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Empirical Analysis of the Role of Nominal Flexibilities in Economic Fluctuations: The Case of Japan and the United States*

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This paper examines the role of nominal flexibilities in economic fluctuations between Japan and the United States. Most monetary business cycle theories imply that increased nominal flexibility leads to stabilizing the economy. It is empirically shown that differences in nominal flexibilities are a significant part of the explanation for the difference in output fluctuations between two countries. These differences are characterized through simple reduced-form vector autoregression models and the moving average representations that capture the dynamic interrelationships between nominal flexibilities and output fluctuations.

I. Introduction

This paper examines the differences between economic fluctuations in Japan and the United States during the last 20 years. During this period the size of the fluctuations in real output in Japan was much smaller than in the United States. According to most monetary business cycle theories, increased nominal flexibility leads to stabilizing the economy.[1] This paper shows empirically that differences in nominal

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1. Most monetary business cycle theories, which emphasize technological as well as monetary factors, suggest that the increased nominal flexibilities are stabilizing. However, there are differing views about the effect of nominal rigidities on macroeconomic fluctuations. For example, DeLong and Summers (1986) show the possibility that nominal rigidities tend to decrease the size of economic fluctuations. However, many empirical evidences are contrary to their theoretical hypothesis. See Taylor (1989) for a good

wage and price flexibilities are a significant part of the explanation of the difference in economic fluctuations between two countries.

Nominal wages and prices in Japan do seem to be more responsive to economic movements than those in the United States. Especially, the difference in nominal wage flexibility may be explained by two striking features in Japanese labor market. First, Japanese wages, which are partly paid in the form of bonus payments, reflect well economic conditions which include prices as well as productivity or profitability per employee. Second, the existence of annually synchronized wage negotiation, so called Shunto, is responsible for the higher nominal wage flexibility compared to that in the United States.

We use simple reduced-form vector autoregressions to analyze the dynamic interrelationships between nominal flexibilities and output fluctuations in these two countries. It is generally known that the vector autoregressive (VAR) technique is a good descriptive device for investigating a system's response to typical random shocks.[2] In particular, the moving average (MA) representations generated by those typical random shocks enable us to characterize the dynamic interactions among endogenous variables, and observe the amplitude and persistence of adjustment of the variables in the system.

This paper is organized as follows. Section II begins with a simple statistical comparison of nominal wage, price, and output variabilities which are measured by the standard deviations of three series in Japan and the United States. Section III discusses the VAR model used and the selection of the optimal lag length in the VAR model. In Section IV we present empirical results of the VAR and, by using the MA representations, characterize the dynamic properties between nominal flexibilities and real output fluctuations for the two countries. Conclusions of this paper are contained in the final section.

II. Statistical Comparison

Before conducting an empirical test of the theoretical prediction mentioned above, we compare statistical facts regarding nominal

survey on many competing theories of macroeconomic fluctuations.

2. See Sims (1980) and any textbook on multivariate time-series for details.

flexibilities and real output fluctuations between Japan and the United States during the period 1969. 1 - 1988. 4. This period covers both of the oil shocks and includes a change in monetary policy regime, attempting to minimize exchange rate fluctuations after the end of the Bretton Woods exchange rate system.[3] All the statistical analyses in this paper are based on quarterly data that are seasonally adjusted.

Output and prices are measured by real GNP and the GNP deflator, respectively. Nominal wages are based on average monthly earnings in manufacturing.[4] We choose detrended output using a deterministic trend rather than first differences to capture the tendency for output to converge to its potential growth path after economic shifts in the economy. Thus, output is given by the percentage deviation of the logarithm of real GNP from a exponential time trend.[5] On the other hand, nominal wages and prices are detrended by taking first differences of the logarithms since the trend of these two variables was not present during the last 20 years.

Table 1 presents the standard deviations of the three detrended series. According to the standard deviation measure, the variabilities of nominal wages and prices in Japan are much higher than in the United States, while the size of output fluctuations in Japan was smaller than in the United States. That is, since 1969, nominal flexibilities in Japan have been over two times greater than in the United States. But, real output fluctuations in Japan have been over two times smaller than those in the United States. This statistical comparison indicates that

3. There are some other reasons for not using an earlier starting data. First, since the period after World War II, most regular workers in Japan have been paid a significant fraction of their payments in the form of profit-sharing bonus, which is an important source of nominal wage flexibility. Second, econometric and simulation evidence suggests that flexible exchange rates tend to isolate the effect of monetary policy in one country from those in another, so that it was feasible for two countries to have independent monetary policy in one country from those in another, so that it was feasible for two countries to have independent monetary policy rules during the period after the end of the Bretton Woods exchange rate system (see Carlozzi and Taylor, 1985).
4. For Japan, we used average monthly earning (in manufacturing) as the variable of nominal wage. It is known that average hourly earnings are derived by dividing total earnings by total hours worked in the specified period. By using this definition, we adjusted monthly earning data to hourly earning data. These hourly earning data in Japan yield similar impulse responses to those of monthly earning data.
5. See Chou (1989) for the method of deriving a detrended output.

differences in nominal flexibilities may be a significant factor in explaining the differences in real economic performance between two countries.

Ⅲ. Vector Autoregression Models

The VAR methodology developed and popularized by Sims (1980) is used to analyze dynamic relationships between economic time-series. It manipulates estimates of reduced-form equations instead of structural equations and then characterizes the comovements of the endogenous variables in the system. Especially, the MA representations generated by typical random shocks in the system are used as a tool to analyze the dynamic interactions among endogenous variables as well as the amplitude and persistence of adjustment of the variables in the system. Let us discuss the basic VAR model used here and the method of selecting the optimal lag length in the VAR model.

A. VAR Modeling

It is assumed that the relationships among nominal wage inflation (ΔW), price inflation (ΔP), and the output gap (ΔY^*) defined in the previous section are represented by a linear-invariant relationship. Then, each relationship has the general form in matrix notation

$$A(L)Z(t) = e(t) \tag{1}$$

where A(L) is a matrix polynomial in lag operator (L) $A(L) = I + A_1L + A_2L^2 + \cdots + A_mL^m$ where A_i, i=1, 2, ⋯, m, are 3×3 matrices of time-invariant coefficient, z(t) is the covariance stationary vector valued time-series, and e(t) is a vector of serially independent distributed error terms with zero mean and constant variances. Here, z(t) is the vector $(\triangle W \ \triangle P \ \triangle Y^*)'$. It is also assumed in equation (1) that each of the three components of z(t) is endogenous with respect to the other components of z(t) and the lag structure is symmetric across the variables and equations.

VAR systems like equation (1) are difficult to describe succinctly. It is, especially, difficult to understand and interpret the estimated coefficients.[6] A common practice is to derive a MA representation of equation (2). Except for scaling, this is equivalent to tracing out the system's MA representation by the matrix polynomial long division. That is, the MA representation has the form

$$Z(t) = \sum_{i=0}^{\infty} \Phi(i)e(t-i) \tag{2}$$

where the $\Phi(i)$ matrices are found by successive substitution of lagged z(t)s in equation (1). Alternatively, they can be computed by dynamically simulating the effects of unit shocks to each equation in equation (1). The $\Phi(i)$ matrices are often termed as the impulse response functions and provide the basic ingredients for our analysis. That is, the MA representation enables us to examine the dynamic response of each component of z(t) to a unit shock originating from one of the variables in z(t).

If the residuals are contemporaneously correlated across equations, the simulation could be misleading. Sims (1980) suggests transforming the MA system into a corresponding system with orthogonal residuals after choosing a plausible causal structure. A widely used method is Choleski decomposition, in which the residuals are orthogonalized so that the covariance matrix of the resulting innovations is lower triangular.

B. Selecting Optimal Lag Length

The specification of lag length is one of the tricky problems involved in the implementation of a VAR model. However, there is no obvious criterion for selecting a particular lag length. In practice, lag length is chosen more or less arbitrarily, i.e., it is truncated to some

6. The difficulty arises because the estimated coefficients on successive lags tend to oscillate and there are complicated cross-equation feedbacks.

number that is large enough to ensure that the residuals in the model are white noise but small enough to leave a comfortable margin on the degrees of freedom.

Here the order of a VAR model is determined by statistical methods. First, the optimal order of our VAR model is checked by Akaike's information criterion (AIC) based on the principle of minimizing the residual sum of squares as a guide for selecting the best model. The AIC for the order p and r-dimensional model is given by

$$n\ln(|\Sigma_p|) + 2pr^2 \qquad (3)$$

where $\ln(|\Sigma_p|)$ is the maximum of the log likelihood and pr^2 is the number of parameters in the model. We select the order for which AIC is minimized.[7] For Japan and the United States, the values of AIC indicate that the optimal order of the VAR models is three and two, respectively.

Next, the optimal order of our VAR models is checked by the Box-Pierce (B-P) Statistic, which provides an overall test on the autocorrelations of the estimated residuals. The B-P statistic is given by

$$Q = n\sum_{k=1}^{M} r_k^2 \qquad (4)$$

where n is the sample size, M is the number of autocorrelations being tested against zero, and r_k is the residual autocorrelation at lag k. This statistic is asymptotically distributed as $\chi^2(M)$ under the null hypothesis. The test relies for its validity on M being moderately large (generally, at least equal to 20). Under the third order autoregression and M=30, the hypothesis that the residuals of each equation in our

7. The most widely used criterion for selecting regressors are Akaike, Schwarz, Hannan and Quinn, and the logarithm of the final prediction error (FPE). All of these statistics are concerned with minimizing the value of the determinant of the covariance matrix of the residuals, but differ according to the penalty attached to increasing the number of estimated parameters.

VAR model are white noise is generally not rejected at the 10% or 5% level of significance for both countries. The results are shown in table 3. This implies that the residuals of each equation in the VAR model are approximately white noise.

In addition, the Haugh statistic (1976) tests the hypothesis that the residuals of cross equations in the VAR model are white noise. The Haugh statistic (S) is given by

$$S = n^2 \sum_{k=-M}^{M} (n - |k|)^{-1} r_k^2(x,y) \tag{5}$$

where $r_k(x,y)$ is the residual cross-correlation of two equations, x and y, for k lags or leads. This statistic is used when M is relatively large compared to n (say, M>n/10). S is asymptotically distributed as $\chi^2(2M+1)$ under the null hypothesis. The Haugh test statistics represent that the null hypothesis is rejected at the 10% or 5% level of significance for both countries. In order to correct the problem of cross correlations, we tried higher order VARs but found that they led to similar impulse response functions. Therefore, we select the third order VARs due to the problem of efficiency trade-off.

Ⅳ. Empirical Results

This section provides estimates of three-dimension VAR and then derives MA representations from the VAR in order to analyze the dynamic interrelationships between nominal flexibilities and output fluctuations for two countries. The ultimate goal of this section is to check whether differences in nominal responsiveness to economic movements are a significant part of the explanation of the difference in output fluctuations between two countries.

A. VAR Estimates in Japan and U.S.

First of all, we consider autoregression estimates for nominal wage inflation, price inflation, and output in two countries. These estimates are later used for deriving an MA representation. In table 4 standard deviations of errors can be interpreted as a measure of the size of the underlying impulses hitting the two economies. The sum of square residuals (SSR) to nominal wage inflation and price inflation equations in Japan are much larger than in the United States, reflecting the higher degree of nominal flexibilities in the Japanese economy. On the contrary, the SSR to the output equation in Japan is smaller than in the United States. As mentioned before, these autoregression estimates cannot describe the dynamic interactions among endogenous variables as well as the amplitude and persistence of adjustment of the variables to random shocks in the system. Thus, the next section discusses MA representations which enable us to deal with these problems.

B. MA Representations: Impulse Responses

Now, let us derive MA representations from our VARs in order to analyze the dynamic interactions among all endogenous variables in the system. As shown in table 4, contemporaneous correlation exists in the residual vector, e(t). Then, the simulation of random shocks (innovations) in the system could be misleading since the assumption of a unique error structure is invalid. This problem is avoided by transforming the MA representation into a corresponding system with orthogonal innovations. A widely used method is Choleski decomposition, in which the residuals are orthogonalized so that the covariance matrix of the resulting innovations is lower triangular. This method requires imposition of some causal ordering of the equations in the system, since changing the order can significantly change the impulse response functions. However, all possible orderings were tried and yielded very similar responses.

Impulse Responses: The following figures display the responses of all variables to each shock in the triangularized system.[8] The triangularized system represents that the innovation of the first variable in the ordering contemporaneously affects all other variables, while the innovation of the second variable contemporaneously affects all other

8. Since we use non-structural VAR, the confidence bands for each impulse response function (IRF) need to be figured along IRF. These will be shown in the appendix.

variables but the first variable in the system, and so on. The order of allowing a random shock in our system is price inflation, output, and wage inflation.

First, Figures 1 (a) to (c) depict all variable's impulse responses to one standard deviation (SD) shocks of price inflation for the first quarter to 24 quarters ahead. In the initial period, the size of Japanese and U.S. on standard deviation shocks of price inflation might be different since they are obtained from the residuals of the price inflation equation in each country's VAR. Parts (a) and (c) of Figure 1 show that nominal price and wage flexibilities to the price inflation shock are much higher in amplitude in Japan than in the United States, but the same in persistency for the two countries. Part (b) of Figure 1 represents that output fluctuations to the price inflation shock are smaller in amplitude and less persistent in Japan than in the United States, although the effect of the shock produces a weak response in real output (i.e., the response of the price inflation shock on output oscillates between 0.001 and -0.001).

Next, Figures 4.2 (a) to (c) indicate the responses of all variables to on standard deviation shock of output. Parts (a) and (c) of Figure 2 show that nominal flexibilities to the output shock are similar to the case of allowing the price inflation shock; nominal flexibilities to the output shocks are much higher in amplitude in Japan than in the United States, but the same in persistency for the two countries. Part of (b) of Figure 2 represents that output fluctuations to the output shock are much smaller in amplitude and less persistent in Japan than in the United States. Finally, Figures 3 (a) to (c) show that the responses of all variables to the wage inflation shock are similar to those of the price inflation shock.

These impulse responses suggest significant interrelationships between nominal flexibilities and output fluctuations. The results are consistent with the theoretical prediction; the increased nominal flexibility leads to stabilizing output. Furthermore, the evidence supports the argument that Japanese wage schemes in the form of sharing payments might explain well a part of the smaller output fluctuations in response to output shifts, since sharing compensation structures better reflect productivity or output movements.

V. Conclusions

This paper focused on nominal wage and price behavior as important differences in macroeconomic performance. We examined that differences in nominal responsiveness account for differences in output fluctuations between Japan and the United States. These differences were characterized through simple reduced-form VARs and their MA representations that capture the dynamic interactions between nominal flexibilities and output fluctuations.

The empirical results support current monetary business cycle theories; less flexibility of nominal wage and prices leads to a deterioration in economic performance. Furthermore, the evidence indicates that the Japanese experience is definitely supportive of the fact that annual sharing contracts can be used to foster better macroeconomic performance.

Table 1 Measures of Nominal Wages, Prices, Output Variabilities, 1969.1-1988.4

	Japan	United States
Standard Deviations of Nominal Wages	0.025	0.017
Prices	0.126	0.007
Output Gap	0.003	0.006

Notes: Nominal wages and prices are the first differences of their logarithms. The gap of output is the percentage deviation of the logarithms of real GNP from a constant exponential time trend.

Source: OECD Main Economic Indicators, *Historical statistics*, 1989.

Table 2 Selecting Lag Length by Akaike' Information Criterion

	lag=0	lag=1	lag=2	lag=3	lag=4
Japan	-2237.11	-2423.87	-2432.19	-2434.76*	-2424.66
U.S.	-2310.48	-2517.82	-2519.20*	-2515.22	-2507.30

Note: * represents the optimal order of VAR model in Japan and the United States.

Table 3 Test Results of Autocorrelations and Cross Correlations

	Japan	U.S.
B - P Statistic (degrees of freedom=30)		
$Q_{\Delta w}$	18.29*	18.09**
$Q_{\Delta p}$	21.67	20.68*
$Q_{\Delta Y*}$	18.29**	18.09**
Haugh Statistic (degrees of freedom=61)		
$S_{\Delta w \Delta p}$	76.18	72.86
$S_{\Delta w \Delta Y*}$	70.29	72.65
$S_{\Delta p \Delta Y*}$	54.12	58.98

Notes: The subscript represents each equation in the VAR; nominal wage inflation, price inflation, and output equations.

* denotes significant at 0.10 level.

** denotes significant at 0.05 level.

Table 4 Autoregression Estimates for Nominal Wage Inflation, Inflation, Output, 1969.1-1988.4.

$$Z(t)=AZ(t-1)+BZ(t-2)+CZ(t-3)+e(t),\quad Z(t)=(\Delta w,\Delta p,\Delta Y^{*})'$$

Japan

A			B			C		
-0.51	1.47	3.74	-0.05	0.39	-0.15	-0.18	0.26	-3.63
(-3.44)	(3.23)	(1.75)	(-0.27)	(0.81)	(-0.05)	(-1.28)	(0.65)	(-1.71)
-0.01	0.54	1.03	0.08	0.36	0.86	-0.01	-0.26	-0.75
(-0.13)	(4.30)	(1.76)	(1.71)	(2.76)	(1.09)	(-0.13)	(-2.30)	(-1.30)
-0.001	-0.03	1.07	-0.002	0.07	-0.04	-0.001	-0.03	-0.15
(-0.18)	(-1.19)	(8.16)	(-0.28)	(2.21)	(-0.24)	(-0.12)	(-1.34)	(-1.13)

$(R^2_{\Delta w},\ R^2_{\Delta p},\ R^2_{\Delta Y*})=(0.44,\ 0.84,\ 0.82)$

$(SSR_{\Delta w},\ SSR_{\Delta p},\ SSR_{\Delta Y*})\ =\ (0.0268,\ 0.00199,\ 0.00010)$

$(CORR(\Delta W,\ \Delta P),\ CORR(\Delta P,\ \Delta Y^{*}),\ CORR(\Delta W,\ \Delta Y^{*}))=(0.38,\ 0.01,\ 0.52)$

U.S.

A			B			C		
-0.24	0.57	-0.13	-0.08	0.12	0.74	0.19	0.31	-0.54
(-1.91)	(1.98)	(-0.34)	(-0.53)	(0.42)	(1.30)	(1.45)	(1.19)	(-1.37)
0.17	0.21	0.09	0.14	0.04	-0.15	0.08	0.13	0.32
(3.17)	(1.72)	(0.57)	(2.25)	(0.28)	(-0.61)	(1.51)	(1.13)	(1.87)
0.003	0.06	1.07	-0.03	-0.11	0.04	-0.005	-0.0004	-0.23
(0.06)	(0.62)	(8.54)	(-0.66)	(-1.13)	(0.20)	(-0.12)	(0.005)	(-1.87)

$(R^2_{\Delta w},\ R^2_{\Delta p},\ R^2_{\Delta Y*})=(0.35,\ 0.70,\ 0.86)$

$(SSR_{\Delta w},\ SSR_{\Delta p},\ SSR_{\Delta Y*})\ =\ (0.0053,\ 0.00098,\ 0.00055)$

$(CORR(\Delta W,\ \Delta P),\ CORR(\Delta P,\ \Delta Y^{*}),\ CORR(\Delta W,\ \Delta Y^{*}))=(0.28,\ -0.07,\ 0.24)$

Notes: Each equation was estimated with a constant term. For the definition and source of variables see the note in table 1.
The subscript represents each equation in the VAR; nominal wage inflation, price inflation, output equations. CORR(· , ·) is the contemporaneous correlation between residuals in two equations.

Figure 1

(a) Responses of Nominal Wage Inflation to One SD Shock of ΔP

(b) Responses of Output to One SD Shock of ΔP

(c) Responses of Price Inflation to One SD Shock of ΔP

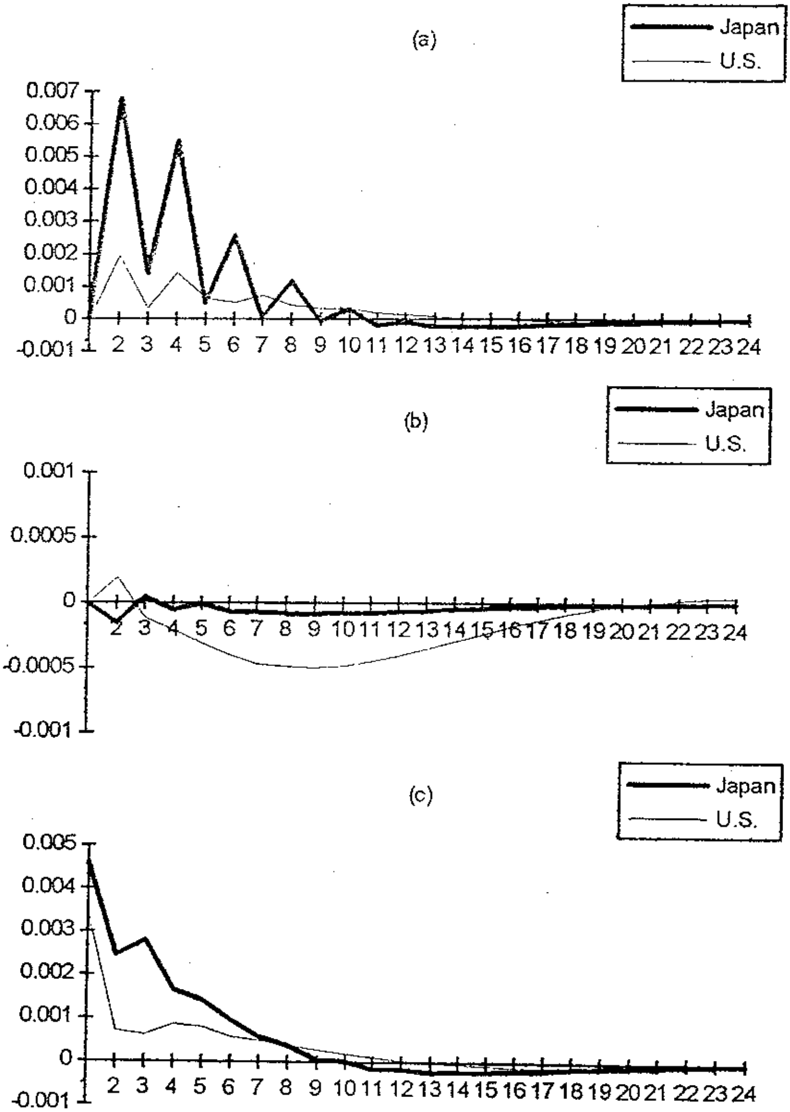


Figure 2

(a) Responses of Nominal Wage Inflation to One SD Shock of ΔY^*

(b) Responses of Output to One SD Shock of ΔY^*

(c) Responses of Price Inflation to One SD Shock of ΔY^*

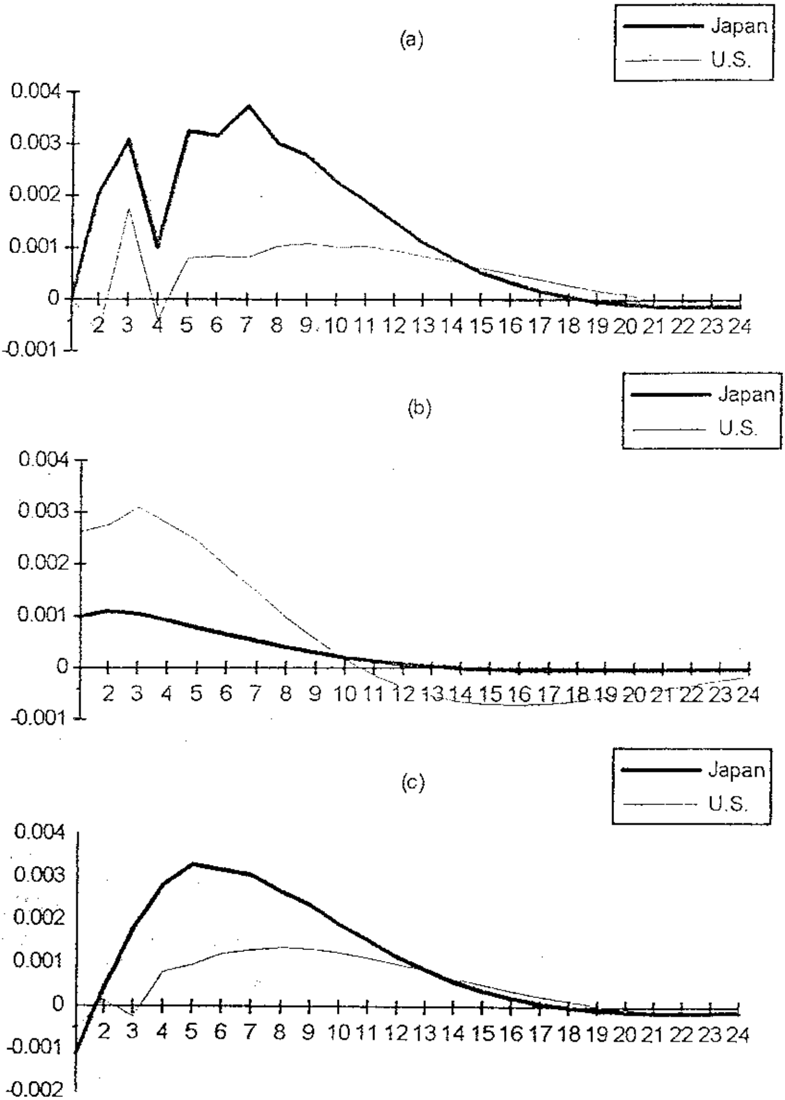
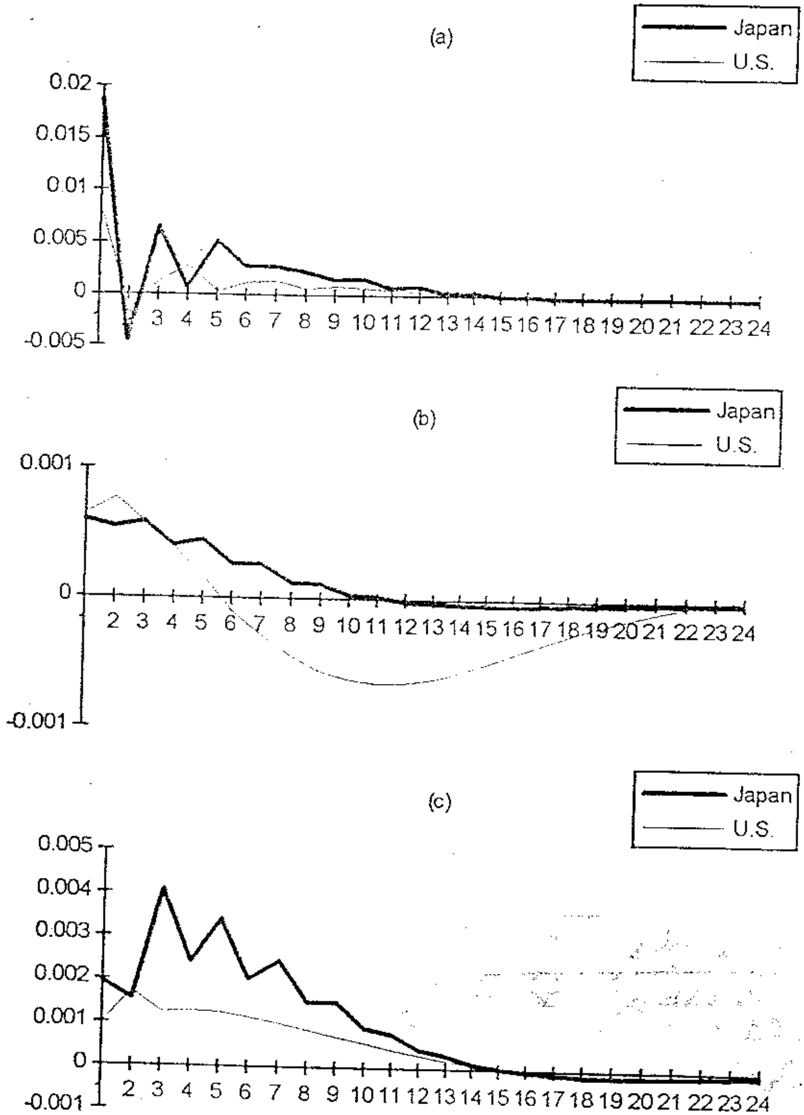


Figure 3

(a) Responses of Nominal Wage Inflation to One SD Shock of ΔW

(b) Responses of Output to One SD Shock of ΔW

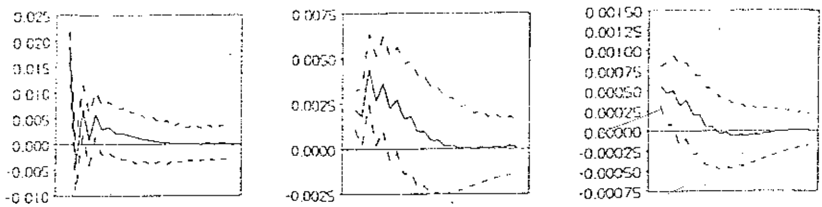
(c) Responses of Price Inflation to One SD Shock of ΔW



Appendix

This appendix represents confidence bands for each impulse response function. (a), (b), and (c) show Japanese responses of endogenous variables (nominal wage inflation, price inflation, output gap) to one SD shock of $\triangle P$, $\triangle W$, $\triangle Y^*$, respectively. Also (d), (e), and (f) show U.S. responses of endogenous variables to one SD shock of $\triangle P$, $\triangle W$, $\triangle Y^*$, respectively.

(a)



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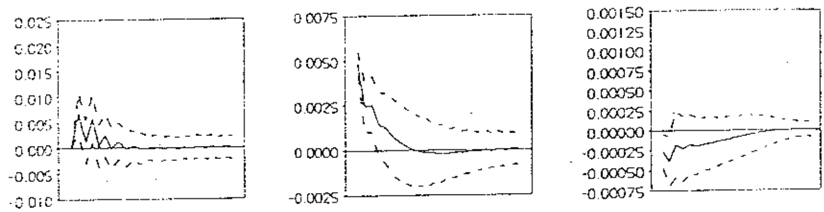
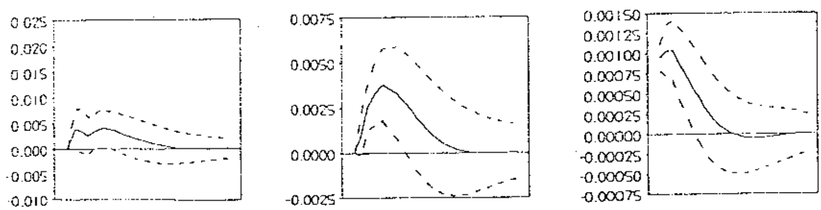


(c)



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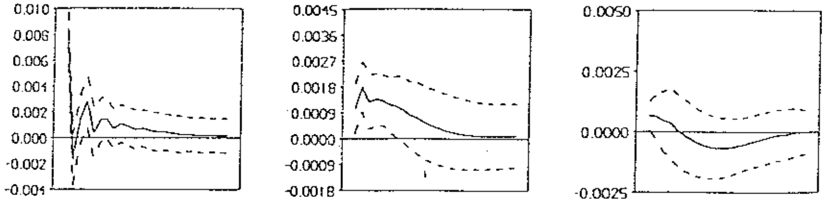
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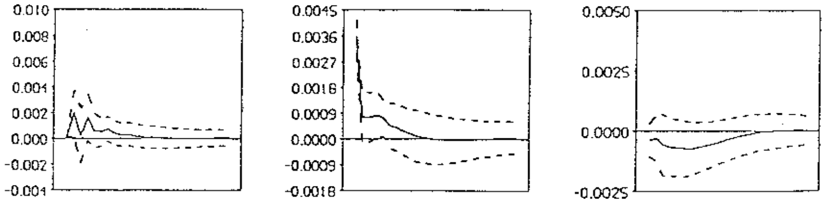
(e)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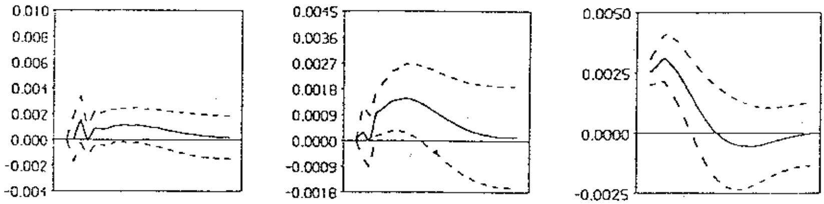
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