones, Ch. (2003), "Growth, Capital Shares, and a New Perspective on Production Functions", mimeo, UC Berkeley (http://emlab.berkeley.edu/users/chad/alpha 100.pdf).

Kalt, J. (1978), "Technological Change and Factor Substitution in the United States: 1929-1967", *International Economic Review* 19, 761-775.

Layard, R., S. Nickell, and R. Jackman (1991), *Unemployment. Macroeconomic Performance and the Labour Market*, Oxford, Oxford University Press.

Lucas, R. (1969), "Labor-Capital Substitution in U.S. Manufacturing", in *The Taxation of Income from Capital*, A. Harberger and M. J. Bailey, eds., Washington, D.C., The Brookings Institution, 223-274.

Masanjala, W. and C. Papageorgiou (2003), "The Solow Model with CES Technology: Nonlinearities and Parameter Heterogeneity", *Journal of Applied Econometrics*, forthcoming.

Nickell, S. (1977), "The Influence of Uncertainty on Investment", *Economic Journal* 87, pp. 47-70.

Organisation for Economic Co-operation and Development (1996), *International Sectoral Data Base (1960-1995)*, Statistics Directorate, Paris.

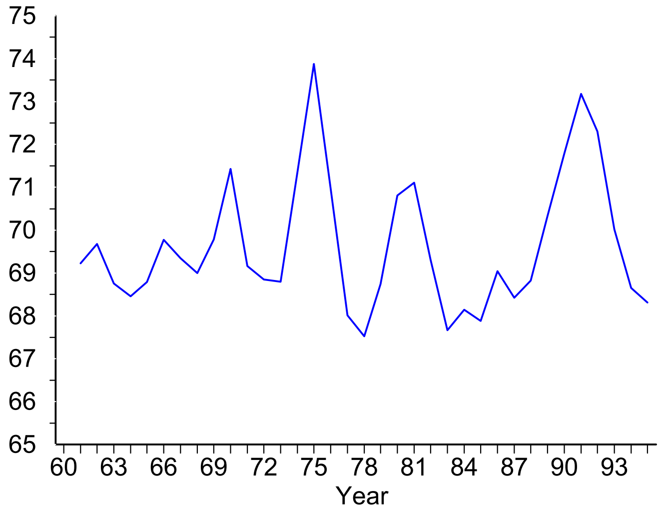
Rotemberg, J. and M. Woodford (1991), "Markups and the Business Cycle", in O. Blanchard and S. Fischer, eds., *NBER Macroeconomics Annual 1991*, Cambridge, Mass., The MIT Press.

— and — (1992), "Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity", *Journal of Political Economy* 100, 1153-1207.

— and — (1999), "The Cyclical Behavior of Prices and Costs", in J. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics*, vol 1B, Amsterdam, Elsevier, 1051-1135.

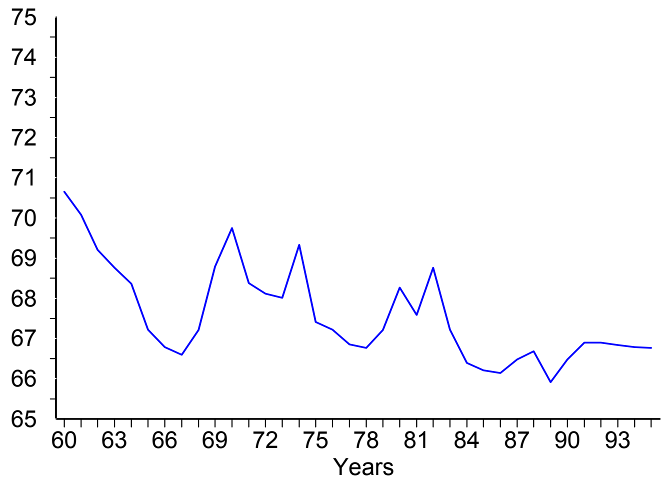
Varian, H. (1984), *Microeconomic Analysis*, 2nd ed., New York, W.W. Norton & Company.

FIGURE 1. THE LABOR SHARE IN THE UNITED KINGDOM



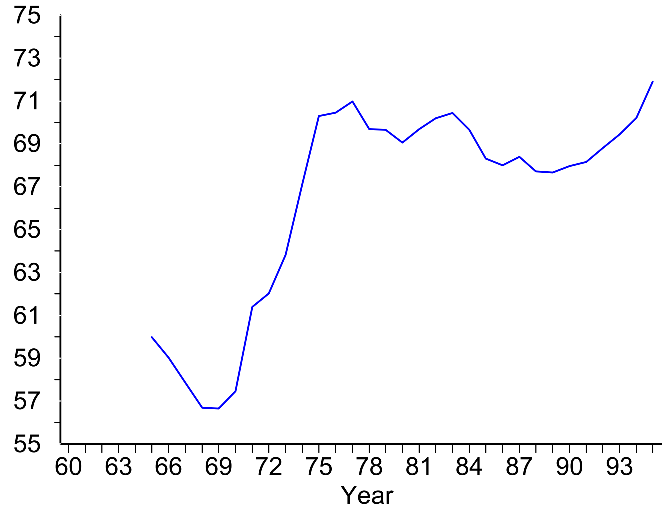
Source: OECD Economic Outlook Statistics on Microcomputer Diskette.

FIGURE 2. THE LABOR SHARE IN THE UNITED STATES



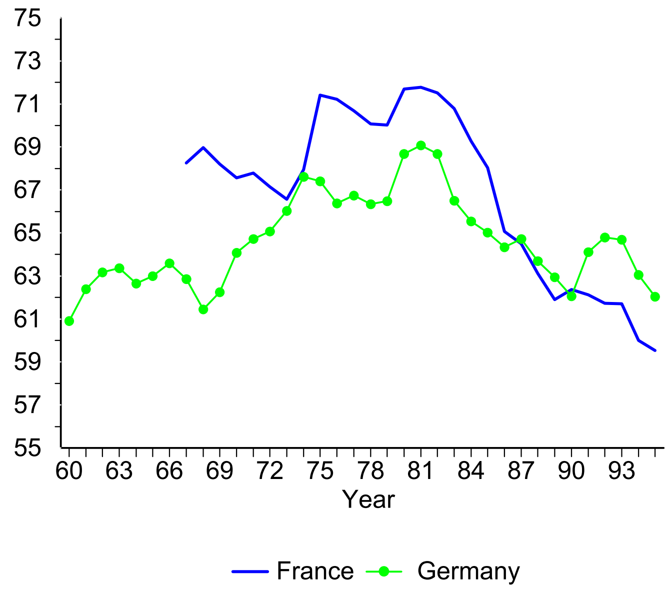
Source: OECD Economic Outlook Statistics on Microcomputer Diskette.

FIGURE 3. THE LABOR SHARE IN JAPAN



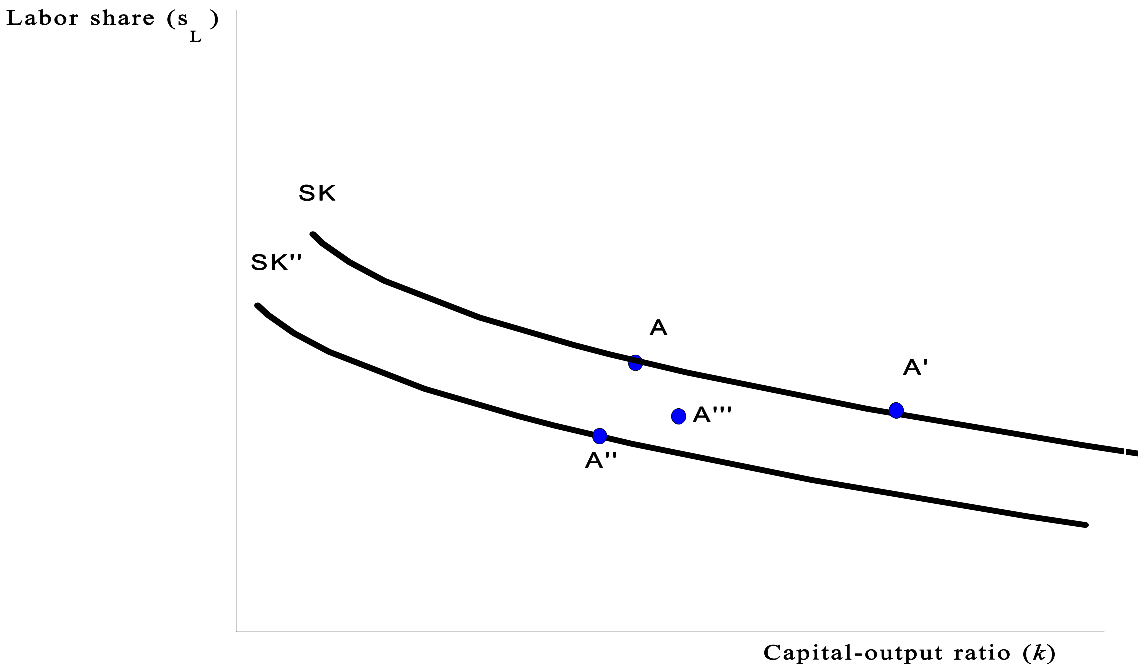
Source: OECD Economic Outlook Statistics on Microcomputer Diskette.

FIGURE 4. THE LABOR SHARE IN FRANCE AND GERMANY



Source: OECD Economic Outlook Statistics on Microcomputer Diskette.

FIGURE 5. THE CAPITAL-SHARE SCHEDULE



A: Initial position of the economy

A': Increase in wages

A'': Change in the price of oil

A''': Increase in the markup