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# WAGES AND PRICES ARE NOT ALWAYS STICKY: A CENTURY OF EVIDENCE FOR THE U.S., U.K. AND JAPAN

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## ABSTRACT

Arthur M. Okun's last book, Prices and Quantities, contributes a theory of universal wage and price stickiness, but provides no explanation at all of historical and cross country differences in behavior. The core of this paper provides a new empirical characterization of price and wage changes over the last century in the U.S., U.K., and Japan, in order to demonstrate the wide variety of historical responses that have occurred. Equations for changes in the GNP deflator, in the hourly manufacturing wage rate, and in the real wage rate are estimated, with attention to the influence of both demand and supply disturbances. Because of the long sample period involved, extending back to 1875 for the U.K. and to 1892 for the other two countries, there is extensive attention to shifts in parameters.

My description of U.S. data differs from Okun's framework by rejecting his wage-wage formulation of the postwar U.S. inflation inertia process, by allowing the impact of demand disturbances to depend on both the level and rate of change of aggregate demand, by allowing demand to influence price-setting as well as wage-setting behavior, and by stressing the fact that inertia in the U.S. adjustment process is purely a postwar phenomenon rather than the universal fact implied by Okun. The results for the U.K. and Japan compound the conflict with Okun's analysis, since in these two countries wages have been far from sticky, even in postwar years. Prices and wages were particularly flexible in the U.S. during World War I and its aftermath, in Japan since 1914, and in the U.K. since the mid-1950s.

The last half of the paper provides an analysis of behavior in labor markets and product markets. The unique nature of the U.S. postwar adjustment reflects its unique institution of three-year staggered wage contracts, and the analysis attempts to explain why we do not observe perfect insulation of nominal wages from shifts in nominal demand. The section on the product markets examines the factors that explain why prices are often pre-set, and why the speed of adjustment to demand shocks is sensitive to the nature of aggregate information available.

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"In dealing with suppliers, says Gale Frank, purchasing manager for Aro Corp., 'the worst problem in purchasing today is the attitude that the supplier has a right to automatically pass along cost increases. We're trying to combat that.'"[1]

## I. INTRODUCTION

Macroeconomic research needs to be reoriented away from a search for the theoretical underpinnings of wage and price stickiness, and toward an explanation for the enormous differences in the degree of stickiness observed over time and across countries. This paper begins by criticizing Arthur Okun's book for contributing a theory of universal wage and price stickiness, and for providing no explanation at all of historical and cross-country differences in behavior. It then provides a new empirical characterization of price and wage changes over the last century in the U.S., U.K., and Japan, in order to demonstrate the wide variety of historical responses that have occurred. Finally, it lays out a series of issues that must be treated in theoretical models, if this historical experience is to be adequately explained.

### Wage and Price Stickiness: The Central Issue in Macroeconomic Theory

Economists have been obsessed with sticky wages for almost 50 years, an occupational disease that can be traced back to Keynes' decision in the General Theory to embed stickiness in his labor market's rigid nominal wage. An initial generation of Keynesian models joined rigid nominal wages to a traditional classical treatment of the product

market that retained perfect competition and price flexibility, as in the General Theory. This competitive product market assumption was retained in most postwar macroeconomics textbooks; in Milton Friedman's verbal treatment that gave rise to the Friedman-Lucas supply function; and in the large new literature on labor-market contracts for firms that are price-takers in product markets and wage-setters in labor markets.[2]

Early in the postwar years, however, "mainline" macroeconomics diverged from the competitive product market assumption, by shifting to a stress on "full-cost pricing" that made the price level mimic the sticky wage level, with little if any role for a flexible price response to changes in aggregate demand. This view of the wage adjustment process as a slowly crawling tortoise, and the price level as the slowly crawling shadow beneath the tortoise, led several prominent economists to develop the "fix-price" model of macroeconomic behavior, in which output is viewed as a residual that reflects the interaction of variable nominal demand growth with sluggish wage and price adjustment.[3] At the same time, frustrated with the failure of mainline macroeconomists to provide an adequate theoretical explanation of stickiness, the "new classical macroeconomists" in the 1970s reverted to the market-clearing paradigm, in which there was no distinction between wages and prices--both could move rapidly enough to clear markets and to allow agents to remain on voluntary (or "notional") supply curves. Neoclassical agents were pushed off their voluntary schedules not by the effective demand constraints of the mainline models, but only by expectational errors having a duration roughly equal to the publication lag of the St. Louis Federal Reserve Bank weekly financial statistics.

Unanswered Questions in Okun's Analysis

Arthur Okun's last book can be viewed as an attempt to provide the missing theory needed to explain the mainline assumption of macroeconomic wage and price stickiness.[4] While initially dazzled by Okun's common sense, insight, and expository skill, however, I have become convinced that this great man wrote a book that is more satisfactory as a description of microeconomic behavior than as a contribution to the macroeconomic debate on the causes of output fluctuations.[5] The basic problem is that Okun treated the postwar U.S. economy in isolation from its own past history and from the development of labor- and product-market institutions in other industrialized nations. The book contains no reference to any event in U.S. history prior to the post-Korean era, other than a single reference to World War II price controls and another to the implausibility of the search model as an explanation of worker behavior during the Great Depression. The book's index contains only a single reference to another country and that, to the U.K., involves incomes policy rather than cross-country differences in macroeconomic behavior. These omissions are serious, for neither Okun's "career" long-term attachments model of the labor market, nor his cost-plus "customer" model of the product market, is able to explain historical and cross-country differences in behavior. Each model emerges from reasoning on the situation of a universal homo economicus floating free in time and space.

Historical and cross-country differences raise questions that must be addressed by any reasonably complete theory of price adjustment and inflation. Okun, with his sluggish wages and sticky prices, seems to be the source for the view that in the current year output responds by 90

percent and prices by only 10 percent of a change in nominal GNP.[6] Yet in the U.S. in World War I and its aftermath, the division was much closer to 10-90 than 90-10 (see below). In the hyperinflations that Sargent has proposed as a counterexample to current mainline thinking, the division was more or less 0-100 within the current month.[7] What factors explain the ability of customer markets to shift from sluggish to speedy price adjustment in these cases, and could those factors recur? Similarly, wages in the postwar U.S. have responded more sluggishly to nominal GNP changes than in most other countries, yet long-term career attachments between workers and firms are as important, if not more important, in Japan, Germany, and elsewhere, as in the U.S.

Okun's labor and product markets not only lack a historical or cultural dimension, but they also provide almost no room for interaction between agents and policymakers. Wage behavior in Germany in 1973-74 or Japan in 1979-80 may be hard to explain in isolation from the expectations of workers and firms about the likely actions of monetary policymakers; reverse causation is relevant as well, if the different "propensity to accommodate" apparent on the part of, say, the British vs. the German central bank, can be traced to their different expectations about the likely behavior of individual wage and price decisions in response to their own monetary initatives.

## Comparative Macroeconomic History as a Stimulus for New Answers

In three previous papers I have suggested economic and noneconomic factors that might help partially to explain historical and cross-country differences in macroeconomic behavior. The first began as a critique of those monetarists whose explanation of inflation consisted of little more than a time-series chart showing a high historical

correlation between prices and money, without any explanation of why the rate of monetary expansion had differed across time and between countries. Although my analysis involved wartime finance, fixity of exchange rates, and the political independence of central banks, its main point was that central banks were less likely to "supply inflation" in response to fiscal or supply-shock pressures if wage- and price-setting institutions allowed a rapid and complete response of prices to monetary restriction.[8] This then required an explanation of differences in those institutions. The second paper suggested that shifts in the degree of price flexibility over time might be fruitfully explained by embedding Friedman's and Lucas' distinction between local and aggregate information in a model of price-setting by monopolists.[9] The most recent exercise documented the unusual sluggishness of U.S. postwar nominal wage adjustment compared to that in Britain and Japan, attributed this difference to the form of labor-market contracts, and suggested that contract form and length was related in part to cultural attitudes toward social and class conflict.[10]

The core of this paper, contained in Part II, consists of an empirical analysis of historical shifts in the degree of price and wage flexibility in the U.S., U.K. and Japan. These results develop a set of puzzles that form a research agenda for macroeconomic theory. Part III develops a few ideas to explain historical and cross-country differences in labor-market behavior. A central issue in any macroeconomic discussion of labor markets is the extent of the contingencies, if any, to which labor-market contracts are indexed; the forces working against full indexation of labor markets are the same as those that prevent firms from fully insulating their own real outcomes from nominal shocks. Part IV investigates the economic forces that distinguish

auction markets from customer markets where prices are set, and addresses the most difficult issue, the determinants of shifts in the speed of adjustment by firms which have access to aggregate information.

This paper does not develop mathematical theorems, or firm solutions to tractable, narrowly defined problems. Instead, it contains conjectures and suggestions about a broad area in which microeconomics and macroeconomics overlap. Although some of the themes developed here echo those of my recent treatment of the product market in the Journal of Economic Literature, this paper differs by including a more extensive empirical treatment of parameter shifts across time and countries, by forswearing any systematic survey of related papers and ideas, and by attempting to include some specific suggestions about the problems that must be faced in developing formal models of product-market behavior.

## II. EMPIRICAL EVIDENCE ON PRICE AND WAGE RESPONSIVENESS

This section presents estimates of simple reduced-form equations that describe the response of price and wage changes to demand disturbances and supply shocks. A single equation, using an identical specification, is estimated from annual data for the U.S., U.K., and Japan over a period beginning in the late nineteenth century and extending to 1980. The main purpose of the econometric work is to characterize shifts in the responsiveness of wages and prices to changes in aggregate demand over this long historical period. The results provide the basis for my claim in the introduction that wages and prices are less sticky and inertia-bound in postwar U.K. and Japanese data than in the postwar U.S., and that inertia in U.S. wage and price behavior is purely a postwar phenomenon.

### The Basic Specification

In the notation used here, upper-case letters designate logs of levels, and lower-case letters designate rates of change. The basic hypothesis to be tested emerges from separate equations for changes in wages ($w_t$) and prices ($p_t$), in both of which the explanatory variables include the level and change in real aggregate demand, and a vector of supply shift terms. In both equations the demand effect is proxied by the level and change in the "output ratio," that is, the ratio of actual real GNP to "natural" (or "potential") real GNP ($\hat{Q}_t = Q_t - Q_t^*$). In the postwar U.S. this output ratio concept has a high negative correlation, through Okun's Law, with the demographically adjusted unemployment rate that George Perry introduced into the U.S. Phillips curve literature a decade ago.[11]

The rate of wage change ($w_t$), then, is written as:

$$(1) \qquad w_t = a_1(a_0 + p_{t-1}) + a_2\hat{Q}_t + a_3\Delta\hat{Q}_t + a_4 z_{wt} + u_{wt},$$

where $z_{wt}$ is a vector of supply shift variables relevant for wage behavior, and $u_{wt}$ is an error term. Here $a_1 = 1$ would be consistent with a vertical long-run Phillips curve, and in this case $a_0$ could be interpreted as the equilibrium growth rate of the real wage when the log output ratio is zero and supply shocks are absent ($z_{wt} = 0$). The parallel price markup equation is:

$$(2) \qquad p_t = b_1(w_t - b_0) + b_2\hat{Q}_t + b_3\Delta\hat{Q}_t + b_4 z_{pt} + u_{pt},$$

where $z_{pt}$ is a vector of supply shift variables relevant for price behavior, and $u_{pt}$ is an error term. The constant term $b_0$ can be interpreted as the rate of productivity growth relevant for price-setting behavior, e.g., "standard productivity," so that $w_t - b_0$ is the growth in "standard unit labor cost."

When the wage change equation (1) is substituted for $w_t$ in equation (2), and when we relabel coefficients, we obtain the following reduced form price-change equation:

$$(3) \qquad p_t = c_0 + c_1 p_{t-1} + c_2\hat{Q}_t + c_3\Delta\hat{Q}_t + c_4 z_t + u_t,$$

where

$$c_0 = b_1(a_1 a_0 - b_0); \quad c_1 = b_1 a_1; \quad c_2 = b_2 + b_1 a_2; \quad c_3 = b_3 + b_1 a_3;$$
$$c_4 z_t = b_4 z_{pt} + b_1 a_4 z_{wt}; \quad \text{and} \quad u_t = u_{pt} + b_1 u_{wt}.$$

Several simplifications are introduced into (1) and (2) in order to allow this simple version of (3) to emerge. First, lagged wages are excluded from both (1) and (2), and thus do not appear in (3). Second, only a single lagged value of price change is entered ($p_{t-1}$), rather than a polynomial in the lag operator as in my more detailed studies of quarterly U.S. data. Next, the growth in the equilibrium real wage and in standard productivity are introduced as constants rather than variables, allowing estimation to proceed without the introduction of data on productivity change. Two obvious advantages of combining (1) and (2) into (3) are evident immediately--no data on wages need be collected, and no attempt need be made to decide in advance which supply shifts (tax changes, programs of government intervention) are relevant for wage-setting as opposed to price-setting behavior.[12]

It is possible to derive an alternative version of (3) by defining "adjusted nominal GNP growth" as the excess of the growth rate of nominal GNP over that of natural real GNP ($\hat{y}_t = y_t - q_t^*$). We can substitute the identity

$$(4) \qquad \hat{Q}_t \equiv \hat{Q}_{t-1} + \hat{y}_t - p_t$$

into (3), and after simplifying, obtain:

$$(5) \qquad p_t = \frac{1}{1+c_2+c_3}[c_0 + c_1 p_{t-1} + (c_2+c_3)\hat{y}_t + c_2\hat{Q}_{t-1} + c_4 z_t + u_t].$$

In this framework the significance of the estimated coefficient on the lagged output ratio indicates the presence of an output "level effect,"

while the difference between the coefficient on adjusted nominal GNP growth and the lagged output ratio indicates the relative size of the "rate of change effect."[13] If the coefficients on lagged price change and on adjusted nominal GNP change sum to unity, then the "accelerationist" hypothesis is validated, in the sense that a positive output ratio ($\hat{Q}_{t-1}>0$) or an adverse supply shift ($z_t>0$) causes an acceleration of the inflation rate relative to its past value.[14]

Questions may be raised about the appearance of nominal GNP change in equation (5), an equation explaining price change. Nominal GNP change is indeed an endogenous variable, although no more so than the current unemployment rate that has traditionally been used in Phillips curve studies. The choice, then, between the alternative specifications (3) and (5) comes down to whether nominal or real GNP is "more exogenous." The advantage of using equation (5) for estimation becomes clear when considering a period like 1915-22, when prices responded extremely rapidly to changes in nominal GNP, with little residual effect on real GNP. The exogenous event in this instance was an upsurge in money-financed nominal spending. In a world of complete and contemporaneous price responsiveness to serially correlated nominal GNP movements, as in some models in the tradition of the "new classical economics," an investigator who forced all of the price adjustment to be explained by real variables and lagged price change, as in (3), would find his results plagued by positive serial correlation and an upward bias in the coefficient on lagged price change.

Another alternative to (3), which would involve replacing nominal GNP change by the change in a monetary aggregate, has the quite different disadvantage that the resulting coefficient on money mixes up

aggregate demand and aggregate supply effects; that is, it reflects the combined influence of the response of velocity to monetary changes, and the response of prices to nominal GNP changes. The most obvious source of bias in the coefficient on nominal GNP change, stemming from the simultaneous increase in prices and in nominal GNP that would occur if supply shocks were accompanied by an accommodating monetary policy, can be mitigated by careful attention to the specification of the supply shift variables ($z_t$).

The tables presented below include not only estimates of (5) with price change as the dependent variable, but also estimates of the same specification with wage change as the dependent variable. A reduced-form wage change equation containing the same variables as in (5) can be derived by solving (2) for $w_t$, substituting out $\hat{Q}_t$ using identity (4), and, finally, substituting (5) for $p_t$. Differences in the coefficients on the same variables in the wage change and price change equations provide evidence regarding the response of the real wage to demand and supply disturbances. Since wage changes and nominal GNP changes are measured independently, and are not linked by a simple identity, the coefficient on nominal GNP change in the wage change equation is less subject to simultaneous equations bias and may provide a more reliable estimate of the "rate of change effect" of aggregate demand.

Estimates of Price and Wage Equations for the U.S.

In this paper, the estimates of (5) for the U.S. attempt to capture the impact of seven supply shifts, of which six are dummy variables to capture the impact of separate episodes of government intervention in the price-and wage-setting process, and the seventh is the annual change

in the relative price of food and energy. Except for the "Wagner Act" variable, the dummy variables are not of the usual "0,1" form. My own previous research on the Nixon controls and the National Recovery Act finds that both programs not only shifted the price level during their official period of impact, but caused a shift in the opposite direction after their termination.[15] The five dummy variables listed in Table 1, lines 5a, 5b, 5d, 5e, and 5f, are defined to sum to 1.0 during the period of a program's impact, and to -1.0 during the period after its termination, thus constraining the impact and rebound efforts to have exactly the same absolute value. The resulting coefficients on those dummy variables indicate the cumulative displacement of the price level during the period of the program's impact. This method implies that, because these five dummy variables sum to zero, collectively they do not explain <u>any</u> of the eleven-fold increase in the GNP deflator that occurred between 1892 and 1980. The sixth dummy variable, representing the impact of the 1935 Wagner Act on unionization in 1936-37, is of the usual "0,1" form, and measures the permanent increase in the real wage achieved by unionization.[16]

One obvious method to provide information on parameter shifts would be to estimate separate versions of (5) for each major sub-period within the available data set. Most previous investigators have followed this approach and have concentrated on "normal" peacetime periods, often omitting the years of the Great Depresssion and World War II. An alternative method involves estimating a single equation for the entire available data period, and then searching for parameter shifts. If additional variables are defined as the product of the individual economic variables of interest ($\hat{y}_t$, $\hat{Q}_{t-1}$, etc.) and "0,1" dummy

variables for each sub-period, then the t-ratios on the additional variables provide estimates of the statistical significance of parameter shifts.

In developing the equations displayed in Table 1, I followed this search procedure in an attempt to locate parameter shifts in both the price and wage equations during the following sub-periods: 1892-1914, 1915-22, 1929-41, 1942-49, 1950-53, 1954-66, and 1967-80. Only six shifts could be located; as shown in the table, all six of these are statistically significant in the wage equation, of which four are also significant in the price equation.

In the equation for price-change in column (1), the elasticity of changes in the GNP deflator to current changes in nominal GNP is stable at about one-third throughout the sample period, except for significant upward shifts during World War I (0.34 + 0.54 = 0.88) and during World War II (0.34 + 0.18 = 0.52). Once the effect of price controls is taken into effect by the method outlined above, it appears that the first-year division of nominal GNP change between output and prices ranged from roughly 50-50 to 10-90 in the two wars, considerably above the peacetime division of 66-34, and far from Okun's estimate of 90-10.

The other variables listed in lines 2 through 4 are all lagged one year. The coefficient on lagged nominal GNP change is quite stable. There is a significant impact of the lagged output ratio--the traditional Phillips curve "level effect"--except during the Great Depression years, 1929-41, when the "level effect" was zero.

Only a small and insignificant "inertia effect" of lagged price change is evident until 1950, when the coefficient exhibits a significant jump from 0.05 to 0.45. I have previously suggested two explanations for this shift:

> "it seems quite consistent with a change in attitude in the first postwar decade toward recognition of a fundamental change in the stabilizing role of government policy (initiatives based more on the automatic stabilizers and new institutions like F.D.I.C. than on countercyclical policy). The shift also emphasizes the crucial role of three-year staggered wage contracts, a unique American institution that dates back to the first postwar decade."[17]

Unfortunately I can provide no easy explanation for the disappearance of the Phillips-curve "level effect" during the Great Depression; this result both describes, and results from, the mysterious absence of downward price pressure emanating from the huge decade-long real output gap. It may suggest an asymmetric price response, with more downward than upward rigidity, but careful testing does not confirm any such asymmetry.

The supply-shift coefficients indicate that World War II price controls cumulatively held down the price level by almost 20 percent, and World War I price controls by almost 10 percent, while the NRA boosted prices by 8 percent.[18] The effects of the Korean war and Nixon episodes were more modest, but nonetheless large in relation to the small year-to-year variance of price change during the postwar era. The Wagner Act had no significant impact on price changes. The effect of food and energy prices is a marginally significant 0.55.

Taken as a whole, the price-change equation in column (1) has important implications for current macroeconomic debates. If the sum of coefficients on nominal rate-of-change variables ($\hat{y}_t$, $\hat{y}_{t-1}$, and $p_{t-1}$) were unity, the equation would be consistent with the "accelerationist hypothesis" that a permanent acceleration in nominal GNP growth leads to

TABLE 1

Equations Explaining Annual Changes in Prices, Wage Rates, and the Real Wage in the United States, 1892-1980[a,b]

| | GNP Deflator | Hourly Wage Rate | Real Product Wage |
|---|---|---|---|
| | (1) | (2) | (3) |
| 1. Adjusted Nominal GNP ($\hat{y}$) | | | |
| a. Entire Period | 0.34*** | 0.32*** | -0.02 |
| b. Extra Effect, 1892-1914 | -0.05 | 0.14* | 0.19* |
| c. Extra Effect, 1915-22 | 0.54*** | 0.51*** | -0.02 |
| d. Extra Effect, 1942-49 | 0.18*** | 0.25*** | 0.07 |
| 2. Lagged Adjusted Nominal GNP ($\hat{y}_{t-1}$) | 0.09** | 0.19*** | 0.10 |
| 3. Lagged Real GNP Ratio ($\hat{Q}_{t-1}$) | | | |
| a. Entire Period | 0.18*** | 0.01 | -0.16* |
| b. Extra Effect, 1892-1914 | -0.01 | 0.30** | 0.31** |
| c. Extra Effect, 1929-41 | -0.16*** | -0.04 | 0.12* |
| 4. Lagged "Net" Price Change ($p_{t-1}$)[c] | | | |
| a. Entire Period | 0.05 | 0.12 | 0.07 |
| b. Extra Effect, 1950-80 | 0.40*** | 0.31** | -0.08 |
| 5. Supply Shifts[d] | | | |
| a. World War I Controls, 1915-22 | -8.72*** | -1.36 | 7.36*** |
| b. NRA, 1933-36 | 7.66*** | 18.78*** | 11.04** |
| c. Wagner Act, 1936-37 | 1.61 | 11.54** | 9.94** |
| d. World War II Controls, 1943-47 | -19.00*** | -10.97*** | 8.01*** |
| e. Korean War Controls, 1950-52 | -2.44** | -1.74 | 0.70 |
| f. Nixon Controls, 1972-75 | -4.77*** | -1.12 | 3.65* |
| g. Relative Price of Food and Energy, 1947-80[e] | 0.55* | -0.46 | -1.01* |
| 6. Constant Term | 0.61** | 1.82*** | 1.20*** |
| $R^2$ | .924 | .878 | .471 |
| S.E.E. | 1.66 | 2.42 | 2.80 |

NOTES TO TABLE 1

a. Asterisks indicate that coefficients are statistically significant at the 10 percent level ($^{*}$), 5 percent level ($^{**}$), or 1 percent level ($^{***}$).

b. Data sources are described in the appendix.

c. Lagged price changes are computed by netting out the influence of the supply shift variables. Thus if $D_{it}$ is the level of dummy variable $\underline{i}$, and $d_i$ is its coefficient, the net lagged price change is calculated as:

$$p_{t-1} = p_{t-1} - \sum_{i=1}^{5} d_i D_{i,t-1} - d_0 p^{FE}_{t-1},$$

where $d_0$ is the coefficient on the relative food-energy price variable ($p^{FE}_t$).

d. All dummy variables, except for the Wagner Act, are defined to sum to unity over the period when a program of government intervention was in effect, and to -1 during the period of its termination. The NRA, World War II, and Nixon dummy variables are defined exactly as in Gordon, "Consistent Characterization," footnote 10. The World War I, Wagner Act, and Korean dummy variables are new:

| World War I | | NRA | | Wagner Act | | World War II | | Korea | | Nixon | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1918 | 1.0 | 1933 | 0.4 | 1936 | 0.5 | 1943 | 0.5 | 1950 | -0.5 | 1972 | 0.5 |
| 1919 | -0.5 | 1934 | 0.6 | 1937 | 0.5 | 1944 | 0.4 | 1951 | -0.5 | 1973 | 0.5 |
| 1920 | -0.5 | 1935 | -0.4 | | | 1945 | 0.1 | 1952 | 1.0 | 1974 | -0.3 |
| | | 1936 | -0.6 | | | 1946 | -0.6 | | | 1975 | -0.7 |
| | | | | | | 1947 | -0.4 | | | | |

Notes to Table 1 (continued)

e. The variable used to represent changes in the relative price of food and energy is the difference between the annual rates of change of the deflators for, respectively, personal consumption expenditures and personal consumption expenditures net of expenditures on food and energy. This variable is available only for 1947-80 and is set equal to zero before 1947.

a permanent acceleration of inflation with no residual impact on real output. For the 1950-80 period the relevant sum of coefficients is 0.89 (0.33 + 0.10 + 0.05 + 0.41), which is not far from unity, and this sum becomes 0.97 when the constant is omitted. Another important implication is contained in the finding that the coefficients are stable for the 1950-80 period, leading me to question the unsupported conjectures by Robert Lucas, William Fellner, and others that a credible return by monetary policymakers to the regime of the 1950s would lead to substantial shifts in parameters.[19]

An equation explaining annual changes in average hourly earnings is presented in column (2). All the right-hand variables are identical to those in column (1). The wage equation exhibits few differences from the price equation in the coefficients on nominal GNP change (lines 1 and 2), and lagged price change (line 4). The nominal GNP responsiveness coefficients in the wage equation exhibit the same overall value of roughly one-third, with the same large and significant upward shift in World War I and World War II. Further, the coefficients on lagged price change (line 4) are similar, while lagged nominal GNP change seems to be somewhat more important in the wage equation.

Perhaps the most surprising result, however, is that the pattern of wage response to the output ratio is completely different. While the wage equation shares with the price equation the absence of any impact of the output ratio in the interval between 1929 and 1941, it differs in the absence of any impact of the output ratio on wage change over the "entire period" (line 3a). I would have guessed on the basis of postwar U.S. evidence that the "rate of change" effect was relatively more important in the price-change equation, and the "level" effect of the

output ratio was more important in the wage-change equation. In fact, the opposite appears to be true.

Finally, both the rate-of-change and level effects of aggregate demand on wages appear to have been substantially more important in the 1892-1914 period than thereafter (lines 1b and 3b). This would seem to be the sole evidence in this paper that, at least for the U.S., the first-year responsiveness of wages has become more "sticky." Prices, on the other hand, have exhibited no important peacetime change in behavior except for (a) the mysterious disappearance of the "level effect" in the 1930s and (b) the emergence of inertia beginning in 1950.

The difference between the coefficients in the wage and price equations, respectively, indicates the effect of the demand, inertia, and supply variables on changes in the real product wage. These real-wage responses are shown separately in column (3), where an equation for the annual change in the real wage has been estimated in order to provide measures of statistical significance of the coefficients. Perhaps the most important finding is that changes in the real wage behave countercyclically; this is a different relationship than Keynes' assumption in the General Theory that there is a negative relation between the level of the real product wage and the level of output. For Keynes' relation to be validated, we should find a significant negative impact of the change of real aggregate demand on the change in the real wage, whereas in fact this coefficient is positive. We can use equation (5) to recover the reduced form parameters as follows:

| | Price Equation | Wage Equation | Implied Real Wage Response |
|---|---|---|---|
| Output "level effect" ($c_2$) | .32 | .02 | -.30 |
| "Rate of change effect" ($c_3$) | .43 | 1.02 | .58 |
| "Inertia coefficient" ($c_1$) | | | |
| Pre-1950 | .09 | .24 | .15 |
| Post-1950 | .79 | .88 | .09 |

The other important finding in column (3) is that several of the supply shift variables have a significant impact on changes in the real wage. Controls in World War I, World War II, and the Nixon era, as well as the NRA, all raised the real wage temporarily (recall that these are dummies of the 1,-1 form), while the Wagner Act appears to have raised the real wage permanently. These coefficients, indicating that government intervention has rather consistently operated to shift the distribution of income toward workers, may help to explain why controls continue to be popular in public opinion polls. The coefficient in line 5g indicates a unit-elastic negative response of the real wage to the relative price of food and energy, achieved in part through a positive response of the price level, and in part through a negative response of the nominal wage rate.

Estimated Price and Wage Equations for the U.K.

The specification of the U.K. price, wage, and real wage equations in Table 2 differs from the U.S. equations in only two respects. First, the lagged change in adjusted nominal GNP ($\hat{y}_{t-1}$) is insignificant, and so does not appear in Table 2. Second, there are obvious differences in the particular programs of government intervention that require the introduction of dummy variables. Three periods of freeze or restraint are included, and in each case the dummy variable is of the "1,-1" form. The choice of timing for the "rebound" or "unwinding" effect of

TABLE 2

Equations Explaining Annual Changes in Prices, Wage Rates, and the Real Wage in the United Kingdom, 1875-1938 and 1955-80[a,b]

| | GNP Deflator | Hourly Wage Rate | Real Product Wage |
|---|---|---|---|
| | (1) | (2) | (3) |
| 1. Adjusted Nominal GNP ($\hat{y}_t$) | | | |
| a. Entire Period | 0.45*** | 0.41*** | -0.04 |
| b. Extra Effect, 1914-23 | 0.13 | -0.16* | -0.28** |
| c. Extra Effect, 1955-80 | -0.13 | 0.17* | 0.30** |
| 2. Lagged Real GNP Ratio ($\hat{Q}_{t-1}$) | | | |
| a. Entire Period | 0.24*** | 0.17*** | -0.07 |
| b. Extra Effect, 1914-23 | 0.45** | 0.67*** | 0.23 |
| c. Extra Effect, 1924-38 | -0.10 | -0.25** | -0.14 |
| d. Extra Effect, 1955-80 | 0.89*** | 0.86*** | -0.03 |
| 3. Lagged Price Change ($p_{t-1}$)[c] | | | |
| a. Entire Period | 0.11** | 0.35*** | 0.24*** |
| b. Extra Effect, 1955-80 | 0.45*** | 0.05 | -0.36*** |
| 4. Supply Shifts [d] | | | |
| a. Late 1960s Intervention (1967-72) | -1.72 | -5.05** | -3.33 |
| b. Early 1970s Intervention (1973-75) | -5.39*** | -3.12** | 2.26* |
| c. Social Contract (1977-80) | -0.67 | -10.33*** | -9.65*** |
| d. Foreign Exchange Rate[e] | -0.08** | -0.16*** | 0.09*** |
| 5. Constant Term | | | |
| a. Entire Period | -0.18 | 0.16 | 0.34 |
| b. Extra Effect, 1955-80 | 1.60** | 1.91*** | 0.31 |
| $R^2$ | .932 | .938 | .536 |
| S.E.E. | 1.91 | 1.95 | 2.07 |

NOTES TO TABLE 2

a, b, c. Same as Table 1.

d. All dummy variables are defined to sum to unity over the period when a program of government intervention was in effect, and to -1 during the period of its termination. The variables are defined as follows:

| Late 1960s Intervention | | Early 1970s Intervention | | Social Contract | |
|---|---|---|---|---|---|
| 1967 | 0.33 | 1973 | 1.0 | 1977 | 1.0 |
| 1968 | 0.33 | 1975 | -1.0 | 1978 | -0.6 |
| 1969 | 0.33 | | | 1979 | -0.2 |
| 1970 | -0.33 | | | 1980 | -0.2 |
| 1971 | -0.33 | | | | |
| 1972 | -0.33 | | | | |

e. The foreign exchange rate included in percentage change form, is the pound-dollar rate for 1900-70, and the effective exchange rate of the pound for 1971-80. See data appendix.

the control programs is based on the same iterative method used in my research for the U.S.; residuals from a first iteration were used to determine the length of time required for the control effect to wear off.

The U.K. price-change equation in column (1) displays a number of similarities to the corresponding U.S. equation, and a few interesting differences. The similarities begin with the stable coefficient on nominal GNP change ($\hat{y}_t$), with a U.K. coefficient in the current year of 0.45, compared to U.S. coefficients in the current and first lagged year summing to 0.43. The "entire period" coefficient on the lagged output ratio, as well as the shift toward increased inertia in the postwar period, seem to be consistent with U.S. behavior. The major differences are the absence of a significant upward shift on the $\hat{y}_t$ coefficient for the U.K. during World War I, and the enormous upward shift in the U.K. output ratio coefficient in the postwar years (line 2d).

It is the wage equation where U.K. behavior contrasts dramatically with the U.S. First, there is a substantially larger impact effect of nominal GNP changes on wage changes in the postwar U.K. than in the postwar U.S. My more detailed analysis of wage responsiveness, based on bivariate Granger causality tests for quarterly data, reached the same conclusion.[20] In Table 2 the contrast shows up not just in the higher U.K. nominal GNP coefficient (line 1a plus 1c), but even more strongly in the large upward shift in the U.K. postwar coefficient on the output ratio (line 2d). Another contrast is in the inertia effect, which shifted upward substantially in U.S. data in the postwar years, but which shows no upward postwar shift in the U.K. from its "entire period" coefficient of 0.35. Overall, the U.K. results are consistent with the

long-run neutrality of nominal GNP changes in the postwar period; the relevant sums of coefficients on the nominal GNP and lagged price variables are 0.88 in the price equation (0.45-0.13+0.11+0.45) and 0.98 in the wage equation (0.41+0.17+0.35+0.05).

The supply shift variables introduce another interesting contrast with the U.S., since the "Late 1960s" and "Social Contract" interventions reduced the real wage temporarily, in contrast to the U.S. intervention programs that consistently increased the real wage. Another interesting contrast is the peculiar response of the real wage to exchange rate changes--a devaluation (treated as a negative change in the exchange rate) increases U.K. wage change more than price change, leading to an increase in the real wage. Exchange rate effects for the U.S., although important in quarterly data for the 1970s, do not have a significant impact on the annual data and thus are omitted from Table 1.[21] In the opposite direction, changes in the relative price of food and energy, although important in the U.S. equations, did not make a significant contribution in the equations for the U.K. and Japan, and are thus omitted in both Tables 2 and 3.

Estimated Price and Wage Equations for Japan

The equations for Japan in Table 3 have fewer variables than those for the U.S. and U.K., both because fewer significant parameter shifts were identified, and because no significant impact was found for changes in the relative price of food and energy nor in the exchange rate. The price-change equation for Japan in column (1) suggests substantially

TABLE 3

Equations Explaining Annual Changes in Prices, Wage Rates, and the Real Wage in Japan, 1892-1940 and 1961-80[a,b]

| | GNP Deflator | Hourly Wage Rate | Real Product Wage |
|---|---|---|---|
| | (1) | (2) | (3) |
| 1. Adjusted Nominal GNP ($\hat{y}_t$) | | | |
| a. Entire Period | 0.77*** | 0.37*** | -0.40*** |
| b. Extra Effect, 1892-1913 | -0.53*** | -0.31*** | 0.21** |
| 2. Lagged Real GNP Ratio ($\hat{Q}_{t-1}$) | | | |
| a. Entire Period | 0.64*** | 0.77*** | 0.13 |
| b. Extra Effect, 1892-1913 | -0.52*** | -0.75*** | -0.22 |
| c. Extra Effect, 1914-22 | 1.46*** | 2.10** | 0.63 |
| 3. Lagged Price Change ($p_{t-1}$) | | | |
| a. Entire Period | 0.05 | 0.22*** | 0.17* |
| b. Extra Effect, 1914-22 | -0.03 | 0.38*** | 0.40** |
| 4. Constant Term | | | |
| a. Entire Period | 2.06*** | 3.66*** | 1.60*** |
| b. Extra Effect, 1961-73 | -1.78* | 5.52*** | 7.30*** |
| $R^2$ | .811 | .813 | .468 |
| S.E.E. | 3.34 | 3.58 | 4.46 |

NOTES TO TABLE 3

a,b Same as Table 1.

greater price flexibility than in either the U.S. or U.K., with large and significant "entire period" coefficients of price change on both current nominal GNP change and on the lagged output ratio. The upward shift in price responsiveness during World War I, which was reflected in a higher coefficient on nominal GNP change for the U.S., is reflected here in a higher coefficient on the lagged output ratio for Japan (line 2c). There is no evidence of price inertia in the price equation in the entire period nor in any subperiod.

Japan, unlike the U.K. and U.S., exhibits virtually no responsiveness of prices (nor wages) to changes in nominal GNP nor to the lagged output ratio before 1914 (lines 1b and 2b). This fact, together with the high standard errors in these equations compared to those for the U.S. and U.K., suggests to me that there may be substantial measurement errors in the early Japanese data. Controlling for this low responsiveness before 1914, as in Table 3, there seems little doubt that the price deflator in peacetime periods after World War I was considerably more flexible and less inertia-bound in Japan than in the U.S. or U.K.

There are two differences between the wage and price equations for Japan, and these show up as significant coefficients in the real wage equation in column (3). First, the rate of change effect in the wage equation is negative, reflecting the fact that an expansion in the economy is associated with a decline in the real wage. Second, there seems to be a somewhat larger impact of lagged prices in the wage equation than in the price equation. The extremely high significance level of the constant shift term for 1961-73 in the wage and real wage equations demonstrates the importance of allowing every parameter to change, including the constant. The implication, of course, is that the

explosive productivity growth enjoyed by the Japanese economy was a temporary phenomenon, since after 1973 real wage growth returned approximately to the average rates experienced before 1940.

Comparison with Okun's Theoretical Framework

The characterization of historical price and wage behavior in the three tables differs substantially from Okun's algebraic theory, as presented in his equations (7) and (8) on p. 259 (renumbered here for convenience):

$$(6) \qquad w_t = (1-s)w_{t-1} + sy_t,$$

$$(7) \qquad p_t^C = (1-s)p_{t-1}^C + sy_{t-1},$$

where the "C" superscript on price change refers to non-auction or "customer" market sector. Otherwise, Okun and I both use the same notation.

To simplify the discussion, I first compare (6) and (7) to the results for the U.S. obtained in Table 1, since this was the nation that most concerned Okun, and subsequently comment on the relation of (6) and (7) to the results for the U.K. and Japan. At least four important differences are immediately apparent between Okun's framework and my description of U.S. data. First, the wage equation (6) embodies Okun's basic theme, that the inflation process is propelled by "wage-wage" inertia. In contrast, the wage equation in Table 1 reflects my long-standing empirical finding that wage changes in the postwar U.S. exhibit feedback from lagged product prices, not lagged wage rates.[22] When a

single lagged wage change term is added to the equation in column (2), its coefficient is 0.05 with a t-ratio of 0.4. Additional shift terms for 1929-41 and 1950-80 are also insignificant.

The second difference is that Okun's model allows only a "rate-of-change effect" in the influence of aggregate demand on wage and price change, whereas the equations in Table 1 also include the traditional Phillips curve "level effect." Third, Okun obtains a relationship between price change and lagged nominal GNP change in (7) by assuming that $p_t^C = w_{t-1}$. This specification is strongly rejected by the U.S. data; when current and lagged wage changes are added to the price equation, their coefficients range from 0.05 to 0.08, with t-ratios below unity, and with no evidence of significant structural shift parameters. This is a finding that is directly relevant to our subsequent discussion of the product market, since the U.S. results in Table 1, column (1) indicate that there is a strong contemporaneous effect of nominal GNP change, with an added impact of the lagged level of real GNP, implying that product prices are not simply set as a mark-up over labor cost. Finally, there is no room in Okun's model for the major parameter shifts that occurred during the two wars, nor any explanation of the shift from zero to positive inertia in the inflation process after World War II.

The results for the U.K. and Japan compound the conflict between Okun's analysis and the facts are presented in the tables. In those two countries, wages are far from sticky, and at least for the postwar years, the main impact of aggregate demand on wage behavior works through the output ratio variable that is omitted from (6) and (7). There is no evidence at all of wage-wage inertia in the postwar results

for the U.K. and Japan, relatively little feedback from lagged prices to wages, and no evidence of Okun's mechanical unit-elastic markup relation between current changes in customer market prices and lagged changes in wage rates. Yet all of the features involved in Okun's theory--the "toll" that produces career labor markets and the information lags that generate the shopping model of customer markets--are shared on common by all three countries and most historical eras.

## Limitations of the Results

There are numerous questions that may be raised about the results displayed in Table 1. There are good reasons to think that the coefficient on current nominal GNP change is biased upward. When the U.S. equation is re-estimated for the postwar years with the fixed-weight deflator rather than the implicit deflator as dependent variable, the coefficient on nominal GNP change drops from 0.34 to about 0.20, indicating that part of the current-year nominal GNP impact may be a spurious weighting effect. Table 1 retains the implicit deflator throughout, simply because the fixed-weight deflator is not available for the prewar years, and a shift in the concept used as dependent variable would prevent any analysis of historical shifts in coefficients. Similarly, the U.S. wage rate series used in columns (2) and (3) is average hourly earnings, not the postwar index that adjusts for changes in overtime and interindustry employment shifts. Thus part of the response of wages to current nominal GNP changes in Table 1 represents a change in overtime and the employment mix, not a change in actual wage rates. Again, comparability prevents a shift in indexes for the postwar.

The possibility that the demand responsiveness coefficients may be biased upward in the results for the U.S., and possibly for the U.K. and Japan as well, limits the usefulness of the empirical results for the analysis of hypothetical future policy changes. The point of the analysis is to use relatively homogeneous data sources across time and to identify shifts in parameters; we are interested in the fact that U.S. prices were more flexible during 1915-22 than before or after, for instance, not the precise quantitative values of the responsiveness parameters. The results are intended to pose a challenge for theorists, not to be used as they stand for short-term forecasting. A better job of identifying the crucial parameters for short intervals, e.g., 1954-80, can be performed with quarterly data and a more complex specification.[23]

# III. WAGES, CONTRACTS, AND THE MYSTERY OF THE MISSING ESCALATOR

Okun's book contains many insights about microeconomic behavior in labor and product markets, but lacks a theoretical explanation for some of the phenomena described in the preceding empirical analysis. The rest of the paper contains some conjectures and speculations about the lines that theorists might fruitfully pursue, with Part III devoted to labor markets, and Part IV devoted to product markets.

## Explaining Cross-Country Differences in Nominal Wage Flexibility

The previous section provided evidence that wage changes in the U.S., U.K., and Japan, have not been characterized by wage-wage inertia, and that nominal aggregate demand influences wage changes through three channels--through the impact of (1) current changes in nominal spending, (2) the output ratio, and (3) the feedback from lagged product prices, which may represent the combined impact of labor demand on the value of labor's marginal product, and of COLA escalation on previously negotiated union wages.[24]

Wage adjustments in postwar Britain and Japan have been more responsive to aggregate demand, and less characterized by inertia, than in the postwar U.S. If the U.S. institution of three-year overlapping wage contracts is cited as an explanation of some or all of this difference in behavior, then an explanation must be provided as to why contract form and length differ among countries that all share long-term labor-market attachments. The fact that Japan can simultaneously achieve lifetime employment (at least for males under 55 in large firms), together with relatively flexible nominal wages, presents a

powerful challenge to proponents of the "career-labor-market-wage-wage-inertia" theory.[25]

My explanation of differences in contract form and length is based on the simple idea, developed by Joanna Gray, Ronald Dye, and others, that the choice of contract length, like most economic choices, involves a balancing of costs and benefits.[26] Long contracts allow a greater period for the amortization of negotiation and strike costs, while short contracts allow agents quickly to adjust to unanticipated nominal and real events. This balancing act will tend to lead to a long contract length in a society like the U.S., with its history of labor strife (particularly between 1935-41 and 1946-48), and a short contract length in Japan, with its tradition of conflict avoidance, on-the-job social equality, and the non-occupational nature of attitudes toward hierarchy.[27]

But both short and long contracts may be fully indexed to a nominal variable like consumer prices, nominal GNP, or a monetary aggregate. The literature on contracts, in fact, views short contracts as a viable substitute for long-contracts-cum-indexing, when low negotiation costs allow short contract lengths to evolve as the dominant form. Thus a central issue in the origin of macroeconomic fluctuations is the absence of full indexation of wages and the product prices of individual firms.

## The Missing Escalator[28]

What range of possible contingencies will be written into contracts? Asymmetric information mitigates against contracts contingent on "local" variables specific to the firm, e.g., firm sales, product price, or worker productivity. Any informational advantage on

the part of the employer leads to a moral hazard problem, that the firm has an incentive to understate the realization of the variable on which the wage is contingent, in order to minimize wage cost. Contracts are thus more likely to be contingent on aggregate nominal variables, i.e., the consumer price index and/or the money supply. But as Gray has shown, indexation to a consumer price index rigidifies real wage growth over the life of the contract. While this is an optimal outcome if all disturbances are nominal, and the growth of productivity is perfectly predictable, full consumer-price indexation imposes an efficiency loss when an unpredictable supply shock (e.g., OPEC) changes the equilibrium real wage.

Since full indexation to the consumer price index has the fatal defect that it rigidifies the real wage, an appealing alternative is indexation to nominal GNP, for this allows the real wage to adjust automatically to unexpected changes in productivity growth (the advantages and disadvantages of indexation to a nominal monetary aggregate are treated below). Adopting the notation in Part I above, with changes in nominal GNP, prices, actual real GNP, and equilibrium real GNP designated respectively as $y$, $p$, $q$, and $q^*$, we have the identity:

$$(8) \qquad y - q^* \equiv p + q - q^*.$$

Let us assume for convenience that equilibrium labor input is constant, so labor productivity growth in equilibrium is the same as equilibrium real GNP growth ($q^*$). Then indexation of the wage rate to nominal GNP ($w = y$) implies, when substituted into (5):

$$(9) \qquad w - p = q^* + (q - q^*).$$

Thus growth in the real wage (w - p) automatically reflects equilibrium productivity growth ($q^*$) as long as there are no fluctuations in real output relative to its equilibrium value ($q - q^* = 0$).

No matter how superficially attractive, nominal GNP indexing of wage contracts has never been observed. This occurs, I suggest, because four sets of barriers prevent agents from making the comfortable assumption that real business cycles have been vanquished ($q - q^* = 0$) and therefore in (9) that the growth of the real wage mimics the growth of productivity. The barriers are (1) pre-set prices and wages, (2) foreign trade, (3) information imperfections and delays, and (4) velocity shifts.

(1) Pre-set prices and wages. Firms have a legitimate reason to fear that nominal GNP fluctuations will, at least initially, take the form of real GNP fluctuations. First, in many markets it is efficient for prices to be pre-set rather than established in auction markets, to save on the time and transportation costs that centralized auctions impose (see Part IV below). Second, prices that are preset for even a short interval imply that firms will initially experience a nominal fluctuation as a real event--a decline in real purchases at the initially pre-set price. Their expectation that the real demand shock will soon be eliminated depends on the speed with which costs of inputs purchased from other firms mimic the movement in nominal demand. If information on the nominal shock is imperfect, firms may, at least initially, interpret it as local rather than aggregate in nature and may believe that there is no reason for their input costs to move in propor-

tion to the demand shift. Once it is admitted that individual product prices, and hence the aggregate price level, may adjust gradually to changes in nominal GNP, then workers will fear the consequences of nominal-indexed wage contracts. Consider a 20 percent decline in nominal GNP, accompanied initially by only a 10 percent decline in the aggregate price level. Workers having a wage contract indexed to nominal GNP would experience a decline in their real wage of 10 percent. Eventually prices would adjust fully in proportion to the nominal GNP change, but workers, particularly if they are risk averse, would object to the instability of real wages implied by nominal-GNP indexation in a world of gradual price adjustment.

The preceding paragraph is unconventional in that it deduces nominal wage stickiness from price stickiness, while it is more common to do the reverse. But in fact the argument works both ways. If nominal wages do not adjust instantly, then firms face nominal marginal costs that are less than unit elastic with respect to nominal GNP changs. The problem is properly treated as dynamic rather than static, in which several sources of resistance to full nominal indexation interact and reinforce each other.

(2) Foreign trade. When firms observe an increase or decrease in their real sales at the initially pre-set price, their choice of a new price depends on a guess about the fraction of the demand shift representing a nominal aggregate shock, as opposed to a real aggregate or real local shock, and, a guess about the extent to which suppliers of inputs recognize the aggregate component of the shock. As will be recognized by economists in Britain, Japan, and other open economies, the perceived stickiness of marginal cost is a rational response when

agents recognize that a substantial fraction of their inputs is imported from abroad, where suppliers may have been unaffected by an aggregate nominal demand shock that is national rather than international in origin. Full insulation of real sales from a perceived nominal national disturbance would require that each agent (a) assumes his national suppliers immediately perceive the same shock and (b) ignores the fact that suppliers of imports are unaffected by a national demand shock. Both (a) and (b) surely strain credulity.

(3) Information imperfections and delays. Prior to the postwar development of monetary aggregates and national income accounts, timely measures of nominal aggregates did not exist, as good a reason as any to explain why nominal aggregate indexation has never occurred. Even today, nominal GNP indexation would require a two-month average delay in the U.S. (data for the second quarter, centered on May 15, become available in the third week of July). Lags are considerably longer in some other countries. Wage contracts indexed to nominal GNP thus cannot prevent a short-run reduction in hours worked in situations when nominal GNP growth suddenly decelerates, as in the U.S. in 1980:Q2 and 1981:Q2. Profit-maximizing firms naturally resist the implications of nominal GNP indexation that, because of information lags in situations of temporary fluctuations of nominal GNP growth, they reduce prices just when the economy is recovering and raise prices just when it is collapsing.

(4) Velocity shifts. Information on monetary aggregates is available fairly promptly, but indexation to a particular monetary aggregate cannot insulate real variables even if information is contemporaneous. Stochastic disturbances in commodity and money demand

functions, which may be serially correlated, lead to serially correlated fluctuations in the velocity of money. A price-setting agent choosing to index his product price to M1 in the U.S. would find that a slump in real sales would occur in any week or month in which velocity grows more slowly than the average written into the indexation formula.

Contractual arrangements cannot obviate fluctuations of hours worked in response to fluctuations in real supply or in nominal demand. Firms and workers are both unwilling to accept the risk implied by a contract that is fully indexed to nominal spending or money. If it is impossible to eliminate fluctuations in nominal demand, then labor-market contracts should be of relatively short duration. Frequent contract renewals can partially substitute for the absence of nominal GNP indexation, by allowing the latest information on both real and nominal shocks to be incorporated into wage-setting and price-setting decisions.

Indexation and Product-Market Adjustment

The preceding discussion, which has emphasized the obstacles to full indexation of labor contracts, would appear to apply with much more force to product markets. Yearly, monthly, and even daily adjustments in relative prices must be accomplished by the price system if it is to perform its traditional job of efficient resource allocation. Thus long-term product contracts that index the nominal price to an aggregate index, while maintaining fixed relative product prices, are rarely observed. Because in most historical eras the variance of relative prices has been greater than that of the aggregate price level, agents have relied on short contract lengths to perform required adjustments in

relative prices, and have been able to eschew formal indexation to aggregate variables, in the knowledge that a near-term contract revision would allow incorporation of any relevant aggregate information.

The cost-benefit approach to explaining contract length would also point out that, while there are much greater disturbances in product markets that would warrant a short contract, there are also much smaller negotiation costs. While strikes are a frequent event in labor markets, there are no "strikes" by suppliers who are unwilling to provide intermediate goods. If a final goods producer is unwilling to accede to a supplier's price "demand," then the supplier will either make a price concession or take his goods elsewhere, depending on his expectations about future demand. Other reasons for the absence of supplier strikes may be legal institutions that prevent supplier collusion but encourage worker collusion, and the fact that most suppliers produce multiple products while most workers do not.

The absence of complete indexation of product prices to nominal demand disturbances opens the way to output fluctuations. This would not matter if all product prices were set in auction markets, with supply and demand equated continually. Nor would it matter if firms could "see through" the fog of information on nominal aggregate demand provided every day by the newspaper, and could believe with certainty that eachsupplier and customer could "see through" to the same true state of affairs. Thus the operational tasks for product-market theorists are, first, to explain why prices for all products are not set on auction markets, and why firms do not and cannot insulate the real economy from nominal disturbances. Okun's book makes a good start on these two questions, but there is more to be said on each one.

## IV. THE RESPONSE OF PRICES TO DEMAND SHOCKS WHEN PRICES ARE PRESET

### Why Prices are Pre-Set

My analysis of product market behavior rests firmly on the same foundation as Okun's; the prices of at least some products must be pre-set for a finite period of time. When combined with the shopping model that Okun formulated, the need to form expectations about the costs of goods provided by suppliers (a factor I have stressed), and the lack of complete indexation, the assumption that prices are pre-set can explain the sluggish adjustment that we sometimes observe in product markets. While some commentators find that the need for pre-setting of prices is too obvious a phenomenon to warrant serious attention, two arguments persuade me that there is a need for a careful analysis. First, a whole tradition has developed in macroeconomics in the last decade that is based on the behavior of "yeoman barbers" who, like "yeoman farmers," are price takers who receive signals from some distant auction market and who, like barbers, produce a service. However attractive for its tractability, this analytical approach impedes understanding by providing no explanation of price tags, and by ignoring the consequence of decentralization in breaking the link between common information and firm behavior.

Heterogeneity is crucial for the theory of price adjustment, because it explains the coexistence of auction markets and price-setting markets. In describing auction markets, Okun (p. 134) states "those commodities traded on auction markets have a large number of producers and of potential buyers; they are homogeneous or readily gradable; and typically they are storable at relatively low cost." My explanation of

price-setting differs from Okun's only by placing more emphasis on heterogeneity of time and space in product markets, and less on the homogeneity of the product itself. Retail transactions are characterized by a large number of customers making brief individual visits to different locations, in contrast to the Board of Trade, where each trader remains continuously at his post throughout the day. In contrast to the empty supermarket, the essence of a spot-auction market is its liquidity, which can only be achieved if many buyers and sellers are present simultaneously. When price tags are pre-set rather than continually changed, as in an auction, goods and services can be made available at conveniently dispersed locations and with a purchase time that is at the discretion of the buyer.

How might a theorist go about building a model to explain the prevalence of price-setting practices? Leaving aside for a moment markets involving manufacturers and wholesalers, he might begin by adopting Gary Becker's treatment of consumption goods as a combination of marketed items and time.[29] For an analysis of markets, the crucial contribution of time is not in the need for time in actual consumption, as when watching television, but rather in the requirement for time to make purchases. On this issue, I like Alan Blinder's subjective reflection of why, when he goes to get stationery from the office supply cabinet, he does not "take just what he needs for the next day (or hour or minute). It is not because there is a large transportation cost, nor because there is bookkeeping to do, nor because the office secretary charges you a 'toll' for the privilege. Rather, it is because each trip to the cabinet occupies some of your <u>time</u>--valuable time that you could spend on something else."[30] Although Blinder was interested in

managerial costs of adjusting inventories by retail firms, time is just as relevant in the shopping decisions of their customers. Our theorist might do well to begin with an explicit model of the resource costs of the shopping process, including both time and distance. The distinguishing feature of retail markets, as compared to centralized auction markets, is that the ratio of the value of shopping time to the value of the average transaction is relatively large. Further, the fact that people and their furniture do take up space, even when crammed closely together as in Manhattan, means that a costly trip is required to buy anything.

Space and time may be convincing as factors requiring decentralization of retail markets, with the resulting loss of liquidity that is an essential prerequisite for an auction market. But these considerations should be less important in sales by manufacturers to wholesalers, and by wholesalers to retailers. Here the contrast between the vegetable market and auto-parts market is instructive. Heterogeneity of product must be the key element that explains the existence of price-setting, for how else are we to explain the central role in most wholesale firms and purchasing departments of the printed catalogue detailing the myriads of available products? The market for a rear trunk lid for a 1969 Plymouth four-door sedan delivered on a Wednesday in 1981 in Evanston, Illinois, is a rather thin one, lacking the liquidity and central location necessary for an auction to take place. Pre-set prices in a catalogue allow transaction times and locations to be freely chosen and thus increase economic efficiency. In the case of the 1969 Plymouth trunk lid, printed prices help the Evanston body shop and the State Farm insurance adjuster located ten miles away to base their allocative

decisions on the same information.

Some theorists might insist that the parts catalogue should be indexed to some nominal aggregate number, so that prices can be marked up each day or month by a fixed parameter that is announced in the newspaper. Recent visitors claim that they have seen this done in Tel Aviv restaurants. But to search so far for an example of this practice is to identify the phenomenon that prevents it from becoming widespread, and this is the low historical variance of aggregate nominal indexes as compared to relative prices. Phillip Cagan's charts document the wide dispersion of price changes in recessions for WPI commodity categories; presumably the dispersion of price changes for individual products is even greater.[31] Because relative prices change all the time, fixed-parameter indexation does not obviate the reprinting of catalogues. And if catalogues must be reprinted (and this is done separately, page by page, in the wholesale business), why should firms bother with indexing except in extraordinary macroeconomic conditions?

Specialists in industrial organization may be surprised to learn that such elementary phenomena as price-setting practices are still under discussion by macroeconomists. Industrial organization, at least as I learned it,[32] would collapse as a sub-discipline if it were stripped of product heterogeneity and pre-set prices. Product heterogeneity, which is ruled out in the new classical "yeoman barber" models, is central not only to an understanding of price-setting, but also of the basic economic concepts of the industry, the firm, and the product. Classic definitions of industries rest on distinctions that revolve around the similarity of products or production processes. The existence of the firm has been explained as a way of economizing on

transactions costs when heterogeneous labor, capital, and materials must be brought together to produce a given range of products. And anyone involved in antitrust cases knows that the ability of firms to pre-set prices is assumed from the beginning, while some of the arguments depend on the definition of product classes or individual products within a vast sea of heterogeneity.

Modeling the Demand Responsiveness of Prices as a Varying Rather than Fixed Parameter

The shopping model and kinked demand curve that play the central role in Okun's chapter on product markets constitute only the beginning of an adequate analysis. Okun has no explanation for a varying responsiveness of prices to changes in nominal aggregate demand, as is exhibited above in Part II, and has occurred in Latin America, Israel, and in various hyperinflations. When provoked, business firms are capable of changing prices very fast. A step forward can be made when we allow the firm to become Janus-faced, looking not only forward in the input-output table toward its customers, but also at the same time backward toward its suppliers. The one-sided forward-looking nature of Okun's analysis is symbolized by his Figure 4-2 on p. 177, which has the demand curve shifting along a constant cost curve. For macroeconomic analysis the central question is, "what factors can be invented to provide a rigorous explanation of the fact that, in the face of public information on nominal aggregate demand, the demand and cost curves faced by a firm do not generally move in proportion?"

The key ingredients in an explanation are, first, a distinction between aggregate and local shocks, and, second, a multiplicity of pieces of available information about nominal aggregate demand that

creates ambiguity about the exact value of current changes. A third ingredient is decentralization combined with imperfect information. The one-good yeoman barber model misses the main point if, through the usual methods of solving models with rational expectations, every agent can casually assume that everyone else is just like him. John Anderson called Reaganomics "economics with mirrors." Yet homogeneous one-good structures are really "models with mirrors," in which agents look around and see only themselves.

In thinking about the sources of gradual price adjustment in a recession, in which agents have a lot of current information about nominal aggregate demand (information which is dispersed around an ever-changing mean), it has always seemed to me that the fundamental source of stickiness involves input costs. For a moment let's ignore labor input and concentrate on materials. Our Janus-faced firm must pay for materials, and this must limit its flexibility in lowering its product price in the face of a perceived drop in nominal demand. In 1980, Chrysler could have offered rebates of 50 percent, instead of 10 percent, if only the cost of steel and other materials had cooperatively dropped by 50 percent in the second quarter of 1980. But our firm looks back into the murky recesses of the input-output table and sees only risk. If the steel firm doesn't cut price because it perceives a sticky price of coal or oil, then a unilateral 50 percent cut in the price of Chrysler autos would lead to bankruptcy even faster than would occur with a smaller price cut.

In contrast to models with mirrors, the essence of the price adjustment problem comes closer to models of public goods, with their prisoner's dilemmas and free-rider problems. Each agent must realize

its fundamental vulnerability, in the absence of a central coordinating authority, because an initial move to cut price--if followed by competitors but not by suppliers--may lead to bankruptcy. The problem is the same in labor markets. No single agent will be willing to agree to a unilateral wage cut when he knows that the cost of its market basket depends on the wages of everyone else.

One reaction to the cost-based story points to an alleged "sunk" nature of input costs. If Chrysler has already bought the steel, the fact that the steel was constructed at the higher cost level of an earlier period is irrelevant. Only demand considerations should govern the price. In the limit, this view must regard all costs as fixed over the discrete length of time during which prices are pre-set, and it thus ignores the numerous day-by-day adjustments to input quantity that a firm can achieve. More basically, it ignores the speculative element involved in holding inventories. The firm may choose to hold the steel, rather than converting it into autos at distress-sale prices, if it believes that conditions will improve next period. This "reluctance to produce" might be interpreted as voluntary underproduction in a model with mirrors. But it translates into sticky final-goods prices in fact, and is just enough to create the wedge between effective and notional demand curves that Barro, Grossman, and Malinvaud need to carry out their "fixprice" analysis.

The story about sunk costs makes it clear that a formal model of this problem must specify quite carefully the kinds of precommitments that firms must make as regards input prices and quantities. And it must specify the timing of firm output and price decisions in relation to the availability of information about nominal demand. Since real-

world firms with pre-set prices must initially learn of a demand surprise through real events--the non-appearance of expected customers and the unexpected buildup of inventories--the model must require firms to set the price before they learn the "news." Without costless communication to every supplier, and every supplier's supplier (both here and abroad), the firm is likely to respond in the next period with an adjustment that partly takes the form of lower production, and partly of lower sales prices. With nothing special on the front page of the daily newspaper, the adjustment may be weighted toward production, but with screaming headlines that a wartime enemy has surrendered, the adjustment may be weighted toward prices.

I suspect that some progress may be possible in building models of a Janus-faced firm by careful specification of the sequential learning process. Imagine that a firm presets its output price and purchases materials one week at a time. At the end of week 1 it receives initial information about its local demand shock, in the form of a buildup or reduction in inventories (and/or unfilled orders) compared to its initial plan. At the same time it may receive a new price list from one or more suppliers and can begin to form an inference about the state of aggregate demand. News about the state of aggregate demand is not received as a neat package, but rather in the form of bits of information arriving week after week. Our firm might learn at the end of week 2 of the Business Week index for week 1, and at the end of week 3 the unemployment rate and index of industrial production for week 1. Because all of these information sources about both local and aggregate demand are noisy, several weeks are likely to be observed before major changes in plans are made. Sluggish price adjustment may emerge from

this process under normal peacetime conditions if firms wait for price cuts by suppliers before feeling that it is safe to cut prices substantially in response to a perceived dip in aggregate demand, while suppliers wait to cut prices until their assessment of the current aggregate demand situation is confirmed by a reduction in orders from final goods producers. The more rapid adjustment of prices during wartime may stem from the role of dramatic political and military news in cutting through the normal drawn-out sequential learning process.

## V. CONCLUSION

This paper has shown that the historical experience of the last century reveals a number of different patterns of price and wage adjustment. In the postwar U.S. prices and wages respond modestly to the level and change in aggregate demand, with a substantial role for inertia. In other times and places, however, prices and wages have responded in greater degree to the change and level of aggregate demand, and have been less influenced by inertia. Prices and wages were particularly flexible in the U.S. during World War I and its aftermath, in Japan after 1914, and in the postwar U.K.

Some of these changes in behavior seem to have plausible explanations. For instance, the theoretical ideas sketched in the last section may have some potential for explaining the greater degree of price responsiveness in the U.S. during World War I. The postwar inertia in the U.S. as contrasted with the U.K. and Japan, seems consistent with the interpretation that the unique U.S. institution of three-year staggered wage contracts plays a central role in price and wage dynamics. Other changes in behavior are more mysterious. The "output level" impact of aggregate demand on price and wage changes seems to have disappeared in the U.S. between 1929 and 1941, and in the U.K. between 1924 and 1938. This merely restates what we already knew, that high unemployment in those episodes did not lead to the expected downward adjustment in prices and wages. Yet tests not reported here decisively reject the hypothesis of asymmetric adjustment.

Neither the empirical estimates nor the theoretical suggestions contained in this paper are intended as final answers. Parameters estimated from a century of annual data should not be used to make

precise assessments of current policy issues, but rather should be regarded as providing some rough guidelines regarding the frequency and magnitude of parameter shifts that seem to characterize the price and wage adjustment process in different countries. Interpretation of policy mistakes in past historical episodes, and estimates of the impact of future policy actions, requires more careful attention to shorter periods using quarterly or monthly data, and indexes of price and wage changes that distinguish between shifts in output and employment mix from actual changes in individual prices and wage rates. The research agenda for econometricians and theorists seems, as always, to be a full one.

FOOTNOTES

1. Wall Street Journal, January 28, 1981, p. 42.

2. Milton Friedman, "The Role of Monetary Policy," American Economic Review, vol. 58 (March 1968), pp. 1-17; Robert E. Lucas, "Some International Evidence on Output-Inflation Tradeoffs," American Economic Review, vol. 63 (June 1973), pp. 326-34; Martin N. Baily, "Wages and Unemployment Under Uncertain Demand," Review of Economic Studies, vol. 41 (January 1974), pp. 37-50.

3. The best exposition remains Robert J. Barro and Herschel I. Grossman, Money, Employment, and Inflation (Cambridge: Cambridge University Press, 1976), especially Chapter 2.

4. Arthur M. Okun, Prices and Quantities: A Macroeconomic Analysis, Washington: Brookings, 1981.

5. My overall assessment thus coincides with Edmund S. Phelps, "Okun's Macro-Micro System: An Appraisal," Journal of Economic Literature, vol. 19 (September 1981), pp. 1065-77.

6. Arthur M. Okun, "Efficient Disinflationary Policies," American Economic Review, vol. 68 (May 1978), pp. 348-52.

7. Thomas J. Sargent, "The Ends of Four Big Inflations", NBER Conference paper 90, 1981.

8. Robert J. Gordon, "The Demand for and Supply of Inflation," Journal of Law and Economics, vol. 18 (December 1975), pp. 807-36.

9. Robert J. Gordon, "Output Fluctuations and Gradual Price Adjustment," Journal of Economic Literature, vol. 19 (June 1981), pp. 492-530.

10. Robert J. Gordon, "Why U.S. Wage and Employment Behavior

Differs from that in Britain and Japan," Economic Journal, vol. 92 (March 1982), pp. 000-00.

11. George L. Perry, "Changing Labor Markets and Inflation," Brookings Papers on Economic Activity, vol. 3, 1970, pp. 411-41.

12. The specification in equation (3) has been tested for postwar U.S. quarterly data, using Perry's weighted unemployment rate instead of the output ratio, in my "Inflation, Flexible Exchange Rages, and the Natural Rate of Unemployment," NBER working paper no. 708, July 1981, forthcoming in Martin N. Baily, ed., Workers, Jobs, and Inflation (Washington: Brookings, 1982). That paper is the source of the estimates of postwar natural real GNP used to generate the postwar annual output ratio series used in the current paper; it also tests and accepts the restrictions assumed in (3), that lagged wage changes are absent; and, finally, it allows changes in standard productivity to depend partially on the evolution of actual productivity behavior.

13. The specification written as equation (2) below was first estimated in "A Consistent Characterization of a Near-Century of Price Behavior," American Economic Review, vol. 70, (May 1980), pp. 243-9. Subsequently the same approach has been used with quarterly data to test the Lucas-Sargent-Wallace policy ineffectiveness proposition in "Price Inertia and Policy Ineffectiveness in the United States, 1890-1980," NBER working paper no. 744, September 1981.

14. While a sum of coefficients of unity is consistent with the accelerationist hypothesis, a sum of coefficients below unity does not necessarily conflict with that hypothesis, an important point originally made in Thomas J. Sargent, "A Note on the Accelerationist Controversy," Journal of Money, Credit, and Banking, vol. 3 (August 1971), pp. 721-5.

15. The most recent evaluation of controls is contained in Jon Frye and Robert J. Gordon, "Government Intervention in the Inflation Process: The Econometrics of 'Self-Inflicted Wounds'," American Economic Review, vol. 71 (May 1981), pp. 288-94. Econometric estimates of equation (3) for the interwar period are presented in Robert J. Gordon and James A. Wilcox, "Monetarist Interpretations of the Great Depression: An Evaluation and Critique," in K. Brunner, ed., The Great Depression Revisited (Boston: Martinus Nijhoff, 1981), pp. 49-107 (see especially Table 8 on p. 88).

16. The dummy variables are defined in note d to Table 1. The odd timing of the Korean war variable reflects my verdict that the Korean war controls did no more than consolidate the unwinding of the speculative commodity boom of 1950-51. This interpretation is supported by the fact that the variable is significant in the price equation but not in the wage equation.

17. "A Consistent Characterization," p. 249.

18. On World War I controls, see F. W. Taussig, "Price-Fixing as Seen by a Price-Fixer," Quarterly Journal of Economics, vol. 33 (February 1919), pp. 205-41.

19. The major parameter shift evident in a more detailed study of quarterly postwar data is a shortening after 1966 in the mean lag of the distribution of weights on past inflation, which I interpret as due to the growing importance of cost-of-living escalators. A return to a low-inflation regime might well cause COLA escalators to become less important, but this would not reduce the output cost of the transition to that regime.

20. "Why U.S. Wage and Employment Behavior Differs From That in

Britain and Japan," Table 3.

21. "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment" finds significant exchange rate effects in quarterly U.S. data.

22. I emphasized the role of product prices as far back as "Inflation in Recession and Recovery," Brookings Papers on Economic Activity, vol. 2, 1971, no. 1, pp. 105-58. A contest between lagged product prices and lagged wages in "Inflation, Flexible Exchange Rates," Table 6, p. 48, yields a coefficient on lagged wages that is both insignificant and of the incorrect sign.

23. This is performed in "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment."

24. Although not included in Table 1 to simplify the presentation, the difference between changes in the CPI and in the GNP deflator makes a small and significant contribution in the U.S. wage equation, particularly in the 1967-80 subperiod.

25. In light of Bob Hall's recent evidence on the importance of lifetime jobs in the U.S., it is interesting to find that in 1966, 56 percent of males aged 35 to 39 had more than ten year's seniority in Japan, against only 34 percent of the same group in the United States. See Robert E. Cole, "Permanent Employment in Japan: Facts and Fantasies," Industrial and Labor Relations Review, vol. 26, no. 1, pp. 615-30 (citation from p. 618).

26. Joanna Gray, "On Indexation and Contract Length," Journal of Political Economy, vol. 86 (February 1978), pp. 1-18; and Ronald Dye, "Optimal Contract Length," Carnegie-Mellon working paper, October 1979.

27. These generalizations are supported by citations and additional arguments in Part IV of "Why U.S. Wage and Employment Behavior Differs."

28. This section overlaps with part of Section III.2 of "Why U.S. Wage and Employment Behavior Differs."

29. Gary Becker, "A Theory of the Allocation of Time," Economic Journal, vol. 75 (September 1965), pp. 493-517.

30. Alan S. Blinder, "Retail Inventory Behavior and Business Fluctuations," Brookings Papers on Economic Activity, vol. 12 (1981, no. 2), pp. 000-00.

31. Phillip Cagan, "Changes in the Recession Behavior of Wholesale Prices in the 1920s and Post-World War II," Explorations in Economic Research, vol. 2 (Winter 1975), pp. 54-104.

32. From Carl Kaysen, with frequent interruptions by Frank Fisher, at Harvard in 1960-61.

# DATA APPENDIX

(Key to data source codes is given after the listing for each country)

## UNITED STATES

1890-1928: All data are from LTEG.

Nominal GNP: Series A7, linked in 1909 to Series A8.

Real GNP: Series A1, linked in 1909 to Series A2.

GNP Deflator: Nominal GNP divided by Real GNP.

Wage Rate: "Total compensation per hour of work in manufacturing, production workers, in 1957 dollars," series B70, times "Consumer Price Index," series B69.

Natural Real GNP: 1892-1953, RJGM, Appendix B.

1929-1980:

Nominal and Real GNP: SCB, December 1980, page 17, table 7, and SCB June 1981, Table 1.1-1.2.

GNP Deflator: Nominal GNP divided by Real GNP.

Natural Real GNP: 1954-1980, RJGI, Appendix B.

Wage Rate: 1929-1946, "Total compensation per hour of work in manufacturing, production workers, in 1957 dollars," Series B70 in LTEG multiplied by "Consumer Price Index," series B69.
1947-1980, "Total private non-agricultural average gross hourly earnings, current dollars," Table B36, ERP, 1981.

Key to Data Sources for U.S.:

ERP Economic Report of the President.

LTEG Long-Term Economic Growth 1860-1970, U.S. Department of Commerce, 1973.

RJGI Robert J. Gordon, "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment."

RJGM Robert J. Gordon, Macroeconomics, Second Edition.

SCB Survey of Current Business.

UNITED KINGDOM

1870-1938: All data from F.

Nominal GNP: Table 1, col. (1).

GNP deflator at factor cost: Table 61, col. (7).

Natural Real GNP: Broken exponential trend line benchmarked in 1913, 1922, 1937, and 1950.

Wage Rate: "Average full-time weekly wage rate," Table 65, col. (1).

Foreign Exchange Rate: see below.

1955-1980: From IMF (1981 and 1971), unless otherwise specified.

Nominal GDP: Line 99b.

GDP deflator — Nominal GDP divided by real GDP.

Real GDP — Line 99b.p.

Natural Real GDP: Broken exponential trend line benchmarked in 1950 and 1970.

Wage Rate: Average monthly earnings, all industries, line 65.c.

Foreign Exchange Rate: 1900-1970 - Annual Average dollar exchange rate: BEKS 1900-1970.
1970-1980 - Effective exchange rate, IMF line amx.

Key to Data Sources for U.K.:

BEKS — The British Economy Key Statistics, London/Cambridge Econ. Series, 1973.

F — Charles H. Feinstein, National Income, Expenditure, and Output of the U.K., 1853-1965.

IMF — International Monetary Fund Annual Yearbook, 1971 and 1981.

JAPAN

1870-1940

Nominal GNP: OHK (1957), Table 3, col. (1), linked in 1905 to OHKR (1973), Table 1, col. (6).

GNP deflator: OHK (1957), Table 3, col. (1), divided by Table 4, col. (1), linked in 1905 to OHKR (1973), Table 14, col. (3).

Real GNP: Nominal GNP divided by GNP deflator.

Natural Real GNP: Broken exponential trend benchmarked in 1855, 1890, 1903, 1914, 1919, 1929, 1938, and 1953.

Wage Rate: "Wage Index," OHK (1957), Table 1, col. (1).

1960-1980. All data from IMF (1971, 1981).

Nominal GNP: Line 99a.

Real GNP: Line 99a,r.

Natural real GNP: Broken exponential trends benchmarked in 1953 and 1971.

GNP deflator: Nominal GNP divided by Real GNP.

Wages: Line 65.

Key to Data Sources for Japan:

IMF International Monetary Fund Annual Yearbook (1971, 1981)

OHK K. Ohkawa, The Growth Rate of the Japanese Economy Since 1878, Tokyo: Kinokuniya University, 1957.

OHKR K. Ohkawa and H. Rosovsky, Japanese Economic Growth, Stanford: Stanford University Press, 1973.