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Relative Prices, Real Wages, and the Appropriate Stance of Macroeconomic Policies: Some Evidence from Manufacturing in Japan and the United Kingdom 1/

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Abstract

Industries in most countries were buffeted by input price changes in the 1970s, but countries differed in their adjustment to these shocks. In some countries there was very little real wage adjustment so that the brunt of the adjustment was born by profits; in others there was a relatively high degree of real wage adjustment. The extent of wage adjustment is important to an understanding of the current recession and unemployment problem--that is, whether it is principally cyclical (Keynesian) or classical (high real wage) in origin--and to the debate on the efficacy of demand management for raising output and employment. This paper uses a simple econometric model to separate the cyclical and classical influences on manufacturing output and employment. It compares the results for Japan with those for the United Kingdom, uses these results to compute indices for comparing wage cost behavior, and draws inferences from this analysis for macroeconomic policy.

1/ This paper has benefited from comments by Jacques Artus, Robert Feldman, Harold Furchtgott-Roth, Kazumasa Iwata, Robert Lawrence, Yuzuru Ozeki, Alessandro Penati, Heizo Takenaka, and Yoichi Takahashi. Linda Galantin and Mahshid Shizari provided efficient research assistance. Responsibility for remaining errors, of course, rests solely with the authors.

I. Introduction

As inflation appears to have been brought under control in many industrial countries, debate about the timing and degree of reflationary policies is assuming greater importance. The debate centers on the extent to which consolidating the gains against inflation should be given priority over demand stimulus aimed at increasing growth and employment. Too often, however, there is insufficient attention to the fact that, even among countries that have relatively low inflation rates, there are important differences in underlying conditions that should influence the stance of policy. This paper is an attempt to point out and quantify some of these differences.

Industries in most countries were buffeted by similar relative price changes--principally large and sudden increases in the costs of raw materials and fuels--during the 1970s, but countries differed in their adjustment to these changes. It is easy to characterize the polar extremes of the adjustment continuum: at one extreme, real wages (or the growth of real wages) remained unchanged, thereby pushing the entire burden of adjusting to the input price shocks onto profits; at the other pole, real wages were cut sharply to maintain profit shares. The position of countries on the adjustment continuum between these polar extremes has been critical to the debate on the nature and origin of the recession of the last few years. For countries close to the first extreme it is arguable that the problem resides essentially in low profitability and high unit labor costs owing to the unwillingness of labor to accept some of the burden of adjustment to higher input prices during the 1970s. According to this view, recent poor output and employment performance is due more to relative price developments than to inadequate domestic demand, and is therefore less amenable to correction by demand management policies. Indeed, without a period of tight demand management and some slack in employment, it might not have been possible to dampen inflationary expectations and restore a sense of realism to the labor market. For countries that have managed a greater degree of wage adjustment, it can be argued that the recession has persisted largely because of a dearth of demand. In this case, less stringent demand management might now facilitate more rapid growth and an environment more conducive to an improvement in economic fundamentals.

The present paper draws on and updates work done within the IMF during the last few years in an attempt to quantify aspects of this discussion. 1/ The quantification concentrates on a comparison of the

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1/ Enormous debts to work done outside the Fund will also be apparent to the informed reader. In particular, papers by Basevi, Blanchard, Buiter, Dornbusch, and Layard (1983); Bruno (1981); Bruno and Sachs (1979 and 1982); Grubb, Jackman, and Layard (1982); and Sachs (1979) have been extremely helpful.

manufacturing sectors in Japan and the United Kingdom. Both were hard hit by the input price disturbances of the 1970s, but conventional wisdom would have it that they were quite different in the extent to which they were able to adjust to these disturbances. Wage developments have been the focus of attention in both countries: in Japan the labor market can generally be characterized as flexible, with a relatively unified system for annual wage negotiations and a strong social consensus allowing for a sharing of the burden of adjustment between capital and labor. In the United Kingdom, the labor market is usually seen as having been less flexible, with wage settlements based on short-term power relationships between government, management, and unions rather than on agreement about employment and sustainable wage increases over the longer run. Thus, while real wage increases in Japan accelerated from the late 1960s through the middle of the 1970s, this gave rise to relatively little political tension and contributed to the emergence of a consensus on the need for more moderate wage behavior. In the United Kingdom, in contrast, wage disputes and developments contributed to the fall of the Government in 1974 and have been at the center of the political debate during the last decade. Formal incomes policies, which seemed to meet with some short-term successes in the period 1976-78, were subsequently abandoned. It is because of these differences between the conventional perceptions of Japan and the United Kingdom that they seemed likely candidates for fruitful comparison.

The paper proceeds as follows. In section II the questions to be addressed are set up and the simple model in terms of which they are analyzed is specified and estimated. In section III the results of the econometric work are used to analyze wage developments. Finally, in section IV, inferences are drawn from the analysis for the conduct of macroeconomic policies.

II. Relative Prices and Cyclical Influences in the Manufacturing Sector

1. Two views

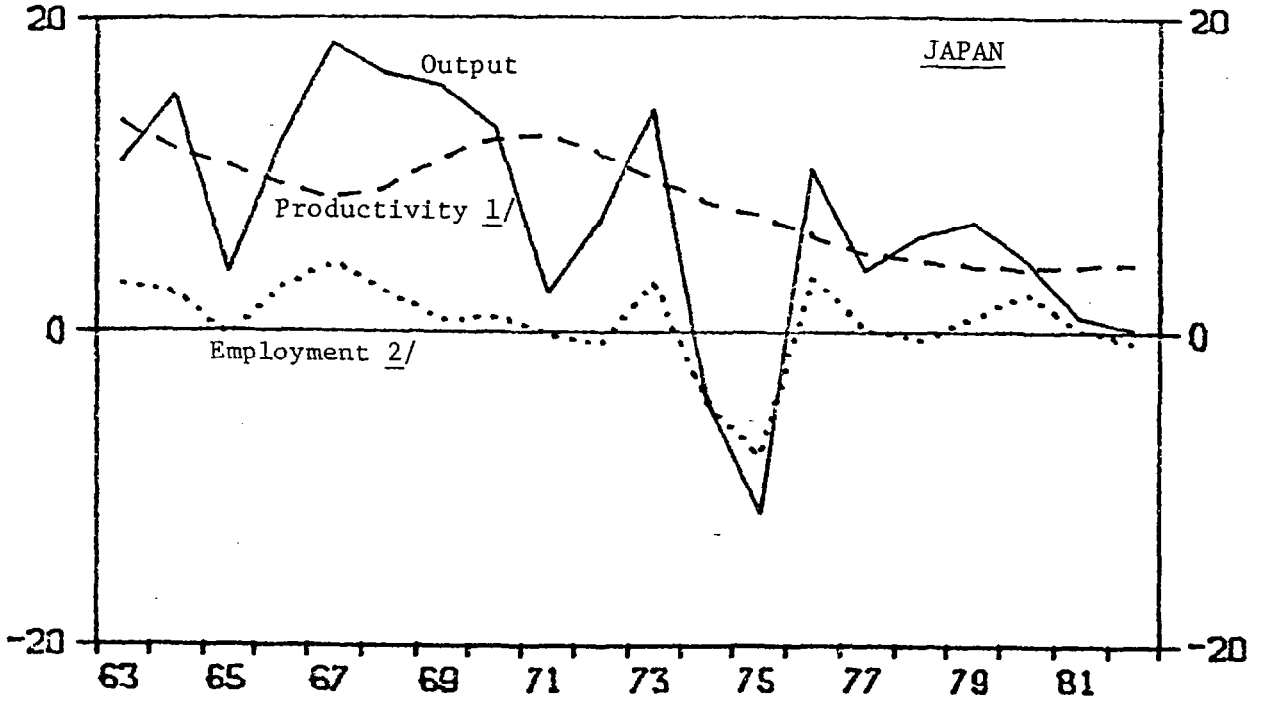
In both Japan and the United Kingdom the performance of the manufacturing sector has deteriorated since the middle of the last decade, in terms of output, employment, profitability, and productivity (Chart 1 and Tables 1 and 2). The model described in this section attempts to separate various influences on output and employment in manufacturing.

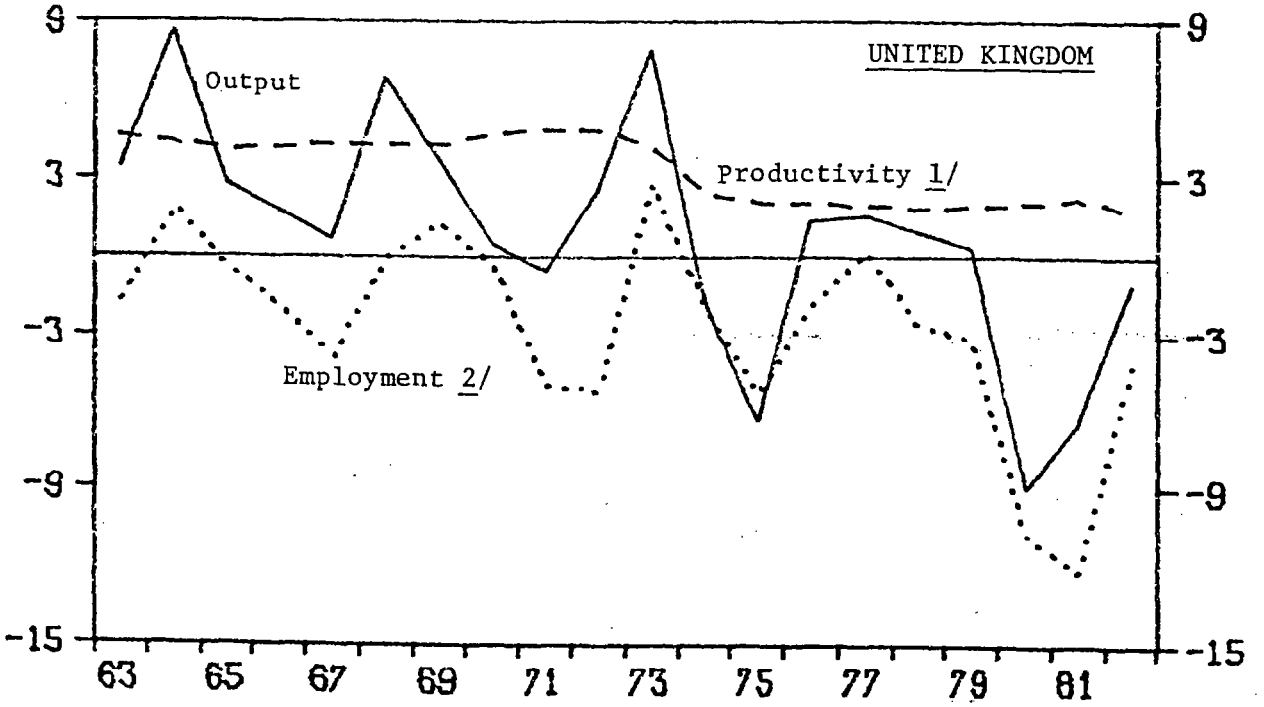
In strictly classical terms, profit-maximizing producers of manufactured goods are assumed to choose the amount of output they supply and inputs they use by employing all variable factors of production up to the point where the marginal product of each is equal to its product price. Output prices, in turn, adjust to ensure that any level of output is absorbed by consumers. This proposition leads to the conclusion

CHART 1

JAPAN AND THE UNITED KINGDOM: PERFORMANCE IN THE MANUFACTURING SECTOR

(Annual percentage changes)





Source: Data sources are listed in Appendix I.

1/ Productivity is normalized to eliminate the cyclical component.
2/ Employment is measured in terms of manhours worked.

Table 1. Japan: Some Basic Data

(Average percentage change per annum unless otherwise specified)

	1963-1972	1973-1982
Manufacturing output	11.6	3.2
Labor input (hours worked)	1.6	-0.3
Productivity in manufacturing (normalized) 1/	11.0	5.9
Gross real fixed investment in manufacturing	12.7	5.5
Share of capital in value-added (in percent, average rate)	54.3	44.7 2/
Real rate of interest (average rate) 3/	2.7	--
Output price index (all manufactured products)	1.0	6.7
Hourly compensation in manufacturing 4/	13.5	10.7
Input price index (materials and fuels purchased by manufacturing industry)	1.9	13.6

Sources: Data sources are listed in Appendix I.

1/ Normalized to exclude cyclical fluctuations.
2/ 1973-81.
3/ Yield on longest remaining maturities of interest bearing Nippon Telephone and Telegraph bonds deflated by the actual increase in consumer prices during this period.
4/ Includes cash earnings of workers plus employment taxes paid by employers.

Table 2. United Kingdom: Some Basic Data

(Average percentage change per annum unless otherwise specified)

	1963-1972	1973-1982
Manufacturing output	3.0	-1.2
Labor input (hours worked)	-1.5	-3.9
Productivity in manufacturing (normalized) 1/	4.5	2.3
Gross real fixed investment in manufacturing	0.9	-2.3
Pretax real rate of return on capital (average rate)	10.1	5.7
Cost of capital (average rate)	5.1	6.3
Output price index (all manufactured products)	4.0	13.5
Hourly earnings in manufacturing	8.7	16.5
Input price index (materials and fuels purchased by manufacturing industry)	3.6	17.0

Sources: Data sources are listed in Appendix I.

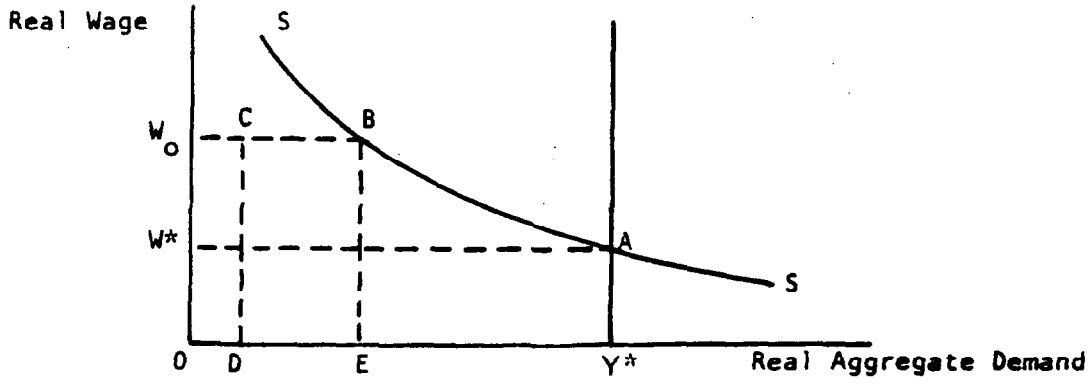
1/ Normalized to exclude cyclical fluctuations.

that the increases in real wages or real prices of raw materials during the last decade have reduced the profit maximizing levels of labor and materials inputs and production. 1/

The Keynesian counter-argument holds that, while relative price shifts have had a depressing effect on employment and output, a deficiency of demand has far overshadowed this influence. In other words, at the given historical relative price levels, producers have been forced, by a deficiency of demand, to produce less than they would have were they not demand constrained. Output rather than prices adjusted downward--that is, producers have been off their supply curves and demand, rather than supply, has been the operative constraint. The issue addressed in this section is the following: to what extent has the decline in the growth of output and employment in manufacturing been due to higher real wages and prices of raw materials, and to what extent to a deficiency of demand?

The two arguments are depicted in Figure 1.

Figure 1. Keynesian and Classical Unemployment 2/



The schedule SS is the locus of points at which real wages are such that firms are willing to supply the amount of output demanded. It embodies a given state of technology and stock of capital, and is negatively sloped to indicate that an increase in employment and therefore supply requires a reduction in real wages. The vertical line drawn at y* represents full employment. The area to the left of the SS schedule

1/ Throughout this paper, real wages and real prices of raw materials will refer to nominal wages and raw material prices each deflated by the price of manufactured output. These terms should be distinguished from nominal wages or materials prices deflated by consumer prices. The latter are relevant to wage earners or consumers, the former to producers.

2/ This figure is taken from Basevi et. al. (1983). The authors of that paper acknowledge that it is adopted from the early disequilibrium model of Mundell (1964).

represents Keynesian unemployment. The area to the left of the full employment line (Y*) but on or to the right of SS represents classical (high-wage) unemployment.

At point C, for example, output is constrained by demand which amounts to OD while at the given real wage rate W_o firms would willingly produce OE. Clearly, demand stimulus could increase output to the point B. At this point, however, real wages become the operative constraint. Supply would be impervious to further demand expansion unless real wages were reduced. 1/ At any real wage above W*, there will not be full employment. Unemployment may be purely classical, as at point B, or a combination of classical and Keynesian as at point C. The analysis that follows attempts to separate these influences.

2. The model

It is easiest to begin with a simple framework relating gross manufactured output to three factors of production, labor, capital, and raw materials. Upon substitution of the conditions that marginal products equal real prices for each variable input, 2/ a production function relating output to product wages, product prices of raw materials, technological change, and the capital stock may be derived. Similarly, a labor demand equation can be derived from the condition that the marginal product of labor equals the real wage. To the strictly classical framework of these equations is added an expression to pick up cyclical changes in

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1/ Of course, if output prices responded to demand while nominal wages were relatively sticky, a further demand expansion might indeed be effective in reducing real wages. Insofar as workers were in a position to restore the real wage level to W_o, however, the gain would be only transitory. The classical view that real wages are countercyclical was retained by Keynes (see the General Theory, Chp. 20), but has since been subject to great debate. See for example Dunlop (1938), Tarshis (1939), Malinvaud (1977). Otani (1978) provides a useful examination of the recent data, and Sachs (1983) an excellent discussion of this point.

2/ For the purpose of this exercise, labor and raw materials are assumed to be variable inputs, while the capital stock is assumed to be fixed in the short run. Despite lifetime employment practices affecting many workers in Japan's manufacturing sector, labor can be viewed as a variable input because of the substantial variations in average working hours and the flexibility with which a large number of young women enter and leave the work force. The assumption that capital is a fixed input in the short run reflects the tendency for investment to respond slowly to changes in the rate of return on capital.

demand that temporarily push producers off their desired supply functions. 1/

$$q = c_1 - (\alpha\sigma_1/\gamma)(w_p - \lambda_1 t + \lambda_2 t^2) - [\beta(\sigma_1\alpha + \sigma_2\gamma)/(1 - \beta)\gamma]prm_p + k + m_1 cyc(-1) \quad (1)$$

$$n = c_2 - [(1 - \beta)\sigma_1/\gamma](w_p - \lambda_1 t + \lambda_2 t^2) - (\beta\sigma_1/\gamma)prm_p + k - \lambda_1 t + \lambda_2 t^2 + m_2 cyc(-1) \quad (2)$$

Where

Q = Gross output in manufacturing.

W_p = Nominal wages deflated by the price of manufactured output.

t = Time trend.

PRM_p = Nominal price of raw materials and fuels inputs into manufacturing deflated by the price of manufactured output.

K = Capital stock in constant price terms.

N = Total hours worked in manufacturing.

1/ The equilibrium version of equations (1) and (2) (that is, when cyclical influences are neutral) is derived from a two-tier CES production function which is one of the simplest ways to characterize the case of three factors of production. This involves the specification of gross output as a function of value added and raw material inputs and of value added as a function of labor and capital.

$V^{\rho_1} = a[N \cdot \exp(\lambda_1 t - \lambda_2 t^2)]^{\rho_1} + (1 - a) K^{\rho_1}$ Value added

$Q^{\rho_2} = bV^{\rho_2} + (1 - b)RM^{\rho_2}$ Gross output

where $\rho_1 = (\sigma_1 - 1)/\sigma_1$ and $\rho_2 = (\sigma_2 - 1)/\sigma_2$, and σ_1, σ_2 are elasticities of substitution between labor and capital, and value-added and raw materials, respectively. V is value added, RM the raw materials input, and N the labor input. Several simplifications implicit in this model should be noted. First, the aggregation of energy and other raw materials inputs ignores possible differences between the effects of changes in their prices. Second, all technological progress is labor-saving. Finally, the degree to which technology is capital-intensive (as indicated by 'a') and raw material intensive (as indicated by 'b') is fixed over the time period. For an examination of bias resulting from some of these simplifications, see Artus (1984). Appendix II provides a detailed derivation of equations (1) and (2) from profit-maximization subject to these production functions.

CYC = Deviations of actual expenditure from a quadratic trend. 1/

α, β, γ = Shares of labor, raw materials, and capital in total costs. 2/

Lower case letters of variables (other than t) represent natural logarithms. Changes in the productivity of labor owing to technological progress are proxied by a second order polynomial in t with parameters λ_1 and λ_2 on t and t^2, respectively. 3/

Tables 3 and 4 show the results of estimation of equations (1) and (2) with data from Japan and the United Kingdom. 4/ For each country, the two-equation system is estimated simultaneously with across-equation restrictions on parameters imposed to ensure consistency. For both countries, all the structural parameters have the expected signs and are of plausible magnitude. All the structural parameters are significantly different from zero at the 95 percent confidence level.

In Japan the average share of raw materials costs in gross output is estimated at 28 percent. The implied shares of labor and capital in gross output are about 37 and 36 percent respectively. Labor productivity growth is estimated to be about 5.6 percent on average over the period. The elasticity of substitution between raw materials and value added--that is, capital plus labor--is estimated to be 0.586 and significantly different from 1. This is an important figure because it indicates the degree to which capital and labor can be substituted for raw materials as their relative prices change. 5/ The elasticity of substitution between capital and labor is estimated to be 0.409--also significantly different from 1. These results imply that increases in the real price of raw materials and in real wages over the period

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1/ For Japan gross national expenditure was used, for the U.K. gross domestic expenditure. The t^2 is included to capture the slowdown in growth during the sample period.

2/ The mean of the ratio of the value of labor to capital inputs (α/γ), which is available from national accounts statistics was imposed in the estimation to improve the efficiency of results.

3/ The t^2, which was included to capture the slowdown in productivity growth during the sample period, was not significantly different from zero in preliminary estimation results for Japan and was dropped from the final estimation.

4/ Appendix I provides details on data and data sources.

5/ For example, a zero elasticity of substitution implies that the given technology allows no substitution to occur. An increase in the relative price of raw materials simply leads to a corresponding increase in the share of raw materials in total costs which, of course, must be offset by a lower share for labor and for capital. An elasticity of substitution equal to one implies that a given increase in the relative price of raw materials would lead to a proportionately equal decline in the volume of raw material inputs so that the shares of labor, capital, and raw materials in total costs would remain constant.

Table 3. Japan and the United Kingdom: Estimation Results from Manufacturing Output and Labor Demand Equations 1/

Structural Parameter	Japan	United Kingdom 2/
c_1 2/	-0.474 (0.042)	6.632 (0.515)
c_2 2/	0.186 (0.042)	9.322 (0.602)
β 3/	0.277 (0.018)	0.165 (0.046)
σ_1 4/	0.409 (0.014)	0.518 (0.056)
σ_2 5/	0.586 (0.168)	0.540 (0.268)
λ_1	0.056 (0.005)	0.057 (0.004)
λ_2 6/	--	0.001 (0.000)
m_1	1.578 (0.278)	1.016 (0.432)
m_2	0.314 (0.126)	1.271 (0.542)
Standard error of estimate	0.048	0.045
Pearsonian squared correlation coefficient	0.99	0.95

1/ The model was estimated with annual data for 1962 through 1982 by a three-stage least-squares program that allows for across-equation constraints on parameters. Numbers in parentheses are standard errors on the corresponding parameter estimates.

2/ Differences in the constant terms reflect differences in the index bases rather than differences that are economically meaningful.

3/ Cost share of raw materials in total inputs. The shares of labor and capital were obtained from national income statistics and not estimated.

4/ Elasticity of substitution between labor and capital.

5/ Elasticity of substitution between value added and raw materials.

6/ The estimate of $\lambda 2$ for the United Kingdom was significantly different from zero at the 99 percent confidence level. The standard error was too small to be picked up in the 3 decimal place format of the table.

Table 4. Japan and the United Kingdom: The Estimated Equations with Composite Coefficients 1/

	Composite Coefficient Estimates					
	Constant	w_p	prm_p 2/	t	t^2	cyc(-1)
Japan						
1. Output per unit of capital (q-k)	-0.474 (0.417)	-0.419	-0.386	0.024	--	1.578 (0.278)
2. Labor demand per unit of capital (n-k)	0.186 (0.042)	-0.829	-0.318	-0.010	--	0.314 (0.126)
United Kingdom						
1. Output per unit of capital (q-k)	6.632 (0.515)	-1.279	-0.359	0.073	-0.001	1.016 (0.432)
2. Labor demand per unit of capital (n-k)	9.322 (0.602)	-1.797	-0.354	0.046	-0.001	1.271 (0.542)

1/ The models were estimated with data for 1962-82 by a three-stage-least squares program that allows for across-equation constraints on parameters. Where available, standard errors are given in parentheses below parameter estimates.

2/ This variable was contemporaneous in the estimates for Japan, but lagged one period in the estimates for the United Kingdom.

were only partially offset by reductions in the use of these inputs. Consequently, their shares in total costs increased at the expense of profits. Finally, the coefficients on the cyclical variable (1.58 for output and 0.31 for labor demand) indicate that a 1 percent increase of actual demand relative to trend gives rise to an almost 1.6 percent increase in manufactured output and an increase of just under one third of one percent in labor demand.

In the United Kingdom, the average share of raw materials costs in gross output is 16.5 percent. While this initially seemed rather low, it corresponded very closely to the coefficient obtained from the 1974 input-output tables. 1/ The implied average shares of labor and capital are 59.5 and 24 percent, respectively. 2/ Labor productivity growth, characterized by a quadratic in time, shows a dramatic slowing down in the latter part of the period, owing to the small but highly significant coefficient on t^2. Along this curve, productivity growth falls from about 5.6 percent at the beginning of the sample period to about 1.6 percent at the end of the period. Point estimates show both elasticities of substitution at about 0.5; but, while that between capital and labor is significantly smaller than unity at the 99 percent confidence level, that between raw materials and value added is not significantly smaller than one at the 95 percent confidence level. Clearly, higher wages reduce profits but, although the presumption from the results is that higher raw materials prices reduce the combined share of labor and capital, this latter effect cannot be asserted with a high degree of confidence. The coefficients on the cyclical variables show that manufacturing output is slightly more volatile than total expenditure. The coefficient in the labor demand equation is surprisingly large. It is probably larger than that in most other estimates for two reasons: the importance of the most recent cycle (in which there was little trace of labor hoarding) in our sample, and the use of a quadratic in time rather than a simple trend to derive the cyclical variable. The difference in labor hoarding during cyclical downturns between Japan and the United Kingdom is brought into sharp relief by the estimated values of m_2--a 10 percent fall below trend in Japanese aggregate demand reduces manhours worked in manufacturing by 1.7 percent

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1/ Gross output is defined as output of manufacturing industries less that part of output which serves as an intermediate input into other manufacturing industries. Raw materials and fuels inputs in 1974 constituted 17.8 percent of gross output. Our estimated share (β), adjusted for relative price changes given the estimated elasticity of substitution, amounted to 16.8 percent in 1974 and 18.3 percent in 1975. This is remarkably close to the input-output coefficient.

2/ This is oversimplified insofar as only three factors are admitted. In fact, the share of value added is somewhat lower when we allow inputs of other sectors such as services, construction, etc. We are implicitly assuming that the prices of labor and capital move similarly in these sectors and that the share of raw materials in these sectors is negligible.

while a similar downturn in the United Kingdom reduces manhours in manufacturing by 12.7 percent.

On the basis of the estimated equations, it is possible to separate the contributions of the various explanatory variables to output and labor demand. Table 5 does this separately for the first decade (1963-1972) and the second decade (1973-1982) of the sample period. The results are not terribly dramatic because they are averaged over 10-year periods--clearly if one were to look at single years immediately after oil price shocks or major union wage offensives they would be more dramatic. But they are in line with expectations. The fall in output growth in the second decade is striking in the United Kingdom, but even sharper in Japan. In both countries the lower rate of capital accumulation is the major explanatory factor behind the fall in growth, but, as expected, higher materials prices contribute significantly to this fall as does the dearth of aggregate demand. Interestingly, real wage costs contribute negatively to output in Japan in the first decade, but positively in the second; in the United Kingdom, the negative wage push effects worsen from the first to the second decade. The labor demand equations exhibit similar causal influences, with a sharp negative effect from wages in the first decade in Japan that is turned around in the second, and a worsening of the real wage position in the United Kingdom.

III. Wage Push, Factor Shares, and Employment

In comparing actual wage movements with those warranted by underlying conditions, the conventional model focusses on cost shares of factors of production and defines warranted wage movements as those that are consistent with constant cost shares in value added. This is a reasonable approach if one is concerned with the incidence of the burden of an increase in raw materials prices--fixed cost shares in value added would mean an equal sharing of the burden. Over time, however, there are likely to be other influences on warranted wage movements. For example, in a situation with relatively abundant capital but a binding labor supply constraint, the market-clearing wage rate might well be above that which maintains fixed cost shares. To calculate the warranted wage in this situation, a labor-supply function must be added to the labor demand equation estimated in the previous section. In addition, the elasticity of substitution between capital and labor becomes relevant to the determination of the warranted wage rate.

In the sections that follow we start with the conventional analysis, proceed to considerations of the labor supply and finally recalculate warranted wage movements that are consistent with our estimated equations and a given supply of labor. While the policy implications for the 1980s are not much affected by differences between the conventional analysis and the more elaborate calculations, the latter do help resolve some puzzles raised by the conventional analysis.

Table 5. Japan and the United Kingdom: Components of Change in Output and Labor Demand, 1963-1982

(Annualized percentage changes)

	1963-1972		1973-1982	
	Japan	United Kingdom	Japan	United Kingdom
Output	11.561	3.037	3.222	-1.235
Of which:				
Wages 1/	-2.855	-0.987	0.680	-1.620
Capital	12.885	4.175	6.335	2.014
Materials prices	-0.346	0.194	-2.653	-1.288
Cyclical influence	1.404	0.084	-1.069	-0.386
Unexplained residual	0.473	-0.429	-0.071	0.045
Labor demand	1.611	-1.540	-0.288	-3.910
Of which:				
Wages 1/	-5.640	-1.387	1.344	-2.276
Capital	12.885	4.175	6.335	2.014
Materials prices	-0.285	0.192	2.187	-1.272
Cyclical influence	0.279	0.105	-0.213	-0.483
Labor-saving technology	-5.635	-3.943	-5.635	-1.708
Unexplained residual	-0.007	-0.682	-0.358	-0.185

1/ Adjusted for changes in productivity.

1. Actual and warranted wage increases: the conventional analysis

In the production functions from which the estimated equations were derived the degree of homogeneity was set at unity to ensure that the total product would be exactly exhausted if factors were paid their marginal products. On the basis of estimated factor shares it is therefore possible to disaggregate the unit output price of manufactures into wage costs, raw materials costs, and the cost of capital per unit of output. In percentage changes (that is, differences of logarithms, represented by dots over variables), therefore:

$$\dot{p} = \alpha(\dot{w} - \dot{prod}) + \beta \dot{prm} + \gamma \dot{r} \qquad (3)$$

where α, β, and γ are respectively cost shares of labor, materials, and capital in gross output, and

p = Output price.

w = Nominal wage rate.

prod = Labor productivity.

prm = Nominal price of raw materials.

r = Nominal cost of capital per unit of output.

Expressing all prices in terms of output prices and rearranging (3), the relationship between the real cost of capital per unit of output and relative price changes is:

$$\dot{r}_p = -(\alpha/\gamma)(\dot{w}_p - \dot{prod}) - (\beta/\gamma)\ \dot{prm}_p \qquad (4)$$

where p subscripts denote nominal prices relative to output prices. Clearly, increases in real wages in excess of productivity growth and in real prices of raw materials reduce the share of output going to capital. Since changes in the latter translate into changes in the rate of return on capital when changes in the capital stock are small, r_p directly affects investment incentives.

Equation (4) is particularly useful in highlighting the fundamental relationship between wage behavior and capital's share of output and, therefore, in formulating an objective for wage determination given developments in productivity and raw materials prices. In the extreme, for example, one could set as an objective that wages adjust to maintain

a constant real flow to capital per unit of output (i.e., $\dot{r}_p = 0$). This would require that wages bear the entire burden of terms of trade changes and adjust according to the following formula.

$$\dot{w}_p = \dot{prod} - (\beta/\alpha)\ \dot{prm}_p$$

For Japan, given the estimated factor shares, product wages would have to decline by approximately three quarters of a percentage point for every 1 point increase in the relative price of raw materials; for the United Kingdom the coefficient is lower at slightly over a quarter. During the latter decade of the sample period, this would have required an increase in real product wages of 18 percent in Japan and 13 percent in the United Kingdom compared with the increases of 40 percent and 30 percent, respectively, that actually occurred.

An alternative, and probably more reasonable, objective for wage adjustments, given the large changes in raw materials prices in recent years, is the maintenance of the shares of labor and capital in value added, or, equivalently, the equal sharing by capital and labor of any terms of trade loss resulting from increases in materials prices. Wage changes following this objective, which we call "warranted" changes in real wages (ww_p), can be characterized as follows:

$$\dot{ww}_p = \dot{prod} - (\beta/(1-\beta))\dot{prm}_p \qquad (5)$$

In calculating warranted real wage changes according to the formula in equation (5), the price of labor relative to capital is held constant by construction so that, even if the elasticity of substitution between capital and labor differed from unity, the shares of these factors in value added would not change. No such construction, however, is applicable to the share of raw materials (β) in gross output, so that insofar as the elasticity of substitution is less than unity, the share of raw materials will vary positively with the relative price of raw materials. For this reason, in calculating warranted real wage changes it is necessary to adjust the estimated average β for relative price changes using the estimated elasticity of substitution. 1/

Before proceeding to compare actual and warranted real wage movements in Japan and in the United Kingdom, it is useful to compare the starting points--in 1961 the share of labor in value added in Japan was 44 percent, while that in the United Kingdom was 69 percent. Labor appropriated so much larger a portion of value added in manufacturing in

1/ The precise adjustment required is shown in Appendix II.

the United Kingdom at the beginning of the sample period that a substantial and sustained larger wage gap--that is, actual less warranted real wage increases--in Japan would be required before factor shares could be equalized. However, while market forces might tend to produce factor price equalization, this need not imply factor share equalization.

The top panel of Chart 2 shows actual and warranted changes in real wage rates in Japan while the bottom panel shows the corresponding real wage levels. In Chart 3 the same information is provided for the United Kingdom. The data are quite dramatic and, superficially at least, seem to undermine the conventional perceptions of the two countries. In Japan actual wages rise more rapidly than warranted by our calculations from the second half of the 1960s, thereby opening up a sizable wage gap. By the beginning of the last decade of the sample period, 1973, the actual real wage level in Japan is already some 20 percent higher than the warranted level, while in the United Kingdom there is still no significant difference. Subsequently, in both countries the input price disturbances and the slowdown in productivity growth sharply reduced warranted rates of change of real wages.

It is interesting to compare the performance of Japan and the United Kingdom in each of the two decades of the sample period. To facilitate this comparison, wage gap indices are computed separately for the two subperiods. 1/ The top panel of Chart 4 shows wage gap indices for the two countries (based so that 1967 = 100) during 1963-1972. In this decade--one of rapid (11 1/2 percent annual average) expansion of output in Japan and modest (3 percent annual average) expansion of output in the United Kingdom--the indices show a substantial wage gap emerging in Japan with virtually none emerging in the United Kingdom. Notably, the dip in the wage gap in 1967-68 in the United Kingdom coincided with the devaluation of sterling in November 1967. This suggests that the devaluation was sustained, at least for a couple of years, in real terms. Despite the much larger wage gap indicated for Japan, by the end of this decade the share of labor in value added in Japanese manufacturing had risen to only 48 percent, compared with 69 percent in the United Kingdom.

The bottom panel of Chart 4 shows wage gap indices for 1973-1982 (based so that 1977 = 100). In this decade, which was characterized by a deterioration of output performance and an erosion of the share of profits in value added in both countries, the wage gap in the United Kingdom worsened by more than that in Japan. In Japan, actual real wages increased considerably more rapidly than warranted rates during the two years following the 1973 oil price hike. After 1975,

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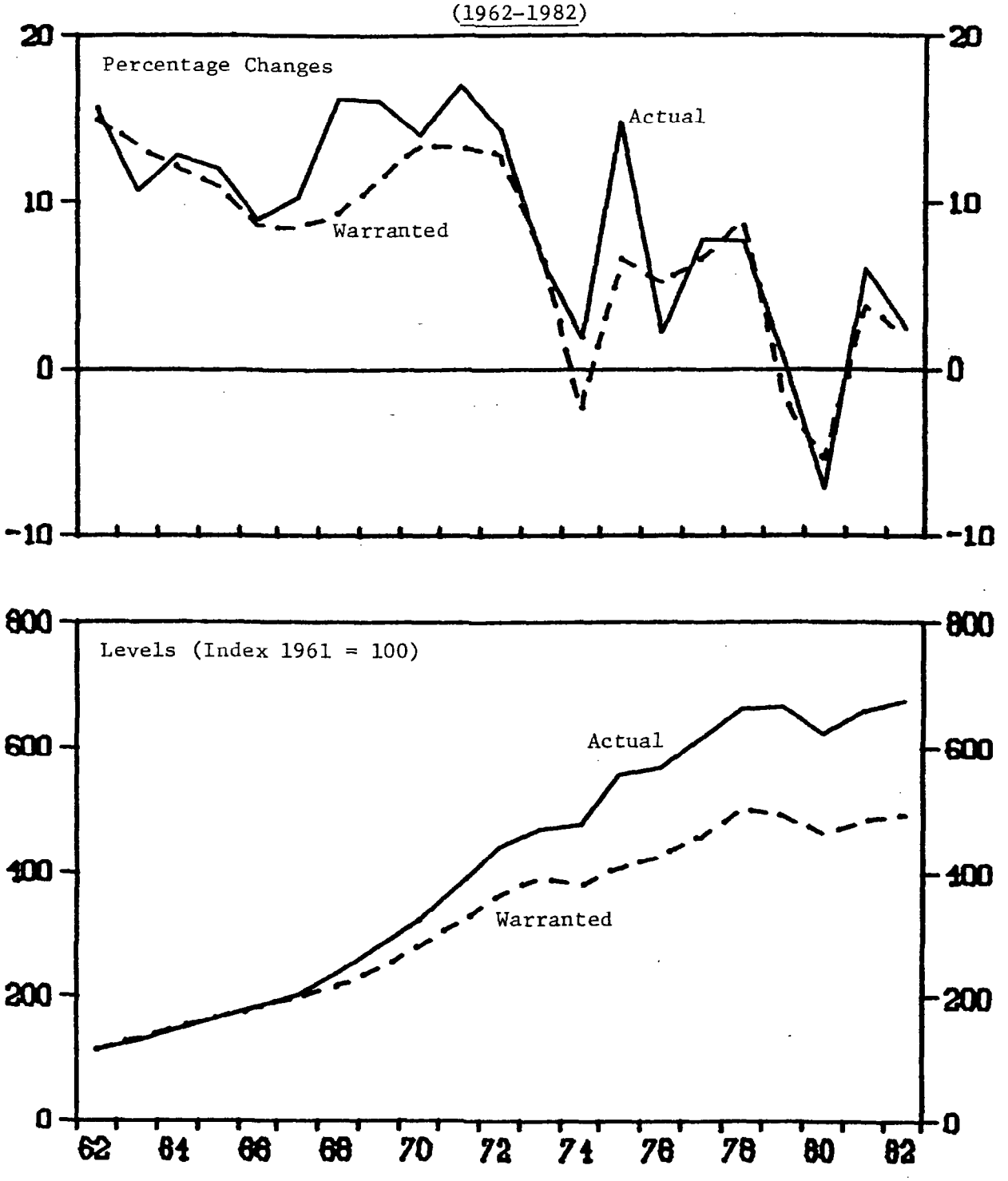
1/ For each country, the wage gap index is simply an index of the actual over the warranted real wage level.

CHART 2

JAPAN

ACTUAL AND WARRANTED REAL WAGE DEVELOPMENTS

(1962-1982)



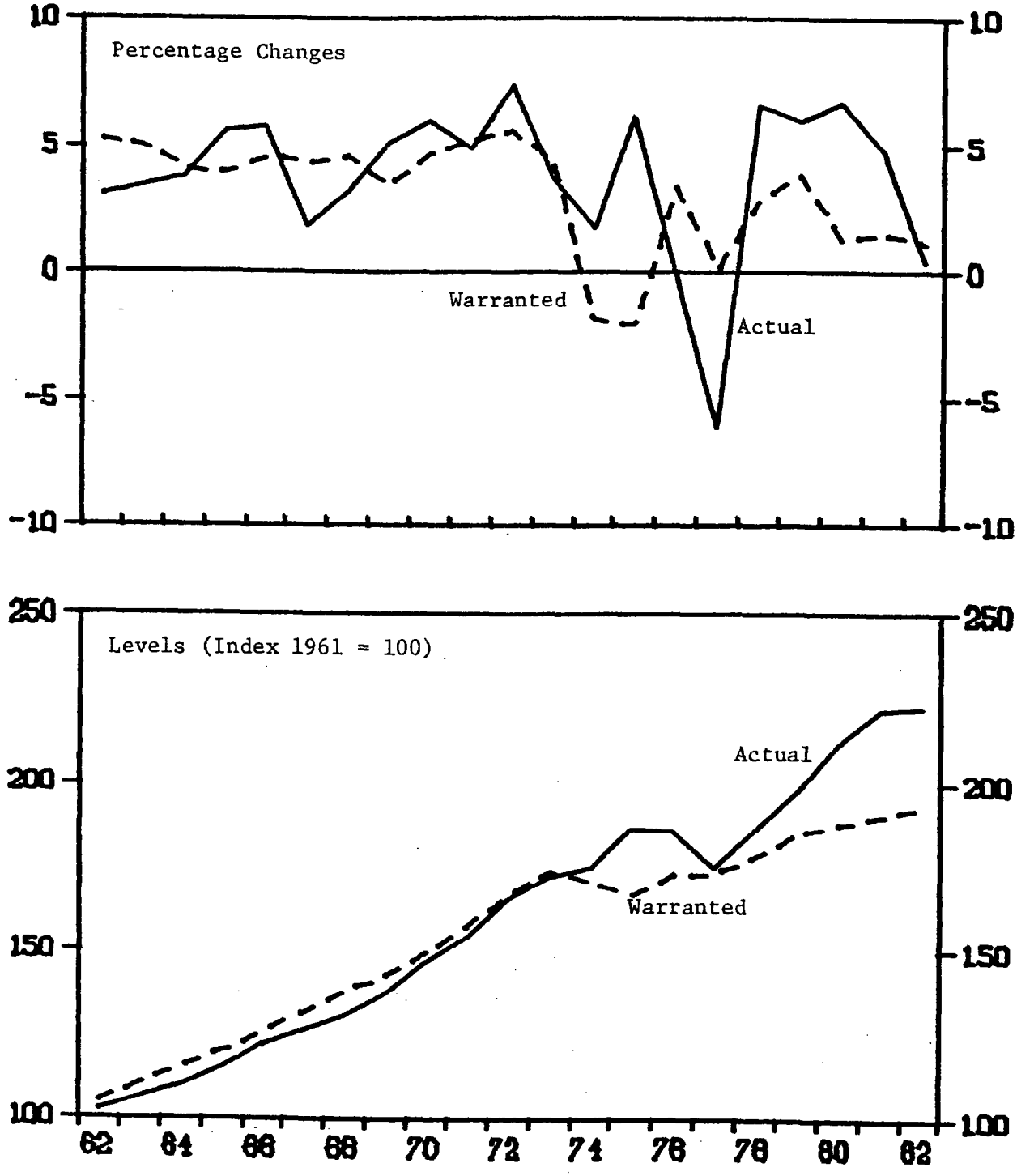
Source: Data sources are listed in Appendix I.

CHART 3

UNITED KINGDOM

ACTUAL AND WARRANTED REAL WAGE DEVELOPMENTS

(1962-1982)



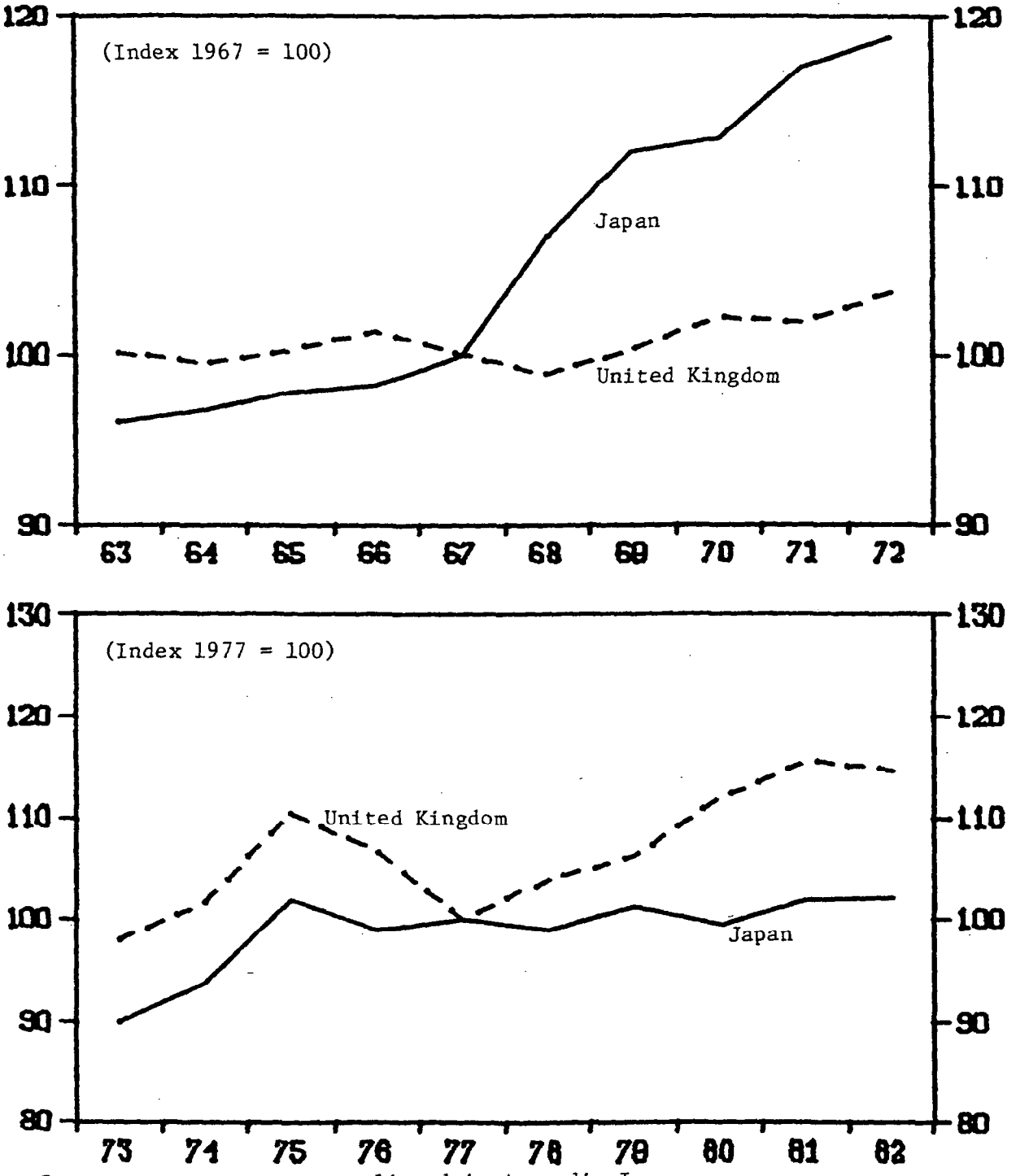
Source: Data sources are listed in Appendix I.

CHART 4

JAPAN AND THE UNITED KINGDOM

WAGE GAP INDICES 1/

(1963-1982)



Source: Data sources are listed in Appendix I.

1/ The wage gap is measured simply as an index of the actual over the warranted real wage level.

however, the wage gap index saw no further increase for the rest of the sample period. In the United Kingdom too, real wages rose rapidly during 1974 and 1975 despite the reductions in the warranted rate of increase. Wage settlements in 1973-74 were influenced by the Stage III incomes policy which encouraged cost-of-living adjustments in private wage agreements. A sharp downward adjustment, or correction, was achieved during 1976-77, with real wages falling by more than 6 percent over the two-year period, but subsequently the position deteriorated rapidly.

Developments during the most recent period--say 1975-82, giving the economies a year to adjust after the first oil shock--provide a useful perspective on the problems that policymakers in these countries face at present. Manufacturing output and employment have been depressed by historical standards in both countries, but while the annual average growth rates of these variables simply slowed in Japan, in the United Kingdom output and employment actually fell. In Japan, the first wave of increases in materials prices in 1973-74 lowered the share of capital in value added but, after 1975, shares stabilized, and there was no significant further erosion of capital's share. Both the sharp decline in the growth of the capital stock in manufacturing and, to a lesser extent, the cyclical position of the economy, however, had a negative influence on both output and employment. In the United Kingdom the wage gap widened significantly after the 1976-77 adjustment. At the same time, changes in the cyclical position and a slowdown in the growth of the capital stock were important factors behind the decline in output and employment.

2. The supply of labor and the real wage

In examining the data thus far, it has been difficult to draw valid inferences because of the partial equilibrium nature of the analysis. The implicit assumptions behind this sort of wage gap measurement are that the price of labor is set exogenously and that employment is determined by demand. In modeling manufacturing alone, it is difficult to take account properly of changes in the supply of labor. A shift of the labor demand function in some other sector would affect the supply to manufacturing in a manner quite independent of developments in manufacturing. Nevertheless, to appreciate the differences between Japan and the United Kingdom, it is useful to depart for a moment from the formal, exogenous-wage model, and to consider simultaneously the demand for and supply of labor.

As has been noted, the substantial (14 percent annual average) rise in real wages in Japan between 1966 and 1972 was very much greater than the (11 percent annual average) rate required to maintain factor shares in value added. It is not clear, however, whether this sharp increase in labor's share in value added was due to wage push or was an

equilibrating response to a labor supply constraint. To answer this question, it is useful to look at what would have happened to output growth and the demand for labor if actual wage rates had moved like warranted wage rates--that is if wages had moved simply to maintain factor shares in value added.

Between 1966 and 1972, actual output in manufacturing in Japan rose at an annual average rate of 12 percent and employment rose at an annual average rate of 1.3 percent. If wages had moved simply to maintain distributional shares, output would have risen at an average rate of almost 15 percent and labor demand at an average rate of 4.5 percent per year. Even with the rapid actual real wage increases, the total labor force rose by only 1.1 percent per year so that an annual increase of 4.5 percent in employment in manufacturing would have been quite impossible, especially given the growth of the services sector (Chart 5). It would be difficult not to conclude from this exercise that at least prior to 1973 actual wage increases in Japan were largely a market equilibrating phenomenon. Wage increases, if not "warranted" in the sense of maintaining factor shares, were certainly warranted in the sense of reconciling the demand for labor with the scarce supply. In contrast, the large increase in actual wages (and the share of labor costs in output) between 1973 and 1975 coincided with a sharp drop in the demand for labor; this suggests that wage movements were not simply a market clearing mechanism in these two years.

In the United Kingdom, the view that employment is demand determined, that the supply of labor is not an important constraint on employment in manufacturing, and that wage rates are not determined so as to clear the labor market is more plausible. In the first decade of the sample period, when actual wage movements were close to warranted wage movements, employment (that is manhours) in manufacturing fell on average by 1 1/2 percent per annum; in the second decade, despite an average annual reduction in employment of more than 3 1/2 percent, actual real wage increases exceeded warranted increases on average by 1 1/2 percentage points per year. Obviously, the classical wage-employment mechanics are being obscured to some extent by structural change as the share of the manufacturing sector in the economy shrinks. But it is clear from unemployment developments in the most recent period that the fall in manufacturing employment is not a matter of workers being bid away by other sectors as the economic structure adjusts. Rather, the fall in manufacturing employment and the wage push have coincided with growing unemployment.

3. An alternative warranted wage calculation

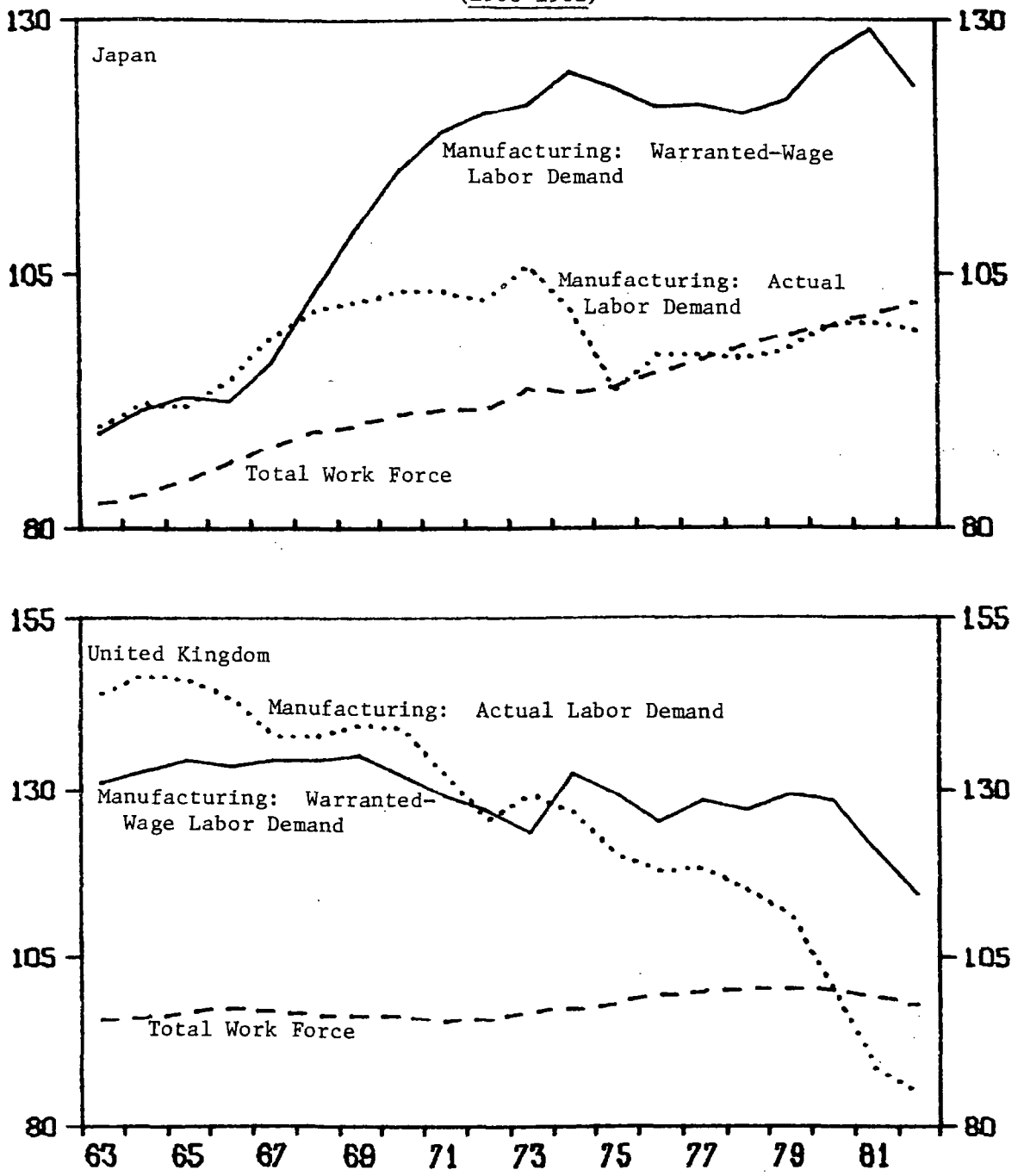
An alternative approach to the wage gap analysis that takes account of the supply of labor relative to that of capital and the elasticity of substitution between them may be derived by inverting equation (2) and setting labor demand equal to labor supply (which

CHART 5

JAPAN AND THE UNITED KINGDOM

LABOR DEMAND IN MANUFACTURING AND TOTAL LABOR FORCE GROWTH 1/

(1963-1982)



Source: Data sources are listed in Appendix I.

1/ Labor demand in manufacturing is measured in hours worked. Warranted-wage labor demand is obtained by simulating labor demand setting wage rates equal to warranted-wage rates. The actual labor demand in manufacturing and the total work force are measured as indices with the value in 1980 set equal to 100. The simulated warranted-wage labor demand is derived from the estimate of equation (2).

again, very simplistically, is assumed to grow at the same rate as the total work force). The following equation for the warranted change in the real wage rate results.

$$\dot{ww}_p = \lambda_1[1- \gamma/\sigma_1(1- \beta)] - \lambda_2[1- \gamma/\sigma_1(1- \beta)](t^2 - t(-1)^2)$$
$$- (\beta/(1-\beta))\dot{prm}_p + (\gamma/\sigma_1(1-\beta))(\dot{k}-\dot{n}) + m_2(\gamma/\sigma_1(1-\beta))\dot{cyc}(-1) \quad (6)$$

Of course, this is not an entirely satisfactory procedure insofar as the total workforce is that available to the economy as a whole and not to the manufacturing sector alone. The analysis rests, therefore, on the assumption that a constant share of the labor force is available to manufacturing industry. A further weakness is that the labor supply is assumed to be unaffected by the wage rate. Even with these weaknesses the methodology seems more defensible than the conventional model.

The wage gap indices derived by this method are shown in Chart 6, which, for ease of comparison, is set up identically to Chart 4. In the first decade of the sample period, the wage gap that emerged for Japan in the conventional analysis (and that appeared to be related to a labor supply constraint), is now entirely absent. Indeed, the actual wage relative to the warranted wage falls by about 2 percent over the decade. The difference between the results of this analysis and the conventional analyses is largely due to the explicit introduction of the capital/labor ratio which grew very rapidly throughout the period until 1973. This, of course, produced a large warranted increase in labor's share. The performance of the United Kingdom over the same period is slightly less satisfactory than it seemed from our initial calculations; the wage gap increases by 6 percent over the period compared with an increase of less than 4 percent in the conventional calculation.

During the second decade of the sample period, the wage gap that emerges from this analysis is somewhat larger than in the conventional calculations, but the pattern of changes is similar. In both countries, there is a large increase in the wage gap in the immediate aftermath (1-2 years) of the first oil price increase. In the United Kingdom, this is corrected sharply in 1977 with both real wages and the wage gap reduced by about 7 percent. Subsequently, there is a continuous deterioration in the wage gap in the United Kingdom which is exacerbated by the second oil shock. In Japan, there is no correction of the wage gap that emerged after the first oil shock but the adjustment to the second oil shock is far better than that in the United Kingdom. While the wage gap in Japan increased by less than 2 percent between 1978 and 1982, it increased by 14 1/2 percent during the same

period in the United Kingdom. Purged of cyclical influences, the gap increased by only slightly more than 1 percent in Japan but by 11 percent in the United Kingdom.

To gain some perspective on considerations relevant to the current stance of policy, it is again useful to examine more closely developments during 1975-82. Developments affecting labor's position in wage negotiations and the evolution of the real economy contributed to the determination of wage gaps during this period. Fluctuations in nominal exchange rates, which frequently translated into changes in the real exchange rate--measured as relative unit labor costs--constituted an additional influence on wage gaps. To the extent that labor costs are sticky in domestic currency terms, and international competition limits changes in foreign currency prices of output, a real depreciation tends to redistribute income away from labor toward capital. It therefore enhances international competitiveness and, in our terminology, reduces the wage gap relative to that in trading partners.

In Japan, the relative stability of the wage gap between 1975 and 1982 is impressive when viewed against the exchange rate and raw material price developments during the period. The yen appreciated against the U.S. dollar by 57 percent between early 1976 and late 1978; dollar prices of Japanese products, however, were allowed to increase by about 52 percent, so that export prices in yen terms declined by only about 5 percent. The needed restraint on wage increases was facilitated by the moderation of consumer price increases as a result of a decline in import prices. Consequently, actual wages moved in line with warranted wages. The response of wages to the second round of oil price increases was contained by two factors; first, the excessive wage growth following the first oil price increase had produced a consensus that sharing the burden of a terms of trade loss in order to minimize disruptions to output and employment was beneficial to both employers and employees. The wage restraint in the first yearly wage negotiation after the 1979 oil price increases resulted in a 7 percent fall in real wages in 1980. Second, the sharp depreciation of the yen between late 1978 and early 1980 tended to put downward pressure on real wages and enhance profitability. Consequently, there was an almost 4 percentage point reduction in the wage gap in 1980. By 1982, the wage gap was still 2 percentage points below the 1979 peak.

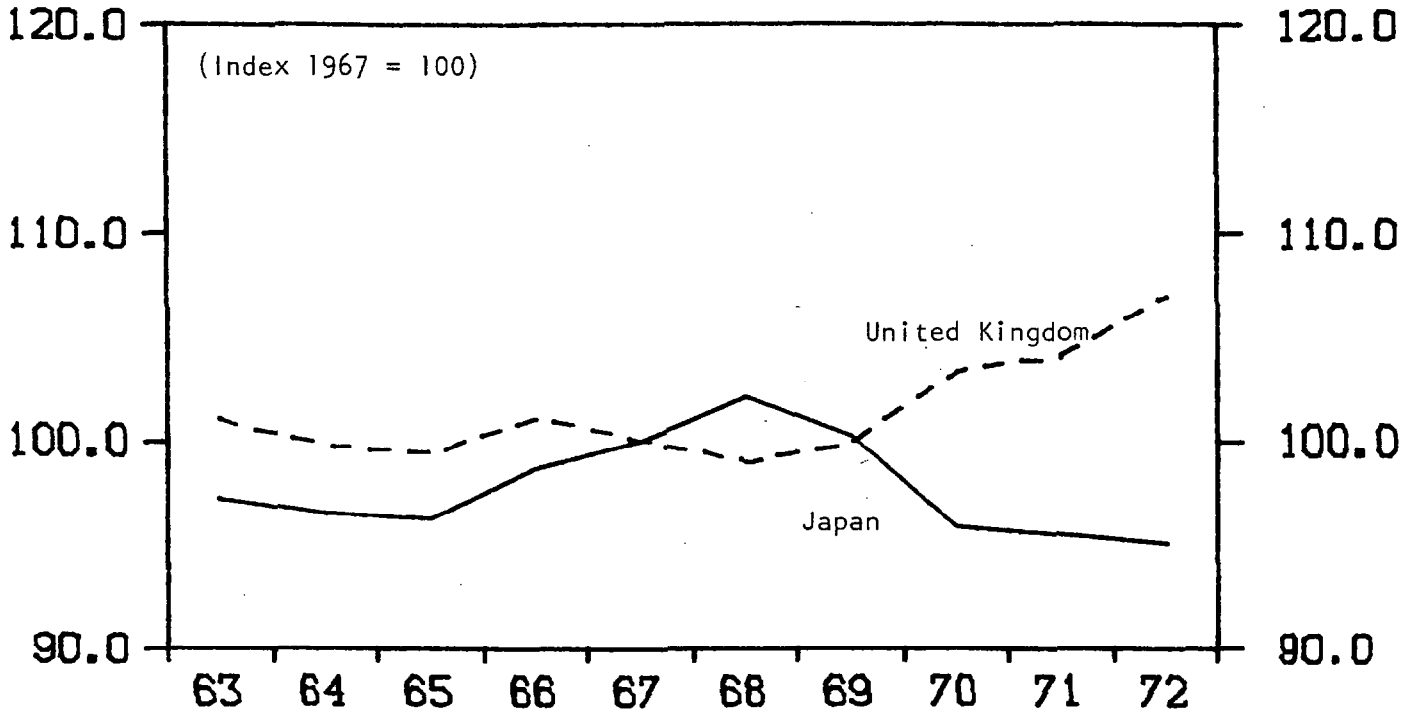
In the United Kingdom the period is characterized by quite distinct phases. The real wage correction in 1976-77, after the widening wage gap of the previous two years, was remarkable. In August 1975 (the beginning of the 1975-76 pay round) an incomes policy was introduced. While this was largely abided by through 1977, it had little apparent effect on the perception of the value of sterling in the foreign exchanges. Thus, while the annual rate of change of average earnings in manufacturing fell from 21 1/2 percent in 1973-75 to less

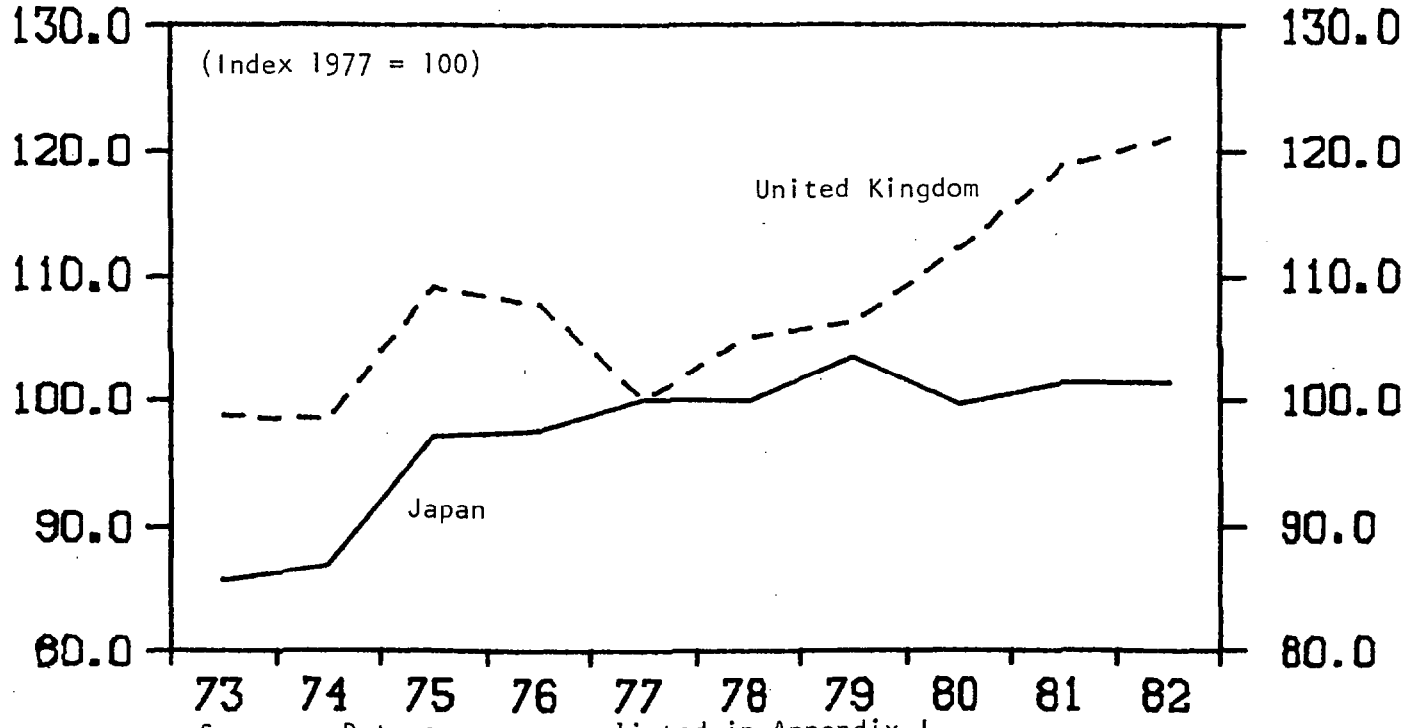
CHART 6

JAPAN AND THE UNITED KINGDOM

ALTERNATIVE WAGE GAP INDICES 1/

(1963-82)





Source: Data sources are listed in Appendix I.

1/ The wage gap is measured simply as an index of the actual over the warranted real wage level.

than 13 1/2 percent in 1976-77, 1/ the average effective value of sterling in 1976-77 was some 17 percent lower than in 1975.

The second phase saw a rapid deterioration. 2/ The incomes policy began to come undone and was abandoned by the new government in 1979, and the coincidence of a host of developments conspired to exacerbate the situation. First, the emergence of the United Kingdom as a major oil producer together with the rise in the price of oil strengthened the external payments position and increased the value of sterling on the exchanges. Second, the announcement and implementation of the strongly anti-inflationary strategy in 1979-80 had inconsistent effects in different markets. The strategy was immediately credible in financial markets--sterling appreciated and long-term interest rates fell below short rates for the first time in the decade. In the labor market, however, the response was perverse as the credibility of the policy was undermined by the substantial increase in public sector pay, the price effects of the near doubling of the value-added tax, and higher oil prices. Average earnings in manufacturing rose at an annual rate of 15.5 percent--or 2.5 percent in real terms--between 1978 and 1981 despite low productivity growth and rising unemployment. The coincidence of higher labor costs and a stronger exchange rate led to a real appreciation of sterling of about 60 percent between 1978 and the peak in the first part of 1981. This produced a rapid erosion of profitability, and a substantial worsening of the competitive position of British manufacturing industry.

The third phase, which began in 1981, is still too young to be fully assessed. Preliminary evidence suggests that the anti-inflationary policy of the authorities has now won credibility in the labor market (albeit at a substantial cost), that a new realism in pay bargaining has emerged, and that there has been a substantial acceleration of productivity. The reduction in the wage gap, evident in the conventional measure, is obscured by the cyclical effect in the alternative measure; purged of the cyclical effect, the latter measure shows a fall in the gap of one half of one percent in 1982. This implies that while there is some wage restraint, it has not been adequate to absorb the labor force.

IV. Some Tentative Conclusions

The analysis of the preceding sections leads to some tentative conclusions. First, as may be expected, the influence of raw materials and fuels prices on manufacturing output and employment becomes sharply

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1/ The rate of change in real terms fell from -1 percent per annum in the former period to -5 percent per annum in the latter period.

2/ See Buiter and Miller (1981) and (1983).

negative for both countries in the second decade (1973-1982) of the sample period. In the first decade (1963-1972), raw materials cost developments had exerted a mildly positive influence on average in the United Kingdom and a slightly negative influence in Japan. A more interesting distinction between the countries relates to the effects of wage developments and the cyclical positions. In Japan in the first decade of the sample, cyclical influences were on average positive with respect to output and employment, while labor cost developments had a strong negative effect. In the second decade, cyclical influences became negative, and labor cost developments had a positive influence. In the United Kingdom, however, both cyclical and labor cost developments worsened from the first to the second decade of the sample period.

Secondly, an answer to the puzzle of the enormous wage gap in the conventional analysis--that is, the rapid increase in real wages--in Japan between 1966 and 1972 that coincided with a period of rapid output growth is suggested by either our simulation exercise or our model-based wage gap calculations. This wage expansion appears to have been necessary to balance the rapidly growing demand for labor with the much slower labor force growth. While wage movements in Japan appear usually to be responsive to market forces, in the United Kingdom it appears that large wage increases have often occurred despite considerable excess supply in the labor market.

Thirdly, during the last few years of the sample period, excessive real wage growth has been much more of a problem for output, employment, and profit shares in the United Kingdom than in Japan. The recent history underscores the generalization that emerges from the entire sample period: in Japan increases in labor's share in value added have tended to occur during periods of expansion and binding labor supply constraints; in the United Kingdom sharp increases in the share of labor costs have generally been correlated with recession and a fall in the demand for labor.

Four implications for macroeconomic policy emerge from a comparison of the data analyzed and the simple model illustrated in Figure 1. 1/ In both countries, the weak cyclical position indicates that short-run gains in output and employment may be obtained by expansionary demand management. Present labor market conditions, however, suggest that these gains would be smaller in the United Kingdom than in Japan. Secondly, the sustainability of any such gains would depend upon whether an expansion of demand would elicit higher real wage demands. A priori

1/ It should be clear that the partial equilibrium nature of the estimated model prevents a firm conclusion on the sustainability of gains from more expansionary demand management policies. The analysis in this paper is designed rather to assess the relative cost position of manufacturers as one factor that could limit the effectiveness of such policies for countercyclical purposes.

one might expect this danger to be more present in Japan where there is relatively less slack in the labor market, but the history of wage developments in the United Kingdom is less than comforting on this question. Another important factor is the response of capital investment to an expansion of demand. The relatively more favorable evolution of capital's share in value added in Japan during recent years may mean that Japanese manufacturers are better placed to invest as a cyclical upturn occurs. Thirdly, in view of the size of the wage gap in both countries, policies to reduce the overhead costs of employment (such as the employers' national insurance surcharge in the United Kingdom) are sensible; however, since unemployment is less of a problem and labor hoarding more of a problem in Japan than in the United Kingdom, the argument for such policies is stronger for the United Kingdom. Finally, the analysis underscores the critical importance of one of the most fundamental policy initiatives of the present British Government--that of altering the nature of wage bargaining to make it more responsive to market forces. Insofar as changes in labor legislation and bargaining practices achieve this end, a different pattern of comparative data might be forthcoming over the next decade.

APPENDIX I

Data Sources

1. Japan

Five data sources were used.

a. U.S. Department of Labor: International Comparisons of Manufacturing Productivity and Labor Cost Trends.

Total hours worked in manufacturing (N) and total hourly compensation for employees (W) were taken from this source. The hourly compensation series includes workers' earnings plus social security contributions paid by employers.

b. Economic Planning Agency: Stock of Capital in Private Enterprises.

The gross capital stock of private manufacturers excluding work in progress in 1975 prices (K) and gross fixed investment by private manufacturers in 1975 prices also excluding work in progress were taken from this source.

c. Bank of Japan: Prices Indexes Annual, various issues, and Economic Statistics Annual, various issues.

From these sources, the price index of manufactured output (P), the price index of raw materials inputs (PRM), manufactured output (Q), consumer prices, and the long-term interest rate were taken. The output price index is the index for prices of manufactured goods taken from the wholesale price index. While WPI coverage and weights differ from those that are appropriate for an output price index, the WPI series for output prices was compared to an index of manufactured output prices (available only since 1967) and found to be very similar. The price index for raw materials is the wholesale price index for raw materials, taken from the wholesale price index by special use.

d. Economic Planning Agency: Annual Report on National Income Accounts, various issues.

Gross national expenditure, used to calculate the cyclical indicator (cyc) and shares of labor and capital in value added were taken from this source. The share of capital is calculated as

$$\frac{OS + DEP}{GO - IIM - IBT}$$

where OS = operating surplus
DEP = depreciation
GO = gross output in the manufacturing sector
IIM = intermediate inputs
IBT = indirect business taxes less subsidies

The share of labor is simply the ratio of total labor compensation (including social security contributions by employers) to gross output less intermediate inputs and indirect business taxes less subsidies.

e. International Monetary Fund - Research Department.

Data on productivity normalized to remove cyclical influences, as calculated in Artus (1977), was obtained on request.

2. United Kingdom

Six data sources were used.

a. Central Statistical Office: Economic Trends, various monthly issues and the annual supplement for 1983.

The series from this source were *manufacturing output* (Q), *gross* fixed investment in manufacturing, the output price index (P), the raw materials and fuels input price index for manufacters (PRM), GDP expenditure estimate in constant market prices (from which the cyclical indicator (cyc) was calculated), and total labor force. It is worth noting that the index of manufacturing output and the manufacturing output price index are based on gross output--that is, they do not net out that part of manufacturing output that goes back into the manufacturing sector as an input. Our implicit assumption is that the share of gross manufacturing output that goes back into manufacturing is more or less constant over time in both value and volume.

b. Central Statistical Office: National Income and Expenditure, various issues.

The shares of labor and capital in value added in manufacturing were obtained from this source.

c. Business Monitor: Input-Output Tables for the United Kingdom (1974), compiled by the Central Statistical Office.

This source was used to check the estimated value of the share of raw materials in total factor costs (β) (see footnote 1 page 11). In the calculation, the numerator was total purchases of fuels and raw materials by manufacturing industry from both domestic and foreign sources. The denominator was gross output of manufacturing industry less those intermediate inputs purchased from other domestic manufacturers. It is worth noting that only three factors of production are admitted--labor, capital, and raw materials. Inputs from other sectors --such as services--are aggregated in with labor and capital, thereby raising the estimate of value added as a proportion of gross output. This presents less of a problem to the extent that labor and capital are the principal inputs in these other sectors, and prices of labor and capital are arbitraged between sectors.

d. U.S. Department of Labor: International Comparisons of Manufacturing Productivity and Labor Cost Trends.

Total hours worked in the manufacturing sector (N) as well as nominal hourly earnings (W) were taken from this source. Hourly earnings are calculated from the perspective of costs to employers; as such they contain employer's national insurance contributions for employees as well as national insurance surcharges.

e. The Bank of England.

Data on the cost of capital and the pretax real rate of return on capital were supplied by the Bank of England on request. These data are revised and updated each year in the June issue of the Quarterly Bulletin of the Bank of England. For a description of the methodology employed in their derivation, see the March and June 1976 issues of the Bulletin (Volume 16, Nos. 1 and 2).

f. International Monetary Fund - Research Department.

Data on productivity normalized to remove cyclical influences and on the capital stock in manufacturing were obtained on request. Both series are based on calculations in Artus (1977).

APPENDIX II

Derivation of Estimated Output and Labor Demand Equations

1. The Labor Demand Function[1] We start with a two tier CES production function:

$$1. \quad V^{\rho 1} = a[N \cdot \exp(\lambda_1 t - \lambda_2 t^2)]^{\rho 1} + (1-a)\, K^{\rho 1}$$

$$2. \quad Q^{\rho 2} = bV^{\rho 2} + (1-b)RM^{\rho 2}$$

Equation (1) describes value added (V) as a function of labor (N) and capital (K) inputs, with technical progress characterized as a quadratic in time. The symbox exp( ) denotes the exponent of the term in parentheses. Equation (2) describes gross output (Q) as a function of value added and raw materials (RM) inputs. Both equations are restricted to exhibiting constant returns to scale; $\rho_1 = (\sigma_1 - 1)/\sigma_1$ and $\rho_2 = (\sigma_2 - 1)/\sigma_2$ where σ_1 is the elasticity of substitution between labor and capital and σ_2 is the elasticity of substitution between value added and raw materials.[2]

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1. The derivations presented in this appendix draw heavily on Bruno and Sachs (1979) and (1982).

2. The use of two-tier production functions does have certain restrictive implications for substitution among the three-factors of production. For example, the separability of raw materials implicit in the two-tier production functions ensures that an increase in the price of raw materials reduces the demand for labor. If the three factors of production were included in a single production function this would not necessarily be the case. Various empirical studies of the United States and Japan, however, suggest that the restrictive form of the production function is not inconsistent with the data. See Berndt and Wood (1979) and Lipton (1979).

APPENDIX II

Taking first differences of natural logarithms of the first order conditions of equation (1) (ignoring technical progress for the moment) gives the following marginal product conditions:

$$3. \quad -\frac{1}{\sigma_2}(\dot{v}-\dot{q}) - \frac{1}{\sigma_1}(\dot{n}-\dot{v}) = \dot{w}_p$$

$$4. \quad -\frac{1}{\sigma_2}(\dot{v}-\dot{q}) - \frac{1}{\sigma_1}(\dot{k}-\dot{v}) = \dot{r}_p$$

where small letters of variables (except for t) denote logarithms, dots represent first differences, w_p is the wage rate and r_p the capital cost in terms of product prices. Substituting equation (4) into equation (3) yields

$$5. \quad \dot{n} - \dot{k} = -\sigma_1 \dot{w}_p + \sigma_1 \dot{r}_p$$

Given homogeneity of degree one, from the dual of the production function, we know that:

$$6. \quad \dot{r}_p = -\left(\frac{\alpha}{\gamma}\right)\dot{w}_p - \left(\frac{\beta}{\gamma}\right)\dot{prm}_p$$

where prm_p is the raw material price in terms of product price and α, γ, and β are, respectively, the cost shares of labor, capital and raw materials in gross output.

The labor demand function is derived by substituting equation (6) into equation (5) and recalling, from the adding up condition, that $\alpha+\beta+\gamma=1$, such that

$$7. \quad \dot{n} - \dot{k} = -\left[\sigma_1(1-\beta)/\gamma\right]\dot{w}_p - \sigma_1\left(\frac{\beta}{\gamma}\right)\dot{prm}_p$$

It is estimated in level form with a constant and with the technical progress terms reinserted.

2. Output

From equations (1) and (2), the partial derivative of gross output with respect to the labor input is:

$$8. \quad \frac{\partial Q}{\partial N} = ab\, N^{-1/\sigma_1}\, V^{(1/\sigma_1 - 1/\sigma_2)}\, Q^{1/\sigma_2}$$

which we may set equal to w_p as a first-order condition. In first differences of logarithms, this may be written as

$$9. \quad \sigma_2\, \dot{w}_p = \dot{q} - \left(1 - \frac{\sigma_2}{\sigma_1}\right) \dot{v} - \left(\frac{\sigma_2}{\sigma_1}\right) \dot{n}$$

Given constant returns to scale, factor shares sum to unity, therefore

$$10. \quad Q = W_p N + R_p K + PRM_p\, RM$$

With fixed factor shares, this adding-up condition may be rewritten as

$$11. \quad \dot{q} - \dot{k} = \alpha(\dot{n} - \dot{k}) + \beta(\dot{rm} - \dot{k})$$

and

$$12. \quad \dot{v} - \dot{k} = \left(\frac{\alpha}{1-\beta}\right)(\dot{n} - \dot{k})$$

Substituting equation (12) into eqution (9) and rearranging yields:

$$13. \quad \dot{n} = -\left(\frac{\sigma_2}{\eta}\right)\dot{w}_p + \left(\frac{1}{\eta}\right)\dot{q} + \left(\frac{\eta-1}{\eta}\right)\dot{k}$$

$$\text{where} \quad \eta = \left[(1-\beta)^{-1} \left\{ \alpha + \left(\frac{\sigma_2}{\sigma_1}\right)(1 - \alpha - \beta) \right\} \right]$$

Substituting equation (13) into equation (11) (and setting $\dot{rm} = \dot{q} - \sigma_2 p\dot{rm}_p$ from the first-order conditions) yields:

$$14. \quad \dot{q} - \dot{k} = -\left(\frac{\alpha\sigma_1}{\gamma}\right)\dot{w}_p - \left(\frac{\beta\eta\sigma_1}{\gamma}\right)p\dot{rm}_p$$

Clearly, unless σ_1 and σ_2 are valued at unity, factor shares are not constant over the sample period. For estimation, therefore, a linear approximation of both the labor demand and the output equation is employed around fixed factor shares which can be considered means. This involves simply estimating the equations in level form and adding an intercept term.[1] In addition, a quadratic in time (t) is added to capture labor-saving technological change. Finally, these equations represent desired levels of output and employment on the basis of lagged, or correctly anticipated, relative prices and a given capital stock. Any deviation of actual (q and n) from desired (q^* and n^*) levels is due to cyclical factors that push producers off their normal output supply and labor demand curves. This may be characterized as

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1. For similar treatment, see Bruno and Sachs (1982). As they point out an equation $\underline{z} = \underline{a}\underline{\dot{x}} + \underline{b}\dot{y}$ can be transformed to $z = c+ax+by$ where $\dot{x}=x-\bar{x}$ and $c = \bar{z}-a\bar{x}-b\bar{y}$

$$Q/Q^* = CYC^{m_1}$$

and

$$N/N^* = CYC^{m_2}$$

In terms of logarithms, this requires that the term $m_1 cyc$ be added to the output equation and $m_2 cyc$ be added to the labor demand equation. In both cases, in fact, lagged cyclical indicators were used. The equations for estimation, therefore, were as follows:

15. $$q-k = -(\alpha\sigma_1/\gamma)(w_p - \lambda_1 t + \lambda_2 t^2) - [\beta(\sigma_1\alpha+\sigma_2\gamma)/(1-\beta)\gamma]\, prm_p + m_1 cyc(-1) + c_1$$

16. $$n-k = -[(1-\beta)\sigma_1/\gamma](w_p - \lambda_1 t + \lambda_2 t^2) - (\beta\sigma_1/\gamma)\, prm_p - \lambda_1 t + \lambda_2 t^2 + m_2 cyc(-1) + c_2$$

3. Adjusting the Share of Raw Materials (β) for the elasticity of substitution

In calculating the "warranted" rate of real wage expansion, the relative price of capital and labor is held constant thus eliminating any incentive for substitution between these factors. The price of raw materials, however, is allowed to vary so that unless σ_2 is valued at unity factor shares will change. In calculating the warranted wage rate, this is taken into consideration in the following way. From equation (2) the first-order conditions with respect to RM is:

17. $\frac{\partial Q}{\partial RM} = (1-b)\left(\frac{RM}{Q}\right)^{-1/\sigma_2} = PRM_p$

therefore, $\beta = PRM_p \left(\frac{RM}{Q}\right) = (1-b)^{\sigma_2} PRM^{1-\sigma_2}$

and

18. $\ln(\beta) = \sigma_2 \ln(1-b) + (1-\sigma_2)prm_p$

It is easy to get an estimate of (1-b) from our estimates of σ_2, the mean value of prm_p and our estimate (that is, the mean sample value) of β. Thus

19. $\ln(\hat{1-b}) = \frac{1}{\sigma_2} \ln(\hat{\beta}) - \left(\frac{\hat{1-\sigma_2}}{\sigma_2}\right) \bar{prm}_p$

where ($\hat{}$) indicates estimated value and ($\bar{}$) indicates mean value. It is then possible to derive a series for β which takes into account relative price movements and the elasticity of subsitutiton such that

20. $\ln(\beta) = \hat{\sigma}_2 \ln(\hat{1-b}) + (\hat{1-\sigma_2})\, prm_p$

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