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# Real Wages and the Japanese Economy

**HIROSHI YOSHIKAWA* and YOSHIYUKI TAKEUCHI****

*This paper analyzes the determinants of real wages in Japan by using panel data. One finding is that the dispersion of sales across industries tends to suppress wage increases in Japan. In addition, a comparison of Japan's prewar and postwar economies presents some evidence suggesting that the flexibility of wages does not necessarily enhance the stability of the real economy. Furthermore, estimations of investment functions reveal that an increase in real wages tends to raise investment. This evidence suggests that for the most part the Japanese economy in the 1970s and 1980s was quantity-constrained in the Keynesian sense.*

## I. Introduction

This paper studies the relationship between real wages and the macroeconomic performance of the Japanese economy from several different angles. Our primary aim is to see whether or not the Japanese economy works in the neo-classical way.

The labor market was largely ignored during the post-war development of macroeconomics, as is represented by the IS/LM model. Today, however, the situation has dramatically changed. Analyses of the labor market, particularly of real wages, now play an important role in macroeconomics. There are two primary reasons for this change. First, analyses of the labor market was elevated in importance by the rational expectations based neo-classical renaissance since the 1970s. This can be seen in the Friedman-Lucas natural rate theory or the search theory of unemployment. Second, as Figure 1 shows, the unemployment rates in the OECD countries have sharply risen over the past fifteen years. Not surprisingly, these developments have drawn the attention of macroeconomists to the labor market.

* Associate Professor, Institute of Social and Economic Research, Osaka University (currently at Faculty of Economics, University of Tokyo).

** Graduate student, University of Tokyo.

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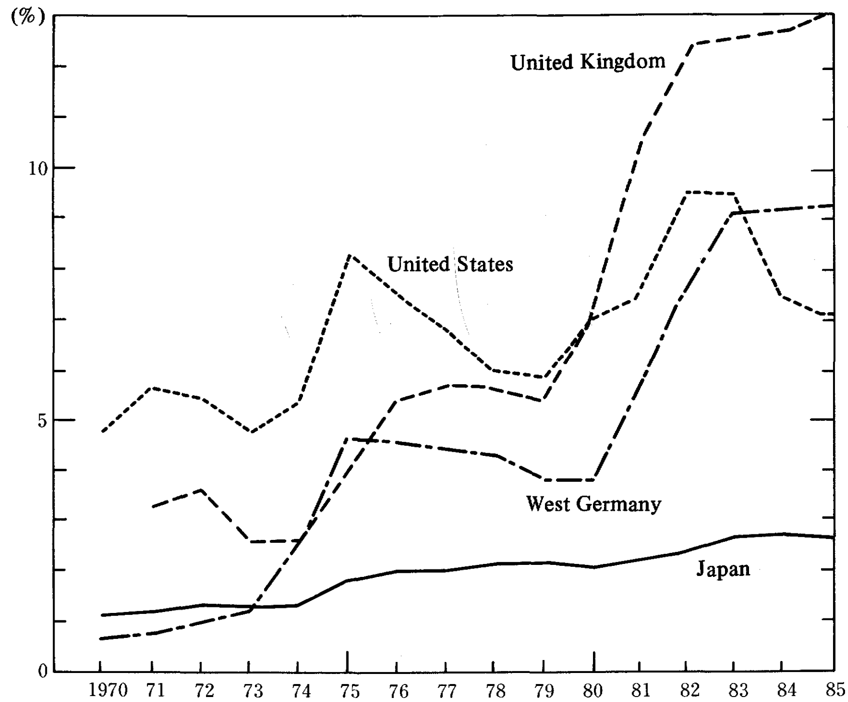
Parallel with these broad developments in macroeconomics, various changes in the labor market have also attracted economists' attention to the more specific effects of the labor market on the performance of the Japanese economy. As will be discussed later, our criterion for measuring macroeconomic performance is not unique. In terms of the unemployment rate, however, Japan's performance was superior, as can be clearly seen in Figure 1. In addition, many economists describe the Japanese economy as quite "strong," especially when compared with the United States, which suffers from the "twin deficits," and other countries. As is well known, Japan's macroeconomic performance was actually the worst among the OECD countries after the first oil crisis, both in terms of the decline in real GNP and the inflation rate. Nevertheless, during the decade since the second oil crisis, arguments stressing the "strength" of the Japanese economy have become all the more prominent. The labor market is frequently mentioned as the main

Figure 1. Unemployment Rate after 1970




Source: Japan : *Labor Force Survey*, Statistics Bureau, Management and Coordination Agency.
U.S.A. : *Employment and Earnings*, Department of Labor.
U.K. : *Employment Gazette*, Ministry of Employment.
West Germany: *Wirtschaft und Statistik*, Federal Department of Statistics.

reason for this "strength."[1]

Against such background, this paper examines several problems concerning real wages and the workings of the Japanese economy. Evaluations of the role played by real wages in the economy vastly differ, depending on whether one applies a neo-classical or Keynesian framework.

The paper is organized as follows: In section II, we explore the sources of the alledged flexibility of Japan's real wages using microeconomic data (on a corporate level). Here we also argue that real GNP is more appropriate than the unemployment rate as a measure of the performance of the real economy.

In section III, we use VAR (Vector Autoregression) analysis to examine the relationship between real wages and other variables. We also compare Japan's prewar and the postwar economies in order to test the proposition deduced from neo-classical economies that the flexibility of real wages improves the performance of the real economy.

In section IV we analyze the relationship between real wages and investment in order to see the effects of real wages on the economy in the long-run. Drawing from a theoretical discussion, we estimate investment functions using data from the Japanese manufacturing industry.

In section V we offer some concluding remarks.

## II. Determination of Real Wages in Japan

In this section, we explore the determination of real wages in Japan. It is actually not clear whether real wages in Japan are flexible or not. On the one hand, Branson and Rotenberg (1980) formulated a model in which nominal wages respond to movement of the "target wages." In their model, the "target wages" are identified by price changes. As a consequence, the more flexible nominal wages are the more inflexible real wages become, and *vice versa*. Using this framework, Brason and Rotenberg conclude that the U.S. economy is characterized by inflexible nominal wages and flexible real wages, while the Japanese and European economies have inflexible real wages.

On the other hand, Gordon (1982) undertook a more direct comparison among leading nations by just looking at standard deviations of changing rates of nominal and real wages. His results are shown in Table 1 (for reference, working hours and employment are also shown). According to the table, the Japanese and U.K. economies are more flexible in terms of both nominal and real wages when compared to the United States. It is worth noting that Ohtake (1986), who has doubts about the flexibility of real wages in Japan, also pointed out that the U.K. has the most flexible real wages among Japan, the United States, United Kingdom, Germany and France. This result suggests

[1]Ueda and Yoshikawa (1984) and Eguchi (1988) study various problems of the labor market in relations to macroeconomics. Also refer to surveys by Tachibanaki (1987) on the problems discussed in sections II and III.

Table 1. Standard Deviations of Rates of Change in Nominal Wage (w), Real Wage (w - p), Labor Hour per Head (h), and Employment (e) in the Manufacturing Sector

(quarterly data)

| | 1963/I ~ 1980/III | | | 1963/I ~ 1972/IV | | |
|---|---|---|---|---|---|---|
| | U.S. | U.K. | Japan | U.S. | U.K. | Japan |
| w | 1.69 | 5.29 | 4.84 | 1.66 | 3.40 | 2.83 |
| Real wage (w − p) | 1.46 | 3.86 | 2.78 | 0.82 | 1.74 | 2.50 |
| h + e | 4.78 | 3.22 | 1.09 | 4.06 | 2.70 | 0.91 |
| h | 1.09 | 1.74 | 1.98 | 1.06 | 1.37 | 1.17 |
| e | 4.05 | 2.18 | 2.03 | 3.39 | 1.95 | 2.15 |

Note: p is the rate of change in GNP deflator.
Source: Gordon (1982).

that, given the notorious "U.K. disease" in the 1970s and early 80s, it is problematic to link the flexibility of real wages directly to good macroeconomic performance.

As briefly surveyed above, economists have not yet reached a consensus regarding the flexibility of real wages in Japan. Here, we have introduced Gordon's Table 1 as a generally accepted standard. That is to say, we assume that real wages in Japan are considerably more flexible than those in the United States, and that real wages in the U.K. are as flexible as or perhaps more flexible than those in Japan.

## A. Estimation of Real Wage Equation

Given that real wages in Japan are relatively flexible, we next explore what factors determine real wages. We analyze this problem using corporate level microeconomic data. Suppose that the following equation describes determination of nominal wages:

$$\dot{w}_{it} = f_{it} + \dot{\bar{w}}_t. \tag{1}$$

Here $\dot{w}_{it}$ is the rate of increase in nominal wages of company i at time t. $\dot{w}_{it}$ depends on both the microeconomic factor $f_{it}$, which is characteristic of company i, and the economy-wide wage increase $\dot{\bar{w}}_t$, which is, of course, the macroeconomic factor. If the labor market is completely homogeneous and there is no firm-specific skill, then $f_{it}$ should not affect $w_{it}$. Accordingly the significance of $f_{it}$ is a measure of the heterogeneity of the labor market.

Turning to data and econometric issues, the data on wages are taken from the Bank of Japan's *Business Analysis of Main Enterprises in Japan*. Since the data are compiled on a fiscal year basis, the wage equation is not estimated for each corporation. To fill this gap, we prepared a panel of 297 corporations in 13 types of industries as shown in Table 2 and then carried out our own estimations based on this panel. The sample period is 18

Table 2. Industry and the Number of Firms

| Industry | Number of firms |
|---|---|
| Foodstuff | 27 |
| Textile | 35 |
| Paper, pulp | 10 |
| Chemical | 57 |
| Oil refinery | 6 |
| Ceramics | 20 |
| Steel | 22 |
| Non-ferrous metals | 4 |
| Machinery | 31 |
| Electric machinery | 27 |
| Transportation equipment | 30 |
| Precision machinery | 8 |
| Total | 297 |

years from 1968 to 1985. The estimation equation consists of three factors: corporation specific factors, industry specific factors and finally the economy-wide factors.

$$\dot{w}_{it} = \mu + F_{it}'\beta_f + D_{j(i)t}'\beta_d + M_t'\beta_m + \varepsilon_{it} \tag{2}$$

Here $\dot{w}_{it}$ denotes the rate of increase in nominal wages of company i at time t. $F_{it}$ is the vector of variables characteristic of firm i at time t. $D_{j(i)t}$ is the vector of variables characteristic of industry j to which firm i belongs at time t. And, $M_t$ is the vector of macroeconomic variables at time t. $\beta_i$ (i=f, d, m) is the corresponding coefficient vector and $\varepsilon_{it}$ is the error term.

The variables used to determine the firm-specific factors are the rate of increase in the firm's real sales and the rate of profit. The industry-specific variable is the index of shipments of each industry. Finally, the macroeconomic variables are the unemployment rate, the expected rate of inflation and the variance of the industry shipment indices. The last variable will be explained in more detail shortly.

All the firm-specific variables are taken from the *Business Analysis of Main Enterprises in Japan*, mentioned above. Nominal wages are taken from the "personnel expenses per employee" in the Analysis. The shipment of each firm is the sales (nominal) deflated by the WPI of respective industry to which the firm belong.[2] The profit rate is the ratio of operating profits to total capital. And the shipment of each industry is taken from the "industrial shipment index" (1980=100) compiled by the Ministry of Interna-

[2]For the general machinery and precision machinery industries, the respective wholesale price indices are not separately available. Accordingly, two industries are deflated by the same wholesale price index of the general and precision machinery industry.

tional Trade and Industry.

After some experimenting, we decided to use the rate of increase in the CPI as the expected rate of inflation. It is, of course, more desirable to generate the inflationary expectation in accordance with an explicit price equation. Such a framework would also enable us to analyze the interdependence of wages and prices. Here, however, for simplicity of the analysis we simply use the consumer price index without a lag as a proxy for inflationary expectations. The coefficient of the rate of increase in the CPI was not significantly different from zero in our preliminary estimation. Therefore, in what follows we report only the *real* wage equation.

Turning to econometric issues, we must note that in an analysis using panel data, there is a strong possibility simultaneous correlation and heteroscedasticity in the error term. Accordingly, we may not assume

$$\mathrm{E}\,(\varepsilon_{is}\,\varepsilon_{jt}) = \begin{cases} \sigma^2 \text{ (if i=j and s=t)} \\ 0 \text{ (otherwise)} \end{cases} \tag{3}$$

which is usually imposed in an OLS (ordinary least squares) estimation. It is well known that in such cases, the OLS estimator is no longer the best linear unbiased estimator (BLUE). With this in mind we use the generalized least squares (GLS) estimation with the following assumptions:[3]

(1) Mean zero $\mathrm{E}(\varepsilon_{it}) = 0$

(2) Heteroscedasticity $\mathrm{E}(\varepsilon_{it}^2) = \sigma_i^2$

(3) Contemporaneous correlation $\mathrm{E}(\varepsilon_{is}\,\varepsilon_{jt}) = \begin{cases} \sigma_{ij} \text{ (s=t)} \\ 0 \text{ (s}\neq\text{t)} \end{cases}$

(4) First order serial correlation $\varepsilon_{it} = \rho_i \varepsilon_{i,t-1} + \nu_{it}$

$\nu_{it} \sim \mathrm{WN}(0, \phi_{ii})$

$\mathrm{E}(\nu_{is}\,\nu_{jt}) = \begin{cases} \phi_{ij} \text{ (s=t)} \\ 0 \text{ (s}\neq\text{t).} \end{cases}$

The estimation results are shown in Table 3. In equation (a), two microeconomic factors, the rate of increase in the sales $S_{it}$ and the rate of profit $R_{it}$ are both significant.

Turning to macroeconomic factors, the unemployment rate $U_t$ and $\sigma_t$, which measures the dispersion of sales over industries, are significant. $U_t$ measures the demand-supply conditions in the external labor market. Considering the possibly nonlinear effects, we put $U_t$ into the equation in a reciprocal form. Accordingly, the expected sign of its coefficient is positive.

More explanation is necessary for $\sigma_t$. Wages set by each corporation depend on the average wage prevailing in the economy as a whole. With this in mind, suppose that the

[3]For details of the methods of estimation, see Fomby *et al.* (1984). What we use here is the TSCSREG procedure of the SAS/SUGI supplement.

Table 3. Estimation Results of Phillips Curve (Real Wage) with Microeconomic Data

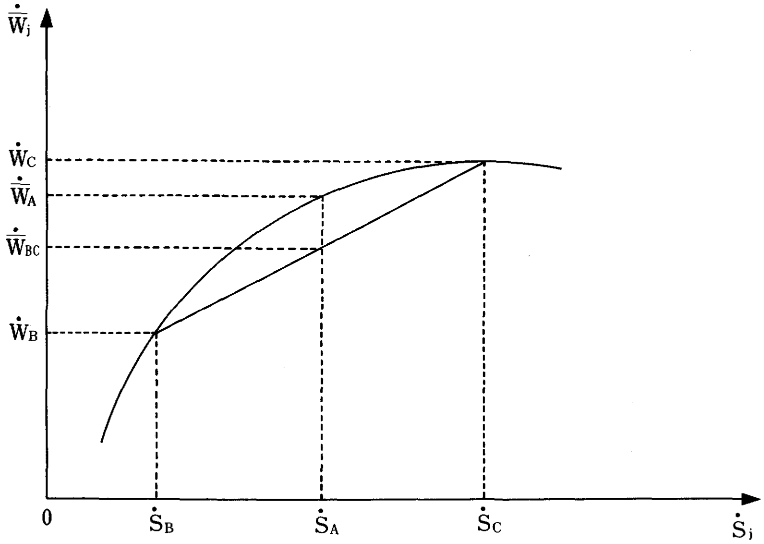
(a) $$\dot{W}_{it} = \underset{(24.3)}{-0.042} + \underset{(22.8)}{0.19\dot{S}_{it}} + \underset{(8.8)}{0.002R_{it}} - \underset{(7.1)}{1.40\sigma_t} + \underset{(38.8)}{0.11}\left(\frac{1}{U_t}\right)$$

(b) $$\dot{W}_{it} = \underset{(24.4)}{-0.042} + \underset{(22.7)}{0.19\dot{S}_{it}} - \underset{(-0.11)}{0.01\sigma_t^i} + \underset{(8.7)}{0.002R_{it}} - \underset{(6.5)}{1.40\sigma_t} + \underset{(36.9)}{0.11}\left(\frac{1}{U_t}\right)$$

(c) $$\dot{W}_{it} = \underset{(13.5)}{-0.075} + \underset{(15.3)}{0.18\dot{S}_{it}} + \underset{(4.3)}{0.001R_{it}} + \underset{(6.5)}{0.013M_t^3} + \underset{(17.5)}{0.14}\left(\frac{1}{U_t}\right)$$

Note: *t value in parentheses.*

Figure 2. Effects of Dispersion of Sales across Industries on the Average Wage Increase



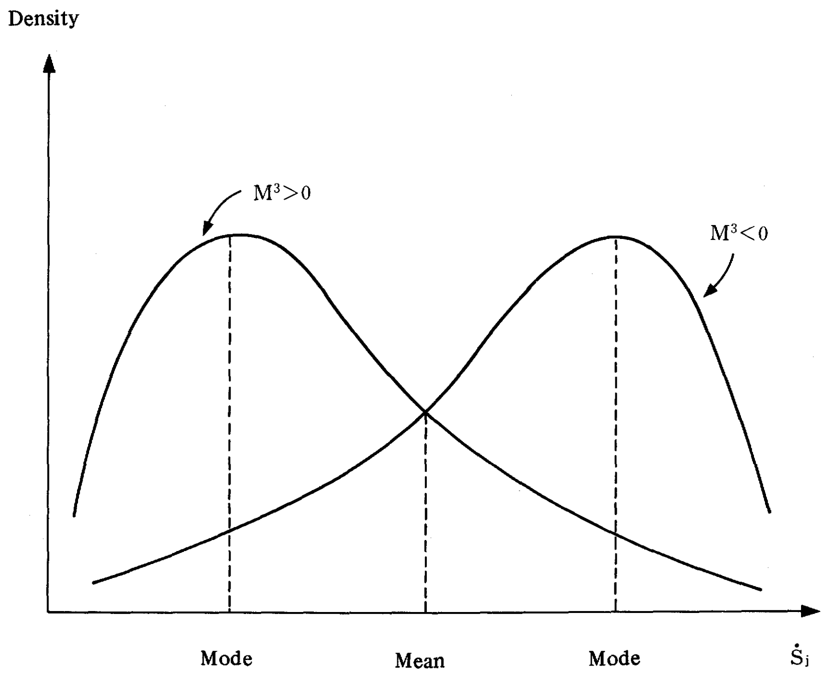

relationship between the rate of increase in wages in each industry and the rate of increase in sales in the respective industry is concave as shown in Figure 2. Under such conditions, the average rate of wage increase declines when the dispersion of sales becomes larger even if the average rate of increase in sales, $\sum_{i=1}^{N} \dot{S}_j/N$ remains same. For simplicity, further suppose that there are only two industries in the economy. When the rates of increase in sales of the two industries are both $\dot{S}_A$, the average rate of wage increase is $\dot{\bar{w}}_A$. When the rates of increase in sales of the two industries are $\dot{S}_B$ and $\dot{S}_C$, respectively, the average rate of wage increase $\dot{\bar{w}}_{BC}$ becomes smaller than $\dot{\bar{w}}_A$, even if the average rate of increase in sales of the two industries remains the same ($\dot{S}_A=(\dot{S}_B+\dot{S}_C)/2$).

Since $\sigma_t$ measures the dispersion of sales across industries, if the relation between $S_j$ and $w_j$ is concave as shown in Figure 2, the coefficient of $\sigma_t$ in the wage equation is expected to be negative. In this framework, the mean of $\dot{S}_j$ must, of course, have a positive effect on $\dot{w}_j$. In our estimations, however, high correlation between $\dot{S}_{it}$ and the mean of $\dot{S}_{jt}$ caused a serious problem of multicolinearity.

In the estimation results shown in Table 3, the coefficient of $\sigma_t$ has a significantly negative sign. That is, the dispersion of sales across industries suppresses the wage increases. On the other hand, the dispersion of sales across *companies* in the same industry, $\sigma_t$ turned out to be insignificant (equation (b) in Table 3). We conclude that the dispersion of sales across industries, rather than across firms in the same industry, suppresses wage hikes.

In the above analysis, we took the *average* wage as the wage prevailing in the economy. Some economists might argue, however, that the "prevailing wage rate" is not an *average* but *a mode*. In order to clarify this point, we added a cubic moment ($M_t^3$) of an increase in sales of industries to our equation instead of the variance $\sigma_t$. As shown in Figure 3, the cubic moment is a measure of skewness of distribution. If the prevailing wage rate which affects each firm's wage decisions is actually a mode, the average wage described by other macroeconomic variables should overestimate this market rate when $M^3>0$ or conversely underestimate it when $M^3<0$. Therefore, given the above reasoning,

Figure 3. Cubic Moment ($M^3$)



the coefficient of $M^3$ in the regression equation is expected to be negative. In fact, the coefficient of the regression equation (equation (c) in Table 3) in which $M^3$ instead of $\sigma_t$ is added, is significantly positive. In short, the "prevailing market wage rate" is influenced by an "abnormal" value of sale (which is the long tail of the distribution) rather than by a mode. More research must be done to determine whether the effects are the same in both the $M^3>0$ and $M^3<0$ cases. In what follows, we refer back to our estimation results with the dispersion measure $\sigma_t$.

Table 4 shows relative contributions of four explanatory variables for each year based on equation (a) of Table 3. Although the figures change considerably over years we can roughly conclude that about 60 to 70 percent of the wage increase are attributable to the macroeconomic factors, while the remainder are attributable to the microeconomic factors. Since the microeconomic factors play the significant roles, we argue that the labor market is not a single homogeneous market but is segmented at the corporate level.

Immediately after the second oil crisis, real wages in Japan were suppressed to a considerable extent (See Table 5). Table 4 shows that the dispersion of sales among industries contributed considerably to suppressing real wages at that time. Some economists argue that the suppression of real wages after the second oil crisis was due mainly to changes in terms of trade (Shinkai 1981). In our experiments, however, strong correlation between terms of trade and the unemployment rate caused a serious problem of multicolinearity.

Table 4. Relative Contribution of Each Explanatory Variables in Wage Equation

| | $S_{it}$ | $R_{it}$ | $\sigma_t$ | $U_t$ |
|---|---|---|---|---|
| 1968 | 22.6 | 14.3 | - 6.6 | 70.2 |
| 69 | 22.6 | 15.4 | - 2.6 | 73.0 |
| 70 | 17.7 | 12.6 | - 1.2 | 62.6 |
| 71 | 9.6 | 15.3 | - 3.2 | 98.5 |
| 72 | 13.5 | 12.3 | - 1.9 | 74.4 |
| 73 | 8.9 | 14.2 | - 3.1 | 61.5 |
| 74 | 0.5 | 15.3 | -13.1 | 71.3 |
| 75 | 28.9 | -21.6 | -17.0 | -186.1 |
| 76 | 26.7 | 18.1 | -10.8 | 92.3 |
| 77 | 11.5 | 11.1 | - 6.2 | 61.7 |
| 78 | 14.8 | 18.2 | - 4.4 | 81.9 |
| 79 | 11.1 | 18.2 | - 4.9 | 62.0 |
| 80 | 20.7 | 33.8 | -32.6 | 114.4 |
| 81 | 14.1 | 21.2 | - 4.5 | 79.8 |
| 82 | 2.4 | 17.2 | - 4.1 | 71.6 |
| 83 | 10.5 | 15.9 | - 8.3 | 62.6 |
| 84 | 15.3 | 14.8 | - 8.4 | 51.5 |
| 85 | 10.3 | 12.9 | - 5.2 | 54.3 |

Table 5. Rate of Change of Real Wage in Japan

| | (%) |
|---|---|
| 1968 | 9.1 |
| 69 | 8.8 |
| 70 | 9.9 |
| 71 | 4.0 |
| 72 | 6.2 |
| 73 | 9.2 |
| 74 | 5.6 |
| 75 | −7.1 |
| 76 | 1.6 |
| 77 | 4.1 |
| 78 | 1.7 |
| 79 | 4.2 |
| 80 | 0.2 |
| 81 | 1.7 |
| 82 | 1.8 |
| 83 | 2.1 |
| 84 | 3.5 |
| 85 | 3.1 |

## B. Phillips Curve and Aggregate Supply Curve

The coefficient of $U_t$ in Table 3 is the slope of the Phillips curve. As pointed out by Shimada (1981), and Grubb *et al.* (1983), this coefficient is very large in Japan compared with other countries. This finding has been frequently interpreted to show that prices fluctuate more and quantities fluctuate less for a given demand shock and therefore that Keynesian demand management is ineffective. Such an interpretation is, however, not quite correct as explained below.

A steep Phillips curve means that the unemployment rate does not fluctuate much. If changes in the unemployment rate precisely reflected the level of the economy's over-all activities, the above-mentioned interpretation would be correct. As it turns out, however, the differences in the unemployment rates among countries are due mainly to different definitions of the unemployment rate as well as to institutional differences in the labor markets. In Japan, for example, it is well known that labor input is adjusted mainly by changing the number of working hours per worker rather than changing the number of workers (Table 1). On the labor supply side, it is also well recognized in Japan that the labor force participation rate fluctuates procyclically to a considerable extent, (Umemura 1963; Ono 1981). Since the unemployment rate is defined as $1-E/L^s$ (E: number of employers, $L^s$: labor force), if $L^s$ declines parallel with a plunge in E, any change in the unemployment rate becomes insignificant. According to Ono (1981), those who stop looking for employment or give up participating in the labor force in recessions account for 8.9% (or 2.87 million people) of the non-labor force in Japan as of 1978. In the United States, in contrast, this rate is only 1.4%. In the case of Japan, these 2.87 million people equal about four or five percent of the unemployment rate. We do not intend to argue that these people should all be included in the unemployed category but we do think that the difference between such people and the unemployed is slight.

Any comparison of unemployment rates across different countries must therefore be made very carefully. In particular, the unemployment rate is not a good indicator of the level of macroeconomic activity in Japan. In the United States, workers are laid off in accordance with a decline in output, which leads to a rise in the unemployment rate. In contrast, in Japan, a similar drop in output will not cause the unemployment rate to rise comparably because the necessary adjustment of labor input is made through changing working hours or a rise in the "disguised unemployment." The difference in the levels of the unemployment rate in Japan and the United States, therefore, reflects mainly the difference in income distribution, who bears burdens of the decline in output. The problem of income distribution is, of course, very important, but is a different issue from measuring the level of macroeconomic activity. As an indicator of the level of macroeconomic activity real GNP is actually a clearer and more appropriate concept than the unemployment rate.

Thus, it is necessary for us to consider the aggregate supply function which shows the relation between real GNP and wages or prices. As mentioned previously, it is often taken for granted that a steep Phillips curve means a steep aggregate supply function. However, while the slope of the Phillips curve is $\Delta w/\Delta u$ or $\Delta\pi/\Delta u$ (w, $\pi$, u denote the rate of increase in wages, the rate of increase in prices and the unemployment rate, respectively), the slope of the aggregate supply function is $\Delta w/\Delta y$ or $\Delta\pi/\Delta y$ (y=real GNP).

$$\Delta w / \Delta y = (\Delta w / \Delta u) / (\Delta y / \Delta u) \tag{4}$$

As shown by equation (4), large $\Delta w/\Delta u$ does not necessarily mean large $\Delta w/\Delta y$. $\Delta y/\Delta u$ in equation (4) is the so-called Okun coefficient, and it is extremely large in Japan as shown by Kurosaka and Hamada (1982). Accordingly, it is not only a logical possibility but is actually likely that large $\Delta w/\Delta u$ coexists with small $\Delta w/\Delta y$. This point was emphasized by Ueda and Yoshikawa (1984) and later tested by Kurosaka and Goto (1987). Table 6 shows the slope of the aggregate supply curves estimated by Kurosaka and Goto (1987). Japan has the smallest coefficient among the major countries.

Since the Phillips curve estimated by Kurosaka and Goto (1987) does not include a measure of industry-wide dispersion, $\sigma_t$, the coefficient of the unemployment rate $U_t$ is overestimated. With a linear approximation of the unemployment rate $U_t$ in equation (a) of Table 3 and a mean value 1.88% of $U_t$ in the sample period, we can find that the coefficient becomes 3.11. Accordingly, the Japanese aggregate supply curve is even

Table 6. Slopes of Aggregate Supply Curve

| Country \ Variable | Slope of Phillips curve | Inverse of Okun coefficient | Slope of aggregate supply curve |
|---|---|---|---|
| Japan | 3.112 (7.642) | 0.027 | 0.084 (0.207) |
| United States | 0.611 | 0.371 | 0.227 |
| West Germany | 1.094 | 0.277 | 0.303 |
| United Kingdom | 1.980 | 0.462 | 0.915 |
| France | −2.046 (60-73) | 0.173 | −0.353 (60-73) |
| | 2.807 (74-84) | | 0.485 (74-84) |
| Italy | 3.928 | 0.166 | 0.651 |

Note: From Kurosaka and Goto (1987). However, for Japan the figures are based on equation (a) in Table 3, and the figures of Kurosaka and Goto are listed in parenthesis.

flatter than was estimated by Kurosaka and Goto.

In sum, real GNP is more appropriate than the unemployment rate as an indicator of the level of macroeconomic activity. The Phillips curve in Japan is steep, but the aggregate supply curve is in fact very flat compared to those of the other major countries.

## III. VAR Analysis and a Comparison of the Prewar and Postwar Japanese Economies

In this section, we analyze the effects of wages on the real economy from two different angles.

### A. VAR Analysis

In this section, we present a VAR (Vector Autoregression) analysis including real wages. As a prelude, we explain the purpose of the analysis by referring to the concept of factor price frontier.

The neo-classical theory of factor prices can be summarized by the factor price frontier. (Concerning alternative theories of factor prices, see Kaldor (1956) and Morishima (1958).) Consider the simple case of two factors of production: capital and labor. In this case, the factor price frontier can be obtained by the maximization of profit, $F(K, L)-wL-rK$, which generates factor demand functions. Here, K denotes capital, L the labor input, w real wages, and r the rate of return on capital, respectively. If F is homogeneous of degree one, using the definition of $F(K/L, 1)\equiv f(k)$, $k\equiv K/L$, we can derive $w=f(k)-f'(k)k$, and $r=f'(k)$. Since $f''(k)<0$, w is an increasing function of k, while r is a decreasing function of k. Therefore w and r reduce to a downward locus on the (w, r) plane with a parameter k. This is the factor price frontier.

Countless points exist on any particular factor price frontier. The one point which corresponds to the actual factor endowment K/L in the economy is the neo-classical equilibrium. At that point all factors of production are fully employed.

Suppose that for some reason real wages become higher than their equilibrium level. This can happen, for example, if wages rise autonomously. It can also happen in an economy with three factors of production, capital, labor and energy, when real energy prices rose. In this case, the frontier on the $r-w$ plane shifts inward as illustrated in Figure 4. The new equilibrium shifts from A to B. If real wages are rigid, however, disequilibrium will ensue at point C.

If for any reason real wages become higher than their equilibrium level, the employment level becomes lower than the equilibrium level and the output also declines. This is the basic framework of Bruno and Sachs (1985). For instance, the "wage gap" estimated by Sachs (1983) is, simply speaking, $(W_B-W_A)/W_A$ in Figure 5.

As is well known, the share of labor income rose rapidly in Japan around the time of the first oil crisis. It is not exactly clear, however, what effects real wages have on the real economy when they are considered in conjunction with other factor prices. In order to look at the dynamic relations among factor prices and real variables, we conduct a VAR analysis introducing five variables; real wages, the profit rate and real energy prices as factor prices, the production index of the manufacturing industry as a variable reflecting the real economy, and nominal interest rate as a monetary variable. We must admit that VAR analysis has several serious difficulties, but we do not discuss in detail here. The interested readers are referred to Cooley and LeRoy (1985) and Runkle (1987).

We use the following five variables: Real wages are the index of cash salaries for full-time workers of the manufacturing industry (100=1980) taken from the Ministry of Labor's *Monthly Labor Statistics* divided by the product of the index of aggregate working hours of full-time workers of the manufacturing industry and the wholesale price index of the manufacturing industry. For energy prices, we use the import price index of coal, oil and natural gas divided by the wholesale price index of the manufacturing industry. As a measure of the level of output, we use the manufacturing industry's output from the Bank of Japan's *Short-term Economic Survey of Enterprises*.

Profit rate data is usually based on one of two sources. One source is the Ministry of Finance's *Statistics on Corporations*, and the other source is the Economic Planning Agency's *National Accounts (New SNA)*. Figure 6 shows time series of two different profit rates which are defined by the following equations, respectively:

Based on *Statistics on Corporations*

Profit rate=Operating Profit / Total Net Worth

(manufacturing industry: Capital more than ¥100 million)

Based on *New SNA*

$$\text{Profit rate}=\frac{\text{Nominal Operating Surplus}}{\text{Deflator of Equipment (Private Sector)}\times\text{Capital Stock at installation}}.$$

Figure 4. Shift of Factor-price Frontier Caused by a Rise in Real Energy Prices

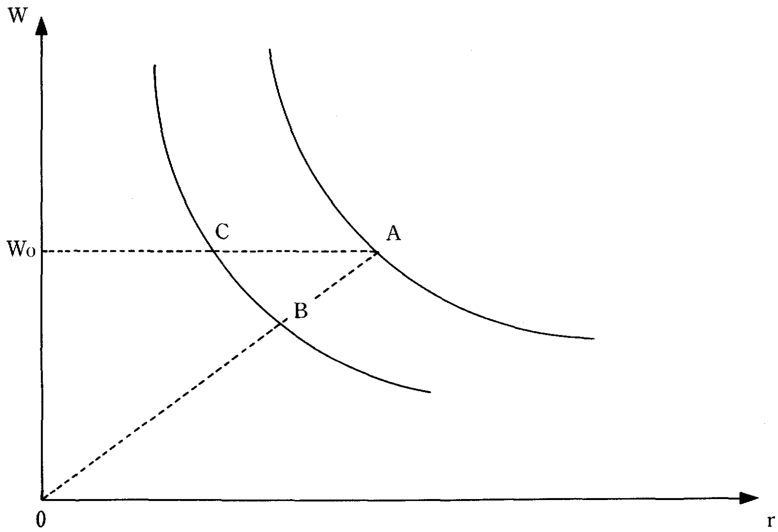



Figure 5. Disequilibrium in the Labor Market

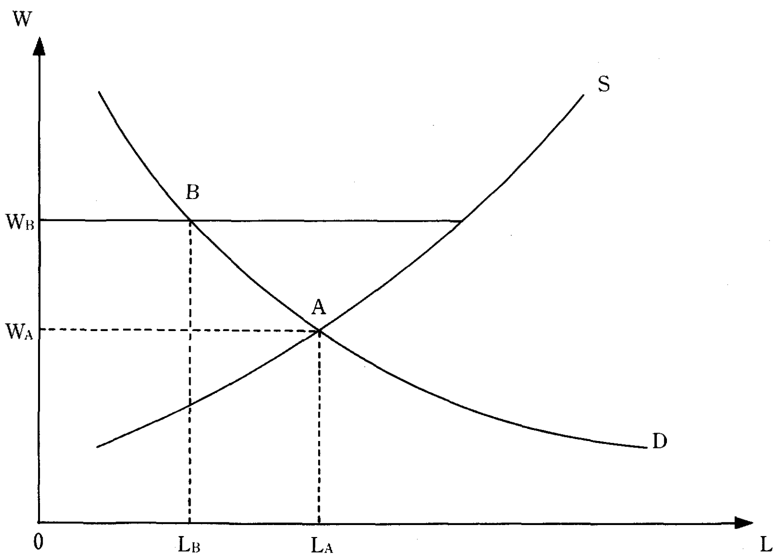
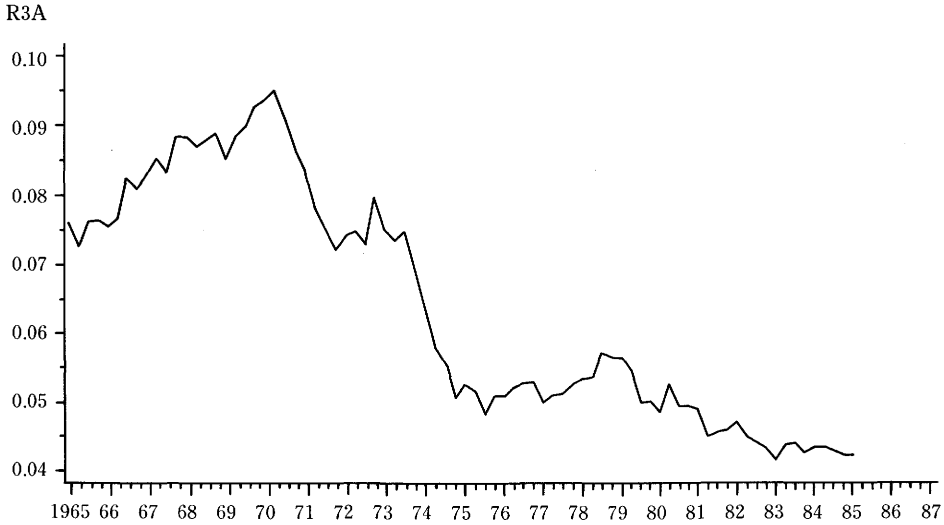


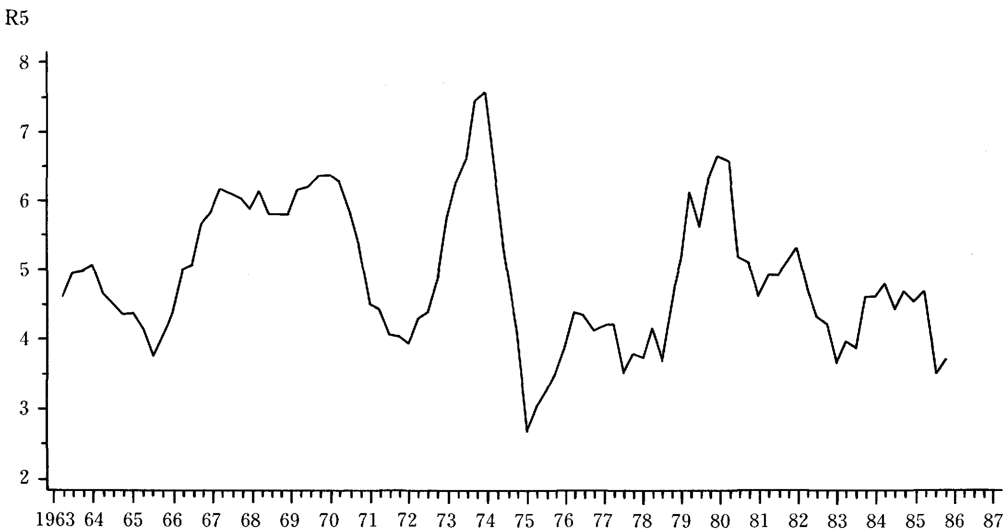
Figure 6. Profit Rate Calculated on SNA




$$\text{Profit Rate} = \frac{\text{Nominal Operating Surplus}}{\text{Deflator of Equipment (Private Sector)} \times \text{Capital Stock at Installation}}$$

Source: *National Accounts*, Economic Planning Agency.

Profit Rate Calculated on Statistics on Corporations




Profit Rate = Operating Profits/Total Net Worth (manufacturing industry: capital more than ¥100 million)
Source: *Statistics on Corporations*, Ministry of Finance.

As shown in Figure 6, the patterns of these two profit rates differ considerably. This difference is clearly due to the difference in estimations of either operational profits or capital (total assets). Since the estimates are based on book values in the case of the *Statistics on Corporations*, calculated profits ignore changes in the inventory valuations and total assets are likely to be underestimated. As a result, the estimated profit rate is comparatively high. Under the *New SNA* method, on the other hand, the effects of fluctuations in inventory valuations are excluded and the estimated total assets are closer to their market values. One remaining problem, however, is that profits based on the *SNA* include the managerial surplus of unincorporated small businesses. After weighing the merits and demerits of each method, we decided to use the *New SNA*-based profit rate.

We must also address two problems concerning interest rates: nominal v.s. real rates and short-term v.s. long-term rates. As is well known, it is extremely difficult to measure the expected rate of inflation in order to obtain unobservable real interest rates. If we assume perfect foresight, the calculated real rate will still include observational errors and their correlations with the error term in the VAR model could cause serious problems at the time of estimations. Moreover, real interest rates calculated this way fell sharply in the high inflationary periods, such as the first oil crisis from 1971 through 1974 and the second oil crisis in 1979, and therefore they are likely to be nonstationary. In light of these problems, we decided to use nominal interest rates here. It must be noted that in the neo-classical equilibrium where Tobin's q is one, the movements in real interest rates would be captured by profit rates and that as long as the Fischer equation is satisfied, nominal interest rates equal real rates plus the *exact* inflationary expectations. There are some economists who argue that the expected rate of inflation has greater effects on the real economy than do real interest rates (See Litterman and Weiss 1985). We use interest rate on five-year government bonds as the interest rate in our analysis below.

Since the *New SNA*-based data are not available for the pre-1965 period, the sample period for our VAR analysis is 81 quarters from 1965/I through 1985/I. Considering the possible structural change caused by the first oil crisis, we divided the whole sample period into two sub periods — the first from 1965/I to 1972/IV and the second from the 1973/I through 1985/I. To remove seasonality and assure stationarity, we use logarithmic differences for the three variables excluding interest rates and profit rates. For profit rates we use the data which are seasonally adjusted by the X–11 method.

The estimated VAR models are shown in Table 7. Our model selection is based on the minimum AIC. The VAR (2) models were selected for both periods.

Table 8 shows results of the variance decompositions based on the VAR models. The results are quite robust with respect to the order of orthogonalizations of the error terms. Some of the important results are summarized below:

(1) The exogeneity of real energy prices becomes stronger (25%→90%) in the second period (1973/I–1985/I). The role of real energy prices in explaining the variances

## Table 7. Estimation Results of the VAR Model

### (a) Period: 1965/I ~ 72/IV
Order of VAR model: k = 2 (minimum AIC)

$$
\begin{aligned}
p^e_t = {} & \underset{(***)}{1.14p^e_{t-1}} - \underset{(***)}{.659p^e_{t-2}} + .117w_{t-1} + .082w_{t-2} \\
& - 2.53r_{t-1} - 1.89r_{t-2} - .362y_{t-1} + \underset{(***)}{.630y_{t-2}} \\
& + .065i_{t-1} + .065i_{t-2} - \underset{(*)}{.651}
\end{aligned}
$$

$$
\begin{aligned}
w_t = {} & -.112p^e_{t-1} + .129p^e_{t-2} + \underset{(**)}{.537w_{t-1}} + .064w_{t-2} \\
& - .613r_{t-1} + .604r_{t-2} - .238y_{t-1} + \underset{(**)}{.361y_{t-2}} \\
& + .018i_{t-1} + .007i_{t-2} - .145
\end{aligned}
$$

$$
\begin{aligned}
r_t = {} & -.006p^e_{t-1} - .011p^e_{t-2} - .029w_{t-1} + \underset{(**)}{.054w_{t-2}} \\
& + \underset{(**)}{.423r_{t-1}} + .271r_{t-2} + \underset{(**)}{.047y_{t-1}} - .029y_{t-2} \\
& + .003i_{t-1} - \underset{(*)}{.011i_{t-2}} - \underset{(**)}{.079}
\end{aligned}
$$

$$
\begin{aligned}
y_t = {} & -.041p^e_{t-1} + .011p^e_{t-2} - .233w_{t-1} + .074w_{t-2} \\
& + 1.12r_{t-1} + .960r_{t-2} + \underset{(***)}{1.22y_{t-1}} - \underset{(***)}{.558y_{t-2}} \\
& - .044i_{t-1} - .033i_{t-2} + .458
\end{aligned}
$$

$$
\begin{aligned}
i_t = {} & .757p^e_{t-1} - .376p^e_{t-2} - 2.03w_{t-1} + .555w_{t-2} \\
& + 16.0r_{t-1} + 8.28r_{t-2} - .541y_{t-1} - .449y_{t-2} \\
& + \underset{(**)}{.561i_{t-1}} + .001i_{t-2} + 1.49
\end{aligned}
$$

### (b) Period: 1973/I ~ 85/I
Order of VAR model: k = 2 (minimum AIC)

$$
\begin{aligned}
p^e_t = {} & \underset{(***)}{1.38p^e_{t-1}} - \underset{(***)}{.672p^e_{t-2}} + .681w_{t-1} + .683w_{t-2} \\
& - .283r_{t-1} + 6.44r_{t-2} + .151y_{t-1} - .281y_{t-2} \\
& + .049i_{t-1} - .030i_{t-2} - .416
\end{aligned}
$$

$$
\begin{aligned}
w_t = {} & .014p^e_{t-1} - .010p^e_{t-2} + .287w_{t-1} + \underset{(**)}{.425w_{t-2}} \\
& - 3.72r_{t-1} + 2.68r_{t-2} - .320y_{t-1} + \underset{(**)}{.436y_{t-2}} \\
& - .017i_{t-1} + .016i_{t-2} + .056
\end{aligned}
$$

$$
\begin{aligned}
r_t = {} & -\underset{(*)}{.006p^e_{t-1}} + \underset{(**)}{.099p^e_{t-2}} - .000w_{t-1} - .001w_{t-2} \\
& + \underset{(***)}{.586r_{t-1}} + \underset{(*)}{.336r_{t-2}} + .015y_{t-1} - \underset{(*)}{.021y_{t-2}} \\
& - .002i_{t-1} + \underset{(*)}{.001i_{t-2}} - .010
\end{aligned}
$$

$$
\begin{aligned}
y_t = {} & \underset{(**)}{.132p^e_{t-1}} - \underset{(**)}{.130p^e_{t-2}} + .044w_{t-1} - .188w_{t-2} \\
& + \underset{(**)}{6.33r_{t-1}} - 2.89r_{t-2} + \underset{(***)}{1.05y_{t-1}} - \underset{(***)}{.520y_{t-2}} \\
& + .003i_{t-1} + .009i_{t-2} - \underset{(*)}{.218}
\end{aligned}
$$

$$
\begin{aligned}
i_t = {} & .198p^e_{t-1} + .598p^e_{t-2} + .939w_{t-1} + .638w_{t-2} \\
& + 14.8r_{t-1} - 4.56r_{t-2} + \underset{(**)}{3.75y_{t-1}} - \underset{(**)}{3.38y_{t-2}} \\
& + \underset{(***)}{.812i_{t-1}} - .052i_{t-2} + 1.13
\end{aligned}
$$

Note: The asterisk in parenthesis (*) shows that the coefficient is significant in the next significance level: *** 1%, ** 5%, * 10%

Table 8. Variance Decomposition of Real Factor Prices, Profit Rate, Interest Rate and Production Level

(a) Period: 1965/I ~ 72/IV (%)

| | Order of Orthogo-nalization | Energy Prices | Real Wages | Profit Rate | Production Level | Long-term Interest Rates |
|---|---|---|---|---|---|---|
| Energy Price | 1 | 25 | 22 | 15 | 8 | 29 |
| | 2 | 25 | 28 | 10 | 2 | 35 |
| | 3 | 25 | 17 | 15 | 13 | 29 |
| Real Wages | 1 | 11 | 51 | 7 | 15 | 17 |
| | 2 | 11 | 49 | 8 | 7 | 24 |
| | 3 | 11 | 43 | 7 | 23 | 17 |
| Profit Rate | 1 | 9 | 27 | 25 | 13 | 26 |
| | 2 | 9 | 34 | 19 | 3 | 35 |
| | 3 | 9 | 17 | 26 | 23 | 26 |
| Production Level | 1 | 13 | 16 | 18 | 27 | 26 |
| | 2 | 13 | 21 | 13 | 13 | 40 |
| | 3 | 13 | 9 | 19 | 34 | 26 |
| Long-term Interest Rates | 1 | 9 | 28 | 25 | 8 | 30 |
| | 2 | 9 | 37 | 16 | 1 | 37 |
| | 3 | 9 | 19 | 27 | 16 | 30 |

(b) Period: 1973/I ~ 85/I

| | Order of Orthogo-nalization | Energy Prices | Real Wages | Profit Rate | Production Level | Long-term Interest Rates |
|---|---|---|---|---|---|---|
| Energy Prices | 1 | 89 | 2 | 5 | 2 | 3 |
| | 2 | 89 | 1 | 7 | 1 | 3 |
| | 3 | 89 | 3 | 5 | 1 | 3 |
| Real Wages | 1 | 31 | 55 | 3 | 10 | 2 |
| | 2 | 31 | 34 | 23 | 9 | 3 |
| | 3 | 31 | 44 | 3 | 21 | 2 |
| Profit Rate | 1 | 51 | 10 | 25 | 5 | 9 |
| | 2 | 51 | 0 | 35 | 4 | 11 |
| | 3 | 51 | 10 | 26 | 5 | 9 |
| Production Level | 1 | 41 | 17 | 11 | 29 | 2 |
| | 2 | 41 | 4 | 24 | 27 | 4 |
| | 3 | 41 | 8 | 9 | 39 | 2 |
| Long-term Interest Rates | 1 | 42 | 2 | 9 | 9 | 38 |
| | 2 | 42 | 5 | 6 | 6 | 41 |
| | 3 | 42 | 1 | 9 | 10 | 38 |

Note: 12 periods ahead. Three cases are shown for order of orthogonalization.
Order of orthogonalization 1 1 – 2 – 3 – 4 – 5
2 1 – 3 – 2 – 5 – 4
3 1 – 4 – 2 – 3 – 5

of other variables also becomes noticeably high in the second period (10%→40%).

(2) While the influence of nominal long-term interest rates on other variables is considerably large in the first period (about 30%), it sharply decreases in the second period (about 3%). This is in contrast to the results obtained by Horiye, Naniwa and Ishihara (1987).

In the VAR analysis of Horiye, Naniwa and Ishihara, the influence of long-term *real* interest rates on domestic private demand increased in the second period, while the influence on exports and the government expenditures decreased. It is usually thought that macroeconomic fluctuations are due mainly to domestic private demand in the first period and to exports and government expenditures in the second period. Therefore, it may be reasonable to find that the influence of long-term interest rates decreased in the second period in our study which deals with the economy as a whole.

(3) The role of innovations in real wages in explaining other variables weakened in the second period. Since the "wage gap" widened in Japan after 1973,[4] this finding casts some doubt on the proposition that the increased wage gap affected to a large extent the macroeconomic performance of Japan's economy.

**B. A Comparison of the Flexibility of Wages in Japan's Prewar and Postwar Economies**

The VAR analysis used in section III.A. showed the effects fluctuations of real wages have on other macroeconomic variables. Although the role of innovations of real wages can be seen through the VAR analysis, it is difficult to directly evaluate the role of the flexibility of real wages. There is an argument that flexible real wages enhance macroeconomic performance of the economy. (See, for example, Komiya and Yasui 1984; Suzuki 1985; and Bruno and Sachs 1985). To see whether this argument is plausible or not, we compare Japan's prewar and postwar economies.

The issue here is illustrated in Figure 7. Suppose that the labor demand curve shifted downward for some reason and, as a result, the equilibrium point changed from A to B. If real wages are flexible, they would go down from $W_A$ to $W_B$. Accordingly, the employment and the production levels would remain unchanged (for simplicity, the supply curve is set vertical). In contrast, if real wages remain at the level of $W_A$, employment would go down to L and output would also decline. Therefore, the more rigid real wages are, the greater the fluctuations of output become. This is a natural conclusion obtained in the neo-classical paradigm; illustrated by the well-known proposition "It is because prices are rigid that the Keynesian quantity adjustment occurs." We compare Japan's prewar and postwar economies to see whether this proposition is really substantiated.

Table 9 shows the means, standard deviations, coefficients of variation and autocorrelation of the nominal prices, nominal wages, real wages and production indices in the prewar (1905-38) and postwar (1966-85) periods. As the coefficients of variation show

[4]For the "wage gap" in Japan, see Schadler (1984) and Gordon (1987).

Figure 7. Fluctuation of Real Wages and Employment Level

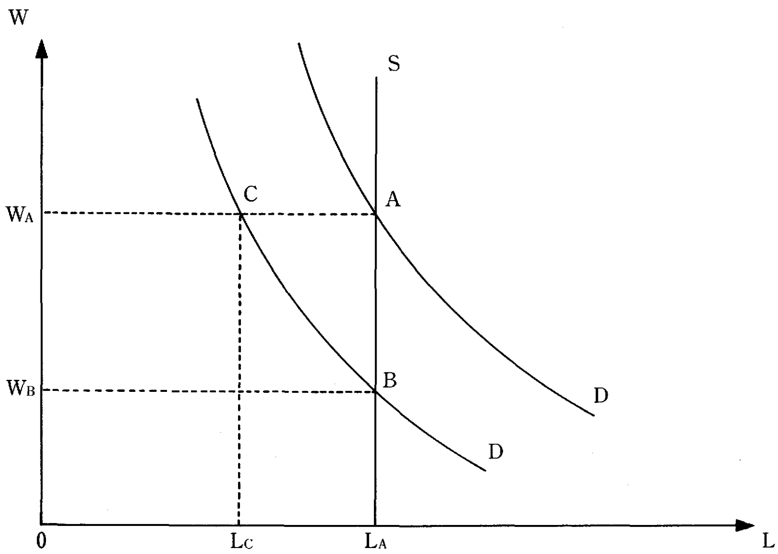



Table 9. Changes in Prices/Wages and Production

| | (1) Mean (%) | (2) Standard Deviation (%) | (3) Coefficient of Variation ((2)/(1)) | (4) First Order Autocorrelation Coefficient | (5) Second Order Autocorrelation Coefficient |
|---|---|---|---|---|---|
| 1905 – 38 | | | | | |
| Nominal Prices | 2.2 | 12.0 | 5.45 | 0.45 | –0.01 |
| Nominal Wages | 4.9 | 9.8 | 2.00 | 0.64 | 0.30 |
| Real Wages | 2.4 | 6.3 | 2.63 | 0.39 | –0.12 |
| Production Index | 6.8 | 6.9 | 1.01 | –0.04 | –0.15 |
| 1966 – 85 | | | | | |
| Nominal Prices | 4.1 | 7.3 | 1.78 | 0.28 | –0.16 |
| Nominal Wages | 10.7 | 5.6 | 0.52 | 0.76 | 0.54 |
| Real Wages | 4.4 | 3.6 | 0.82 | 0.56 | 0.50 |
| Production Index | 6.6 | 7.1 | 1.08 | 0.33 | –0.00 |

clearly, both nominal and real wages were three to four times more flexible in prewar Japan than in postwar Japan. A comparison of the autocorrelation coefficients shows that the persistence of real wages also increased in the postwar period. Nevertheless, the coefficients of variation of the production index are almost the same for both sample periods.[5] This result causes us to question the widely accepted, yet not fully substantiated proposition that rigid prices are the most important factor leading to output fluctuations.[6]

Thus, our findings do not substantiate the neo-classical proposition that flexibility of wages and/or prices enhances economic stability. Works by DeLong and Summers (1986), Iwai (1987) and Yoshikawa (1987) actually suggest the possibility that flexibility of wages or prices creates greater instability in the real economy. Not surprisingly, in their works, effective demand plays an important role. This point awaits further investigations. At present we have no well-developed alternative to the neo-classical framework.

## IV. Real Wages and Investment[7]

In the earlier sections, we studied the short-run effects of real wages on the macroeconomy from several different angles. In this section, we focus our attention on the relationship between real wages and investment in order to analyze the long-run effects of real wages on the economy. First, we present a theoretical model of investment, and then estimate the investment functions for the Japanese manufacturing industries based on this model.

### A. The Model

It is well known that the dynamic model of investment based on convex adjustment costs can be interpreted in the context of Tobin's q theory (1969) (see, for example, Yoshikawa 1980 and Hayashi 1982). In terms of this theory, all the information relevant for investment decisions is conveniently summarized in a single variable q. Thus this approach is elegant in its simplicity, and it also easily lends itself to empirical implementation.

Despite these appealing features, several puzzles and problems associated with the q approach have arisen in empirical studies. (1) Without exception, empirical q equations contain lagged qs, or they show low Durbin-Watson statistics if no lags in q are introduced. Note that only current q should matter in the ordinary q theory. (2) The perform-

[5]A glance at the autocorrelation coefficient of the first degree, however, shows that the persistence of changes in the production index slightly increased after the World War II. This point remains a topic of further investigations.

[6]For the United States, the similar result is obtained by Taylor (1986). Concerning comparisons between Japan, the United States and other OECD countries, see Summers and Wadhwani (1987).

[7]This section draws heavily on Yoshikawa (1988).

ance of empirical q equations is often reported to be "poorer" than simple accelerator-type models (see Clark 1979). (3) In many countries investment is known to be highly correlated with current "real" variables such as profits, profit rate or capacity utilization rate. Abel and Blanchard (1986), for example, include the profit rate together with q in their investment equations and find that current profit rate is always quite significant and that in some cases q even turns out to be insignificant. The Abel and Blanchard work is based on a carefully constructed *marginal* q series, and yet their findings are very similar to the results obtained relating investment to *average* q. Therefore they conclude it is very unlikely that the low explanatory power of q is due to the fact that average q is simply a poor proxy for the theoretically relevant marginal q (see also Gordon and Veitch 1986).

In an attempt to solve these problems associated with q theory, Ueda and Yoshikawa (1986) showed that the introduction of the two important factors — delivery lags for capital and differences in the time series properties of profit rates and discount rates — leads to a crucial modification of the standard q theory of investment. To be specific, under the assumptions made, it is shown that investment depends on distributed lags of profit rates and discount rates (or costs of capital) *separately*. In other words, we do not obtain a simple expression of q, which gives a particular constraint on two series of profits and costs of capital as the determinants of investment. Moreover investment is correlated more with profit rates than with discount rates if profit rates contain more permanent movements than discount rates. The reason is that with time to build, investment ordered today starts being productive only after a certain interval, and therefore rational investment decisions must regard temporary fluctuations in the discount rate as irrelevant.

The model presented below is similar to the one in Ueda and Yoshikawa (1986), and is based on the same observation that the distinction between permanent and transitory shocks in the determinants is important. In particular, here we explore the importance of such components of profits as sales, real wages and real energy costs in determining investment in Japan. Suppose that the firm maximizes the following discounted sum of future profits, $V_t$:

$$V_t = E\left[\sum_{j=0}^{\infty}\left\{\prod_{i=0}^{j}(1 + E(R_{t+i}|\Omega_{t+1-1}))^{-1}D_{t+j}\right\}\Omega_{t-1}\right] \tag{5}$$

where the one-period discount rate $R_t$, and profits $D_t$ are both taken as stochastic. $E(\cdot|\Omega_{t-1})$ stands for the expected value operator conditional on the information set as of time $t-1$. $\Omega_{t-1}$.

We assume that profits $D_t$ can be written as follows:

$$D_t = F(K_t, L_t) - w_tL_t - (1 + E(R_t|\Omega_{t-1}))^{-1}\phi(I_{t-k}). \tag{6}$$

$F(K_t, L_t)$ is the amount of output or sales, and $K_t$ and $L_t$ are capital stock and variable input, respectively. Production function F is assumed to have the neo-classical properties. $w_t$ is the real input price of $L_t$. As usual both $w_t$ and $L_t$ can be vectors. The last term in (6) is investment expenditures inclusive of adjustment costs. The presence of the discount factor simply indicates that payment on investment goods is made at the beginning of the period t. The function $\phi$, reflecting increasing adjustment costs, is assumed to be convex:

$$\phi(0) = 0, \phi' > 0, \phi'' > 0. \tag{7}$$

An important feature of the model is the existence of a time-to-build or delivery lag (k periods). As a result, $I_{t-k}$, the order of investment goods for delivery in period t enters the $\phi$ function in period t. Here just for expository simplicity, it is assumed that investment expenditure is made when the project is completed and starts being productive, i.e. starts becoming a part of $K_t$. Noting the existence of a k period time to build, we have the following equation for capital accumulation:

$$K_{t+1} = K_t + I_{t-k}. \tag{8}$$

Next we assume a possible quantity constraint on the firm's sales.

$$Q_t \geqq F(K_t, L_t). \tag{9}$$

$Q_t$ is exogenous stochastic sales. When the above inequality strictly holds, the firm is in the neo-classical regime whereas when the equality holds, the firm is in the quantity-constrained (or perhaps Keynesian) regime.

The firm maximizes (5) under constraints (6), (8), and (9) with respect to $I_t$ and $L_t$. $W_t$, $R_t$, and $Q_t$, all stochastic, are taken as exogenous, together with suitable initial values of $K_t$. In general, the optimizing firm would anticipate a switch or even switches of two regimes in future. In the deterministic model, this possibility is explored by Precious (1986). In the present stochastic model, however, it is simply too difficult to analyze to obtain interesting economic implications. Therefore in what follows, we assume that the firm is in either the neo-classical or the quantity-constrained regime. We must analyze two possible regimes separately. As is usual, when the solution exists, it is unique under the strict concavity assumption.

## B. Quantity-Constrained Regime

In this case, equality holds in constraint (9). The optimality condition for investment is given by

$$\phi'(I_t) = E(q_{t+k} \mid \Omega_{t-1}). \tag{10}$$

Here the variable $q_{t+k}$ can be interpreted as Tobin's marginal q, and is as follows:

$$q_{t+1} = E\left[ \sum_{i=0}^{\infty} \rho_{t+k}^{i+1} \frac{(w_{t+k+i}) \left(\frac{\partial F}{\partial K_{t+k+i}}\right)}{\left(\frac{\partial F}{\partial L_{t+k+i}}\right)} \mid \Omega_{t+k-1} \right]. \tag{11}$$

For simplicity, we use the discount factor $\rho_\tau^{j+1}$ in (11):

$$\rho_\tau^{j+1} \equiv \prod_{i=0}^{j}\{1 + E(R_{\tau+i}|\Omega_{\tau+i-1})\}^{-1} \quad (j=0, 1, 2, ..., \tau=t, t+1, ...). \tag{12}$$

We note that

$$\begin{array}{ll} \rho_t^1 \in \Omega_{t-1}, \rho_t^{j+1} \notin \Omega_{t-1} & \text{for } j > 0 \\ \rho_{t+i}^j \notin \Omega_{t-1} & \text{for all } i, j > 0. \end{array} \tag{13}$$

The marginal q (11) is the discounted sum of future savings in labor cost due to capital accumulation. In the present quantity-constrained regime, the firm can reduce labor cost and produce the same amount of output by increasing its capital stock. Note that $q_{t+k}$ is stochastic as of time t. The optimality condition (10) then says that investment is determined in such a way that the expected value of $q_{t+k}$ conditional on $\Omega_{t-1}$ is equal to the marginal adjustment cost of investment, $\phi'(I_t)$. Only in the degenerate case when k is zero, i.e., when there is no delivery lag or gestation period for investment, do we obtain the usual optimality condition involving the current nonstochastic q:

$$\phi'(I_t) = q_t. \tag{14}$$

With a lag to build, however, the q theory must be modified in the way indicated by (10). In particular, the current investment decision $I_t$, depends on the expected value of *future* marginal q evaluated at the beginning of time t. Alternatively, investment expenditure (or simply investment, in the usual sense of the term) at t, $INV_t \equiv \varphi(I_{t-k})$, depends on the *expected value* of $q_t$ evaluated at the beginning of t−k, rather than on current $q_t$ itself:

$$INV_t \equiv \varphi(I_{t-k}) = \psi[E(q_t \mid \Omega_{t-k-1})] \qquad \psi' > 0. \tag{15}$$

Our investment function is given by (11) and (15). To proceed further, it is useful to use the Cobb-Douglas illustration. Assume that the production function F is of the Cobb-Douglas type:

$$F(K, L) = K^\alpha L^{1-\alpha} \qquad (0 < \alpha < 1). \tag{16}$$

Then the marginal q, (11) is:

$$q_t = E\left[\sum_{i=0}^{\infty}\left(\prod_{j=0}^{i}\beta_{t+j}\right)W_{t+i}\left(\frac{Q}{K}\right)_{t+i}^{\frac{1}{1-\alpha}}\left(\frac{1}{1-\alpha}\right) \mid \Omega_{t-1}\right] \tag{17}$$

where for notational simplicity, we define

$$\beta_s \equiv \rho_s' = \frac{1}{1+E(R_s|\Omega_{s-1})}. \tag{18}$$

Although the right hand side of (17) is a nonlinear function of $\beta_t$, $W_t$, $Q_t$, and $K_t$, we know that its linearization is not a bad approximation: See, for example, Abel and

Blanchard (1986) on this point. Choosing the stable solution, and substitution $K_t$ out by (8), the linearized $q_t$ becomes

$$q_t = \bar{q} + \sum_{i=0}^{\infty} [a_i E(\beta_{t+i} - \bar{\beta} \mid \Omega_{t-1}) + b_i E(W_{t+i} - \bar{W} \mid \Omega_{t-1})$$

$$+ c_i E(Q_{t+1} - \bar{Q} \mid \Omega_{t-1})] \qquad (a_i, b_i, c_i > 0 \text{ for all i}). \tag{19}$$

From (15), therefore, investment as of time t, $INV_t$, depends on

$$E(q_t \mid \Omega_{t-k-1}) = \bar{q} + \sum_{i=0}^{\infty} [a_i E(\beta_{t+i} - \bar{\beta} \mid \Omega_{t-k-1})$$

$$+ b_i E(W_{t+i} - \bar{W} \mid \Omega_{t-k-1}) + c_i E(Q_{t+1} - \bar{Q} \mid \Omega_{t-k-1})]. \tag{20}$$

The most important point to note is that investment is affected by only those parts of $\beta_t$, $W_t$ and $Q_t$ that were *anticipated* k periods before. In other words, if $\Omega_{t-k-1}$ contains current and past values of $\beta_t$, $W_t$, and $Q_t$, i.e., $\beta_{t-k-i}$, $W_{t-k-i}$, and $Q_{t-k-i}$ ($i \geq 1$), then it is *not*, $\beta_{t-k-i}$, $W_{t-k-i}$, and $Q_{t-k-i}$ but rather only the persistent or "permanent" components of these variables that affect investment. In the quantity-constrained regime, an increase in the discount factor (or a decrease in the discount rate), an *increase* in the real price of variable input, and/or an increase in demand, if "permanent", all *raise* investment. The empirical investment functions we will estimate are based on these observations.

## C. Neo-classical Regime

In this regime, the inequality constraint (9) is not binding and the firm is assumed to take only the real price of variable input $W_t$, and discount factor $\beta_t$ as given.

The optimality condition (10) remains unchanged, and therefore we obtain the same investment function (15). However the marginal q in this case is

$$q_t = E\left[\sum_{j=0}^{\infty} \rho_t^{j+1} \frac{\partial F}{\partial K_{t+j}} \mid \Omega_{t-1}\right]. \tag{21}$$

Here again we will use the Cobb-Douglas illustration. In the case of the Cobb-Douglas production function, after the linearization, (21) becomes

$$q_t = \bar{q} + \sum_{i=0}^{\infty} [\alpha_i E(\beta_{t+i} - \bar{\beta} \mid \Omega_{t-1}) + \beta_i E(W_{t+i} - \bar{W} \mid \Omega_{t-1})]$$

$$(\alpha_i, \beta_i, > 0 \text{ for all i}). \tag{22}$$

As explained previously (equation (15)), investment at time t, $INV_t$, depends on $E(q_t|\Omega_{t-k-1})$:

$$E(q_t \mid \Omega_{t-k-1}) = \bar{q} + \sum_{i=0}^{\infty} [\alpha_i E(\beta_{t+i} - \bar{\beta} \mid \Omega_{t-k-1})$$

$$-\beta_i E(W_{t+i} - \bar{W} \mid \Omega_{t-k-1})]. \quad (23)$$

We note that in the present neo-classical regime, a permanent increase in $W_t$ *lower* investment. This result is in sharp contrast to that obtained in the quantity-constrained regime. In the quantity-constrained regime, the firm is on a particular isoquant. Therefore an increase in $W_t$ makes the firm substitute capital for labor and as a consequence raises investment. In the present neo-classical regime, on the other hand, the firm is on a particular factor price frontier. In this case, an increase in $W_t$ lowers profits and thereby discourages investment. *Changes in the real price of variable input* $L_t$ *have just the opposite effect on investment depending on whether the firm is in the quantity-constrained regime or in the neo-classical regime.*

**D. Estimation of Investment Functions**

Based on the theoretical analysis above, we estimate investment functions for Japanese manufacturing industries. Our investment function is equation (15). The expected marginal q in (15) is given by (20) in the case of quantity-constrained regime and by (23) in the case of the neo-classical regime.

Our theoretical model indicates the importance of the distinction between permanent and transitory shocks in $Q_t$, $W_t$ and $\beta_t$. In current practice, there is no generally accepted methods of doing such decompositions.[8] The approach we use in this paper is the Beveridge and Nelson (1981) decomposition.th We briefly summarize their technique in the Appendix.

We assume that the firm's information set $\Omega_{t-k-1}$ contains $\beta_{t-k-i}$, $W_{t-k-i}$, and $Q_{t-k-i}$ ($i \geqq 1$) and also that in its investment decisions the firm responds only to what it perceives as the permanent components of the relevant variables. There is no knowing how the firm actually extracts the permanent components from the observed series. We simply apply the Beveridge-Nelson decomposition to the explanatory variables.

We estimate investment functions for Japanese manufacturing industries using quarterly data (1971/I–1985/II). Since investment in the 70s and 80s seems to be governed by micro-specific factors, as Yoshikawa and Ohtake (1987) and Yoshikawa (1988) argue in detail, it makes sense to estimate *industry* investment equations rather than an *aggregate* equation. Investment figures, $I_t$, are from the "newly acquired fixed assets" series compiled by the Ministry of Finance. For demand variable $Q_t$, we use an index of

[8]We cannot use the usual regression analysis of time trend (linear and quadratic curve) as a method to decompose a time series into permanent and transitory components. For it makes the transitory component pseudo periodic when the permanent component is stochastic (See Nelson and Kang 1981).

shipments, $S_t$, published by the Ministry of International Trade and Industry. We identify labor and energy as variable inputs and define the real wage, $RW_t$, and the real energy price, $RE_t$, as follows:

$$RW \equiv \frac{\text{(Index of Total Payment in Cash to Regular Employees)}}{\text{(Index of Total Working Hours of Regular Employees)} \times \text{(WPI of Domestic Manufactured Products)}} \tag{24}$$

$$RE \equiv \frac{\text{(Index of Prices of Imported Oil, Coal and Natural Gas)}}{\text{(WPI of Domestic Manufactured Products)}} \tag{25}$$

We also use the price of investment goods, $PI_t$, which is defined as

$$PI \equiv \frac{\text{(WPI of Investment Goods)}}{\text{(WPI of Domestic Manufactured Products)}} \tag{26}$$

Note that PI is implicit in function $\psi$ in (15), but that investment is a decreasing function of PI. For simplicity, we assume that RE and PI are the same across industries.

We tried several cost of capital or interest rate variables, corresponding to $\beta$, in our preliminary set of estimations. However the results were not satisfactory, and therefore we dropped them from the final set of estimations presented below.

As the first step, we applied the Beveridge-Nelson decompositions to $S_t$, $W_t$, $RE_t$, and $PI_t$. For this purpose, we first fitted the ARIMA (Autoregressive Integrated Moving Average) models to S, RW, RE, and PI. All the variables including I are in *natural logarithms*. We use the same notation for the logs of the variables. The final models were selected by Akaike's Information Criterion (AIC). It turned out that all the variables are first-order integrated. Therefore only the ARMA parts are shown in Table 10.

Based on these models, we decompose $S_t$, $RW_t$, $RE_t$, and $PI_t$ into the Beveridge-Nelson permanent components denoted by $S_t^*$, $RW_t^*$, $RE_t^*$, $PI_t^*$, and the transitory components, $\tilde{S}_t$, $\tilde{RW}_t$, $\tilde{RE}_t$, $\tilde{PI}_t$. For reference, $RW^*$, $\tilde{RW}$, $S^*$, $\tilde{S}$ of non-ferrous metal industry and $S^*$, $\tilde{S}$, $RE^*$ and $\tilde{RE}$ of electric machinery industry are illustrated in Figures 8-15.

In the second step, we estimated industry investment equations using $S_t^*$, $\tilde{S}_t$, $RW_t^*$,

Table 10. ARIMA Model of S, RW, RE

| Industries | S | RW | RE | PI |
|---|---|---|---|---|
| Non-ferrous metals | MA (3) | AR (2) | MA (3) | AR (4) |
| Chemicals | MA (4) | AR (2) | | |
| Machinery | AR (4) | white noise | | |
| Electrical machinery | MA (3) | MA (2) | | |
| Transportation equipment | MA (2) | ARMA (3, 1) | | |
| Paper, pulp | MA (4) | ARMA (2, 1) | | |

Note: All variables were transformed with $\ell n X_t - \ell n X_{t-1}$ ($X = S_t, RW_t, RE_t$)

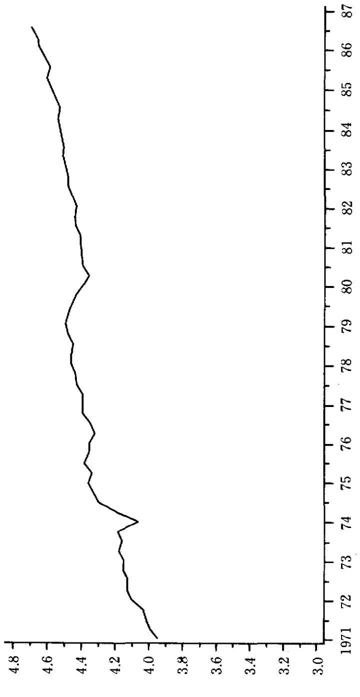



Figure 8. $RW_t^*$ of Non-ferrous Metals

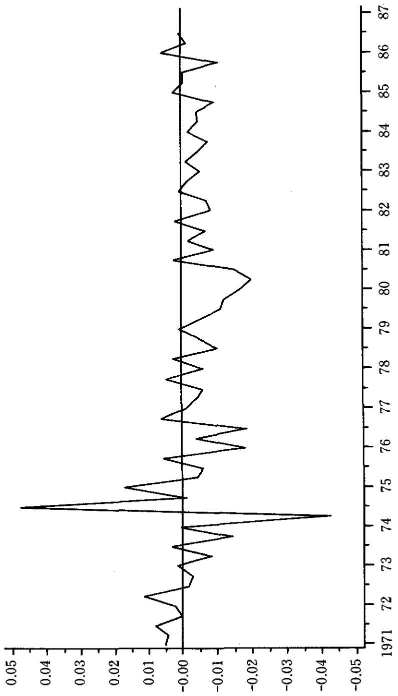



Figure 9. $\widetilde{RW}_t$ of Non-ferrous Metal

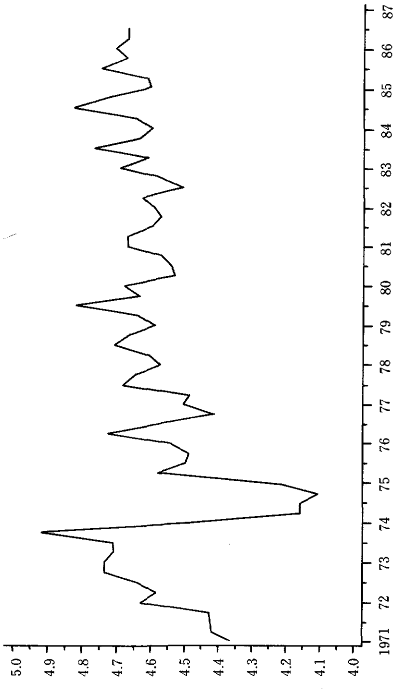



Figure 10. $S_t^*$ of Non-ferrous Metals

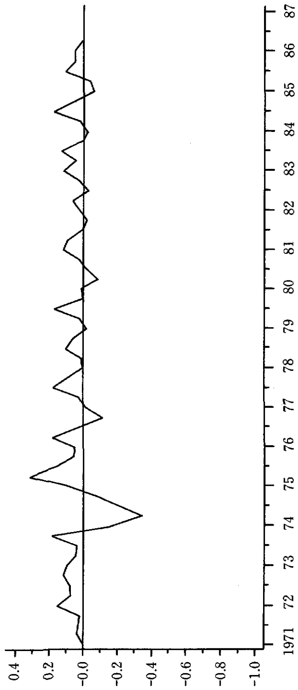



Figure 11. $\tilde{S}_t$ of Non-ferrous Metals

Figure 12. $S_t^*$ of Electrical Machinery

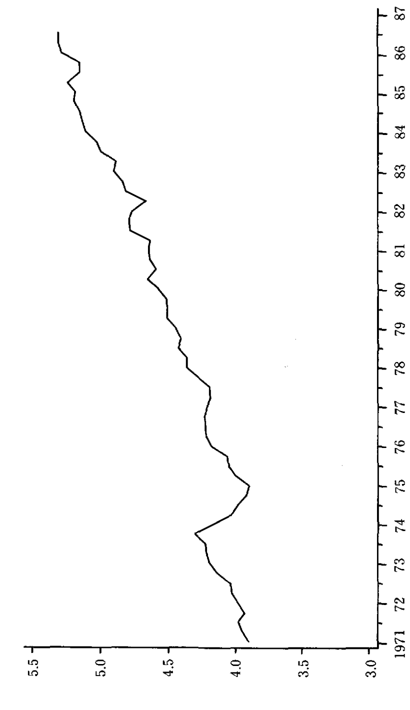



Figure 13. $\tilde{S}_t$ of Electrical Machinery

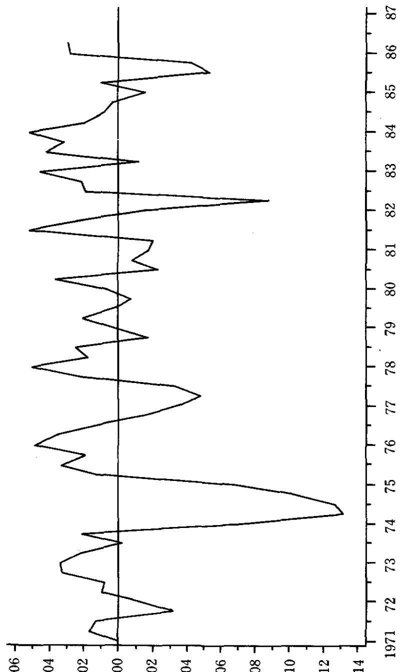



Figure 14. $RE_t^*$ of Electrical Machinery

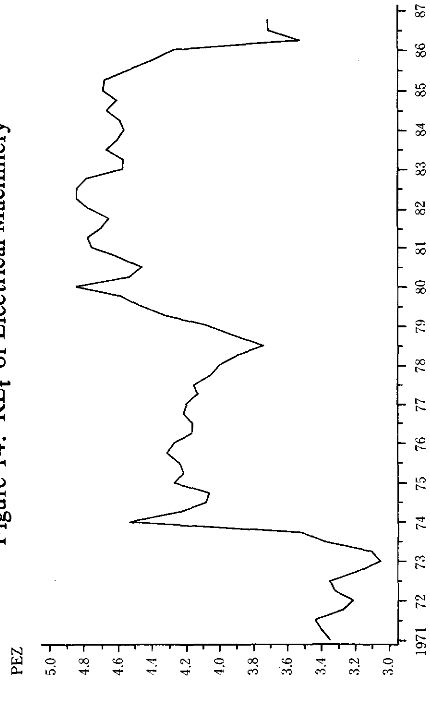
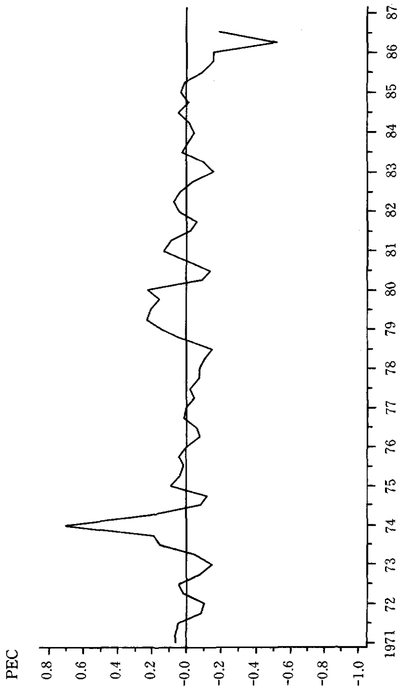



Figure 15. $RE_t$ of Electrical Machinery



$\tilde{RW}_t$ and so on rather than $S_t$, $RW_t$, $RE_t$, $PI_t$ as explanatory variables. In addition to the six industries we have here, the steel and textile industries were included in our preliminary set of estimations. However, we did not succeed in obtaining satisfactory results for these two industries. It is very interesting that these two industries were proto-typical declining industries over the sample period. For example, the Japanese steel industry's capacity was a hundred million tons in 1971. Thereafter e industry never tried to expand its capacity and has consistently suffered from overcapacity. For the purpose of increasing capacity, net investment was always negative over the sample period. Due to the appreciation of the yen and stiffer competition from the NICs in recent years, this process has accelerated. Therefore it may not be so surprising after all that our theory of investment is not applicable to the Japanese steel industry. The situation is very similar in the textile industry.

Table 11. Estimation Results of Investment Functions

(a) Non-ferrous metals

$$I_t = -1.36 + 1.54 S^*_{t-4} - 1.81 \tilde{S}_{t-4} + 0.18 RE^*_{t-4} + \varepsilon_t$$
$$(-0.79)\ (3.98)\ (-3.63)\ (1.90)$$
$$\hat{\rho} = 0.55, \quad R^2 = 0.75$$

(b) Chemicals

$$I_t = 3.55 + 0.82 S^*_{t-4} - 0.85 \tilde{S}_{t-4} + 0.15 RE^*_{t-1} + \varepsilon_t$$
$$(3.36)\ (3.23)\ (-1.40)\ (2.25)$$
$$\hat{\rho} = 0.79, \quad R^2 = 0.89$$

(c) Machinery

$$I_t = -4.37 + 0.58 RW^*_{t-3} + 1.83 S^*_{t-3} + 0.22 \tilde{S}_{t-2} + 0.16 RE^*_{t-1} + \varepsilon_t$$
$$(-5.42)\ (2.93)\ (9.06)\ (0.39)\ (2.26)$$
$$\hat{\rho} = 0.19, \quad R^2 = 0.91$$

(d) Electrical machinery

$$I_t = -1.52 + 0.61 RW^*_{t-3} - 2.70 \tilde{RW}_{t-3} + 1.48 S^*_{t-3} - 0.64 \tilde{S}_{t-3} + \varepsilon_t$$
$$(-1.98)\ (2.35)\ (-2.26)\ (11.0)\ (-1.43)$$
$$\hat{\rho} = 0.62, \quad R^2 = 0.98$$

(e) Transportation equipment

$$I_t = 12.1 + 1.00 RW^*_{t-5} + 1.67 S^*_{t-5} - 0.47 RE^*_{t-5} - 0.90 \tilde{RE}_{t-5} - 2.99 PI^*_{t-5} + \varepsilon_t$$
$$(1.50)\ (2.80)\ (5.25)\ (-2.72)\ (3.05)\ (-1.82)$$
$$\hat{\rho} = 0.56, \quad R^2 = 0.91$$

(f) Paper, pulp

$$I_t = 0.87 + 0.79 RW^*_{t-4} + 0.42 S^*_{t-1} - 0.84 \tilde{S}_{t-4} + 0.11 RE^*_{t-1} + \varepsilon_t$$
$$(0.54)\ (2.57)\ (1.13)\ (-0.99)\ (1.20)$$
$$\hat{\rho} = 0.69, \quad R^2 = 0.77$$

The final equations estimated for the six industries are shown in Table 11. In every case, we tried lags of from one to six periods. These lags correspond to delivery lags, k, and they will differ for structures and machinery. The existing empirical studies suggest a lag of from an year to an year and a half. The method of estimation is generalized least squares; to be specific, full transform estimation (cf. Harvey 1981, ch. 6) was employed.

Except for the pulp and paper industry, permanent shipments, $S^*$, has significant effects on investment. The elasticity is 0.8 for the chemical industry, but for other industries it is about 1.5. In theory, transitory shipments, $\tilde{S}$, should not affect investment. On the whole, only $S_t^*$ is significant. The exception is the nonferrous metal industry. We note, however, that $\tilde{S}$ based on the Beveridge-Nelson decomposition does not exactly correspond to its counterpart in theory.

As for real factor prices, their effects on investment are mostly positive. This is consistent with the above result that shipments significantly affects investment. These results suggest that firms were in the quantity-constrained regime over the sample period. An increase in real wages raises investment in the three machinery industries and the pulp and paper industry with the elasticities ranging from 0.6 to 1.0. An increase in real energy costs, on the other hand, raises investment in such industries as nonferrous metals, chemicals, general machinery and transportation machinery. The elasticities in this case are smaller than the wage elasticities and are about 0.2.

The estimation results are on the whole in accord with our theory. In particular, the significant effects of shipments and positive effects of real factor prices imply that firms were in the quantity-constrained regime. Shapiro (1986) argued that if the production function is subject to technological shocks, then output and profits and hence also investment all simultaneously increase. In this case, shipments may appear to drive investment even if the firm is in fact in the neo-classical regime. We argue, however, that (1) the important technological improvements are embodied in new investment and (2) the short-run fluctuations of labor productivity are demand-induced given the firm's labor hoarding; therefore Shapiro's argument is extremely unconvincing. In any event, if firms are demand-constrained, the straightforward application of the neo-classical factor price frontier is questionable. In the Japanese economy, our results indicate that increases in real wages or real energy costs raised rather than lowered investment.

Whether the economy is in the quantity-constrained or the neo-classical regime is also an important issue in business cycle theory. Recent real business cycle theory of Kydland and Prescott (1982), Long and Plosser (1983) and others take the view that the economy is always in the neo-classical equilibrium. In the context of the Japanese economy, Yoshikawa and Ohtake (1987) presented some evidence that real shocks are important but they are mostly demand shocks rather than the supply side technological shocks whose role is emphasized by real business cycle theorists. The estimation results of investment functions in this paper also suggest that the economy was demand-constrained over the period.

Table 12. Real Growth Rate of GNP and Its Components

(%)

| | GNP | Consumption | Fiscal Expenditure | Equipment Investment | Inventory Investment | Current Account |
|---|---|---|---|---|---|---|
| 1953 | 5.7 | 7.6 | 0.2 | 2.6 | −3.0 | −1.8 |
| 54 | 6.1 | 3.2 | 0.4 | 1.5 | 1.0 | 0.2 |
| 55 | 9.1 | 5.0 | −0.1 | 0.3 | 2.9 | 1.0 |
| 56 | 8.0 | 4.9 | −0.1 | 3.9 | −0.2 | −0.6 |
| 57 | 8.0 | 3.9 | −0.1 | 3.8 | 1.3 | −1.0 |
| 58 | 5.4 | 4.5 | 0.6 | 0.9 | −2.6 | 2.0 |
| 59 | 9.2 | 4.9 | 0.6 | 3.2 | 1.1 | −0.6 |
| 60 | 14.1 | 6.3 | 0.5 | 7.3 | 0.7 | −0.6 |
| 61 | 15.6 | 5.1 | 0.6 | 7.5 | 4.1 | −1.8 |
| 62 | 6.4 | 5.4 | 0.8 | 3.2 | −4.3 | 1.4 |
| 63 | 10.6 | 5.7 | 0.9 | 3.0 | 2.0 | −1.0 |
| 64 | 13.4 | 6.4 | 0.6 | 5.2 | 0.8 | 0.4 |
| 65 | 4.5 | 2.9 | 0.6 | 0.7 | −1.2 | 1.4 |
| 66 | 10.5 | 6.2 | 0.7 | 3.6 | 0.3 | −0.3 |
| 67 | 10.4 | 5.9 | 0.6 | 4.9 | 1.4 | −2.4 |
| 68 | 12.5 | 5.2 | 0.7 | 5.9 | 0.7 | 0.1 |
| 69 | 12.1 | 6.0 | 0.5 | 5.8 | −0.2 | −0.1 |
| 70 | 9.5 | 4.1 | 0.6 | 5.6 | 0.6 | −1.4 |
| 71 | 4.3 | 3.2 | 0.5 | 1.5 | −1.5 | 0.6 |
| 72 | 8.5 | 5.4 | 0.5 | 3.5 | −0.1 | −0.9 |
| 73 | 7.9 | 5.4 | 0.5 | 4.5 | 0.5 | −3.0 |
| 74 | −1.4 | −0.2 | 0.3 | −3.6 | 0.8 | 1.2 |
| 75 | 2.7 | 2.6 | 0.7 | −0.4 | −2.1 | 1.9 |
| 76 | 4.8 | 2.1 | 0.5 | 0.9 | 0.4 | 1.0 |
| 77 | 5.3 | 2.6 | 0.4 | 1.3 | 0.2 | 0.9 |
| 78 | 5.2 | 3.2 | 0.5 | 2.7 | −0.4 | −0.9 |
| 79 | 5.3 | 3.9 | 0.4 | 1.7 | 0.6 | −1.4 |
| 80 | 4.3 | 0.9 | 0.3 | 0.0 | −0.3 | 3.4 |
| 81 | 3.7 | 0.8 | 0.5 | 1.0 | −0.1 | 1.5 |
| 82 | 3.1 | 2.4 | 0.2 | 0.3 | −0.1 | 0.3 |
| 83 | 3.2 | 1.9 | 0.3 | −0.1 | 0.3 | 1.5 |
| 84 | 5.1 | 1.6 | 0.2 | 1.4 | 0.5 | 1.3 |
| 85 | 4.7 | 1.6 | 0.2 | 1.7 | 0.1 | 1.0 |

Real Contribution Rate of Components to GNP

(%)

| | GNP | Consump-tion | Fiscal Expenditure | Equipment Investment | Inventory Investment | Current Account |
|---|---|---|---|---|---|---|
| 1953 | 100.0 | 134.3 | 4.4 | 46.1 | −53.3 | −31.5 |
| 54 | 100.0 | 51.3 | 6.3 | 24.0 | 15.7 | 2.7 |
| 55 | 100.0 | 54.6 | −0.8 | 3.4 | 32.2 | 10.6 |
| 56 | 100.0 | 61.2 | −0.7 | 49.2 | −2.4 | −7.3 |
| 57 | 100.0 | 49.1 | −1.0 | 47.3 | 16.6 | −12.2 |
| 58 | 100.0 | 83.0 | 10.3 | 17.3 | −47.9 | 37.1 |
| 59 | 100.0 | 53.2 | 6.8 | 34.7 | 11.6 | −6.4 |
| 60 | 100.0 | 44.3 | 3.7 | 51.5 | 4.8 | −4.3 |
| 61 | 100.0 | 33.0 | 4.2 | 48.1 | 26.0 | −11.3 |
| 62 | 100.0 | 83.3 | 12.8 | 49.4 | −67.0 | 21.4 |
| 63 | 100.0 | 53.6 | 8.2 | 28.8 | 18.6 | −9.2 |
| 64 | 100.0 | 47.6 | 4.4 | 38.9 | 5.8 | 3.3 |
| 65 | 100.0 | 66.1 | 12.4 | 15.8 | −26.7 | 32.4 |
| 66 | 100.0 | 58.6 | 6.9 | 34.3 | 3.2 | −3.0 |
| 67 | 100.0 | 57.2 | 5.5 | 47.0 | 13.3 | −22.9 |
| 68 | 100.0 | 41.3 | 5.2 | 46.7 | 5.7 | 1.0 |
| 69 | 100.0 | 50.0 | 4.5 | 48.1 | −1.4 | −1.2 |
| 70 | 100.0 | 42.9 | 6.0 | 59.1 | 6.7 | −14.8 |
| 71 | 100.0 | 74.8 | 12.3 | 34.1 | −35.5 | 14.4 |
| 72 | 100.0 | 63.7 | 6.4 | 41.5 | −0.7 | −10.9 |
| 73 | 100.0 | 68.3 | 6.6 | 57.4 | 5.8 | −38.0 |
| 74 | 100.0 | −11.7 | 20.2 | −250.4 | 59.3 | 82.6 |
| 75 | 100.0 | 99.0 | 24.5 | −15.7 | −80.3 | 72.5 |
| 76 | 100.0 | 44.5 | 9.9 | 18.4 | 7.4 | 19.8 |
| 77 | 100.0 | 48.0 | 8.3 | 24.1 | 3.3 | 16.3 |
| 78 | 100.0 | 62.4 | 10.1 | 52.6 | −7.2 | −18.0 |
| 79 | 100.0 | 73.4 | 8.3 | 32.9 | 11.8 | −26.0 |
| 80 | 100.0 | 20.2 | 6.6 | 0.3 | −6.9 | 79.0 |
| 81 | 100.0 | 20.6 | 12.8 | 27.1 | −1.5 | 41.0 |
| 82 | 100.0 | 76.9 | 6.2 | 8.2 | −1.9 | 10.5 |
| 83 | 100.0 | 57.9 | 8.9 | −2.4 | −10.8 | 46.4 |
| 84 | 100.0 | 32.4 | 4.7 | 26.7 | 9.9 | 26.3 |
| 85 | 100.0 | 33.4 | 5.2 | 36.6 | 2.7 | 22.1 |

Table 13. Variance Decompositions of Investment, Exports, and Domestic Demand

(a) Period: 1966/IV ~ 73/I

| | S.E. | Investment | Export | Domestic Demand |
|---|---|---|---|---|
| Investment | .0679 | 72.93 | 14.48 | 12.58 |
| Export | .0603 | 29.35 | 39.91 | 30.74 |
| Domestic Demand | .0339 | 51.96 | 20.18 | 27.86 |

(b) Period: 1973/II ~ 84/IV

| | S.E. | Investment | Export | Domestic Demand |
|---|---|---|---|---|
| Investment | .0494 | 43.28 | 51.53 | 5.18 |
| Export | .0907 | 25.92 | 71.51 | 2.57 |
| Domestic Demand | .0112 | 32.501 | 27.80 | 39.70 |

Note: According to VAR of 4-term lag.
Source: Yoshikawa and Ohtake (1987).

Finally, we should pay special attention to the role of exports as a demand factor influencing investment in recent years. In Table 12, for example, we observe high levels of investment from 1977 to 79 when the economic growth rate was over 5%. This high level of investment was most likely triggered by a permanent increase in future exports centering on the machinery industries. Using a VAR analysis which includes investment and exports separately, we can confirm a stronger dependency of investment on exports in recent years (Table 13). Similar observations are reported in the April 1986 issue of the *Monthly Report* of the Bank of Japan and also by Horiye, Naniwa and Ishihara (1987).

## V. Conclusion

The primary aim of this paper was to investigate the relationship between the flexibility of real wages and macroeconomic performance. Although previous studies suggest that flexible real wages enhance performance, the counter example of the U.K., which has experienced both flexible wages and poor economic performance, led us to doubt these earlier conclusions. We focus our current study on the relationship between the flexibility of wages and economic performance in Japan. Our analysis and conclusions are summarized below.

In section II, we analyzed the determinants of real wages in Japan by using panel data. If labor service is homogeneous and no internal labor market exists, then the wages determined at the corporate level should depend only on macroeconomic variables. According to our estimations, however, microeconomic variables such as the profit rate of each corporation are just as significant as macroeconomic variables. The relative contribution of macroeconomic variables and microeconomic variables are roughly seven to three (Table 4). It is tempting to interpret the significance of microeconomic variables in terms of bonus payments. But, there are actually two quite different views concerning the contribution of the Japanese bonus system to flexibility of wages (for a positive view see Freeman and Weitzman (1987) and for a negative view see Brunello and Ohtake (1987)).

In our study of wage functions, we also found that the dispersion of sales across industries tends to suppress wage increases. This effect was particularly pronounced after the second oil crisis. In view of this effect, we argue that wage increases become moderate in the process of structural shifts among industries.

We also point out that the slope of the short-run Phillips curve has been overestimated because the dispersion term was not appropriately incorporated into the analysis. Still the Phillips curve in Japan is very steep by international standard. The aggregate supply curve in Japan, however, has a very flat slope. Thus, it is not appropriate to interpret the steep Phillips curve as evidence of the ineffectiveness of demand management policies.

The labor's share in Japan has risen since around the first oil crisis and the "wage gap" has also widened. In section III, we first studied the extent to which innovations of real wages account for the variances of other variables by using VAR. Our finding is that the role of innovations of real wages has been quite limited, particularly since the first oil crisis.

We also compared Japan's prewar and postwar economies in order to analyze the relationship between the flexibility of real wages and the stability of the real economy. Compared to the postwar era, the prewar economy was three to four times more flexible in terms of both nominal and real wages, but the variability of the production index was almost exactly the same for both periods. This finding suggests that there is a fundamental flow in the conventional understanding that rigidity of prices is the major source of quantity fluctuations.

In section IV we analyzed investment functions to see what influence real wages have on the long-term trend of the economy. We obtain very different investment functions, depending on whether we approach the problem using a neo-classical framework or a Keynesian framework. Our estimation results suggest that firms are under Keynesian quantity constraints and thus rising real wages raise investment.

The results we obtained in sections III and IV indicate that the common neo-classical interpretation of the role of real wages is not necessarily appropriate. How then should one approach this problem? One way would be to consider the flexibility of real wages in relation to factor distribution and the stability of employment.

Suppose that a firm's production Y is determined by demand which is exogenous to this firm. If capital K and labor L are factors of production, we have

$$w = \frac{Y - rK}{L}. \tag{27}$$

This implies

$$\hat{w} = (\frac{1}{\sigma} - \frac{1-\sigma}{\sigma}\Psi - \phi)\hat{y}. \tag{28}$$

Here $\hat{x}$ is the rate of change in x. $\sigma$, $\Psi$, $\phi$ represent the labor's share, and degrees of responses of $\hat{r}$ and $\hat{L}$ to $\hat{y}$, respectively. The correlation between $\hat{w}$ and $\hat{y}$ becomes stronger when $\Psi$ and $\phi$ are small. At any rate, $\hat{w}$ does not affect at all the movement of $\hat{y}$ (See Kaldor (1956) on this point).

Although $\hat{y}$ is exogenous in the analysis above, effective demand would be the most obvious candidate for explaining it. Therefore we are led to conclude that we need to study the relationship between real wages and the effective demand. In this paper we discussed only the relationship between investment and real wages. Solow (1987) and Yoshikawa (1987) study the relation between real wages and effective demand in a broader context, but neither has gone much beyond the first step. This problem awaits further investigation.

## Appendix: The Method Used to Decompose the Nonstationary Time Series into a Permanent Component and a Transitory Component

In section IV, we analyse the investment function by decomposing each explanatory variable into permanent and transitory components. We use the ARIMA type decomposition method proposed by Beveridge and Nelson (1981), Cuddington and Winters (1987) and others. This methodology assumes that a nonstationary time series can be well represented by an ARIMA (p,d,q) process and that a time series is decomposed into the two components. For simplicity, we assume $\{x_t\}$ as a nonstationary time series with one unit root on the AR part. By taking the first differences, the stationary stochastic process,

$$\Delta x_t = (1 - L)x_t = w_t \tag{A-1}$$

is obtained. Here L express a lag operator. By Wold's decomposition theorem, $w_t$ can be well expressed by the infinite MA process

$$w_t = \mu + \epsilon_t + \lambda_1\epsilon_{t-1} + \lambda_2\epsilon_{t-2} + \cdots. \tag{A-2}$$

Next, we consider a conditional forecast of this type of nonstationary time series in time t+k at time t. Then we obtain,

$$\begin{aligned}\hat{x}_{t+k} &\equiv \hat{x}_t(k) \\ &= E(x_{t+k} \mid \Omega_t) \\ &= E(w_{t+1} + \cdots + w_{t+k} \mid \Omega_t) \\ &= x_t + \hat{w}_t(1) + \cdots + \hat{w}_t(k).\end{aligned} \tag{A-3}$$

Here $\Omega_t$ indicates the information set at time t and consists of $\{x_t, x_{t-1}, \ldots\}$. From equation (A-2), a conditional forecast of $w_{t+k}$ at time t can be expressed as,

$$\begin{aligned}\hat{w}_t(k) &= \mu + \lambda_k\epsilon_t + \lambda_{k+1}\epsilon_{t-1} + \cdots \\ &= \mu + \sum_{j=1}^{\infty} \lambda_{k+j-1}\epsilon_{t-j+1}.\end{aligned} \tag{A-4}$$

By replacing this with equation (A-3), we get

$$\hat{x}_t(k) = k\mu + x_t + \left(\sum_{i=1}^{k} \lambda_i\right)\epsilon_t + \left(\sum_{i=2}^{k+1} \lambda_i\right)\epsilon_{t-1} + \cdots + \left(\sum_{i=n}^{k+n-1} \lambda_i\right)\epsilon_{t-n+1} + \cdots \tag{A-5}$$

and when $k \to \infty$,

$$\hat{x}_t(k) \approx k\mu + x_t + \left(\sum_{i=1}^{\infty} \lambda_i\right)\epsilon_t + \left(\sum_{i=2}^{\infty} \lambda_i\right)\epsilon_{t-1} + \cdots \tag{A-6}$$

can be asymptotically established. The second, third and left of the terms in equation (A-6) can be treated as permanent components; because those are components which do not diminish even when $k \to \infty$, in the information we have at time t. Beveridge and Nelson (1981) define whole of them as the permanent component of $x_t$ and express it as

$$\bar{x}_t \equiv x_t - s_t. \tag{A-7}$$

Therefore, $s_t$, the transitory component of $x_t$ is given by equation (A-8).

$$s_t = -\left[\left(\sum_{i=1}^{\infty} \lambda_i\right)\epsilon_t + \left(\sum_{i=2}^{\infty} \lambda_i\right)\epsilon_{t-1} + \cdots\right] \tag{A-8}$$

It can easily be seen from equation (A-6) that $\{\bar{x}_t\}$ is a stochastic trend, and is a random walk with drift.[9] This can be confirmed as follows. First, taking the first differences of $\bar{x}_t$, it is transformed to

$$\begin{aligned}\Delta\bar{x}_t &= \bar{x}_t - \bar{x}_{t-1} \\ &= x_t - x_{t-1} + \left(\sum_{i=1}^{\infty} \lambda_i\right)\epsilon_t - (\lambda_1\epsilon_{t-1} + \lambda_2\epsilon_{t-2} + \cdots) \\ &= \mu + \left(\sum_{i=0}^{\infty} \lambda_i\right)\epsilon_t\end{aligned} \tag{A-9}$$

[9]Note that this method regards the permanent component as a stochastic trend. This method cannot be used, if the true process has a deterministic trend. The estimation cannot be done using a normal method because the MA part ($\theta(L)$) of equation (A-10) has a single unit root.

For further discussion on the relationship between macroeconomic time series and stochastic trend, for example, see Nelson and Plossor (1982).

where $\lambda_0=1$. In the above equation, the infinite sum in the second term is bounded by the assumption of stationarity of $w_t$. Therefore it entails that $\Delta\bar{x}_t$ follows a white noise process (with drift $\mu$) that has a finite variance.

We can express the second, third and left of the terms in equation (A-2) as a lag polinomial:

$$w_t = \mu + \lambda(L)\epsilon_t. \tag{A-2'}$$

By replacing L with unity in equation (A-2′), it is clear that this also represent $\Delta\bar{x}_t$. Since $\lambda(L)$ is the infinite lag polynomial, we usually approximate it by the finite lag polynomial. Practically, the ARMA (p,q) model,

$$\begin{aligned} w_t &= \mu + \theta(L)/\phi(L)\epsilon_t \\ \theta(L) &= 1 + \theta_1 L + \cdots + \theta_q L^q \\ \phi(L) &= 1 - \phi_1 L - \cdots - \phi_p L^p \end{aligned} \tag{A-10}$$

is applied to $w_t$, and we obtain the estimate

$$\hat{\lambda}(L) = \hat{\theta}(L)/\hat{\phi}(L).$$

Therefore, $\Delta\bar{x}_t$ can be derived from the ARMA representation of $w_t$ as follows

$$\Delta\bar{x}_t = \mu + \hat{\theta}(1)/\hat{\phi}(1)\epsilon_t.$$

Under the assumption of $s_0=0$, we estimate the series of $\bar{x}_t$ and $s_t$ in this paper.

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