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An Empirical Evaluation of the Disequilibrium Real Wage Rate Hypothesis 1/

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Summary

The rise in the share of labor costs in value added and in the unemployment rate in many industrial countries during the 1970s and early 1980s has led many observers to conclude that real wages are now too high and a source of "classical" unemployment. These conclusions are not necessarily valid. The increase in the labor share could be warranted by long-run changes in production techniques, in the price of energy, or in the relative availability of labor and capital. Moreover, the observed unemployment could be structural or Keynesian, rather than classical. In this paper, a production function approach is used to examine these possibilities and to subject the disequilibrium real wage hypothesis to a more rigorous empirical test than has been conducted in the past. The study focuses on the manufacturing sector in the seven largest industrial countries.

We conclude that there are indeed reasons to believe that in France, the Federal Republic of Germany, the United Kingdom, and possibly even in Japan, real wages in the manufacturing sector are now too high, in the sense of being incompatible with "high employment." On the other hand, our results indicate no real wage problem in the United States and Canada. We find no evidence of a real wage problem in Italy either, but poor data prevent a firm conclusion in this regard. These findings are derived from an analysis in which the capital stock and the exchange rate are assumed to be exogenous. A partial reversal of the exchange rate movements of recent years--even though desirable in many respects--could widen the dichotomy between France, the Federal Republic of Germany, and Japan, on one side, and the United States and Canada, on the other, while it could alleviate the real wage problem in the United Kingdom.

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I. Introduction

The present paper examines the validity of the hypothesis that the level of the real wage rate, inclusive of employers' expenditures for social insurance and employment or payroll taxes, is a major obstacle to a return to "high employment" in industrial countries. 1/ It does this by estimating a production function, solving it for the real wage rate that would be consistent with the high-employment level of labor input given the existing capital stock, and comparing this "warranted" wage to the actual real wage. This exercise is carried out for the manufacturing sector of the seven largest industrial countries (the United States, Canada, Japan, France, the Federal Republic of Germany, Italy, and the United Kingdom). In each country, the estimate of the high-employment level of labor input makes due allowance for regional and skill mismatches between labor supply and demand. As a by-product, the study casts some light on the relative contribution of low capital formation and high energy prices to the decline in the growth of labor productivity during the 1970s and early 1980s.

The disequilibrium real wage rate hypothesis is largely based on the observation that, at least in manufacturing, the real wage rate defined from the employer's standpoint--that is, the nominal wage rate deflated by the value added deflator rather than the consumer price index--has tended to grow faster than labor productivity during the past decade and a half, leading to a rise in the share of labor costs in value added and a corresponding decline in the capital share. 2/ (See Table 1.) However,

1/ Malinvaud (1977, 1982) presents an updated theoretical analysis of the relation between inappropriate real wages and unemployment. Sachs (1979, 1983), Branson and Rotemberg (1980), Drèze and Modigliani (1981), Bruno and Sachs (1982), Giersch (1982), Kouri, Braga de Macedo, and Viscio (1982), Grubb, Jackman, and Layard (1983), Knight (1983), Steinherr (1983), and Lipschitz and Schadler (1984) are some of the main advocates of the view that the level of the real wage rate is a major obstacle to a return to high employment in European countries. Sachs (1983) and others found evidence of inappropriately high real wages in the United States and in Japan, but they did not detect marked effects on unemployment in these two countries.

2/ There is also some evidence that in a number of countries the share of labor costs in value added has risen in other sectors during the past decade and a half, but this evidence is difficult to interpret. Sectors such as transport, communication, and utilities are largely under public control in most industrial countries so that the profit motive does not play an important role in determining their demand for labor. In the private service sector, it is difficult to define the share of labor costs because of the high proportion of persons working on their own account.

Table 1. Labor Productivity and Real Wage Rates in Manufacturing 1/

(Average rate of growth in percent per annum; for S_L, average level in percent)

	1956-69	1970-72	1973-82	1956-69	1970-72	1973-82
		United States			Canada	
Y	3.7	1.8	1.1	5.6	4.0	1.2
K	2.8	3.2	2.0	4.3	4.4	2.2
L	1.2	-1.7	-0.5	1.3	-0.3	-0.3
Y/L	2.5	3.6	1.6	4.2	4.3	1.5
w/p	2.7	3.3	2.4	4.5	4.0	2.0
S_L	75.3	76.9	77.7	66.7	69.2	67.7
		Japan			France	
Y	16.1	10.1	6.3	7.0	6.7	2.3
K	11.8	16.1	5.1	4.1	6.0	3.4
L	4.8	0.1	-0.3	1.0	0.7	-2.2
Y/L	10.8	10.2	6.6	6.0	6.0	4.6
w/p	10.2	14.5	8.7	5.2	8.6	5.5
S_L	44.7	46.0	55.5	61.3	62.6	68.9
		Germany			Italy	
Y	5.7 2/	3.1	1.3	7.7	4.1	3.2
K	9.1 2/	6.9	1.8	3.9	3.9	1.4
L	-0.3 2/	-0.9	-2.8	1.9	-1.2	-0.9
Y/L	6.0 2/	4.0	4.2	5.8	5.4	4.1
w/p	5.7 2/	6.6	5.2	6.7	9.1	4.0
S_L	65.3 3/	67.2	71.4	60.2	69.3	70.9
		United Kingdom				
Y	3.2	0.4	-1.2			
K	4.7	4.0	0.5			
L	-0.5	-4.0	-3.8			
Y/L	3.7	4.6	2.7			
w/p	4.3	5.0	3.7			
S_L	70.5	74.4	79.1			

Source: See the Statistical Appendix.

1/ Notation: Y, real value added; K, gross fixed capital stock in constant prices; L, labor in man-hours; w/p, real wage rate calculated by using the deflator of value added; S_L, share of labor costs in value added originating in manufacturing.

2/ Average rate of growth during 1962-69.

3/ Average level during 1961-69.

while suggestive, this development can hardly be viewed as a proof that the real wage rate is now too high. It could be that the increase in the labor share was warranted by long-run changes in production techniques, in the price of energy, or in the relative availability of labor and capital. The production function approach allows us to examine these possibilities and to subject the hypothesis to a more rigorous test. 1/

The purview of the paper is limited in three respects. First, only the manufacturing sector is considered. Obviously, conditions in that sector are not necessarily indicative of conditions in other sectors. Furthermore, the narrow focus on only one sector leads to a number of conceptual problems. For example, it is difficult to define precisely the high-employment level of labor input for the manufacturing sector. Second, the capital stock is viewed as an exogenous variable and no attempt is made to explain investment. It is possible that a disequilibrium real wage rate reduces investment, which would in turn reduce the growth of the warranted real wage rate. The result could be a vicious circle with higher and higher unemployment. In the absence of an explanation of investment, these dynamic considerations are outside the scope of the present paper. 2/ Third, prices in the goods markets, including prices of manufactures, intermediate inputs used in the manufacturing sector, and consumer goods, are also viewed as exogenous variables. This last assumption implies that the exchange rate is taken as given, a point to which we return in the concluding section.

Section II of the paper describes the theoretical framework that is used in the empirical investigation. Section III discusses the empirical results. Some concluding remarks are presented in Section IV.

II. The Theoretical Framework

In the first part of this section, a simple production model is used to clarify the main issues under consideration. Then two more complex

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1/ Among the studies listed in footnote 1 on p. 1, Knight (1983) and Lipschitz and Schadler (1984) use a production function approach to allow for the effect of changes in the relative availability of labor and capital on the warranted labor share, but they ignore the possible effect of changes in production techniques and in the price of energy on this share. The other studies assume that any sustained gap between the growth of the real wage rate defined from the employer's standpoint and the growth of labor productivity implies a disequilibrium situation. Basevi et. al. (1983) have rightly stressed the drawbacks of such an assumption and the need for a comprehensive production function approach.

2/ A discussion of these dynamic effects can be found in Malinvaud (1977, 1982) and Bruno and Sachs (1982).

models are derived to provide a realistic framework for the empirical analysis. Model A is limited to two factors of production, labor and capital, while Model B views energy as a complement to capital. Finally, the major difficulties inherent in the measurement of the actual flows of labor and capital services, as well as in the measurement of the high-employment flow of labor services, are considered.

1. A simple model

The main production characteristics of a large and diversified manufacturing sector can be represented by the following aggregate CES (Constant Elasticity of Substitution) production function with constant returns to scale:

$$Y = \gamma\, e^{\lambda t}\, [(1 - \delta)\, L^{-\beta} + \delta\, K^{-\beta}]^{-1/\beta} \tag{1}$$

where
Y = net output (real value-added)
t = time trend for disembodied productivity change
L = flow of labor services
K = flow of capital services.

This specification assumes that the marginal rate of substitution between labor and capital is effectively independent of the amount of raw materials (N) and energy (E) being used, that is, it assumes that a change in the price of N or E does not call for a change in K/L. Under such conditions, N and E are said to be "weakly separable" from K and L, and one can study the relation between K, L, and the value-added Y without taking account of N and E. (See Leontieff (1947).)

Aside from the weak separability assumption, function (1) is fairly general. In particular, it imposes no constraint on the value of the elasticity of substitution between labor and capital (η, $\eta = 1/(1 + \beta)$) and includes the Cobb-Douglas function (with $\beta = 0$ and $\eta = 1$) as a special case. It does assume that technology is the "putty-putty" type with the same possibility to choose among different ratios of labor to capital services at the time of purchase of equipment and throughout the working life of the equipment, rather than the "putty-clay" type with the choice becoming more limited after purchase. However, this assumption does not seem to do too much violence to the facts. Even after purchase, there is often considerable room for variations in the ratio of labor to capital services, so that, whenever there is a sudden decline in the economically useful capital stock, the demand for labor does not necessarily decline as assumed in the "putty-clay" model.

The assumption of constant returns to scale is also acceptable because in the seven countries under consideration here the manufacturing sector is already so large that a further increase in its size does not *per se* entail important economies of scale. As new products and new production techniques appear, there is often an opportunity for further economies of scale. However, such changes occur gradually over time and are unrelated to the levels of capital and labor in the manufacturing sector. Thus, these changes are more appropriately taken into account by the rate of disembodied productivity change, λ, than by the introduction of economies of scale in the aggregate production function. 1/

To simplify the theoretical analysis as well as the future econometric estimation, it is convenient to work with a linear approximation to equation (1). This approximation is obtained by writing equation (1) in log form, applying a Taylor's series expansion to ln Y around $\beta = 0$, and dropping the terms involving powers of β higher than one. This simplification involves no loss of economic realism because the terms that are dropped have coefficients that can be assumed to be very small. The resulting equation is:

$$(2) \quad \ln Y = \ln \gamma + \lambda\, t + (1 - \delta) \ln L + \delta \ln K - 1/2\, \beta(1 - \delta)\delta\, [\ln (K/L)]^2$$

If K is given, entrepreneurs will recruit labor up to the point where the marginal product of labor is equal to the real wage rate, that is,

$$(3) \qquad \frac{\partial Y}{\partial L} = \frac{w}{p}$$

where w is the money wage rate and p the deflator of value added.

Given that:

$$(4) \qquad \frac{\partial \ln Y}{\partial \ln L} = \frac{\partial Y}{\partial L}\frac{L}{Y}$$

the equilibrium condition (3) is equivalent to:

$$(5) \qquad \frac{\partial \ln Y}{\partial \ln L} = \frac{w}{p}\frac{L}{Y} = S_L = 1 - S_K$$

where S_L is the "labor share of income" and S_K the capital share. We refer to S_L as the labor share of income because it is the expression used in most of the economic literature. However, as noted above, what really matters from the standpoint of the demand for labor is the cost of labor so that employment or payroll taxes have to be included in w and S_L, even though they do not represent an income for labor.

1/ The assumption of constant returns to scale was tested as part of the empirical study by adding a scale parameter to equation (1). This parameter was not found to be significantly different from unity.

After carrying out the partial differentiation of (2), equation (5) can be written:

(6) $$S_L = 1 - \delta + \beta\ \delta\ (1 - \delta)\ \ln\ (K/L)$$

To have equilibrium in the labor market, L must correspond to its high-employment value, $\overline{L}$. The corresponding equilibrium labor share is:

(7) $$\overline{S}_L = 1 - \delta + \beta\ \delta\ (1 - \delta)\ \ln\ (K/\overline{L})$$

The high-employment real wage rate $(\overline{w/p})$ is obtained by calculating the high-employment level of output $(\overline{Y})$ from equation (2) and inserting $\overline{Y}$ and $\overline{L}$ in equation (5). In log form, the result is:

(8) $$\ln\ (\overline{w/p}) = \ln\ (\overline{Y}/\overline{L}) + \ln\ (\overline{S}_L)$$

$$= \ln \gamma + \lambda\ t + \delta\ \ln\ (K/\overline{L}) - 1/2\ \beta\ (1 - \delta)\delta\ [\ln\ (K/\overline{L})]^2$$

$$+ \ln\ (\overline{S}_L)$$

From equations (7) and (8), we conclude that an increase in the high-employment labor share $(\overline{S}_L)$ resulting from a rise in the real wage rate in excess of the rise in labor productivity is at times warranted. In this simple model, it is the evolution of $K/\overline{L}$ and the value of β that determine if it is warranted. More precisely, $\overline{S}_L$ is positively related to $K/\overline{L}$ if β is positive (that is, if $\eta < 1$) and negatively related to this ratio if β is negative (that is, if $\eta > 1$). This share is constant only if $\beta = 0$, the Cobb-Douglas case. The high-employment equilibrium real wage rate $(\overline{w/p})$ is positively related to $\overline{Y}/\overline{L}$ and to $\overline{S}_L$. More fundamentally, $\overline{w/p}$ is increasing at a rate which corresponds to the rate of disembodied productivity change only if $K/\overline{L}$ is constant. If $K/\overline{L}$ is rising, this will boost up the increase in $\overline{w/p}$, especially if β is positive and large.

The other conclusion to be derived from this simple model is that, while the gap between the actual real wage rate (w/p) and the warranted rate $(\overline{w/p})$ is a meaningful indicator of the magnitude of the disequilibrium, the gap between the actual and the warranted labor share can be misleading. Looking back to equation (6), it is clear that an undue rise in the real wage rate that leads to a decline in the demand for labor, and therefore a rise in K/L, could ultimately result in a decline rather than a rise in the labor share. This will be the case whenever β is negative (i.e., $\eta > 1$). In the more likely case where β is positive, the labor share will rise, but only by a small amount if β is small. Thus, neither the sign nor the magnitude of the deviation between the actual and the warranted labor share can be taken as reliable indicators of a real wage rate disequilibrium. When focusing on the share, one should compare the warranted share ($\overline{S}_L$) to the "normalized" share ($\tilde{S}_L$) corresponding to the actual real wage rate and the labor productivity at high employment (i.e., $\tilde{S}_L = \overline{L}w/\overline{Y}p$). The information provided by this latter comparison is, of course, the same as the information provided by a comparison of the actual and the warranted real wage rate.

2. Two more complex models

The above model, while providing a useful introduction to the concepts of a warranted labor share and a warranted real wage rate, needs to be extended considerably before becoming usable for empirical work. First, we will retain the weak separability assumption for both raw materials and energy and extend the above model to take account of the variability in some of the parameters of the production function and the econometric problems raised by its estimation. After developing this new model, named "model A," we will relax the assumption of weak separability with respect to energy. The resulting model, which assumes energy-capital (E-K) complementarity, will be named "model B."

Model A

While in the short run all the parameters in equation (2) can be assumed to be constant, the rate of disembodied productivity change (λ) and the factor weights (δ) and ($1 - \delta$) are likely to change in the longer run. The parameter λ is a "catch all" parameter that represents the multitude of factors that explain why output tends to grow faster than measured inputs; thus, it would be surprising if it did not change as these factors evolve. This is well recognized in the economic literature. What is less well recognized, but possibly even more important in the present context, is that δ may also change over time and affect the high-employment equilibrium labor share as the production techniques and the pattern of production become more, or less, labor intensive. In fact, the evolution of the labor share over the past three decades suggests that the change in δ may have been sizable. The labor share remained roughly constant in most major industrial countries througout the second half of the 1950s and the whole of the 1960s, despite a doubling or tripling of the ratio of capital to labor. Equation (6) indicates that such a development is consistent with firm equilibrium and a constant δ only if the production function is of the Cobb-Douglas type ($\beta = 0$). But if β is zero and δ is constant, then <u>all</u> of the change in the labor share experienced in the 1970s and early 1980s should be viewed as a move away from equilibrium because the equilibrium labor share would be constant. This does not seem plausible.

Allowing λ and δ to change without using many degrees of freedom is not an easy task. For λ, in particular, it is difficult to impose any a priori restriction, so that one cannot avoid a systematic search for statistically-significant shifts despite the cost in terms of degree of freedom. For this reason, this parameter will hereafter be written as λ_t. For δ, the change should be fairly gradual, and over the plausible range of variation one can assume a simple linear function of time ($\delta = \delta_0 + \delta_1 t$).

Even with this restriction on the way δ can change over time, the number of parameters in equation (2) is too large for reliable econometric estimation from a single equation. With periods of observation limited to twenty to thirty years, there is simply too much multicollinearity among the main variables. Frequently, this problem is solved by jointly estimating the production function and the demand for labor. In the present context, however, this method has to be modified for two reasons. First, the demand for labor corresponding to a CES production function with λ_t and $\delta = \delta_0 + \delta_1 t$ is: 1/

(9) $$\ln L = \frac{1}{1+\beta}(\ln(\delta_0 + \delta_1 t) - \beta \ln \gamma) - \frac{1}{1+\beta}\ln(w/p) - \frac{\beta}{1+\beta}\lambda_t t + \ln Y$$

It is apparent that there are two trend elements in equation (9) and that the equation would therefore fail to contribute anything to the estimation of either δ_1 or λ_t.

Second, the demand for labor is derived under the assumption that labor is paid its marginal product. Most studies do take into account that this assumption is plausible only in the longer run by considering equation (9) as a long-run demand for labor. The lagged value of ln L is then added to the right-hand side of equation (9) to reflect the gradual adjustment of the actual demand for labor to its longer-run equilibrium value. The problem is that this specification does not differentiate between the adjustment of L to Y over the cycle, which is often rapid, and the adjustment of L to w/p, which may be quite slow. 2/ Furthermore,

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1/ The demand for labor is derived under the assumption that the flow of capital services is given. To derive it, it is more convenient from a mathematical standpoint to use equation (1) rather than its linear approximation represented by equation (2).

2/ A possible solution would be to have a separate distributed lag on w/p and Y, but here again there would be a problem of multicollinearity. The major change in w/p took place in the early 1970s and it would be difficult to disentangle its effect on the demand for labor from the effect of the likely concomitant change in the rate of technical progress.

as the cyclical movement in Y is usually the dominant factor, the estimated coefficient of adjustment may exaggerate the rapidity with which the equilibrium between the real wage rate and the marginal product of labor is re-established. Thus, imposing equation (9) on the data is nearly equivalent to imposing the constraint that deviations of the real wage rate from the equilibrium value corresponding to the amount of employed labor cannot last more than a few years. Therefore, the change in the labor share of income experienced in most industrial countries over the past ten to fifteen years would have to be viewed as a phenomenon fully warranted by factors such as changes in production techniques and in the relative amounts of labor and capital within firms. Such an assumption would hardly be appropriate in the context of the present study. 1/

The approach adopted here to solve the multicollinearity problem is to use the share equation (6) rather than the normal demand for labor equation. The major advantage of equation (6) is that the rate of disembodied productivity change (λ_t) does not enter into it, while the relative weight of capital ($\delta_0 + \delta_1 t$) does. Thus, this equation is a powerful tool to obtain an estimate of δ_0 and δ_1. As it is also derived under the assumption that labor is paid its marginal product, it will be assumed to hold only on a cyclically adjusted basis, rather than in each phase of the cycle. Furthermore, it will only be assumed to have held during 1955-69 for the European countries and 1955-73 for the United States and Canada, periods for which there is no reason to expect that the real wage rate was out of equilibrium. 2/ For Japan, equation (6) will also be assumed to have held during 1955-73, even though the extremely low labor share during this period suggests that labor was possibly paid less than its marginal product as a result of an implicit social consensus that a high profit rate was the best way to rebuild the capital stock.

After taking account of the considerations discussed above, we obtain the two functions which comprise model A:

$$(10) \quad \ln Y = \ln \gamma + \lambda_t t + (1 - \delta_0 - \delta_1 t) \ln L + (\delta_0 + \delta_1 t) \ln K - 1/2\, \beta\, (1 - \delta_0 - \delta_1 t)(\delta_0 + \delta_1 t)\, [\ln (K/L)]^2$$

1/ Consideration of the conditions in the steel and shipbuilding industries in European countries during the 1970s and early 1980s suggests that a disequilibrium situation involving low or negative profitability and an excess of labor can at times last more than a decade.

2/ In European countries, it is the wage explosion of late 1969 that is usually considered to mark the beginning of the real wage problem. In the United States and Canada, the beginning of the problem is usually traced to the 1973-74 oil price increase.

(11) $$S_L' = (1 - \delta_0 - \delta_1 t) + \beta (\delta_0 + \delta_1 t) (1 - \delta_0 - \delta_1 t) \ln (K/L')$$

where S_L' = the trend-through-peaks value of S_L adjusted downward so that the average of S_L' is equal to the average of S_L

L' = the trend-through-peaks value of L adjusted downward so that the average of L' is equal to the average of L.

As just mentioned, equation (11) is imposed on the data only through 1969 in European countries, and 1973 in the United States, Canada, and Japan.

Once the parameters of the model have been estimated from equations (10) and (11), the labor share and the real wage consistent with high-employment equilibrium can be derived from the modified versions of equations (7) and (8), namely,

(12) $$\overline{S_L} = (1 - \delta_0 - \delta_1 t) + \beta (\delta_0 + \delta_1 t) (1 - \delta_0 - \delta_1 t) \ln (K/\overline{L})$$

(13) $$\begin{aligned} \ln (\overline{w/p}) &= \ln (\overline{Y}/\overline{L}) + \ln (\overline{S_L}) \\ &= \ln (\overline{S_L}) + \ln \gamma + \lambda_t t + (\delta_0 + \delta_1 t) \ln (K/\overline{L}) \\ &\quad - 1/2\ \beta (1 - \delta_0 - \delta_1 t) (\delta_0 + \delta_1 t) [\ln (K/\overline{L})]^2 \end{aligned}$$

The most noticeable difference between model A and the simpler model discussed above is that model A recognizes that a trend increase in the real wage rate that exceeds the increase in labor productivity at high employment ($\overline{Y}/\overline{L}$) is warranted when there is a reduction in the capital weight δ, that is when $\delta_1 < 0$. Such a situation arises when the pattern of production is shifting toward less capital-intensive industries, or when technical innovations are favoring less capital-intensive production techniques. An evolution in the opposite direction would call for a growth of the real wage rate that is below the growth of $\overline{Y}/\overline{L}$.

Model B

Weak separability is broadly accepted as a realistic assumption for raw materials (N), but whether it is a realistic assumption for energy (E) is open to debate. Berndt and Wood (1979) and others have argued that in many instances energy and capital must be viewed as complements. Namely, once entrepreneurs have optimized the energy efficiency of their capital stock on the basis of the relative price of capital and energy, they are largely unable to change K/L without changing E/L. Under such conditions, the relevant production model would involve the following two-level production function:

$$Y^* = Y^*(L, K^*)$$

(14)

$$K^* = K^*(K, E)$$

where Y^* = value-added corresponding to L, K and E

K^* = a composite variable reflecting the joint input of capital and energy.

With E-K complementarity, a marked increase in the relative price of energy, as in 1973-74 and in 1979-80, would lead entrepreneurs to increase their demand for labor and decrease their demand for both energy and capital. Assuming that the functional form for the Y^*-level remains as assumed in equation (10), the labor share and the real wage rate consistent with high-employment equilibrium would still be determined by equation (12) and (13), respectively, but after substituting K^* for K. The labor share would now be the share of labor income in Y^*, and the real wage rate would be defined in terms of p^*, the deflator of Y^*. In equations (10) and (11), S_L would have to be replaced by S_L^* (the cyclically adjusted share of labor income in Y^*), while Y would have to be replaced by Y^*. An increase in the price of energy leading to a decline in K^*/L would shift the distribution of incomes corresponding to Y^* against labor if $\beta > 0$, and in favor of labor if $\beta < 0$.

As the practical relevance of E-K complementarity is still in doubt, we will derive estimates of the warranted real wage rate under each of the two polar assumptions, namely E-K complementarity (model B) and weak separability of energy (model A). In model B, the composite variable K* will be derived by using the linear approximation to the CES functional form (as for output in equation (2) but without the time trend), namely,

(15) $$\ln K^* = \delta_E \ln E + (1 - \delta_E) \ln K - 1/2\, \rho_{EK}(1 - \delta_E)\delta_E\, [\ln(E/K)]^2.$$

3. Measurement issues

The first part of this subsection considers the measurement of L and K, while the second part considers the measurement of $\bar{L}$. The measurement of the other variables is relatively straightforward and is described in the Statistical Appendix. The only point that needs to be noted here is that for France and Italy the national accounting figures on nominal value added in manufacturing include inventory appreciation--an element that should not be regarded as either an income to labor or to fixed capital. For France, we adjusted the figures by using data on inventory appreciation for the whole nonagricultural economy. For Italy, we made an even rougher adjustment on the basis of the observed relation between inflation and inventory appreciation in the other six countries. For both countries, but especially Italy, the distributional labor and capital shares are thus subject to possibly sizable errors.

Measurement of L and K

There is no generally accepted way to measure the flows of labor and capital services. In this paper, we can only provide a brief analysis of the measurement problems and an explanation of what we did. As in most other studies, the present analysis uses series on man-hours worked 1/ and on the gross capital stock 2/ as proxies for the unavailable series on the flows of labor and capital services. As well known, this procedure requires that an additional variable be inserted in the production function to pick up cyclical movements in the intensity of use of labor and capital. 3/ The reason is that fluctuations in output corresponding to unanticipated changes in aggregate demand do not immediately result in corresponding changes in either the number of man-hours worked or the level of capital stock. Initially, unexpected variations in demand lead to changes in the intensity of use of labor and capital, that is, the amount of services obtained from a given number of man-hours and a given capital stock varies. Gradually, however, the number of man-hours and the level of capital stock are changed, and their intensity of use is brought back to normal. As in Artus (1977), we will assume that the cyclical variable, to be denoted as D and introduced with a coefficient of one, is a lagged function of the actual rate of change of output, net of the expected long-run rate of change (μ). More specifically, it will be assumed that:

1/ For the United States, the only data available are for man-hours paid.

2/ The gross capital stock refers to the equipment that has not been discarded. In this context, if some equipment has lost x percent of its initial efficiency, then x percent of the equipment is considered to have been discarded. By contrast, the net capital stock excludes not only discards, but also the depreciation of the equipment that has not been discarded. This depreciation reflects the fact that while the equipment still has its original efficiency, its remaining expected life expectancy is shorter than on the date of purchase. In the main, the net capital stock can be viewed as the discounted value of the expected stream of capital services to be derived from the existing capital stock. Thus, normally, the net value of equipment will start declining well ahead of any decline in the flow of services that can be derived from that equipment. For that reason, no attempt is made to use the net capital stock in the present study.

3/ The other equations involve variables such as S_L', $\overline{S_L}$, $\overline{w/p}$, and $\overline{L}$ that are not influenced by cyclical developments.

(16) $\ln D = \rho \ [\ln (Y/Y_{-1}) - \mu]_L$

where the notation $(--)_L$ indicates a geometrically distributed lag operator. The expected long-run rate of change of output will be approximated by a ten-year lagged moving average of ln (Y/Y_{-1}).

Even with D in the production function, there are still various measurement problems that must be considered. For L, the main problem is that the available data on man-hours do not reflect the level of education and technical expertise of the work force. In the present context, however, it is likely that the problem is not too severe because those changes occur only gradually. Even when demographic and economic developments lead to a marked increase in the growth of the work force and a decline in its mean age, there is no strong reason to assume that the average level of education and technical expertise is affected. While new entries in the labor force tend to be younger and better educated, they also have less on-the-job experience. 1/ Thus, the measurement error in L can be assumed to be highly collinear with a simple time trend. It could lead to a bias in the econometric estimates of the trend coefficients (λ_t and δ_1), but the estimates of the other coefficients would be unaffected. Even more importantly, the estimates of S_L and $\overline{w/p}$ would also be unaffected.

For K, the remaining problems are more severe. All of them result from the fact that currently the only practical method to obtain an estimate of the gross capital stock is the rather mechanical one of cumulating past investment flows, net of discards. This method, if applied carelessly, may lead to a growing measurement error which, this time, would not necessarily be collinear with the trend rates already in the model. Three considerations are especially important.

First, the cumulation of real investment flows does not take proper account of the fact that a piece of machinery bought in year t + 1 embodies more technical knowledge and is thus more efficient than one bought in year t. The reason is that the price series used to deflate the investment flows tend to exaggerate the amount of inflation because

1/ It has been argued that various other factors, especially the male-female ratio, should be taken into account in the calculation of the amount of labor input. This has led Perry (1971), Perloff and Wachter (1980) and others to calculate weighted indices of man-hours, with the weights based on the relative pay scales for the various components of the labor force. However, for the manufacturing sector, these indices have usually been found to deviate little from simple indices based on the unweighted man-hours. A good review of issues related to the measurement of labor services can be found in Baily (1981).

the price increases that reflect the efficiency increases are not properly separated from the prices increases reflecting inflation. When there is a decline in the growth of investment, as after 1973, it is likely that this will be followed by a temporary decline in the growth of the average efficiency of the capital stock because of the temporary reduction in the proportion of relatively new equipment in the total stock of equipment. Such a decline in the growth of the average efficiency of the capital stock will not be reflected in the capital stock series obtained by cumulating investment flows. To reduce this type of measurement error, the capital stock series used in this study were adjusted by an efficiency scalar that is function of the mean age of the capital stock. A detailed description of how this adjustment was carried out can be found in the Statistical Appendix.

Second, voluntarily or as a result of government regulation, firms purchase equipment that produces products that are omitted from the measured GNP. In particular, firms purchase equipment to reduce environmental pollution. As long as the proportion of such investment in total investment is constant, the problem is not severe because the rate of growth of the "productive" capital stock is unaffected. However, in the United States, Canada, and Japan, new government regulations led to an upward shift of that proportion in the late 1960s and early 1970s. The data published by the U.S. Department of Commerce indicate that the proportion of pollution abatement investment in total U.S. investment in manufacturing rose from about 1 per cent in the mid-1960s to about 8 percent in the mid-1970s, then declined gradually to around 5 percent in the late 1970s and early 1980s. 1/ A series for expenditure on pollution abatement was derived from these data, and it was subtracted from the U.S. investment series to get a measure of "productive" investment. No precise data are available for Canada and Japan, but, as a rough adjustment for the jump in pollution abatement expenditures, the investment figures for these two countries were reduced by 5 percent from 1969 onwards. If anything, this adjustment is probably on the low side.

Third, the major unanticipated structural changes that took place in the aftermath of the 1973-74 and 1979-80 oil price increases are likely to have caused the premature obsolescence of part of the capital stock. Capital is heterogeneous and specialized. Sudden changes in the structure of demand faced by firms and the relative costs of using specific energy-intensive equipment leave some equipment without any economic value even though it may be relatively new. Even in less extreme cases,

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1/ See the article on "Capital Expenditures by Business for Pollution Abatement" in each June issue of the Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis. See also the November 1982 issue.

there may be an incentive for firms to speed up the replacement of some equipment by more energy-efficient equipment. Of course, a one-time loss of equipment does not lead to a permanent decline in the capital stock because normal obsolescence would, in any case, eventually lead to the discard of this equipment. Unless premature obsolescence is taken into account, however, the capital stock can be seriously overestimated in the first few years that follow the demand or supply shock.

The extent of this phenomenon in the aftermath of the 1973-74 and 1979-80 oil price increases is still an unsettled issue. Economists such as Baily (1981) take the large decline in the market value of corporations relative to the replacement cost of tangible assets, Tobin's q, as an indication that a large part of the capital stock (perhaps 20 percent) was prematurely discarded just after the first wave of oil price increases, and presumably as much after the second wave. Others, such as Bosworth (1982), compare the historical cost valuation of gross stocks derived from surveys conducted by the U.S. Bureau of the Census with the results derived from the perpetual-inventory valuation method with a fixed-discard pattern, and conclude that only a small part of the capital stock (perhaps 2-3 percent) was prematurely discarded. Both methods have major weaknesses. Tobin's q is likely to reflect many factors that have little if anything to do with the effective size of the gross capital stock and the flow of services that can be derived from it. As to the historical cost valuation of gross stocks derived from surveys, it is notoriously unreliable. The estimates of gross capital stock used in the present study assume that 10 percent of the existing capital stock was prematurely retired during 1974-76, and that the same proportion was prematurely retired during 1980-82. As this estimate is highly tentative, a sensitivity analysis was carried out with a 5 percent and a 15 percent estimate.

Measurement of $\overline{L}$

To obtain an estimate of the high-employment labor input in manufacturing ($\overline{L}$) that is consistent with the definition of high employment for the whole economy, we use the method developed in Artus and Turner (1978). This method is based on the estimation of the following simple equation relating the actual labor input in manufacturing (L) to a nonlinear time trend and to the unemployment rate in the whole economy (U):

$$\ln(L) = a_0 + a_1 t + a_2 t^2 + a_3 t^3 - a_4 U \tag{17}$$

At cyclical peaks, the value of $\overline{L}$ is calculated as

$$\ln(\overline{L}) = \ln(L) + \hat{a}_4 (U - \overline{U}) \tag{18}$$

where $\overline{U}$ is the unemployment rate corresponding to a situation of high employment in the whole economy, and $\hat{a}_4$ is the estimated value of a_4.

In between peaks, the value of $\bar{L}$ is calculated by fitting log-linear trends between the successive peak values of $\bar{L}$ obtained from equation (18). After the last cyclical peak, the assumed growth rate of $\bar{L}$ is an extrapolation of the estimated rate between the last two observed cyclical peaks. The extrapolated figures are adjusted when necessary for changes in demographic factors and in the length of the normal work week.

The most difficult task is to estimate the high-employment rate $\bar{U}$, that is, the rate where labor shortages become widespread because the residual unemployment is due to the normal turnover in the labor market and to regional and skill mismatches between labor supply and demand. In the present study, the estimate of $\bar{U}$ is derived from the "Beveridge Curve," a graphical presentation of the inverse relationship between unemployment and vacancies. 1/ More specifically, $\bar{U}$ is defined as the unemployment rate where the curve becomes nearly vertical, with large increases in vacancies associated with only small reductions in the unemployment rate. Allowance is made for shifts in the curve and therefore shifts in $\bar{U}$ that reflect changes in the amount of frictional and mismatch unemployment. Over the past decade, however, some of the countries considered here experienced few, if any, years where the number of vacancies was high, so that it is difficult to draw complete Beveridge Curves for this period. In such cases, we examine whether the unemployment rates corresponding to relatively low numbers of vacancies have changed from the 1960s to the 1970s and early 1980s, and we assume that the vertical part of the curve has shifted by the same amount as the part corresponding to relatively low numbers of vacancies. For Italy, where there is no data on vacancies, $\bar{U}$ was derived by using a more ad hoc method (see the Statistical Appendix).

Table 2 presents the main results related to the estimation of $\bar{L}$. A striking result is the large value of $\hat{a}_4$ for Japan, which reflects the effect of labor-sharing arrangements and the apparent greater ease with which the service sector absorbs the increase in labor force during periods of slow growth in the manufacturing sector. Another striking result is the marked reduction in the growth rate of $\bar{L}$ in Japan and in European countries during the past decade and a half. This reduction reflects a marked increase in the value of $\bar{U}$ during this period (see the Statistical Appendix), as well as an acceleration of the historical trend in the allocation of the labor force in favor of the service sector, possibly caused by the rapid growth of government services, a change in comparative advantages vis-à-vis the newly industrialized countries, and special factors such as North Sea oil in the United Kingdom. Despite the reduction in the growth rate of $\bar{L}$, we find that at the cyclical peak

1/ For a discussion of the theoretical underpinning of the Beveridge Curve, see Bowden (1980).

Table 2. Actual (L) and High-Employment ($\bar{L}$) Labor Input in Manufacturing, Latest Peak Year and 1982 1/

		Unemployment in Latest Peak Year for L 3/			Unemployment in 1982		Average Rate of Growth of $\bar{L}$		
Country	$\hat{a}_4$ 2/	U	$\bar{U}$	$(\bar{L} - L)/\bar{L}$	U	$(\bar{L} - L)/\bar{L}$	1956-69	1970-73	1974-82
		(in percent							)
United States	4.9 (0.3)	5.8	5.7	0.5	9.7	14.4	0.8	0.6	0.6
Canada	4.0 (0.4)	7.5	7.2	1.2	11.0	11.2	1.1	0.7	0.3
Japan	14.7 (2.6)	2.0	1.6	5.7	2.4	8.1	4.0	1.0	0.2
France	4.0 (1.1)	5.9	3.6	9.2	8.0	15.0	0.8	0.3	-0.9
Germany	5.1 (0.8)	3.8	2.2	8.2	7.5	13.6	-0.1 4/	-1.0	-1.5
Italy	4.2 (1.5)	7.6	6.5	5.0	9.1	11.7	1.6	-0.8	0.0
United Kingdom	4.1 (0.7)	5.1	4.6	2.1	11.7	19.7	-0.3	-2.6	-2.4

1/ Notation: U, unemployment rate in the whole economy; $\bar{U}$, unemployment rate corresponding to a situation of high employment in the whole economy; L, actual labor input in manufacturing in man-hours worked (man-hours paid for the United States); $\bar{L}$, high-employment labor input coresponding to the definition of the L series. The unemployment rate is in percent of the civilian labor force, except for Japan, France, and the United Kingdom, where it is in percent of the total labor force.

2/ Parentheses enclose standard errors. The estimates are obtained by using least-squares methods and annual observations on the period 1955-82.

3/ The latest peak year for L is 1979 for the United States, Canada, France, Germany, and the United Kingdom; and 1980 for Japan and Italy.

4/ Average rate of growth during 1962-69.

in 1979-80 there were still sizable gaps between L and $\bar{L}$ in Japan, France, the Federal Republic of Germany, and Italy. By contrast, the gaps were fairly small in the United States, Canada, and the United Kingdom because in these countries the residual unemployment, even though very high, seemed to correspond to frictional and mismatch unemployment. By 1982, the gaps were large in all seven countries.

These estimates of $\bar{L}$ are of course subject to a large margin of error. In particular, they assume that: (1) at each cyclical peak, the relation between aggregate unemployment (in excess of $\bar{U}$) and man-hours worked in manufacturing is the same; (2) the change in the distribution of employment among sectors between two cyclical peaks is due to long-run changes in comparative advantage and in the pattern of demand, rather than real wage problems in manufacturing; (3) the rate of change of $\bar{U}$ and the rate of change in the distribution of employment among sectors between the last two cyclical peaks, 1973-74 and 1979-80, can be extrapolated to the early 1980s. On balance, it is much more likely that these assumptions lead to an underestimation, rather than an overestimation, of $\bar{L}$ during the late 1970s and early 1980s, at least in Japan and in European countries. Mainly, one cannot but wonder whether the marked shift in the distribution of employment toward the service sector, especially government services, that took place in Japan and in European countries between 1973-74 and 1979-80 was really warranted by long-run growth considerations. In part, this shift may itself be the result of an excessive real wage rate in manufacturing. Some of the persons that could not get a job in this sector because labor contracts prevented entrepreneurs from offering them a wage corresponding to their marginal product were probably recruited in the government sector to limit the rise in unemployment, or absorbed by the private service sector in occupations involving very low marginal product and very low real wages. In addition, it may be unduly pessimistic to extrapolate into the early 1980s the rapid rise in $\bar{U}$ observed between 1973-74 and 1979-80. In fact, the evidence does not suggest a further shift of the Beveridge Curve in the early 1980s, except possibly in France and the United Kingdom.

III. Empirical Results

Parameters of models A and B were estimated for the seven largest industrial countries by using nonlinear least-squares methods and annual observations. For the production function, the observation sample is 1961-82 for the Federal Republic of Germany and 1955-82 for the other six countries. 1/ For the share function, the observation sample is 1961-69

1/ Before 1961, the data for the Federal Republic of Germany exclude Berlin and Saarland; therefore, they are not directly comparable with the data for subsequent years.

for the Federal Republic of Germany; 1955-73 for the United States, Canada, and Japan; and 1955-69 for France, Italy, and the United Kingdom. 1/ The estimated values of the parameters were then used to calculate the warranted labor shares and real wage rates.

1. Parameter estimates

The parameter estimates for model A are presented in Table 3. We find that the rate of disembodied productivity growth (λ_t) increased during the 1960s and then fell back during the 1970s and early 1980s. The only exception is the Federal Republic of Germany, where the rate of disembodied productivity growth was constant throughout the period 1961-82. An examination of the regression residuals for 1981 and 1982 suggests that productivity growth may have picked up again in the United Kingdom in recent years, but it is still too early to say. These results corroborate the findings of Denison (1982), Bosworth (1982), and others, that a significant part of the decline in the growth of labor productivity during the last decade is not accounted for by the decline in the rate of capital accumulation. This is true even when, as in the present study, the rate of capital accumulation is adjusted downward to take account of the rise in pollution abatement investment and premature obsolescence. 2/

Aside from the evolution of λ_t over time, it is striking how much λ_t varies across countries and how stable the cross-country differences are. For the past three decades, λ_t has tended to be about 3 percentage points higher in Japan and 2 percentage points higher in France and Italy than in the United States, Canada, and the United Kingdom. The Federal Republic of Germany, by avoiding a decline in λ_t, has moved from the low group during the 1960s and early 1970s to the middle group during the last ten years. These large and persistent differences have obvious implications

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1/ The estimation was carried out with the minimum-distance estimation routine of the Research Analysis Language (RAL) program. In order to make possible the estimation of the production and share functions as a system of two simultaneous equations, the variables in the share functions were set at zero during 1970-82 or 1974-82, depending upon the group of countries. The estimation was then carried out for the period through 1982. The estimates of the standard errors were recalculated on the basis of the true degree of freedom.

2/ As explained in the Statistical Appendix, in the United States, Canada, France, and Italy, the estimated value of λ_t for 1973-82 in model A may be biased downward to a small extent because the data on real value added for this period are calculated on the basis of the pre-1973 relative price of energy.

Table 3. Estimates of the Parameters of Model A 1/

Country	United States	Canada	Japan	France	Germany	Italy	United Kingdom
ln γ	-0.022 (0.004)	-0.003 (0.003)	-0.016 (0.008)	-0.033 (0.010)	0.041 (0.006)	0.015 (0.005)	0.011 (0.005)
λ_t 2/	1955-60: 1.55 (0.31)	1955-60: 1.89 (0.27)	1955-66: 4.69 4/ (0.19)	1955-64: 4.04 (0.14)		1955-60: 3.21 (0.39)	1955-60: 1.08 (0.45)
	1961-73: 2.71 (0.08)	1961-73: 3.61 (0.07)	1967-70: 6.30 (0.32)	1965-70: 5.35 (0.33)	1961-82: 2.85 (0.14)	1961-73: 4.69 (0.11)	1961-73: 3.01 (0.09)
	1974-82: 0.95 (0.19)	1974-82: 1.13 (0.17)	1971-82: 3.85 (0.29)	1971-82: 2.28 (0.24)		1974-82: 2.74 (0.24)	1974-82: 1.04 (0.30)
δ_0 3/	26.2 (0.3)	33.2 (0.2)	55.0 (0.2)	39.5 (0.2)	34.9 (0.2)	37.9 (0.2)	27.9 (0.3)
δ_1 3/	0.41 (0.05)	0.15 (0.04)	0.38 5/ (0.07)	0.72 (0.05)	0.04 (0.02)	0.01 (0.12)	0.62 (0.39)
β	0.776 (0.140)	0.206 (0.045)	0.191 (0.024)	0.635 (0.054)	-0.031 (0.014)	0.368 (0.127)	0.789 (0.369)
ρ	0.422 (0.037)	0.460 (0.049)	0.654 (0.029)	0.525 (0.123)	0.368 (0.130)	0.492 (0.075)	0.373 (0.108)
Goodness-of-fit statistics							
Production function							
SE 6/	0.017	0.015	0.023	0.017	0.026	0.022	0.022
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Share function							
SE 6/	0.60	0.17	0.45	0.24	0.41	0.42	0.26
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99

1/ Parentheses enclose standard errors.
2/ The trend rates of growth of disembodied productivity are in percent r year.
3/ The weights of capital services are indicated in percent. The trend tes of change in these weights are in percentage point per year.
4/ The estimate of 4.69 (0.14) is for the 1955-58 and 1962-66 periods. r 1959-61, the estimate is 9.93 (0.34).
5/ The estimate of 0.38 (0.05) is for the 1955-70 and 1980-82 periods. r 1971-79, the estimate is -0.19 (0.07).
6/ SE and R^2 denote, respectively, the standard error of estimate and e coefficient of determination of the estimated equation. The standard ror of the share function is in percentage points.

not only for the growth of the real wage rate, but also for employment and capital formation. During the last ten years, manufacturing production had to grow by more than 4 percent per year in Japan and more than 2-3 percent per year in France, the Federal Republic of Germany, and Italy to lead to an increase in the demand for labor and capital services in manufacturing. In the United States, Canada, and the United Kingdom, the same result could be achieved with an increase in production of only slightly more than 1 percent.

We find that in most countries the weight on the capital stock (δ) is increasing over time, that is, δ_1 is positive. Again this is not a surprising result; the tendency for a gradual increase in the capital intensity of production techniques has been in evidence for a very long time. For Japan, however, the data suggest that the tendency for an increase in δ was interrupted during 1971-79. A possible reason for this development is that Japan experienced a marked change in its structure of production after the first wave of oil prices as a result of a deliberate policy to move away from industries involving a high level of raw materials and energy imports. Many of these industries, such as the steel industry, were also capital intensive. In addition, it can be noted that the value of δ was already very high during the second half of the 1950s and during the 1960s; much higher than in other industrial countries.

The parameter β is positive for all countries, except the Federal Republic of Germany where it is negative but small in absolute terms. The corresponding elasticity of substitution between labor and capital (η, $\eta = 1/(1 + \beta)$) is thus lower than one, except in the Federal Republic of Germany where it is close to one. For most countries, η is between 0.5 and 0.8, a result which matches the finding of other studies such as Griffins and Gregory (1976) and Pindyck (1979). The important implication of this result is that a rise in the capital/labor ratio tends to increase the equilibrium labor share of incomes. (See equation (12).) In periods where the capital/labor ratio rises rapidly, this effect may dominate the effect of the gradual rise in the weight on the capital stock, and the equilibrium labor share may increase. In other periods, the weight effect may dominate and the equilibrium labor share may decrease.

The estimates of the parameter ρ are between 0.4 to 0.5 for most countries. This means that a sudden decline in the rate of growth of output of 10 percentage points is normally accompanied by a decline in the intensity of use of labor and capital resources within firms corresponding to a decline in total factor productivity of 4 to 5 percent. Then, the intensity of use of labor and capital is gradually brought back to normal as firms reduce their work force and their capital stock (see equation (16)). In the second year, assuming no further shock, the apparent total factor productivity is only 1 1/2 to 2 1/2 percent below what it would have been without the output decline. In Japan, the adjustment is significantly slower; factor productivity is cut by 6 1/2 percent the first year and it takes four years for the reduction in productivity to become less than 2 percent.

Practically all the parameter estimates have low standard errors. However, this result should not be viewed as an indication that the estimates are highly precise and reliable. First, slight changes in the choice of the subperiods for the λ_t parameters often lead to significant changes in the estimates of the δ_1 and β parameters. The problem is particularly severe for the United Kingdom, where there is a high positive covariance between the estimates of δ_1 and β because during the 1955-69 period S_L is nearly constant and the ratio $\bar{K}/L$ is growing at a stable rate. Second, the estimates for δ_0, δ_1, and β are for all practical purposes determined by the share function. When both equations are estimated separately, the estimates of δ_0, δ_1, and β derived from the share function are practically identical to the estimates presented in Table 3 with the same low standard errors, while the estimates derived from the production function have often implausible values and high standard errors. Therefore, the estimates presented in Table 3 must be viewed as highly dependent on the assumption that during the estimation period S_L was in fact the equilibrium labor share corresponding to the cyclically adjusted level of employment. As this assumption is unlikely to have held exactly, some of the uncertainty is not properly captured by the estimated standard errors.

The above results are based on the assumptions that during 1974-76, and then again during 1980-82, 10 percent of the existing capital stock was prematurely retired. When the assumption was changed from 10 to 15 percent (to 5 percent), the estimated values of λ_t for the 1970s and early 1980s were raised (lowered), but only by 0.1 to 0.2. All the other estimates remained roughly unchanged.

The first step in the estimation of model B is the estimation of β_{EK} and δ_E, parameters that are needed to calculate the flow of services corresponding to the K* input (see equation (15)). In the present study, the parameter δ_E is assumed equal to the share of energy cost in the total of energy and capital costs in 1972, the last year before the first wave of oil price increases. To obtain an estimate of β_{EK}, we have used the following equation:

(19) $$S_E = 1 - \delta + \beta_{EK}\, \delta\, (1 - \delta)\, \ln(K/E)$$

which is the equivalent of equation (6) for the competitive allocation of income between capital and energy. Focusing on the 1972-82 period of doubling real energy prices, we have solved equation (19) for the value of β_{EK} corresponding to the observed changes in S_E and ln(K/E). 1/ The results in Table 4 indicate that the value of β_{EK} is in the order of 2 to 3, which corresponds to a relatively small elasticity of substitution (η_{EK}) of 0.25 to 0.35. 2/ For purposes of the present study, we have taken a value of β_{EK} of 2.5 for all seven countries. As this estimate is subject to a large margin of error, experiments with estimates ranging from 1.5 to 3.5 were carried out with little effect on the estimates of the other parameters of model B, or the estimates of the equilibrium labor shares and real wage rates.

The estimated values of the other parameters of model B are presented in Table 5. The results are similar to those obtained for model A with two exceptions. First, as could be expected, the estimated value of δ_0 is now significantly larger. In all cases, it is approximately equal to the share of capital and energy cost in the total value added corresponding to capital, energy, and labor in the mid-1950s. Second, the reduction in the value of λ_t from the 1960s to the 1970s and early 1980s is now smaller, but generally not by much. Thus, even when the reduction in energy use achieved during the past ten years is explicitly taken into account as it is in model B, there is still a sizable unexplained reduction in the rate of growth of disembodied productivity.

2. Warranted Labor shares and real wage rates

A comparison of the normalized and the warranted labor shares derived from model A corroborates the disequilibrium real wage rate hypothesis (see Chart 1). By the early 1980's, the normalized share is well above

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1/ This method assumes that S_E and ln(K/E) were relatively stable during the pre-1972 period. For Canada, where K/E was declining at a marked rate during the 1960s and early 1970s, the 1972-82 change in ln(K/E) was calculated in terms of deviations from the 1962-72 tendency.

2/ This estimate of η_{EK} can be compared to the E-K gross substitution elasticities of 0.133 for the U.S. manufacturing sector, 0.501 for Canadian manufacturing in Ontario, and 0.650 for Canadian manufacturing in British Columbia, obtained by Berndt and Wood (1979) on the basis of pre-1972 data. It implies that an increase in the price of energy may lead to a decline in the demand for capital services. For example, a 100 percent increase in the price of energy could lead to an increase in p_{K^*} of 15 percent (assuming that energy represents initially 15 percent of the total energy and capital cost), an increase in p* of 5 percent (assuming that energy represents initially 5 percent of the total labor, capital, and energy cost), and a decline in the demand for K* of 7 percent (assuming an elasticity of substitution of 0.7 between K* and L and a fixed amount of L). With an elasticity of substitution of 0.3 between K and E, the ratio of E to K would change by 30 percent. The final result would be a drop in the demand for E of 32 percent and a drop in the demand for K of 2 percent (averaging to the drop in K* of 7 percent given the 15 percent weight on E and the 85 percent weight on K).

Table 4. Estimates of β_{EK} 1/

$$\beta_{EK} = \frac{\Delta_{72-82}S_E}{\delta_E(1 - \delta_E)\Delta_{72-82}\ln(K/E)}$$

Country	$\Delta_{72-82}S_E$	$\Delta_{72-82}\ln(K/E)$	δ_E	β	$\eta_{EK} = 1/(1+\beta_{EK})$
United States	0.242	0.500	0.217	2.86	0.26
Canada	0.183	0.483 2/	0.137	3.21	0.24
Japan	0.118	0.514	0.108	2.39	0.29
France	0.114	0.387	0.135	2.52	0.28
Germany	0.125	0.368	0.155	2.59	0.28
Italy	0.105	0.175	0.219	3.51	0.22
United Kingdom	0.147	0.476	0.224	1.77	0.36

1/ In this table, S_E refers to the share of energy cost in the total of energy and capital costs, while δ_E refers to the weight of energy in the CES function defining the composite E-K input. The value of δ_E is approximated by the value of S_E in 1972. The symbol $\Delta_{72-82}S_E$ refers to the change in S_E from 1972 to 1982.

2/ For Canada, the estimate refers to the change in ln(K/E) from 1972 to 1982, net of the change from 1962 to 1972. The adjustment was made to take account of what appeared to be a long-run trend in ln(K/E).

Table 5. Estimates of the Parameters of Model B 1/

Country	United States	Canada	Japan	France	Germany	Italy	United Kingdom
ln Y	-0.022	-0.029	-0.036	-0.029	0.042	0.016	0.013
	(0.004)	(0.003)	(0.009)	(0.009)	(0.007)	(0.005)	(0.005)
λ_t 2/	1955-60	1955-60	1955-66	1955-64		1955-60	1955-60
	1.59	1.84	4.11 4/	3.81		2.56	0.49
	(0.29)	(0.23)	(0.20)	(0.12)		(0.40)	(0.46)
	1961-73	1961-73	1967-70	1965-70	1961-82	1961-73	1961-73
	2.53	3.36	5.15	4.98	2.62	4.35	2.80
	(0.08)	(0.06)	(0.34)	(0.30)	(0.14)	(0.10)	(0.10)
	1974-82	1974-82	1971-82	1971-82		1974-82	1974-82
	0.96	1.05	4.32	2.24		2.49	1.46
	(0.17)	(0.14)	(0.29)	(0.22)		(0.24)	(0.33)
δ_0 3/	29.4	37.2	59.3	42.8	39.2	43.1	32.6
	(0.3)	(0.2)	(1.0)	(0.8)	(0.3)	(0.2)	(0.3)
δ_1 3/	0.38	0.16	0.48 5/	0.80	0.05	-0.01	0.22
	(0.08)	(0.03)	(0.05)	(0.05)	(0.02)	(0.20)	(0.43)
β	0.617	0.206	0.244	0.682	-0.024	0.294	0.460
	(0.155)	(0.029)	(0.022)	(0.057)	(0.012)	(0.139)	(0.450)
ρ	0.398	0.451	0.709	0.464	0.351	0.491	0.325
	(0.035)	(0.044)	(0.031)	(0.110)	(0.120)	(0.080)	(0.115)
Goodness-of-fit statistics							
Production function							
SE 6/	0.017	0.013	0.026	0.016	0.024	0.024	0.023
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Share function							
SE 6/	0.72	0.13	0.43	0.26	0.45	0.52	0.29
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99

1/ Parentheses enclose standard errors.

2/ The trend rates of growth of total disembodied factor productivity are indicated in percent per year.

3/ The weights of capital services are indicated in percent. The trend rates of change in these weights are in percentage point per year.

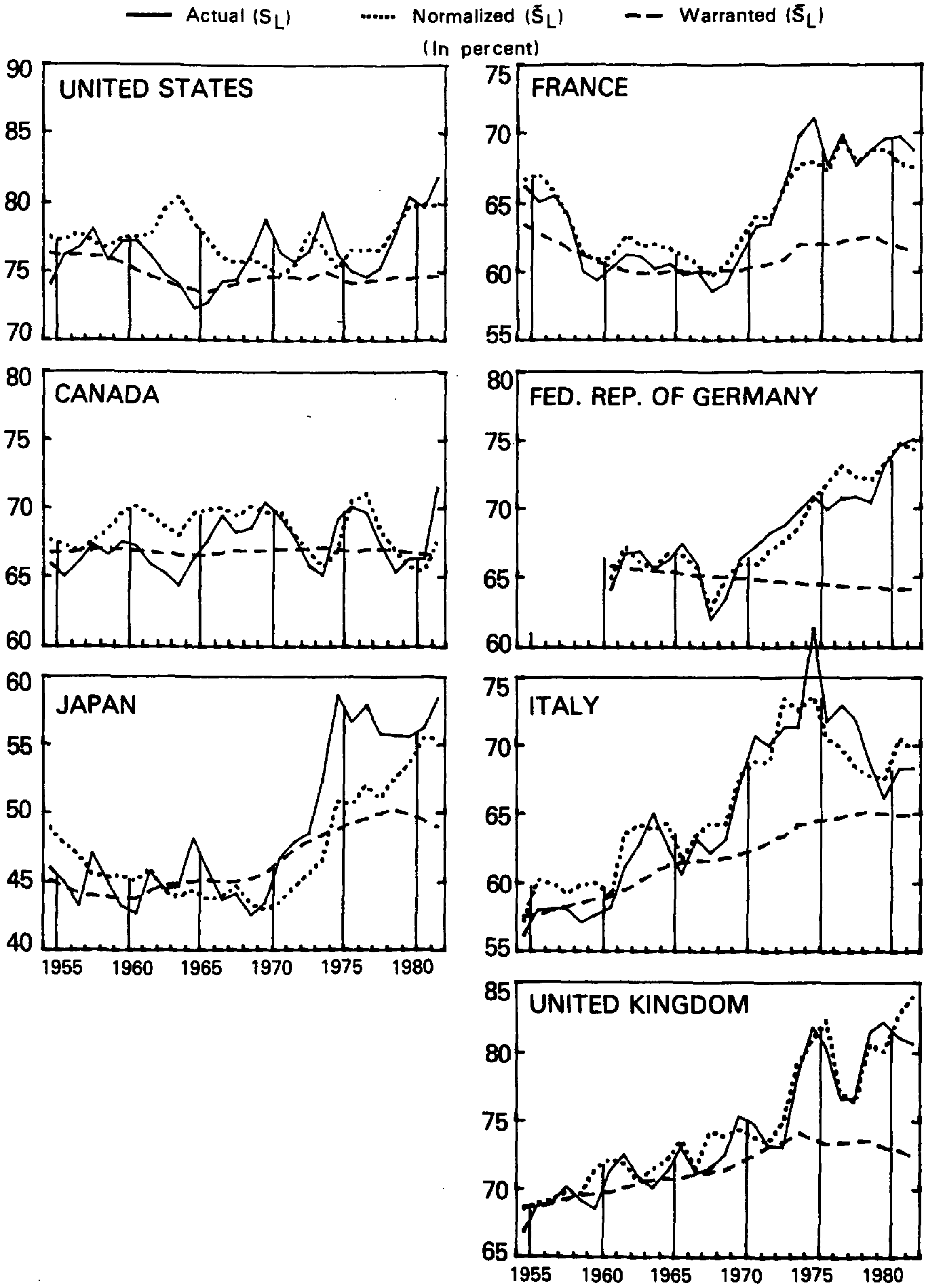
4/ The estimate of 4.11 (0.15) is for the 1955-58 and 1962-66 periods. For 1959-61, the estimate is 8.27 (0.36).

5/ The estimate of 0.48 (0.04) is for the 1955-70 and 1980-82 periods. For 1971-79, the estimate is -0.10 (0.06).

6/ SE and R^2 denote, respectively, the standard error of estimate and the coefficient of determination of the estimated equation. The standard error of the share function is in percentage points.

CHART 1

MODEL A: ACTUAL (S_L), NORMALIZED ($\tilde{S}_L$) AND WARRANTED ($\bar{S}_L$) LABOR SHARES[1]



[1] Labor shares of value added at factor cost, net of inventory appreciation.

the warranted share in all seven countries except Canada. The gap between the normalized and the warranted shares is particularly large in the Federal Republic of Germany and in the United Kingdom, where it reaches nearly ten percentage points. The gap is smaller, but still close to five percentage points, in the United States, Japan, France, and Italy.

The date at which this gap appears differs among countries. In France, the Federal Republic of Germany, and Italy, the normalized share starts to move above the warranted share in the late 1960s and early 1970s, and the move accelerates with the first wave of oil price increases in 1973-74. During the second half of the 1970s, the gap increases further in the Federal Republic of Germany, but it stabilizes in France and declines in Italy. In all three countries, the second wave of oil price increases in 1979-80 is absorbed without much change in the gap. In the United Kingdom, the gap emerges with the first wave of oil price increases, starts to contract, then increases again with the second wave. In the United States and Japan, the gap becomes sizable only with the second wave of oil price increases. The growth of the gap in Japan reflects an average increase in the nominal wage rate of 7 percent per annum from 1978 to 1982 coupled with an average decrease in the value added deflator of 0.5 percent. With an estimated growth rate of labor productivity at high employment ($\overline{Y}/\overline{L}$) of 5 percent, the Japanese case illustrates how adjustment can be extremely successful in nominal terms (in the sense of eliminating inflation), without being fully successful in real terms.

These results are broadly similar to those derived by looking at the deviations of the actual labor shares from their historical averages during, say, 1955-69 as measures of the disequilibrium in income distribution. (See Chart 1.) The reason is twofold. First, the evolution of the normalized shares is not all that different from the evolution of the actual shares. Differences have a tendency to appear during periods of recession such as 1974-75 and 1982, when the actual shares often move above the normalized shares because the reductions in the amounts of employed labor lag the reductions in production. However, except in Japan, the lag is relatively small so that these differences are quickly resorbed. Moreover, the estimated elasticities of substitution between labor and capital are not very different from one so that even in recent years it does not matter too much if we consider the actual labor share, which corresponds to K/L, rather than the normalized share, which corresponds to K/$\overline{L}$. 1/ Second, the estimates of the warranted shares for the

---

1/ From equation (12), we see that if $\overline{L}$ is one percent greater than L, the equilibrium share corresponding to K/$\overline{L}$ will differ from that corresponding to K/L by $\beta(\delta_0 + \delta_1 t)(1-\delta_0 - \delta_1 t)$ percent. Based on the estimates presented in table 3, this difference ranges from plus 0.2 percent in the United Kingdom to zero percent in the Federal Republic of Germany.

1970s and early 1980s are rather similar to the estimates of the warranted shares for 1955-69, which on average are themselves similar to the actual shares during 1955-69. Again the main reason is that the estimated elasticities of substitution are not very different from one, so that the warranted shares remain relatively stable despite sizable changes in the rates of increase of $K/\overline{L}$.

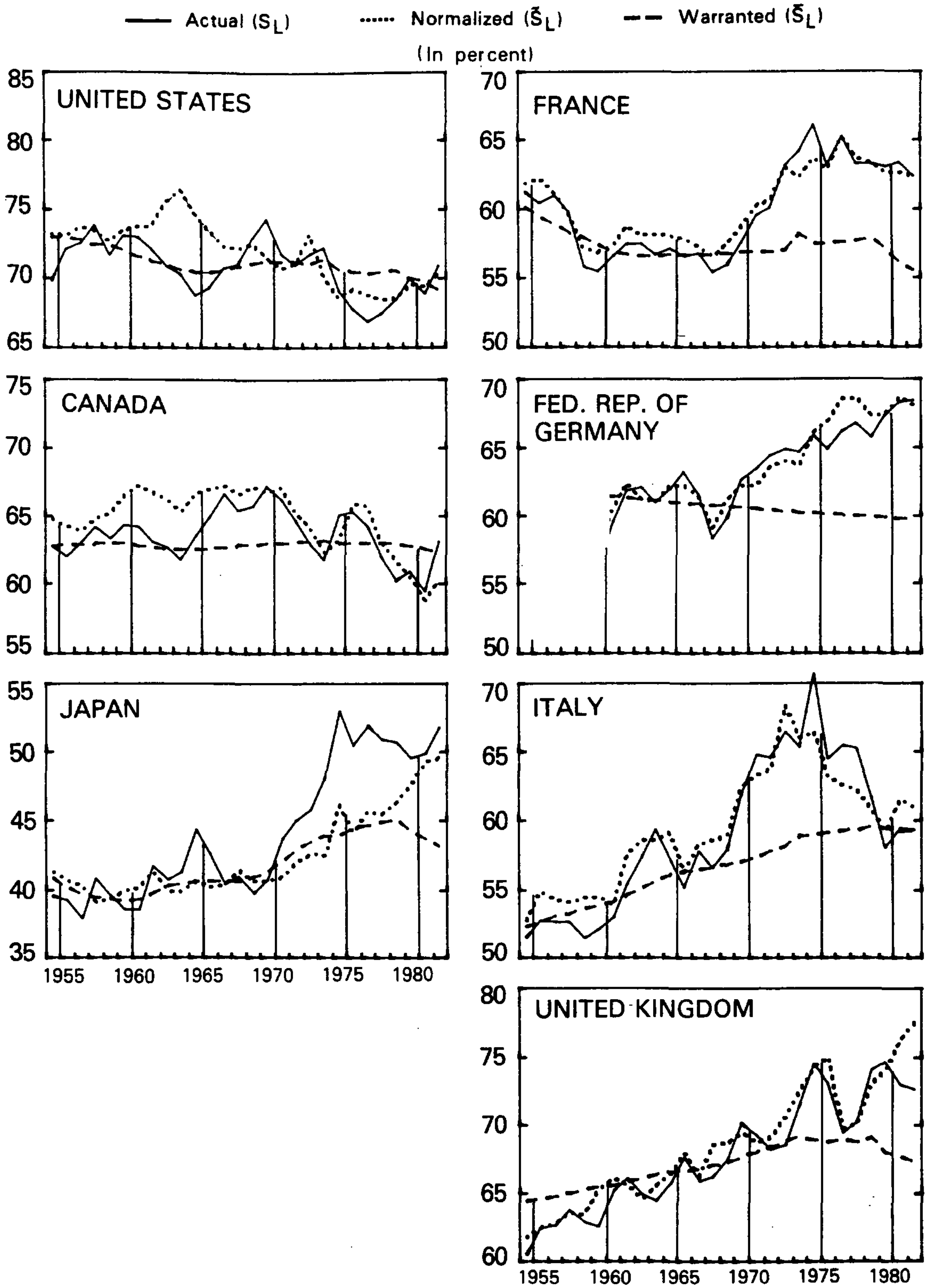
Even though the new results are broadly similar to those derived from simple comparisons of actual shares, the differences between the two sets of results are far from negligible, suggesting that at times comparisons of actual shares are misleading. For example, for the United Kingdom and, especially, for Italy the warranted labor share is estimated to be higher during the 1970s and early 1980s than during 1955-59, so that a simple comparison of actual shares exaggerates the magnitude of the disequilibrium in recent years. The opposite is true for the Federal Republic of Germany. For Japan, the comparison of actual shares is even more misleading. The actual labor share jumps up in the first half of the 1970s, mainly in 1974-75, and then stabilizes, suggesting that Japan adjusted much better to the second wave of oil price rises than to the first. What the new results show, however, is that the jump in the labor share that took place in the first half of the 1970s was not a severe problem. First, it started from a position where the actual share was significantly below the warranted share. Second, it was largely related to the presence of temporary labor hoarding, as evidenced by the much smaller increase in the normalized share. And third, there was a gradual increase in the warranted share during that period because of a rapid increase in $K/\overline{L}$. (See Tables 1 and 2.) By contrast, during the late 1970s and early 1980s, labor hoarding was slowly reduced and the stability of the actual share hides a further rise in the normalized share. Moreover, the warranted share stopped rising and then started to decline because the growth of $K/\overline{L}$ decelerated sharply.

The normalized and the warranted labor shares derived from model B are depicted in Chart 2. All the shares are now in percent of the total of labor, capital, and energy costs, rather than only the total of labor and capital costs. For the United States, Canada, and Italy, the E-K complementarity hypothesis leads to results that differ from those derived from the traditional production model. Focussing on the 1980s, the normalized share is now found to be roughly equal to the warranted share in the United States and Italy, and actually smaller than the warranted share in Canada. For the other four countries, on the other hand, the estimates of the gaps between the normalized and the warranted shares remain roughly unchanged.

To understand why the results of model B differ from those of model A, one must consider the effects of E-K complementarity on both the warranted labor shares and the normalized labor shares. The warranted

CHART 2

MODEL B: ACTUAL (S_L), NORMALIZED ($\tilde{S}_L$) AND WARRANTED ($\bar{S}_L$) LABOR SHARES[1]



[1] Labor shares of total cost of capital, labor, and energy imputs (i.e. labor shares of the sum of value added at factor cost, net of inventory appreciation, and energy cost).

shares tend to rise less, or decline more, in model B than in model A during the past ten years because, with the decline in the use of energy (Table 6), $K^*/\bar{L}$ rises less rapidly than $K/\bar{L}$. As the coefficients of $K^*/\bar{L}$ and $K/\bar{L}$ are larger for the United States, France, and the United Kingdom than for the other four countries, the warranted shares of the former countries are more affected than those of the latter countries. However, these differences are small because the coefficients of $K^*/\bar{L}$ and $K/\bar{L}$ for the former countries are still relatively small. Turning to the normalized shares, they also tend to rise less, or decline more, in model B than in model A during the past ten years because of the increase in the cost of energy used (included in Y^*p^* but not in $Y\ p$). But in this case there are relatively large differences among countries. The share of the cost of energy in the total cost of production rose significantly more in the United States, Canada, Japan, and Italy, than in the other three countries during the past ten years (see last column of Table 6). Furthermore, as the effect of a given rise in the share of energy costs on the normalized labor share is proportionate to the relative size of labor and capital costs, the resulting reduction in the normalized labor share was much larger in the United States, Canada, and Italy, than in Japan.

Chart 3 depicts the wage gaps corresponding to the two models. As noted above, these gaps are equal to the corresponding gaps between the normalized and the warranted labor shares scaled by the ratios of value added (inclusive of energy costs for model B) over warranted labor costs under conditions of high employment. For Japan, the Federal Republic of Germany, and the United Kingdom, the two models yield a wage gap of about 15 percent for the early 1980s. For France, the two models lead to a somewhat smaller gap in the order of 10 percent. For the United States and Italy, model A gives a gap in the order of 5 to 10 percent, while model B gives no significant gap. For Canada, model A suggests no gap, while model B suggests that the real wage rate is, if anything, on the low side.

A sensitivity analysis indicates that the wage gaps are relatively robust to variations in the estimates of the gross capital stocks and the high-employment labor inputs. For example, we recalculated the wage gaps for 1982 from model B after reducing our estimates of the gross capital stock by 10 percent. This change decreased the warranted real wage rate and increased the wage gap to 16 to 18 percent in Japan, France, the Federal Republic of Germany, and the United Kingdom; to about 5 percent in the United States and Italy; and to about zero percent in Canada. When we recalculated the wage gaps after raising our estimates of the high-employment labor input by 10 percent, rather than reducing capital by 10 percent, the estimates of the wage gaps were increased by a further 2 to 3 percentage points.

Table 6. Energy Use and Cost in Manufacturing, 1972-82 1/

	E	Y*	E/Y*	p_e	p*	p_e/p*	$E.p_e$	Y*p*	$E.p_e$/Y*p*
	(Index 1972 = 100)						(In billions of local currency)		(In percent)
United States									
1972	100.0	100.0	100.0	100.0	100.0	100.0	18.3	291.0	6.3
1982	74.0	110.0	67.3	728.0	217.9	334.1	98.6	697.4	14.1
Canada									
1972	100.0	100.0	100.0	100.0	100.0	100.0	1.1	22.5	4.8
1982	102.4	112.2	91.3	606.1	257.4	235.5	6.8	65.0	10.5
Japan									
1972	100.0	100.0	100.0	100.0	100.0	100.0	1.8 2/	30.8 2/	5.9
1982	98.2	178.3	55.1	545.0	146.0	373.3	9.6 2/	80.2 2/	12.0
France									
1972	100.0	100.0	100.0	100.0	100.0	100.0	14.3	265.3	5.4
1982	94.8	124.0	76.5	617.9	243.1	254.2	83.5	893.4	9.3
Germany									
1972	100.0	100.0	100.0	100.0	100.0	100.0	15.5	282.5	5.5
1982	82.3	112.2	73.3	367.5	158.1	232.4	46.9	501.0	9.3
Italy									
1972	100.0	100.0	100.0	100.0	100.0	100.0	1.6 2/	21.0 2/	7.8
1982	96.0	134.2	71.5	1,239.9	495.0	250.5	19.0 2/	139.5 2/	13.6
United Kingdom									
1972	100.0	100.0	100.0	100.0	100.0	100.0	1.3	19.2	6.8
1982	65.6	86.9	75.5	713.1	375.2	190.1	6.1	62.6	9.7

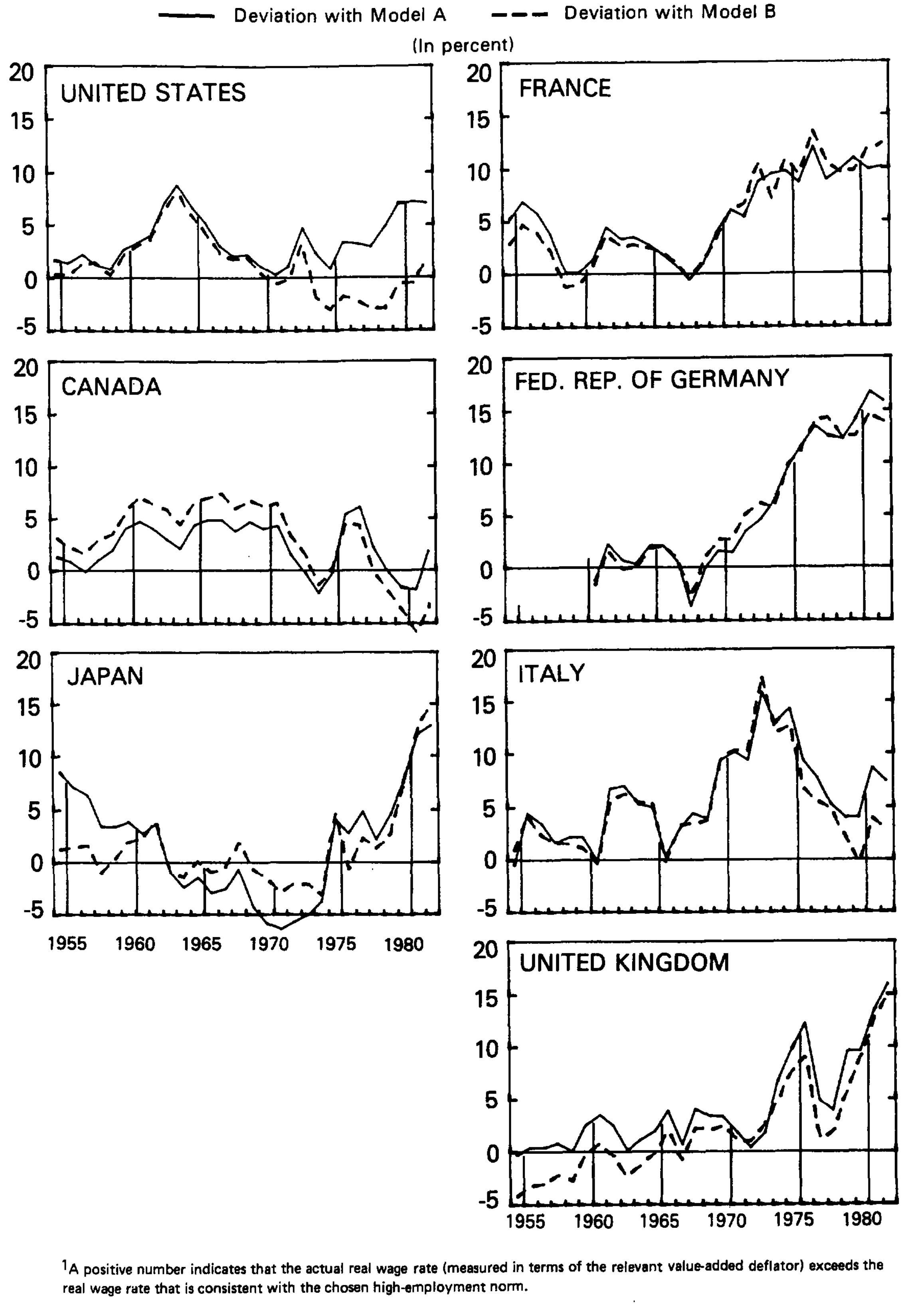
Source: See Appendix.

1/ Notation: E, energy use in millions of tons of oil equivalent; Y*, real value added including the value added corresponding to energy; p_e, price of energy in local currency; p*, deflator of Y* in local currency.

2/ In trillions of local currency.

CHART 3

DEVIATION OF ACTUAL FROM WARRANTED REAL WAGE RATE[1]



[1]A positive number indicates that the actual real wage rate (measured in terms of the relevant value-added deflator) exceeds the real wage rate that is consistent with the chosen high-employment norm.

Finally, we recalculated the wage gaps after reducing our estimates of the high-employment labor input for 1982 to the level of the actual labor input. Even under this extreme--and quite unrealistic--assumption that all the unemployment observed in 1982 was due to regional and skill mismatches between labor supply and demand, we still found a wage gap of about 10 percent in Japan and the Federal Republic of Germany, and about 3 percent in France and the United Kingdom. This finding is very worrisome because it implies that in the four countries concerned the level of the real wage rate may be an obstacle not only to a return to high employment, but even to the maintenance of the 1982 level of employment.

An analysis of the factors that led to the emergence of these gaps is outside the scope of the present study, but the evolution of the rates of growth of warranted real wage rates provides an insight into this question. Table 7 gives the estimates corresponding to model B, both in terms of the deflator of output, p^*, and in terms of consumer prices, p_c. The estimates corresponding to model A would be similar, except that for the United States, Canada, and Italy, the post-1973 rate of growth would be somewhat lower. The most noticeable result is the extremely sharp deceleration in the rate of growth of the warranted real wage rate in terms of p^* in all seven countries after 1972. This deceleration was attributable partly to a decline in the growth of disembodied productivity (λ), and partly to a decline in the growth of the ratio of the composite capital-energy input to the labor input (K^*/L). The deceleration attributable to this ratio was especially marked during the period 1979-82, when energy use fell sharply and investment was depressed. Generally, the change in the terms of trade between manufactures and consumer goods (p^*/p_c) was positive during 1973-78 and negative during 1979-82; thus, it reduced the deceleration of the growth of the warranted real wage rate in terms of consumer prices at first, then increased it. During 1979-82, the rate of growth of the warranted real wage rate in terms of consumer prices was negative in the United States, Japan, and the United Kingdom. In the other four countries, it was only 1 to 2 percent.

In all seven countries, except the United Kingdom, the adjustment to the deceleration in the growth of the warranted real wage rate in terms of consumer prices was considerable, with the rate of growth of the actual real wage rate declining by 2 percentage points or more from 1956-69 to 1979-82. 1/ Thus, it would be an exaggeration to say that the

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1/ It can be noted that this adjustment is more sizable than it appears because in France, Italy, the United Kingdom, and Japan, payroll taxes rose sharply during 1979-82 so that the growth of the take-home wage was even lower than the growth of the gross wage considered here (see Steinherr (1983)). By contrast, in the United States, payroll taxes were reduced during this period, decreasing the need for a cut in the take-home wage.

Table 7. Sources of Growth in Warranted Real Wage Rates in Manufacturing (Model B) 1/

(Percentage change in warranted rate attributable to each source)

	1956-69	1970-72	1973-78	1979-82	1956-69	1970-72	1973-78	1979-82
	United States				Canada			
λ	2.2	2.5	1.2	1.0	2.8	3.4	1.4	1.1
K^*/L	0.9	1.5	1.0	0.1	1.7	2.0	1.2	0.1
$-\delta_1$	-0.5	-0.5	-0.5	-0.5	-0.3	-0.3	-0.3	-0.3
$\overline{w/p^*}$	2.7	3.5	1.7	0.6	4.2	5.2	2.3	0.9
p^*/p_c	-0.5	-1.2	0.1	-1.8	-1.6	-0.4	1.0	-0.1
$\overline{w/p_c}$	2.2	2.3	1.8	-1.2	2.5	4.8	3.3	0.8
w/p_c	2.2	1.5	1.3	0.0	2.8	3.8	2.8	0.0
	Japan				France			
λ	5.2	4.6	4.3	4.3	4.2	3.2	2.2	2.2
K^*/L	6.2	9.8	3.4	-0.5	2.6	4.4	4.6	1.8
$-\delta_1$	-1.2	-0.1	0.2	-0.8	-1.3	-1.3	-1.3	-1.3
$\overline{w/p^*}$	10.4	14.8	8.1	2.9	5.4	6.3	5.5	2.7
p^*/p_c	-3.2	-3.5	-4.9	-3.8	-1.2	-1.8	-0.4	-0.5
$\overline{w/p_c}$	6.9	10.8	2.8	-1.0	4.3	4.4	5.1	2.2
w/p_c	6.7	10.4	3.4	2.1	4.2	6.2	5.7	2.5
	Germany				Italy			
λ	2.6 2/	2.6	2.6	2.6	3.7	4.4	2.8	2.5
K^*/L	3.1 2/	2.6	1.7	0.9	2.8	2.6	2.1	-0.3
$-\delta_1$	-0.1 2/	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
$\overline{w/p^*}$	5.7 2/	5.2	4.2	3.4	6.6	7.1	5.0	2.2
p^*/p_c	-0.2 2/	1.3	0.1	-1.3	-1.4	1.5	1.7	-0.3
$\overline{w/p_c}$	5.5 2/	6.5	4.3	2.0	5.1	8.7	6.8	1.9
w/p_c	5.8 2/	8.0	5.7	1.9	5.3	10.9	5.8	1.4
	United Kingdom							
λ	2.0	2.8	1.7	1.5				
K^*/L	2.2	2.7	1.2	-0.7				
$-\delta_1$	-0.3	-0.3	-0.3	-0.3				
$\overline{w/p^*}$	3.9	5.3	2.6	0.5				
p^*/p_c	-1.0	1.4	0.7	-0.8				
$\overline{w/p_c}$	3.0	6.8	3.3	-0.3				
w/p_c	3.4	6.5	3.5	2.8				

1/ Notation: λ, rate of disembodied productivity change; K^*/L, ratio of the E - K combined input to labor; δ_1, rate of increase in the weight of capital; $\overline{w/p^*}$, warranted real wage rate in terms of the deflator of value added corresponding to labor, capital, and energy; p^*/p_c, ratio between the deflator of value added and consumer prices; $\overline{w/p_c}$, warranted real wage rate in terms of consumer prices; and w/p_c, actual real wage rate in terms of consumer prices.

2/ Average rate of growth during 1962-69.

rate of growth of the real wage rate was rigid. In fact, there was a great deal of flexibility, but not always enough. The two most obvious cases where flexibility fell short from what was needed in recent years were Japan and the United Kingdom, where the actual real wage rate in terms of consumer prices has kept growing at a 2 to 3 percent rate, instead of declining in line with the warranted rate.

For France and the Federal Republic of Germany, the other two countries where there is currently a large gap, it is really in the early 1970s that the gap emerged, at a time when the rate of growth of the warranted real wage rate was both high and increasing. The gap increased further during 1973-78, with the first wave of oil price increases and the decline in productivity growth. But, in recent years, the growth of the actual real wage rate was kept in line with the low growth of the warranted rate despite further supply shocks. These findings suggest that in these two countries the problem is not so much a systematic tendency for inertia in the adjustment of real wages to supply shocks as argued by Branson and Rotemberg (1980), Sachs (1979, 1983), and others, as a failure to reverse the unwarranted increases in real wages of the early and mid-1970s. Increases that had as much to do with the wage explosion of the early 1970s as with the supply shocks of the mid-1970s.

IV. Concluding Remarks

We began this study by noting that the marked increase in the share of labor costs in value added that took place during the 1970s and early 1980s in the manufacturing sector of most major industrial countries does not necessarily imply that the real wage rate is now too high and is causing unemployment. The increase could be warranted by long-run changes in production techniques, in the price of energy, and in the relative availability of labor and capital. After taking into account these considerations, we conclude that, as far as the manufacturing sector is concerned, there are indeed strong reasons to believe that in France, the Federal Republic of Germany, the United Kingdom, and possibly even in Japan, the real wage rate is too high, in the sense of being incompatible with high employment. On the other hand, our results indicate that there is no real wage problem in the United States and Canada. We find no evidence of a real wage problem in Italy but poor data prevent firm conclusion. These findings are derived from an analysis in which the capital stock and the exchange rate are assumed to be exogenous. Moreover, they apply only to the manufacturing sector as a whole; there can obviously be a real wage problem in specific industries even when the average real wage for the manufacturing sector is not unduly high.

While derived from a model that is more elaborate than previous ones, the estimates of the warranted real wage rates on which these conclusions are based must still be regarded as tentative for at least three reasons. First, it is difficult to measure the actual flows of labor and capital services and, a fortiori, the high-employment labor supply in manufaturing. The sensitivity analysis carried out in the present study indicates that the order of magnitude of the warranted real wage rate is relatively robust to plausible variations in the values taken by these variables; nevertheless, the resulting uncertainty is far from negligible. To reduce this uncertainty would require an extension of the study to other sectors of the economy so as to estimate simultaneously the warranted allocation of labor among the various sectors and the warranted real wage rates in all sectors. This extension would be especially useful for countries such as the United Kingdom which have recently experienced a major break in the historical pattern of relative growth of their manufacturing and nonmanufacturing sectors. Reducing uncertainty would also require better data on the flow of capital services. The main problem in this context is the lack of reliable information on the extent of premature obsolescence resulting from the two waves of oil price increases.

Second, the estimates suffer from a number of country-specific problems. For Italy, and to a lesser extent France, the data on nominal value added in manufacturing are somewhat unreliable because of the lack of adequate information on inventory appreciation. Possible errors in our own estimate of inventory appreciation is as likely to have led to an undervaluation as an overvaluation of the wage gap in the early 1980s. For Japan, the main problem arises from the possible inadequacy of the base period. The extremely low share of labor costs in value added during the 1950s and 1960s--20 to 30 percentage points lower than in other industrial countries--may have partly resulted from an implicit social consensus that a high profit rate was the best way to rebuild the capital stock, rather than exclusively from a low marginal product of labor. In this case, our estimate of the wage gap in the early 1980s could be too high.

Third, an aggregate production function for a whole economic sector is an inherently crude empirical tool because the conditions necessary for aggregation over firms and industries are never fully satisfied, particularly if workers are not paid their marginal products. Not much can be done about this, short of confining studies at the firm or industry level. However, there are some aspects of the production function approach used here that are susceptible to further improvements. The two that are particularly worth singling out concern the complementary between capital and energy and the evolution of the relative weights of labor and capital over time. More work is needed to determine how much of the energy input should be viewed as a complement to capital and how much should be viewed as weakly separable. More work is also needed to test our assumption that the evolution of the relative weights of labor and capital was the same during the 1970s and early 1980s as during the 1950s and 1960s.

These limitations mean that the estimates are far from precise. They do not mean that the estimated wage gaps for France, the Federal Republic of Germany, and the United Kingdom merely reflects statistical artefacts. There is more uncertainty in the case of Japan because of the possible problem with the base period, but even there we doubt this can completely explain the measured gap.

A major factor that reinforces us in our belief that the order of magnitude of the gaps is right is the evolution of the unemployment situation. Unemployment can be classical (caused by an unduly high real wage rate), structural (caused by turnover and by regional and skill mismatches), or Keynesian (caused by a deficiency of aggregate demand). Thus, one should not expect a close cross-country correlation between the unemployment rate and the size of the wage gap. However, as of early 1984, the unemployment rate in France, the Federal Republic of Germany, and the United Kingdom is between 5 to 7 percentage points above our estimate of the structural rate for the early 1980s (see the Statistical Appendix) and this gap does not seem to be declining. 1/ In contrast, the unemployment rate is only 2 to 3 percentage points above the structural rate in the United States and Canada, and the spread is decreasing from month to month. In Japan, the economic and social system is such that the rise in unemployment has been quite moderate; nevertheless, employment in manufacturing fell 4 percent from early 1974 to 1982. This is striking, partly because the total labor force increased by 9 percent during this period and partly because, as recently as the 1960s, employment in manufacturing was rising three times faster than the whole labor force.

Last but not least, we regard our findings as particularly worrisome because of the exchange rate developments of recent years. The extremely sharp appreciation of the U.S. and Canadian dollar vis-à-vis the French franc, deutsche mark, and yen over the past four years has had major effects not only on the relative international price competitiveness of the corresponding countries, but also on the profitability of their exports of manufactures, decreasing export profitability in the United States and Canada and increasing it in France, the Federal Republic of Germany, and Japan. It is not a good omen that, despite these developments, there is a real wage problem for the manufacturing sector as a whole for the latter three countries but not the former two. We cannot forecast exchange rates, but we see the risk that a partial reversal of past exchange rate movements--even though desirable in many respects--could squeeze profit margins on exports in France, the Federal Republic of Germany, and Japan, while enlarging them in the United States and Canada, thus worsening the dichotomy between the two groups of countries as far as real wage gaps are concerned. On the other hand, a reversal of exchange rate movements would help to alleviate the real wage problem in manufacturing in the United Kingdom.

1/ A comprehensive empirical analysis showing that increases in labor shares (or in product wages) have had a negative effect on employment growth in Europe can be found in Steinherr (1983).

Statistical Appendix

Value added and labor cost in manufacturing

The data on value added in manufacturing at factor cost in nominal and real terms were obtained from national account statistics. The national account data in nominal terms are net of inventory appreciation, except for France and Italy. For France, we adjusted these data by using an estimate of inventory appreciation derived from the data on inventory appreciation for the whole nonagricultural economy. For Italy, we had to make an even rougher adjustment on the basis of the observed relation between inflation and inventory appreciation in the other five countries.

A problem with the data on value added in real terms is that they are derived by using the double-deflation method. As Bruno (1984) has shown, double deflation may introduce a downward bias in the measurement of the growth rate of real value added when the average price of raw materials and energy changes monotonically relative to the price of output. Actually, there is little risk of a double-deflation bias because of changes in raw material prices as far as the whole 1973-82 period is concerned. In relative terms, the average price of raw materials used in manufacturing declined slowly from 1955 to 1972, rose sharply in 1973-74, declined sharply in 1975, then entered a new period of slow decline interrupted by a brief rise in 1978-79. Thus, as long as the weights used for recent years are not based on the abnormal relative price of 1973-74, which is not the case in any of the seven countries considered here, the bias due to the change in the relative price of raw materials will be small. The doubling in the real price of energy from 1972 to 1982, coming after a period of gradual decline, is a more serious problem. Whenever possible, we have sought to avoid this potential source of bias by using series of real value added based on post-1973 weights from 1972 onwards and on pre-1973 weights for 1955-72. But for four countries, the United States, Canada, France, and Italy, this could not be done because national account statistics based on post-1973 weights are not yet available. For these countries, therefore, the estimate of λ_t in model A for the post-1972 period may be downward biased. However, a comparison of the data on real value added based on post-1973 weights with the data based on pre-1973 weights for Japan, the Federal Republic of Germany, and the United Kingdom suggests that the bias is not very large (say, an average of 0.2 to 0.3 percentage points per annum for the whole period 1973-82). There is no problem in model B because the cost of energy is not subtracted from gross output.

The data on labor cost were also obtained from national account statistics. Labor costs include not only the wage bill, but also all fringe benefits, employers' social security contributions, and employment and payroll taxes.

Man-hours worked in manufacturing

For all countries except France, the data were provided by the U.S. Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology, hereafter referred to as the BLS. The data are for man-hours worked, except for the United States where the only data available are for man-hours paid. For France, the series for the whole manufacturing sector were derived by aggregating the series for the food, intermediate, capital, and consumer goods industries provided by the Institute National de la Statistique et des Etudes Economiques (INSEE).

Overall unemployment and vacancy rates

The data on unemployment and vacancies were obtained from Main Economic Indicators, OECD, Paris, various issues. The data on unemployment are in percent of the civilian labor force, except for Japan, France, and the United Kingdom, where they are in percent of the total labor force. The data on vacancies are in percent of the civilian labor force for the Federal Republic of Germany; in percent of the total labor force for Japan, France, and the United Kingdom; and in index form for the United States and Canada.

The unemployment rate corresponding to a situation of high employment in the whole economy was estimated by using the Beveridge-Curve method (see main text). The estimates are: for the United States, 3.4 percent for 1955-69, 4.8 percent for 1972-74, and 5.7 percent for 1977-80; for Canada, 3.4 percent for 1955-68, 5.5 percent for 1972-74, and 7.2 percent for 1977-80; for Japan, 1.1 percent for 1955-71, 1.3 percent for 1972-78, and 1.6 percent for 1978-80; for France, 1 percent for 1955-68, 2.6 percent for 1972-78, and 3.6 percent for 1979-80; for the Federal Republic of Germany, 0.7 percent for 1961-71 and 2.2 percent for 1975-80; and for the United Kingdom, 1.2 percent for 1955-66, 1.8 percent for 1969-71, 2.6 percent for 1973-76, and 4.6 percent for 1978-80. No estimate is made for years for which the observations fell in between two Beveridge curves. (In the present study, an estimate is required only for years corresponding to a cyclical peak for the number of man-hours worked in manufacturing.) For Italy, the Beveridge-Curve method could not be used because there is no data on vacancies. From 1955 to 1974, we used a "trend-through-peaks" method, with the unemployment rate at each cyclical peak in employment assumed equal to $\bar{U}$. For the 1980 peak, we assumed somewhat arbitrarily that $\bar{U}$ was equal to 6.5 percent, about 1 percentage point above the unemployment rate reached at the 1974 cyclical peak.

Gross fixed capital stock in manufacturing

First, estimates of gross fixed capital stock in manufacturing without adjustment for changes in its mean age were derived from data on gross fixed capital formation in constant prices by employing the perpetual inventory method, which consists of cumulating past investment flows and deducting the equipment discarded from the stock. Except for Japan, the calculation starts from a benchmark estimate of the capital stock at the beginning of 1920. For Japan, the calculation starts from a 1950 benchmark estimate. The capital stock at the beginning of year t, $K^{\surd}_t$, was calculated by the formula:

$$(20) \qquad K^{\surd}_t = K^{\surd}_0 e^{rt} + \sum_{i=1}^{n} (1 - \phi_i) A_{t-i}$$

where e^{rt} is the proportion of the initial (1920) capital stock that remains at the beginning of year t, A_{t-i} is the capital stock installed in year t-i; ϕ_i is the proportion of the capital stock corresponding to A_{t-i} that has been retired by the beginning of year t; t is zero at the beginning of 1920; and A_{t-i} is set equal to zero before 1920.

In the calculation, it is assumed that the capital stock installed in year t is a lag function of the investment flows,

$$(21) \qquad A_t = 0.30\, I_t + 0.50\, I_{t-1} + 0.20\, I_{t-2}$$

where the coefficients take into account the average time needed for new projects to be completed and become fully productive. 1/

The calculations were made separately for machinery and equipment, and for structures, with an average service life of 15 years for machinery and equipment and 35 years for structures. 2/ Actual retirements from capital stock accumulated after 1920 were calculated following a Winfrey S-3 distribution, with discards starting at 45 percent of the average life. 3/ Special adjustments were made for damages suffered during World

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1/ Extensive studies of the lag from start of construction to completion have been made by Mayer (1960). The coefficients of equation (21) are based on Mayer's result and an assumed start-up period of two quarters.

2/ These estimates are based on the 1942 edition of Bulletin F of the U.S. Treasury Department, which remains standard for calculations of capital stocks in the United States. A recent survey by Blades (1983) found that calculation of capital stocks made in other industrial countries are normally based on discard rates similar to the U.S. rates. The two major exceptions are Japan, with more rapid discard rates, and the United Kingdom, with slower discard rates. Given that most capital goods are similar throughout the industrial world, however, there was little reason in the context of the present study to assume that their "economic efficiency" changed persistently at markedly different rates in the various countries.

3/ The Winfrey S-3 distribution is described in Fixed Nonresidential Business capital in the United States, 1925-73, National Technical Information Service (Springfield, Virginia).

War II. Moreover, the energy price increases of 1973-74 and 1979-80 were estimated to have brought about the early discard of, respectively, 10 percent of the capital stock of early 1974 during 1974-76 and 10 percent of the capital stock of early 1980 during 1980-82. (For further explanation on these adjustments for energy price increases, see main text.)

Data on gross fixed capital formation in manufacturing valued at constant prices and disaggregated into machinery and equipment, and structures, were obtained from the following sources.

Canada: Series for 1926-81, Fixed Capital Flows and Stocks 1926-78, Statistics Canada, Ottawa, 1980, and subsequent issues.

United States: Series for 1920-82, unpublished data supplied by Mr. John Musgrave, U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of Economic Analysis.

Japan: Series for 1950-81 on total gross fixed capital formation in manufacturing in current prices, Annual Report on National Income Statistics, Economic Planning Agency, Government of Japan, various issues. These series were deflated by using the deflator of private investment in plant and equipment for the whole economy available from the same source. The series in constant prices were disaggregated into machinery and equipment, and structures, on the basis of data supplied by the Ministry of International Trade and Industry, Japan.

France: Series for 1920-69, "L'Evaluation du Capital Fixe Productif," Jacques Mairesse, in Les Collections de L'INSEE, Serie C, No. 18-19 (November 1972). Series for 1970-81, unpublished data supplied by Mr. Jacques Mairesse, INSEE, France.

Federal Republic of Germany: Series for 1920-66, Wolfgang Kirner, Zeitreihen für das Anlagevermögen der Wirtschaftbereiche in der Bundesrepublik Deutschland, Berlin, 1969. Series for 1967-81, based on data provided by IFO Institute.

Italy: Series for 1921-50, Sommario Di Statistiche Storiche Dell'Italia, 1861-1965, Instituto Centrale Di Statistica, Rome, 1968. Series for 1951-81, National Accounts for OECD Countries, Organization for Economic Cooperation and Development, various issues. These sources provide only aggregate data. The disaggregation of data into machinery and equipment, and structures is based on the study lo'stock'di capitale nell'industria Italiana, Centro Studi Confindustria, Rome, 1979, and more recent data provided by Dott. Giuseppe Rosa of Centro Studi Confindustria. The series for Italy refer to manufacturing, mining, and utilities.

United Kingdom: Series for 1920-38, Domestic Capital Formation in the United Kingdom 1920-38, C.H. Feinstein, Cambridge University Press, 1965. Series for 1939-45, "The Stock of Fixed Capital in the United Kingdom in 1961," G.A. Dean, Journal of the Royal Statistical Society, Series A, Vol. 127, Part 3, 1964. Series for 1949-82, National Income and Expenditure, U.K. Central Statistical Office, various issues.

Data on investment for 1982 were obtained from various published and unpublished sources or were based on Staff estimates; they must be considered very preliminary.

In the calculation of the series on capital stock, the post-1965 data on investment for the United States were adjusted by netting out the pollution abatement investment obtained from the June issues of the Survey of Current Business, U.S. Department of Commerce, various years. For Canada and Japan, the post-1969 data on investment were cut by 5 percent to take into account that, with the intensification of the efforts to reduce pollution, there had also been a marked increase in the proportion of investments that do not contribute to value added in these two countries. (See main text for further explanation.)

Second, estimates of the mean age of the capital stock were obtained from the same investment data, with the same adjustments for war, energy price increases and the drive to reduce pollution. Here also, the calculations were made separately for machinery and equipment, and for structures. The mean age (Z) was calculated by the formula:

$$(22) \qquad Z_t = (t.K_0^{\checkmark} e^{rt} + \sum_{i=1}^{n} i \ (1 - \phi_i) \ A_{t-i})/K_t^{\checkmark}$$

For each of the two types of capital goods, the estimate of the capital stock adjusted for deviations of the mean age from the 1967 level was then defined as:

$$(23) \qquad K_t = K_t^{\checkmark} \ e^{\phi(Z_t - Z_{1967})}$$

where the rate of embodied technical progress (ϕ) is equal to 0.02 for machinery and equipment, and 0.05 for structures. 1/

Finally, data on the total capital stock were obtained by summing the adjusted stocks of machinery and equipment, and of structures.

1/ The estimates of 0.02 and 0.05 were initially suggested by Solow in his pioneering article (1957). Econometric results consistent with these estimates were obtained in Artus and Turner (1978).

Energy use in manufacturing

Data on total final consumption of energy in manufacturing in million tons of oil equivalent were obtained from Energy Balances of OECD Countries, International Energy Agency, OECD, Paris, various issues. 1/ The data excludes the consumption of energy products for purposes other than energy generation.

Indices of the average price of energy inputs in the manufacturing sector were provided by the International Energy Agency. Estimates of average prices in units of local currency were derived by using these indices and the data on prices of individual energy products in 1978 published in Energy Conservation in the International Energy Agency-1978 Review, International Energy Agency, OECD, Paris, 1979; in Doblin (1982); and in International Energy Evaluation System, International Energy Prices, 1955-1980, Service Report (SR/STID/81-21) of the Energy Information Administration, U.S. Department of Energy, December 1981.

1/ The data published by the International Energy Agency refer to the industrial sector, but the definition of the industrial sector used by this Agency is comparable to the normal definition of the manufacturing sector in national account statistics.

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