A COMPARISON OF JAPANESE AND U. S. MACROECONOMIC BEHAVIOR BY A VAR MODEL

by

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Abstract

This paper focuses on macroeconomic behavior of the U.S. and Japan with a special attention to characteristics of Japanese financial markets and the pattern of Japan's trade with the rest of the world. Explanations of observed facts summarized by vector autoregressions (VAR) are given referring to the arrangement of Japanese financial institutions and the economic structure with respect to foreign trade. First, interest rates do not have any explanatory power on production in Japan, unlike in the U.S. This is explained by strong interventions in financial markets by the Bank of Japan. Second, stock prices in both Japan and the U.S. are exogenous. Third, bank loans in Japan plays a similar role to that of money. Last, contrary to our intuition, shocks from abroad in terms of import prices do not have a strong impact of domestic prices and production. This paper, which includes Japan, fills the lacuna in Sims' comparative study in macroeconomic behaviors of the U.S. and the European countries.

1. Introduction

Differences in economic performance during the 1970s among major industrial nations have stimulated comparative studies of macroeconomic behavior with an emphasis on institutional differences. For example, Sachs (1979) and Robert Gordon (1982) advocated a hypothesis that institutional differences in the labor market lead to differences in the estimated adjustment of real wages between the U.S. and other selected OECD countries including Japan. On the causal relationship between money, interest rates, production and other variables, Sims (1980a)(1980c) offers a comparative study among OECD countries excluding Japan, making intensive use of vector autoregressions. Ito and Ueda (1980) employed a disequilibrium model to test a hypothesis that the lending rate always clears the business loan market in the U.S. and in Japan. The lending rate in Japan is shown to be more sluggish than that in the U.S., and the equilibrium hypothesis in Japan is rejected. The result is not surprising in light of the rather strict control of interest rates by the monetary authority in Japan.

This paper focuses on macroeconomic behavior of the U.S. and Japan with a special attention to characteristics of Japanese financial markets and the pattern of Japan's trade with the rest of the world. Not only has Japan achieved remarkable success in rapid economic growth since the Second World War, but also its recent handling of inflation and unemployment seems better than other OECD nations. The purpose of this paper is to explain some of the observed facts, summarized by vector autoregressions (VAR) by recognizing the arrangement of Japanese financial institutions and the economic structure with respect to foreign trade. The paper is also expected to fill the lacuna in Sims' comparative study. Since the econometric method used is the same as in Sims (1980a)(1980b) (1980c), findings in this paper are easily compared and contrasted with his findings in the U.S. and western European countries. Vector autoregression is used to summarize data without imposing too much a prior restrictions on a model.

Section 2 contains a concise review of methods of estimating a VAR model and a summary of results obtained in preceding applied works. Section 3 explains salient features of the Japanese financial institutions and the composition of international trade. A close examination of practices in the Japanese financial market reveals that interest rates, including the call market rate, have been regulated and subject to direct intervention. Monetary policy was conducted mainly through the control of the quantity of business loans from commercial banks. It is conjectured that economic performance in Japan is susceptible to shocks from abroad, since the economy depends on imports and exports more than the U.S. Several but not all conjectures about the Japanese economy in Section 3 are supported by data. Main econometric results of this paper are presented in Sections 4 and 5. First, shocks in the interest rate do not have any explanatory power on fluctuations of production or prices in Japan, contrary to the results for the U.S. economy in Sims (1980b). However, this is not surprising because of the interest rate regulation. Shocks in money supply does not cause price and production fluctuations, either. On the contrary, price and production shocks appear to cause fluctuations in money and interest rates. Second, stock prices in Japan are shown to be exogenous, unlike the interest rate, to the rest of the economy, implying that they reflect "news" in the economy. Third, bank loans in Japan are shown to play a similar role to that of money. This result parallels American results found in B. Friedman (1981). Last, shocks from abroad in terms of import prices, export prices and balance of payments do not have strong impact on the wholesale price index, or industrial production. This result is counterintuitive considering the composition of international trade. However, the timing of import price changes and its interaction with changes in the exchange rate may explain the result. One possible reason for the weak explanatory power of money is explained in Section 5: When feedback policy is successful, causality may appear to point from a target variable to a policy variable. The last section summarizes the results obtained in the paper and suggests topics for further research.

2. Review of Vector Autoregression and its Applications

Vector autoregressions (hereafter VAR) has become increasingly popular recently among macroeconomists. This is partly due to its power in answering questions about causality, and partly due to the relative lack of *a priori* restrictions to obtain "incredible identification," (Sims 1980a)), or not "prentending to have too much *a priori* economic theory," (Sargent and Sims (1977)). Let us review the fundamentals of this estimation method and then survey several findings in the literature relevant to this paper.

A vector autoregression model is expressed as

$$x_i(t) = \sum_{s=1}^{q} \sum_{j=1}^{K} a_{ij}(s)\ x_j(t-s) + \varepsilon_i(t), \quad i = 1, \ldots, K,$$

or in vector form,

$$x_t = \sum_{s=1}^{q} A_s\ x_{t-s} + \varepsilon_t \tag{2.1}$$

where q is the lag length and K is the number of variables in the model. The sequence $\{\varepsilon_t\}$ is serially uncorrelated and uncorrelated with past x_t, so that

$$E(\varepsilon_t | x_{t-s},\ s > 0) = 0 \quad \text{and} \quad E(\varepsilon_t | \varepsilon_{t-s},\ s \neq 0) = 0.$$

Therefore, the use of ordinary least squares is fully justified. If the economic data are not seasonally adjusted, then it is natural to add seasonal dummy variables to the right hand side of equation (2.1). If a time trend, not captured by lagged variables, is relevant, it should also be included in the right hand side of (2.1).

One problem in estimating (2.1) is that we do not know a priori the lag length. We have to estimate the lag length as well as other parameter values. This amounts to a question of choosing the right dimension of a model. Akaike (1974) and Schwarz (1978) proposed slightly different criteria for model selection. Akaike's proposal is essentially to find the dimension which maximizes the difference between the value of the log-likelihood function and the number of parameters in the model, given that the likelihood function is maximized with respect to the parameters for a fixed dimension. Denote the maximized likelihood function for each model j by $M_j(x_1,\ldots x_T)$, where T is the number of observations, and the number of parameters of the model by k_j. Then Akaike's criterion is to choose a model which maximizes $\log M_j(x) - k_j$. Schwarz (1978) proposed replacing the second term by $\{k_j \log T/2\}$. It is obvious that Schwarz's criterion favors lower-dimensional models, provided that there are eight or more observations and the maximized likelihood is concave with respect to the dimension of the model.

The vector stochastic process (2.1) can be expressed using a lag operator,

$$(2.2) \qquad A(L)\, x_t = \varepsilon_t \,, \; A(L) \equiv A_0 - A_1 L - \ldots - A_q L^q \,,$$

where $A_o = I$. This autoregressive process can be transformed, if the process is stationary, into the moving average form:

$$(2.3) \qquad x_t = B(L)\, \varepsilon_t$$

where $B(L) = A(L)^{-1}$. An advantage of the moving average form is that a coefficient of B represents the response of the system to a typical shock. This is one more step for our analysis. We may rewrite (2.3) using innovations which are by definition white noises.

$$(2.4) \qquad x_t = \sum_{s=0}^{\infty} B_s e_t$$

where e_t is a vector of innovations: $e_t = x_t - E[x_t | x_{t-1}, x_{t-2} \ldots]$. Choose a lower triangular matrix W such that $We_t \equiv \eta_t$ has a diagonal covariance matrix. Then we may rewrite (2.4) as

$$(2.5) \qquad x_t = \sum_{s=0}^{\infty} B_s W^{-1} We_t$$

$$= \sum_{s=0}^{\infty} C_s \eta_t$$

where $C_s = B_s W^{-1}$. Since the η_t are by construction uncorrelated with each other, and $\eta_t = We_t$, the C_s gives the impulse response of x to a unit shock. In the following sections one standard deviation shocks are used. When a variable x_i is log transformed, the response of x is equal to percentage deviation caused by the shock. Therefore, a typical element of C_s, say c_{ijs}, represents a response in terms of a percentage deviation of the i-th variable to an isolated standard deviation shock in the j-th variable after s periods. The dynamic pattern of impulse responses, $\{c_{ijs} | s=1, 2\ldots\}$, suggests how the i-th variable is affected by a change in the j-th variable in an economy. It is analogous to the interim multiplier in the conventional analysis.

Another advantage of using the expression in the form of (2.5) is that we can decompose the variance of the forecast errors in x_t:

$$\mathrm{Var}(x_t) = \sum_{s=0}^{n} C_s \Sigma_\eta C_s'.$$

where the covariance of η_i and η_j composes the ij-th element of Σ_η.

where n is the number of steps (periods) taken in forecasting. The variance decomposition, with n = 48, will be referred to later in this paper. The larger the percentage impact of the i-th variable on the j-th variable, the more important is the i-th variable in explaining fluctuations of the j-th variable. Therefore, a table of variance decomposition is helpful to identify which variable is more responsible for business cycles than others.

Tests of Granger-causality can be carried out as likelihood ratio tests between an unrestricted model and one with zero restrictions on particular coefficients.

Let us survey several applied works relevant to this paper. In his seminal paper, Sims (1972) showed that the hypothesis of unidirectional causality from nominal GNP to money is rejected but that the hypothesis of causality in the reverse direction is accepted. Sims (1980b) expanded his previous model to include variables other than money and income. He contrasted the explanatory power of money on industrial production in a system including the interest rate versus one without the interest rate. Based on interwar and postwar U.S. data, money is shown to have a strong explanatory power in a three-variable model with Money Stock (M), Wholesale Price Index (WPI) and Industrial Production (IP). This explanatory power seems to disappear in a four-variable system including the short-term interest rate in addition to the three variables above. This result is consistent with a finding by Mehra (1978).

It should be noted that Litterman and Weiss (1981) decomposed the nominal interest rate into the real interest rate and the expected inflation rate. Then results depend on the particular order of orthogonalization of innovations. Their idea of decomposing the nominal interest rate is interesting but it is not employed in this paper. The Japanese results will be compared solely to those of Sims' study.

In Sims (1980a), the U.S and Germany are compared using a six-variable VAR model. An economic structure with money, real GNP, unemployment rate, real wages, prices and import prices are studied. A few results in that paper are as follows: (i) Money innovations have a very persistent effect on both money and other variables in the U.S., while they are less persistent in Germany. (ii) Price innovations have negligible effects in the U.S. in contrast to those in Germany where they are a major source of disturbance. Furthermore, Sims (1980c) added to the comparative study France and the U.K. The response patterns of industrial production and money to interest rate shocks were shown to be similar among the four countries.

Sims left out Japan from his comparative study. Although Oritani (1979) has studied a three-variable system for Japan using filtered quarterly data, he does not make use of variance decomposition or impulse responses in his analysis. His contribution is limited to its application of simulation with vector autoregressions to the Japanese economy. Therefore, this paper is expected to fill the gap in the comparative studies, which use a VAR model, on the macroeconomic behaviors of OECD countries.

3. Characteristics of the Japanese Economy

3.1 Institutional Framework of Financial Markets

Japanese financial markets have several features distinct from their U.S. counterparts. Thorough description of institutional details as well as analytical investigations are found in Suzuki (1974) and Wallich and Wallich (1976). The conventional view, including that expressed in the above works, stresses the impact of government intervention on interest rates and credit and the resulting disequilibrium as distinctive features of Japanese financial markets. Let us review the important points of the conventional view. The Bank of Japan has provided the city banks (thirteen large commercial banks with nation-wide branch networks) with loans at a relatively low, instead of a punitively high, interest rate. The ratio of borrowing from the Bank of Japan to the total assets of all city banks was always above 5 percent until 1970. In particular, it was above 10 percent for several years during the 1950s and the 1960's, suggesting its important role in the money supply process. The amount of high powered money was controlled mainly by tightening or loosening the amount of low-interest loans to city banks instead of open market operations during those years.

The city banks are still subject to explicit regulations and the implicit "guidance" of the Bank of Japan, in return for low-cost funds. Not only lending rates of various (risk) types of business loans, but also the amount of business loans have been controlled by the Bank of Japan.[1/] Since all the lending rates are set low and are inflexible, excess demand for business loans has been reported for most of the periods after the Second World War.

The existence of these regulations and the observed rigidities in interest rates led many economists including Suzuki and Wallich and Wallich to believe that financial markets in Japan were in disequilibrium. Ito and Ueda [1981] employed a disequilibrium econometric model to find that the equilibrium hypothesis is rejected in the business loans market in Japan while it is accepted in the American counterpart.[2/] Business loans from commercial banks have a strong influence on production and investment behavior, since the ratio of borrowing in corporate financing has been especially high in Japan.[3/]

Controls of money supply through the above process would become partially ineffective if the security and bond markets were open and perfectly competitive. However, the amount of trade of government bonds and of commercial paper was limited until very recently. Long-term government bonds have been issued since 1965, and in significant amounts only after 1975. The interest rate for these bonds were fixed at a level lower than the equilibrium rate. Since there would be excess supply of government bonds at the artificially low rate, an association consisting of city banks and other financial institutions was formed in order to coordinate the "assignment" of government bonds to different institutions. It is alleged that commercial banks are "forced" to hold the bonds.[4/] The low-interest loans from the Bank of Japan and involuntary holding of government bonds differentiate Japanese commercial banks.

A financial market which is considered to be relatively free from intervention is the call market, an equivalent of the federal funds market. Essentially borrowers in the call market are the "city" banks, while lenders are the "local" banks. The interest rate was "set" daily by brokerage firms with the implicit "guidance" of the Bank of Japan until 1979.

Opinions among financial experts in Japan varied on the issue whether or not interventions were significant. Suzuki (1974) emphasized that the flexibility of the call market made it possible to spread the effect of monetary policy to banks other than "city" banks. Horiuchi (1980) claimed that equilibrium in the call market prevailed, despite the "guidance" on the interest rate, because high powered money was supplied to equate demand and supply. However, he noted that from 1965 to 1967, the call market rate was apparently kept lower than it should have been. Since other markets for short-term financing were thin until the late 1970s, the call market rate represents the short-term interest rate in Japan.[5/]

Having described all these features of Japanese financial markets, the first question is whether the Japanese macroeconomic structure is distinctively different from its American counterpart. In particular, does the emphasis of monetary policy on inflexible low interest rates and a credit (quantity) control make a difference in the relationship between the financial and real sectors? It is of great interest to test a hypothesis that money causes income in such an economy. In a more general framework, does the financial sector lead the real sector in the sense of Granger-causality?

Since the call rate represented the banking sector alone and that sector was under some "guidance," we conjecture that innovations in interest rates would not lead to fluctuations in the real sector. It is a debatable issue whether innovations in money cause fluctuations in production. If inflexible low interest rate were achieved as an equilibrium by varying the money supply frequently in large amounts, we would expect to see large innovations in money with a significant impact on prices and production.

The second question is whether credit (quantity) control on "commercial" banks makes a difference in a macroeconomic structure. Observing sluggish interest rates, one might take the disequilibrium view that credit rationing is essential in determining the level of investment. According to this theory, monetary policy in Japan has been conducted by controlling not only the interest rate but also the level of loans outstanding (or sometimes its increment) from city banks. The latter has been considered to be a major determinant of real economic activities. Then innovations in business loans should be Granger-causally prior to the real sector. Comparing estimation results using business loans play a special role in determining other economic activities in Japan.

Thirdly, external shocks might have a large effect on the Japanese economy. We expect that wholesale and consumer prices respond to import prices. Moreover, monetary policy was said to be conducted to "cure" the deficit in the balance of payments under the regime of fixed exchange rates (Suzuki 1974; chapter 13). If this was true, external shocks could be thought of as innovations in balance of payments. We conjecture that the causality runs from external shocks to monetary policy, and then monetary policy to the real sector in Japan.

Although the Japanese financial structure underwent major changes in the late 1970s, we do not have enough observation after the changes described below to test those implications. For example, the ratio of loans from the Bank of Japan total liabilities went down. The call market rate became free from the "guidance" of the Bank of Japan in 1979. Non-financial corporations as well as commercial banks now trade repurchase agreements and CD's, with interest rates which vary more or less in the same manner as their U.S. counterparts. The market for these short-term financial instruments in Japan grew rapidly during 1970s. Therefore institutional differences between Japan and the U.S. in these markets as of 1980 are minimal.

3.2 International Trade

In the comparison of any OECD countries in terms of economic disturbances and performances, the difference in degrees of dependence on foreign trade is an important factor to be considered. An economy with high dependence on imports may be susceptible to highly volatile disturbances originating abroad. External shocks may take a form of an unexpected price increase of imported goods, surprises in the exchange rates, or an unanticipated movement in the demand (quantity) for exportable goods.

Japan, in comparison with the United States, has two distinguishing characteristics with respect to foreign trade. First, the ratio of imports or exports to GNP has been much higher in Japan than in the United States. The import dependence ratio (imports divided by GNP) has been almost always above 10% since 1955 in Japan, while in the United States, the ratio rose slowly from 3% in 1955 to 9% in 1979. A similar trend is observed in exports. Second, a large percentage (about three quarters in 1979) of the Japanese imports consist of food, raw materials and oil, whose prices are subject to high variability. In contrast, the ratio of these commodities in the U.S. import is less than a half. All but a negligible percentage (about 5% in 1979) of Japanese exports are manufactured goods, whose prices are relatively stable. Manufactured goods occupy a moderate ratio (67% in 1979) among the U.S. exports.

The above facts suggest the Japanese economy is more susceptible to external shocks in raw materials such as the oil price increase in 1973. It is of a great interest to investigate an influence of import prices on production. On the other hand, if the cost increase are absorbed in the process of manufacturing through technological progress and conservation induced by supply shocks, then the impact of external shocks on Japan can be mitigated.

Japanese monetary policy was also influenced by external shocks. One of the key objectives of monetary policy under the fixed exchange rate was to maintain a stable balance of payments. Deficits of the balance of payments were reportedly countered by a tight monetary policy in order to suppress the demand for imports.[6/] We expect to find, according to this scenario, a feedback from balance of payments to money supply. After 1971, there is another source of complexity in external shocks. The appreciation of the Yen has had a favorable effect on wholesale prices in Japan because of an effect of cutting costs of raw materials. On the other hand, the currency appreciation has contributed to deterioration of terms of trade, presumably encouraging more imports and fewer exports. Therefore, it is not clear how the deterioration of the terms of trade affects domestic production. What makes things complicated is that there may be a feedback from domestic prices and production to the terms of trade. If the domestic inflation rate is higher than the foreign inflation rate, then the terms of trade improve given the exchange rate. It is an interesting question whether domestic shocks cause the change in the terms of trade or shocks in terms of trade cause changes in domestic variables.

In this section, special characteristics of the Japanese financial market and international trade were described. Effects of these characteristics on the behavior of macroeconomic variables will be examined in section 5.

4. Comparisons of Japanese and the U.S. economy: explanatory power of financial variables

4.1 Variance Decomposition

First of all, we will take Sims' model (1980) as a benchmark for the U.S. and try estimating a VAR model for Japan in the same manner. Comparable data are chosen. Money stock in terms of M1 (currency plus demand deposits), the

Wholesale Price Index (WPI) and the Industrial Production Index (IP) in Japan are comparable in terms of their definitions and accuracy to those in the U.S. The short-term interest rate in Japan, comparable to the U.S. commercial paper rate, is difficult to obtain because of the thinness of markets and tight control over various interest rates by the Bank of Japan and the Ministry of Finance. An interest rate that can be regarded as relatively free of intervention is the call market rate (R) which applies to loans between commercial banks. However, the institutional details are quite different from the U.S. counterpart as explained in the preceding section.[7/]

All the variables are logarithmically transformed. Since we chose to use non-seasonally adjusted data, seasonal dummy variables are included in each equation. First, a three-variable (M1, IP, WPI) system is estimated, using monthly data from 1954 to 1981. By the Akaike Informational Criterion, a thirteen month lag was chosen.[8/] The variance decomposition for the 48-month forecast error is summarized in Table 1-B. The U.S. case, adopted from Sims (1980b), is shown in Table 1-A for comparison. It is obvious that the explanatory power of money on IP and WPI is much smaller in Japan than in the U.S. In explaining the variance of the forecast-error in IP, money is stronger than WPI in the U.S., while the reverse is the case in Japan. Similarly, in the U.S., money dominates IP in explaining the forecast-error variance of WPI, while the opposite is true in Japan. In sum, it appears to be the case in Japan that IP and WPI interact strongly with each other but money is rather independent from them. This result is in contrast to the U.S., where money appears to "cause" IP, lending support to the monetarist explanation of the economy.

Table 1 about here

A key observation in the Sims (1980b) paper is that the explanatory power of money is considerably weakened when the interest rate (represented by the commercial paper rate) is added to the system. The variance decomposition for the U.S. four-variable system is shown in Table 2A, adopted from Sims (1980b). In the U.S., the percentage of forecast-error variance of IP explained by innovations in money decreases from 37 in the three-variable system to 4 in the four-variable system. The interest rate, instead of money, is a variable whose innovations explain the largest percentage (30%) of variance in IP, only after own innovations (52%). Based on these facts, Sims rejected the rational expectation (R.E.) monetarist explanation, in favor of a Keynesian explanation of business cycles.

There is a small difference in how the data are treated between the U.S. variance decomposition (by Sims) and our Japanese variance decomposition. In this paper we estimate the Japanese system non-seasonally adjusted variables but with twelve seasonal dummy variables, while Sims estimates the U.S. system with seasonally adjusted variables and a constant term. Although some degrees of freedom are lost by using seasonal dummy variables, a possible problem associated with a mechanical seasonal adjsutment is avoided. In Table 2-B, our reestimation of the U.S. system using non-seasonally adjusted data are presented revealing that qualitative results do not change if the data are seasonally adjusted before estimation.

Our estimates of a four-variable system in Japan are summarized by the variance decompositions displayed in Table 2-C. No major changes are caused by

TABLE 2 about here

an introduction of the interest rate in Japan. Money remains powerless in explaining industrial production or WPI. What is startling is that even the interest rate lacks explanatory power for WPI or IP. This may be disturbing because neither the monetarist nor the Keynesian view seems to be able to explain this fact. Since monetary surprises have hardly any explanatory value for other variables, rational expectations monetarism does not apply in Japan, just as Sims concluded for the U.S.[9] However, the interest rate does not affect IP, rejecting the Keynesian view of business cycles in that changes in future profitability, represented in interest rate innovations, cause changes in investment. From the variance decomposition table, it seems that IP and WPI have a lot of interaction with each other. However, a hypothesis that a block of WPI and IP is Granger-causally prior to R and M1 is rejected at the 1% significance level.

The above findings support our conjecture that the interest rate innovations do not lead other variables. In other words, the results of the variance decomposition reported in Table 2-C suggests that the call market rate does move passively. Unlike the U.S., "bad" or "good" news in the real sector is not immediately reflected in the call market rate. Therefore, if the Keynesian explanation should be applied to the Japanese economy, the call market rate is not the interest rate which offers information to the real sector, thereby causing the business cycles. In other words, the free market interpretation of the call market is dubious. Let us consider our conjecture that money must fluctuate to keep the call market in equilibrium at its present level, so becoming a source of business cycles. Looking at the variance decomposition table, we do not find any support for this conjecture.[10] The explanatory power of money is extremely weak not only in the four-variable system but also in the three-variable system.

4.2 Impulse Responses

In this subsection, we examine the question whether institutional differences in Japan created a totally different structure in terms of dynamic response of a variable to a "typical" shock in another variable. Figures US-1 to US-4 and and JA-1 and JA-4 illustrate the impulse responses of R, M1, WPI and IP to shocks in other variables, respectively, in the U.S. and Japan. The vertical axis measures the percentage change in a month of the variable of the figure caused by different sources of "typical" shocks. Solid lines are ±2% and 0% changes and broken lines are ±1% changes. In Figure US-2, no lines except 0% are shown because all the responses are within ±1%.

Figures US-1-4 and JA1-4 about here

Comparing the corresponding figures for the U.S. and Japan (US-1 vs. JA-1, and so forth), we notice striking similarities in the way economic variable respond to various shocks. The sign and oscillating pattern of responses are very much alike between the two countries: an unanticipated increase in money will cause inflation (see Figures US-3 and JA-3); declines in the interest rate will stimulate production (see Figures US-4 and JA-4); a surprise increase in prices will increase production for a while (7 months in the U.S., and a year in Japan) but eventually decrease production (see Figures US-4 and JA-4); responses to own innovations are always positive and persistent except in the case of the interest rate. Overall magnitudes of responses have common features, such as large responses of interest rates and small responses of money in both countries. These observations seem to give support to the view that the Japanese economy responds to shocks in a similar manner to its American counterpart despite institutional differences in the two countries.

Although sign and fluctuating patterns are similar, some responses differ in magnitudes. Detailed examination of the magnitude of responses to specific shocks give us more evidence for or against our conjectures. In the U.S, the response of industrial production (IP) following an interest rate shock (in Figure US-4) is slightly positive for about 6 months, and then becomes strongly negative. Production is depressed by about 1% from a year after a shock for 15 months. This is taken as evidence for the relatively slow adjustment of the price of investment goods, supporting the Keynesian explanation of business cycles. In Japan, as shown in Figure JA-4, there is no phase(except after 40 months)where responses of industrial production to the interest shock are positive. However, the magnitude of response is very small. The largest decline in responses occurs at the 19th month after the shock with only a 0.6%

change in magnitude. This gives further support to our view that the interest rate does not carry much information because of sluggish adjustment by the authorities.

Responses of IP to innovations in prices will show how economic agents react to unexpected changes in prices. Both in Japan and the U.S., negative responses of industrial production to a price shock do not reach their full strength until about a year after the shock, as shown in Figures US-4 and JA-4. However, the difference in magnitudes is quite remarkable. In the U.S., the maximum change is only about -0.5%, while in Japan it is more than -1.2% after two years. This gives more support to our conjecture that external shocks play an important role since Japan imports large amounts of raw materials. External shocks might take the firm of price shocks. This line of argument will be further examined later in section 4.5. Similarly, the response of WPI to shocks in IP in Japan, say, an unexpectedly good productivity increase, are characterised by a large decrease with a maximum of -1.5% in prices after a delay of a year or so, as shown in Figure JA-3. Negative relationship between prices and industrial production suggest that most shocks to the economy are supply shocks in Japan. Long delays in response, however, suggest that there are some frictions or long-term contracts which prevent prices from responding immediately.

The familiar argument that an unexpected increase in money causes inflation can be examined by checking the response of WPI to innovations in money as shown in Figures US-3 and JA-3. In the U.S., responses of WPI to the money innovations are always positive and increasing, to the magnitude of 0.7%. Responses of WPI to other variables are smaller. In Japan, although the responses are always positive, the effects die down after the peak of about 0.5% change at around two and a half years. Moreover, the negative responses of prices to production innovations dominate those to monetary innovations in magnitude. Therefore, monetary innovations in Japan do not have as much importance in explaining inflation as they do in the U.S.

Responses of money in the U.S., shown in Figure US-2, suggest a very weak influence from surprises in prices and production. Innovations in the interest rate will decrease money but not more than 0.5%. Responses of money to own innovations are less than 0.5%. In Japan responses of money to different types of shocks are slightly larger than the U.S. This difference does not conflict with a view that U.S. monetary policy authorities try to form monetary growth targets independently of shocks in other sectors of the economy.

Our last observation on impulse responses concerns the magnitude and persistence of responses of production to own innovations. They are quite large and persistent in Japan. They fluctuate between 1.3% and 2% all the time after the shock. In the U.S., they hit the peak influence with 1.6% in three months and then fall below 1% after a year. This difference again suggests a different type of production shock in the two countries. The Japanese case strongly suggests that supply shocks may come in the form of increased productivity which influences production for a long time.

4.3 Robustness

Before we change the specification of equations and consider different variables for Japan, robustness of the above results with respect to trend terms and sample periods are examined.

One might think that adding the time trend would change the results if the trend was not well represented by lagged variables. However, adding the time trend in each regression does not affect the conclusions of the preceding subsections.[11/]

More serious concerns are raised about the homogeneity over the sample period. The shift to the floating exchange rate regime might have changed the structure of the Japanese economy. The oil shock of 1973-74 and the subsequent adjustment of the economy is another possible source of qualitative change in the economy. First, the same four-variable systems are run for the U.S. and Japan with data ending October 1973, the month when the oil crisis started and Japan shifted to the floating exchange rate. Variance decompositions for Japan and the U.S. for this sample period are shown in Tables 3-A and 3-B.

TABLE 3 about here

We cannot detect any significant change in Tables 3-A and 3-B from corresponding Tables 2-B and 2-C. There is also little difference in impulse responses obtained by data up to October 1973 (which are not reported here) from those reported in Figure US-1 to US-4 and JA-1 to JA-4. One prominent difference occurs in the response of production to price shocks. During the years prior to the oil crisis of 1973, it took longer for production to turn negative after price shocks in both countries than it did for the entire samples, suggesting the possibility of more demand shocks before 1973. In the smaller sample, the response of industrial production turned negative 19 months after price shocks in Japan and after 10 months in the U.S. For the larger sample the lags were 12 and 8, respectively. This finding is much in line with our conjecture that supply shocks as oil price increases become more prevalent after 1973.

Several other possible subsamples were estimated, with no dramatic changes in results except one. Estimating the four-variable U.S. system for 1960-1981, the explanatory power of money on IP was found to be very strong, contradicting the earlier result.[12/] This is shown in Table 3-C. This result suggest a possible shift in how monetary policy was conducted after 1960. Possible reasons for this are discussed in section 6.

In this section, a comparison of Japan and the U.S. has been carried out in the four-variable system employed in Sims' study on the U.S. To sum up, the explanatory power of the interest rate shows a contrast between two countries. However, sign and fluctuation patterns of impulse responses are quite similar. In the next section, important variables which are included in Sims' system will be added to the system in order to investigate the Japanese economy with institutional characteristics described in section 3. A measure of outstanding business loans will be added to see whether credit rationing has a significant effect on real activity. The import or export price index, and balance of payments will be added to check whether external shocks are a significant driving force of the Japanese economy. Stock prices are introduced in search of variables which have strong explanatory power and impact on production.

5. Further Study in the Japanese Economy

5.1 Stock Prices

As a candidate for a variable which picks up "good" or "bad" news first, and appears to lead other variables, one might naturally suggest stock prices. A four variable system with stock prices replacing the interest rate is estimated for Japan and the United States.

In Japan, variance decomposition reveals that explanatory power of M1, WPI, and IP on SP is very small, as summarized in Table 4. Though SP has moderate explanatory power for other variables, SP appears independent from shocks in other variables. Therefore we perform the exogeneity test, that is, we test whether or not all the coefficients of lagged M1, WPI, and IP can be restricted to be zero in the equation which has SP on the lefthand side. The likelihood-ratio test indicates that SP is Granger-causally prior to other variables.[13/]

TABLE 4 about here

Impulse responses show that when "news" hits the stock market with a size of a standard deviation, it will cause a 1% (monthly) change in production after a year, (though it diminishes later), and a 0.7% change in money supply after a year, which persists for a long time. Figure 5 shows the response of industrial productions to various one-standard deviation shocks, including a shock in stock prices. Comparing Figures JA-4 and 5, we notice that stock prices appear to have a strong impact on industrial production without changing response patterns to other shocks.

Figure 5 about here

The same four-variable system is estimated for the United States. The stock prices are shown to be as powerful as interest rates in influencing industrial production. Variance decomposition, described in Table 4-B, shows that stock prices have a strong explanatory power on industrial production.[14/] Impulse responses show that the effect of a shock in stock prices on industrial production persists in the 0.8% to 1% range after 48 months, unlike the declining effect in Japan. Stock prices are shown to be exogenous in the U.S., too.[15/] Recall that the interest rate in Japan does not have any impact on production. In other words it does not lead the movement in production as it does in the U.S. On the other hand, stock prices in Japan behave more or less like their U.S. counterparts and lead other variables. We suspects that "news" in an economy appears not in the financial market but in the stock market, because of the special Japanese financial regulations.

5.2 Business Loans

One of the most important monetary policy tools in Japan is the restriction on business loans from "city" banks (hereafter LOAN) as explained in Section 3. We posed a question in section 3.1 whether credit controls in Japan made a difference in the workings of the Japanese economy. If innovations in business loans are important in determining production activities, then we should expect strong explanatory power of LOAN on IP in a variance decomposition. Two sets of estimation of a four variable system were done, one replacing money by LOAN and the other replacing the interest rate by LOAN. The results are summarized in Table 5.

TABLE 5 about here

LOAN does not have explanatory power for either industrial production or the interest rate. In this sense, LOAN is no better than money or the interest rate in search of the cause of business cycles. Innovations in LOAN, which may be interpreted as an unexpected ease in credit rationing, do not seem to have a large impact on industrial production. Impulse responses of industrial production to LOAN are positive and steady but small in magnitude.[16/] From Table 5-A, we also learn that explanatory power of industrial production for LOAN is rather strong, suggesting that there is a strong feedback from productivity shocks to the demand for loans.[17/] An inspection of impulse responses confirms findings in variance decomposition. Neither the wholesale price index nor production is affected by more than 0.5% in any of the 48 months following a one standard-deviation shock in loans.[18/] Therefore, an unexpected change in the amount of credit available to industries does not make much differences in prices and output. It is fair to summarize that the credit (quantity) control, if any, is not much different from the control of money supply in (not)causing production fluctuations. The apparent difference in the operation of monetary policy in Japan does not seem to characterize the fluctuations in prices and production.

B. Friedman (1981) investigated the relationship between different kinds of debt, such as bank loans, and income in the U.S., and found that the debt-income relationship is as stable as the money-income relationship. However, he did not proceed to obtain variance decompositions and impulse responses.

5.3 Shocks from abroad

Since imports and exports have been a larger proportion of GNP in Japan than in the U.S., external shocks have been suspected to be important in explaining business cycles in Japan. Most of the raw materials for industrial production in Japan are imported from abroad. An increase in the price of raw materials from abroad would increase WPI and decrease industrial production, possibly with some delay. The relation between wholesale prices and industrial production documented in previous subsections might have reflected this effect. The above scenario is most plausible in a case like the oil price increase in the 1970s because it is an essential raw material and only a negligible amount is produced in Japan. We conjecture that import prices should lead wholesale (domestic) prices and industrial productions. An increase in costs of raw material is expected to increase wholesale prices and to decrease industrial production.

First, the import price (PIM) is introduced into the system replacing the interest rate. The variance decomposition is reported in Table 6-A.

Table 6 about here

A notable effect of shocks in the import price index appears in WPI. The explanatory power of PIM on IP is negligible. Impulse responses show that PIM causes a strong positive response in WPI and weak but positive response in IP; thus the above conjecture was not supported. We should make a quick remark on the order of orthogonalization. The contemporaneous correlation between innovations of PIM and WPI is .41, suggesting that changing the order of orthogonalizing innovations may have a significant effect. This is checked by comparing the original ordering of (PIM, WPI, M1, IP) with a different ordering (WPI, PIM, M1, IP). Variance decomposition shows that the percentage of the WPI forecast error explained by PIM innovations is much less in this ordering than in the previous ordering. Impulse responses in the new ordering show that one-standard deviation PIM innovations has only a negligible impact on WPI. Two possible explanations are offered for the counterintuitive result that import prices do not appear to lead WPI or IP. First, most of the import contracts are written with a fixed nominal price for a certain period. Under a fixed exchange rate regime, it takes time to see a full scale effect in import prices after an external shock, say an increase in the spot-market oil price, through renewal of contracts. On the other hand, domestic producers may increase prices as soon as they know that the costs of raw material are soon to increase. Therefore, WPI appears to pick up "news" first, and followed by PIM. In a regime of the floating exchange rates, the external price increase, say food price increase, may be mitigated by currency (Yen) appreciation, while the supply shocks may be common to domestic suppliers (in case of crop failures due to a change in world wide weather). Second, innovations in import prices and export prices are highly correlated. Suppose that export prices of manufactured goods increase more than import prices of raw material, because price shocks in raw materials are universal. The question becomes whether Japan can adapt itself to shocks better than other countries. If so, the simultaneous increase in import prices may cause positive production responses through increased exports to other countries.

Next, in order to consider a separate effect of export prices, the export price index (PEX) is added to a system. Estimating this system shows, there are strong feedback between PIM, WPI, and PEX as well as a high correlation between innovations of any two variables in that set. The table of variance decomposition is shown as Table 6-B. Impulse responses show that the effect of PIM innovation on IP is still positive but negligible (i.e., a change by less than .5%) over a four-year period. An unexpected change in PEX induces a negative but also negligible impact on IP. The same shock causes a positive response in WPI. In order to see a relative shock of import and export prices, we defined relative import prices by dividing PIM by PEX.[19/] This corresponds to a reciprocal of the terms of trade. An unexpected deterioration of the terms of trade, i.e., an increase in the terms of trade, is associated with a significant increase in WPI and a negative but negligible response in IP.

To sum up, external shocks measured by import prices have a significant impact on the domestic price levels. We conjecture that shocks in import prices would decrease production, considering the facts that domestic prices and production are negatively associated in impulse responses, and that most of Japanese imports are raw materials. However, this conjecture was refuted by the data. Responses of production to innovations in import and export prices are both small but have a positive sign. It is fair to summarize that external shocks have an impact on domestic prices but not on production.

The last variable representing an external shock is the balance of payments on current account. Recall the argument in section 3 that the balance of payments was cited as an influential variable in the formation of monetary policy including the choice of the discount rate. We expect to find some causality from the balance of payments to the interest rate and money supply.

Since the balance of payments have negative entries, they cannot be logarithmically transformed. Instead, they are divided by M1 in order to be normalized. The result of variance decomposition is given in Table 6-C. The explanatory power of the balance of payments on the interest rate or money supply is very small as measured by variance decomposition. However, the response of the interest rate, shown in Figure 6, to shocks in the balance of payments show a significant decline, i.e., one standard deviation shock in the balance of payments measure caused a 2% decline in the interest rate during the 8-12 month period immediately following the shock. An unexpected deficit in the balance of payment clearly induced an increase in the interest rate, as we conjectured. However, the change is not persistent.

Figure 6 about here

6. Optimal Control Problem and Causality

The fact that money and the interest rate do not have significant explanatory power for industrial production does not mean that monetary policy has not been effective in Japan. On the contrary, if a list of objective variables does not include policy variables and policy is quite successful in controlling the objective variables, then causality might appear to go from objective variables to policy variables. An example of this phenomenon, which is a paraphrasing of Sims (1977; pp. 36-38), is illustrated as follows:

Suppose that a stochastic process y_t, is described by an autoregressive form:

(5.1) $$y_t = \beta_1 m_t + \beta_2 y_{t-1} + \eta_t$$

where η_t is a white noise process and $E\{\eta_t | x_{t-1}, y_{t-1} \ldots\} = 0$. The monetary policy, m_t, affects x_t only with some errors. The choice of m_t is made with information of all the past x's and y's.

(5.2) $$x_t = m_t + \varepsilon_t$$

where ε_t is a white noise and $E\{\varepsilon_t | x_{t-1}, y_{t-1}, m_{t-1} \ldots\} = 0$. Suppose that the government is interested in minimizing the expected squared deviation of y_t from its target $\bar{y}_t$. By certainty equivalence, it can easily be shown that

(5.3) $$m_t = \{\bar{y}_t - \beta_2 y_{t-1}\}/\beta_1$$

Therefore, substituting (5.3) into (5.2) and (5.1), we have the stochastic processes of x_t and y_t,

(5.2') $$x_t = \bar{y}_t/\beta_1 - (\beta_2/\beta_1) y_{t-1} + \varepsilon_t$$

(5.1') $$y_t = \bar{y}_t + \eta_t.$$

The next question is how the target of $\{\bar{y}_t\}$ is formed. As long as it is a linear function of $\{y_{t-1}, y_{t-2},...\}$, the following conclusion holds true. Estimating a vector autoregressive model consisting of (5.1') and (5.2') would lead us to the conclusion that $\{y_t\}$ Granger-causes $\{x_t\}$ Rewriting this system into a moving average form, one would find that $\{x_t\}$ consists of $\{\varepsilon_t\}$ and $\{\eta_t\}$, while $\{y_t\}$ consists only of $\{\eta_t\}$. Therefore, innovations in $\{y_t\}$ explain not only y_t, but x_t, while innovations in $\{x_t\}$ explain only x_t. The above argument can be generalized to a case where x and y are vectors without altering the conclusion. This example suggests one possible explanation for what we observe in Japan. The Bank of Japan has been controlling the interest rate, money and loans so that wholesale price and industrial production achieve target levels. Note that if target levels $\bar{y}_t$ includes the policy variable, $\{x_{t-1}, x_{t-2},...\}$, then causality in the direction from $\{x_t\}$ to $\{y_t\}$ would be present.

Therefore, if the target monetary growth rate is set independently from other variables, as a monetarist would advocate, then money would have explanatory power. This may be the case for the U.S. after the 1960 s, which is shown in Table 3-C.

6. Conclusions

This paper has demonstrated some differences in macroeconomic behavior between Japan and the U.S. with a special emphasis on the Japanese institutional framework and the relative "openness" of the Japanese economy due to the composition of its trade. Because of a monetary policy which allegedly pursued inflexible low interest rates, we made a conjecture that the call market rate did not quickly move to reflect the good and bad news in the economy, unlike the commercial paper rate in the U.S. In other words, innovations in the interest rate do not explain fluctuations in production. This conjecture was confirmed in our variance decomposition and impulse responses. However, the Japanese financial structure underwent major changes in the 1970s, as described in section 3.1. Although it is interesting to repeat the variance decompositions of this paper with samples after 1981 and compare them with the current results for samples before 1981, we do not have enough observations at this time. The task is left for a future investigation.

Whether money in Japan had to fluctuate more to maintain an inflexible low interest rate was a debatable issue. It was shown that money had weak explanatory power over fluctuations in wholesale prices and production both in the three-variable and four-variable systems. This is in contrast to the U.S. case where money has strong explanatory power for prices and production in the three-variable system and on prices but not production in the four-variable system. One possible explanation of this difference was presented in Section 6. When a policy variable (say, money) is well controlled to stabilize a target variable (say, production), the causality appears to go from the target variable to the policy variable. This might have been the case in Japan.

Despite the above differences in the variance decomposition results, impulse responses show strikingly similar sign and oscillatory patterns for these two countries. This implies that, in response to a shock in a variable, the two economies respond qualitatively in the same direction over time. However, the magnitudes of those responses show important differences.

Japan is expected to be susceptible to supply shocks from abroad because major raw materials are imported. This conjecture was investigated by impulse responses and variance decomposition for a system including variables such as import prices, export prices and balances of payments. Impulse responses show that wholesale prices strongly respond to innovations in import prices, as we expect. However, impacts of external shocks on industrial production, if any, are negligible.

One qualification to this study is the change in the foreign exchange regime in the early 1970s. The shift from fixed to floting exchange rates might have changed the structure of stochastic processes in an economy. This was examined in section 4.3 to some extent.

Most western European countries depend on international trade more than Japan and the U.S. They also have their own peculiarities in financial markets. We wonder whether results described as common features between Japan and the U.S. in this paper can be generalized to western European countries and whether Japan or the U.S. becomes an outlier when they differ as described above. Sims (1980c) compares impulse responses of a four-variable system with CPI replacing WPI of the U.S. with those of the U.K., France, and Germany. Some of the U.S. results differ from those of the western European countries and some of the results are common. There is no clear tendency one way or another on this issue. We hope to carry out in the future further investigation of international differences considering the differences in institutional frameworks or in an economy's dependence on international trade.

FOOTNOTES

1/ See Suzuki [1974/1980 (English); Ch. 10, section 3] for a description of the legal restriction and the cartel agreement on various lending rates from commercial banks.

2/ Some economists believe that most financial markets have been in equilibrium despite the rigidities mentioned. Since commercial banks are alleged to ask borrowers to keep some balances in their demand deposits, the "effective" rate has been much higher than the "nominal" lending rate. Moreover, window guidance by the Bank of Japan may be nullified if the "local" banks in place of the "city" banks increase their lending or if firms raise funds by issuing securities. See Horiuchi [1980; Chapters 3 and 4] for this viewpoint. It is a debatable issue whether these alternative routes were plausible in Japan. The coverage of this kind of credit (quantity) control has been increased as described in Horiuchi [1980; Table 4-1]. See also Sakakibara, et. al., (1981) for the equilibrium view

3/ Suzuki [1974; Table 1-5] reported that the ratio of borrowed money in financing in the corporate sector is 49% in Japan as opposed to 12.4% in the U.S. The ratio in Japan declined through the 1970s, to around 32% in 1978-79, while the ratio in the U.S. rose to 25% in 1978-79.

4/ More than half of outstanding government bonds are held by the central bank and commercial banks in Japan, while the ratio is about 25% in the U.S.

5/ Trades of repurchase agreements increased sharply among corporations and security brokerage firms only after 1970. Large CD's were created in 1979.

6/ Seo and Takahashi (1981) explains monetary policy was conducted under the fixed and flexible exchange rate regimes. They note, "the primary goal during the 1960s (except for the discount rate changes of August/60, June/65, and September/69) was correction of balance of payments disequilibrium," based on the minutes of the Bank's Policy Board meetings.

7/ The Bank of Japan is alleged to have "advised" the interest rate to brokers in the call market until recently. The character of the call market changed over the sample period. Especially during the 1950's and the first half of the 1960's, the call market rate should be considered to be only a proxy for the interest rate, although no such reservation is made in the OECD publications.

8/ According to the Schwartz criterion, the maximum is attained at a lag length less than twelve, and the value of $(\log M_j - k_j)$ is monotonically decreasing after 12 lags.

9/ The weak explanatory power of money holds true for quarterly data, too. Therefore, the possible explanation that the time delay relevant to rational expectation business cycle theory is longer than monthly breaks down. (See Sims 1980b; p. 254).

10/ It may still be true that money becomes more volatile in pursuing the inflexible low interest rate policy without causing too much disequilibrium in the call market in Japan. Actually, the variance of monetary innovations in Japan is ten times higher than the U.S. However, the variance decomposition results imply that these volatile innovations do not contribute to explaining the variance of forecast errors in production.

11/ For the U.S., introducing time trend in estimation does not change the order of the four variables in explanatory power of variance decomposition with only one exception: the percentage that monetary innovations explain in industrial production rose to 16% from 4%, surpassing the ratio explained by WPI. With this exception, variables with weak explanatory power (10% or less) remain weak and these with large explanatory power (30% or more) remain strong. An introduction of time trend does not change the picture of variance decomposition in Japan, either. The order of explanatory power switched in only one case. The percentage that IP innovations explain in WPI forecast errors dropped from 50% to 38% and became the second strongest behind WPI's innovations. Variables with weak explanatory power remained weak, too.

12/ Burbidge and Harrison (1982 and private correspondence) obtain a similar result for a seven-variable system using data from 1961 to 1981. I appreciate their willingness to let me see some results in their project in progress.

13/ Comparing the unrestricted and restricted systems, the computed test statistic was $\chi^2(39) = 32.1$ with significance level .77, allowing us to accept the null hypothesis that the coefficients were zero.

14/ Chris Sims told me that he had studied the system with stock prices for the U.S. and found that stock prices played a role, just like interest rates, of causing other variables. He chose interest rates over stock prices for describing an economy because of the "fit" of the model is slightly better with interest rates. In the Japanese case, the qualitative results are different and the "fit" is better with stock prices.

15/ Comparing the unrestricted and restricted systems, the computed test statistic $\chi^2(42) = 6.3$ with significance level .07, allowing us to accept the null hypothesis that the coefficients were zero in the regression of SP on M1, WPI, and IP.

16/ The maximum change is only half of 1% in the four-variable (LOAN, WPI, IP, M1) system.

17/ This seems to justify employing industrial production on the right hand side of the demand function for loans in Ito and Ueda (1981).

18/ This is true for a system with loans replacing either money or the interest rate.

19/ Jeff Sachs suggested to me to adopt the relative prices.

DATA

Japan: (1955-81)

M1: Money M1 (= currency and demand deposits) ¥ 100 mil; not seasonally adjusted; balance at the end of month with adjustment for average balances during the month: source: Annual Economic Statistics, Bank of Japan.

IP: Industrial Production Index, total; 1963 = 100 not seasonally adjusted. Source: Main Economic Indicators, Historical Statistics 1955-1971, 1960-1975; and Main Economic Indicators, 1976-1981, O.E.C.D.

R: Call Market Rate; Annual rate in Tokyo, no restriction. Source: same as IP.

WPI: Wholesale Price Index; total 1975 = 100; not seasonally adjusted: source: same as M1.

LOAN: Commercial loans outstanding from "city" banks: ¥100 mil. Source: Annual Economic Statistics, Bank of Japan.

PEX: Export Price Index; 1963 = 100. Source: same as M1.

PIM: Import Price Index; 1963 = 100. Source: same as M1.

BP: Balance of Payment (current account) divided by M1. Source: same as IP.

SP: Stock Prices. Source: Citibase FPS6IP.

U.S.: (1947-81)

M1: Money M1 (1947-59) and M1B (1959-81) spliced. not seasonally adjusted. Source: M1 (All Bank Statistics, 1940-1970, Fed. Board of Governors) M1B, (Citibase FZM1B).

IP: Industrial Production Index, Total; not seasonally adjusted; 1967 = 100. Source: Business Statistics 1979; and Federal Reserve Bulletin, 1979, 1980, 1981.

R: Commercial Paper Rate, Source: Citibase FYCP.

WPI: Producer Price Index, total; not seasonally adjusted. Source: Citibase PW.

CPI: Consumer Price Index, total; not seasonally adjusted. Source: Citibase PZU.

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TABLE 1 VARIANCE DECOMPOSITION:
Percentages of 48-month Forecast-Error Variance Explained by Innovations in a three-variable (M1, IP, WPI) system.

1-A. U.S. 1948-78. [adopted from Sims (1980b)]

Variables Explained	By Innovations in M1	IP	WPI
M1	97	2	1
IP	37	44	18
WPI	14	7	80

1-B. JAPAN 1956-81

Variables Explained	By Innovations in M1	IP	WPI
M1	75	12	13
IP	14	54	32
WPI	5	46	49

Note: M1 = Money Stock (M1); IP = Industrial Production Index; WPI = Wholesale Price Index; each variables in the log-form. Monthly data with seasonal adjustment for the U.S. and without seasonal adjustment for Japan. The JAPANESE system is estimated with 13 lags of each variable and seasonal dummies. The U.S. system is estimated with 12 lags of each variable.

TABLE 2 VARIANCE DECOMPOSITION:
Percentages of 48-month Forecast-Error Variance Explained by Innovations in a four-variable (M1, IP, WPI, R) system.

2-A. U.S. 1948-78 [adopted from Sims [1980b)]

Variables Explained	By Innovations in R	M1	WPI	IP
R	50	19	4	28
M1	56	42	1	1
WPI	2	32	60	6
IP	30	4	14	52

2-B. Seasonally Unadjusted Data
U.S. 1948:3 - 1981:4

Variables Explained	By Innovations in R	M1	WPI	IP
R	47	26	1	26
M1	45	53	1	1
WPI	1	39	49	11
IP	36	4	5	55

Note: Table 2-B is estimated with 14 lags of each variable and with seasonal dummies. M1 in the U.S. is spliced with M1 and M1B.

2-C. JAPAN 1956-81

Variables Explained	By Innovations in R	M1	WPI	IP
R	42	10	30	18
M1	10	54	3	33
WPI	3	6	41	50
IP	4	5	15	76

Note: See Table 1; R = Short-term Interest Rate; the commercial paper rate for the U.S. and the call market rate for Japan.

Table 3 Structural Stability with respect to Sample Period

3-4 Japan 1956:2 - 1973:10

Variable Explained	By Innovations in			
	R	M1	WPI	IP
R	58	1	28	13
M1	13	23	9	55
WPI	2	7	60	31
IP	7	1	33	59

3-B U.S. 1948 - 1973:10

Variable Explained	By Innovations in			
	R	M1	WPI	IP
R	57	15	2	26
M1	30	67	2	1
WPI	4	36	47	13
IP	30	12	3	55

3-C U.S. 1960:4 - 1981:4.:

Variable Explained	By Innovations in			
	R	M1	WPI	IP
R	27	57	9	7
M1	50	21	25	4
WPI	8	35	47	10
IP	25	39	17	19

Table 4 Variance Decomposition:
Percentages of 48-month Forecast-Error Variance Explained by Innovations in a four-variable system.

4-A JAPAN 1956-81

Variable Explained	By innovations in SP	M1	WPI	IP
SP	91	1	4	4
M1	28	48	10	14
WPI	12	1	31	56
IP	9	13	14	64

4-B US 1955-81

Variable Explained	SP	M1	WPI	IP
SP	74	2	16	8
M1	16	43	40	1
WPI	3	15	80	2
IP	47	3	37	13

Table 5 Variance Decomposition:
Percentages of 48-month Forecast-Error Variance Explained by Innovations in a four-variable (CMR, LOAN, IP, WPI) system.

5-A LOAN replacing M1
JAPAN 1956-81: Time out

Variables Explained	By Innovations in CMR	LOAN	WPI	IP
CMR	42	6	39	13
LOAN	6	49	5	40
WPI	5	3	61	31
IP	3	1	25	71

5-B LOAN replacing CMR
JAPAN 1956-81: Time out

Variables Explained	By Innovations in M1	LOAN	WPI	IP
M1	62	10	14	14
LOAN	45	35	9	11
WPI	2	2	51	45
IP	10	0	33	57

Table 6 External Shocks

Percentages of 48-month Forecast-Error Variance Explained by Innovations in a four-variable system

6-A JAPAN 1956-81:

Variables Explained	By Innovations in PIM	M1	WPI	IP
PIM	30	3	32	35
M1	3	76	10	11
WPI	19	4	35	42
IP	7	14	27	52

6-B JAPAN 1956-81

Variable Explained	By Innovations in PIM	M1	WPI	IPS	PEX
PIM	42	2	25	20	11
M1	6	61	10	13	10
WPI	31	2	28	24	14
IPS	14	13	25	44	4
PEX	33	1	23	18	25

6-C JAPAN 1956-81

Variable Explained	By Innovations in BP	CMR	M1	WPI	IP
BP	10	13	12	56	9
CMR	5	33	6	43	13
M1	5	13	36	15	31
WPI	3	6	15	61	15
IP	3	6	14	52	26

FIGURE US-1

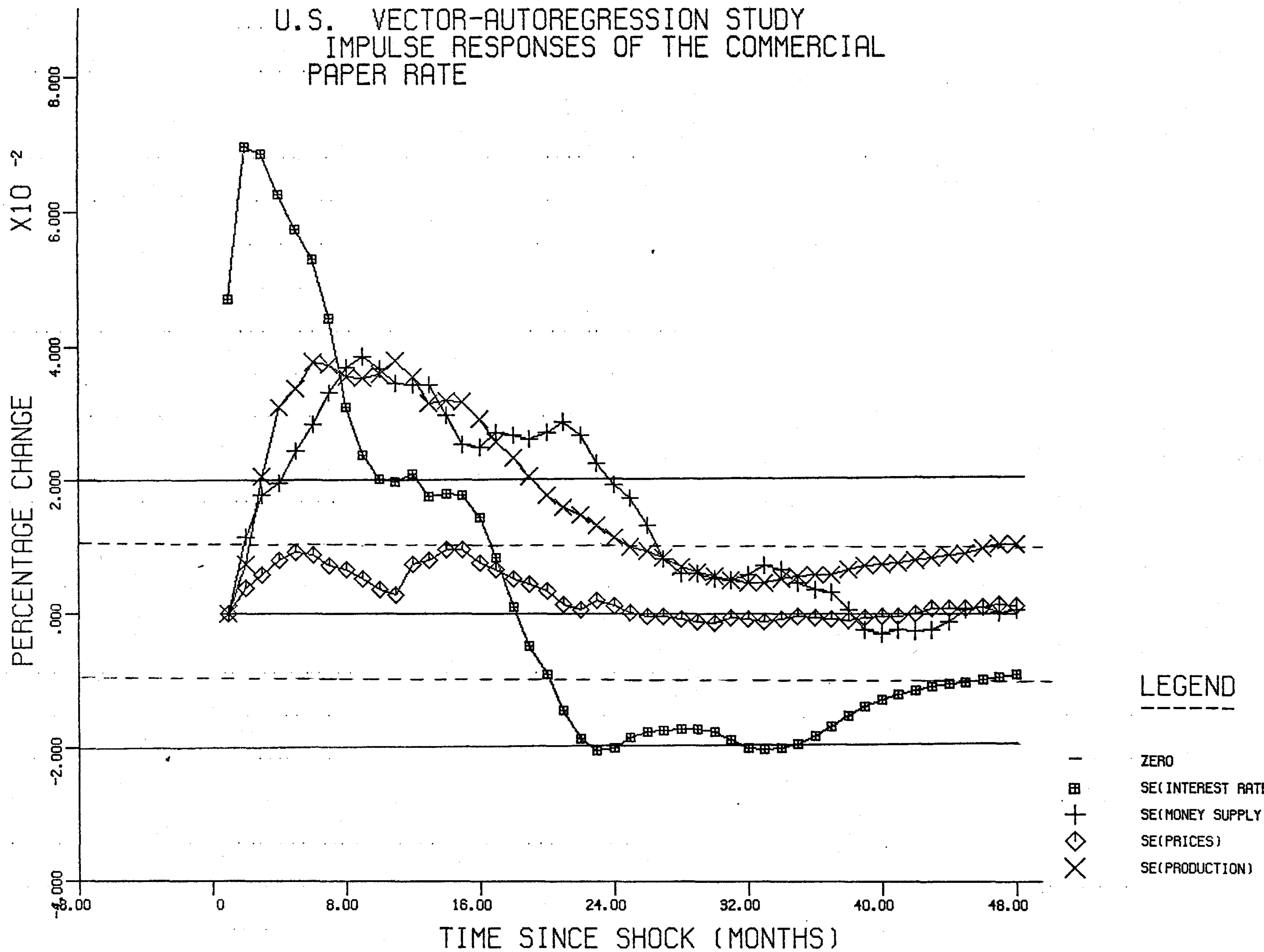

U.S. VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES OF THE COMMERCIAL
PAPER RATE
X10 -2
PERCENTAGE CHANGE
8.000
6.000
4.000
2.000
.000
-2.000
-4.000
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (MONTHS)
LEGEND
ZERO
SE(INTEREST RATE)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

Figure US-2

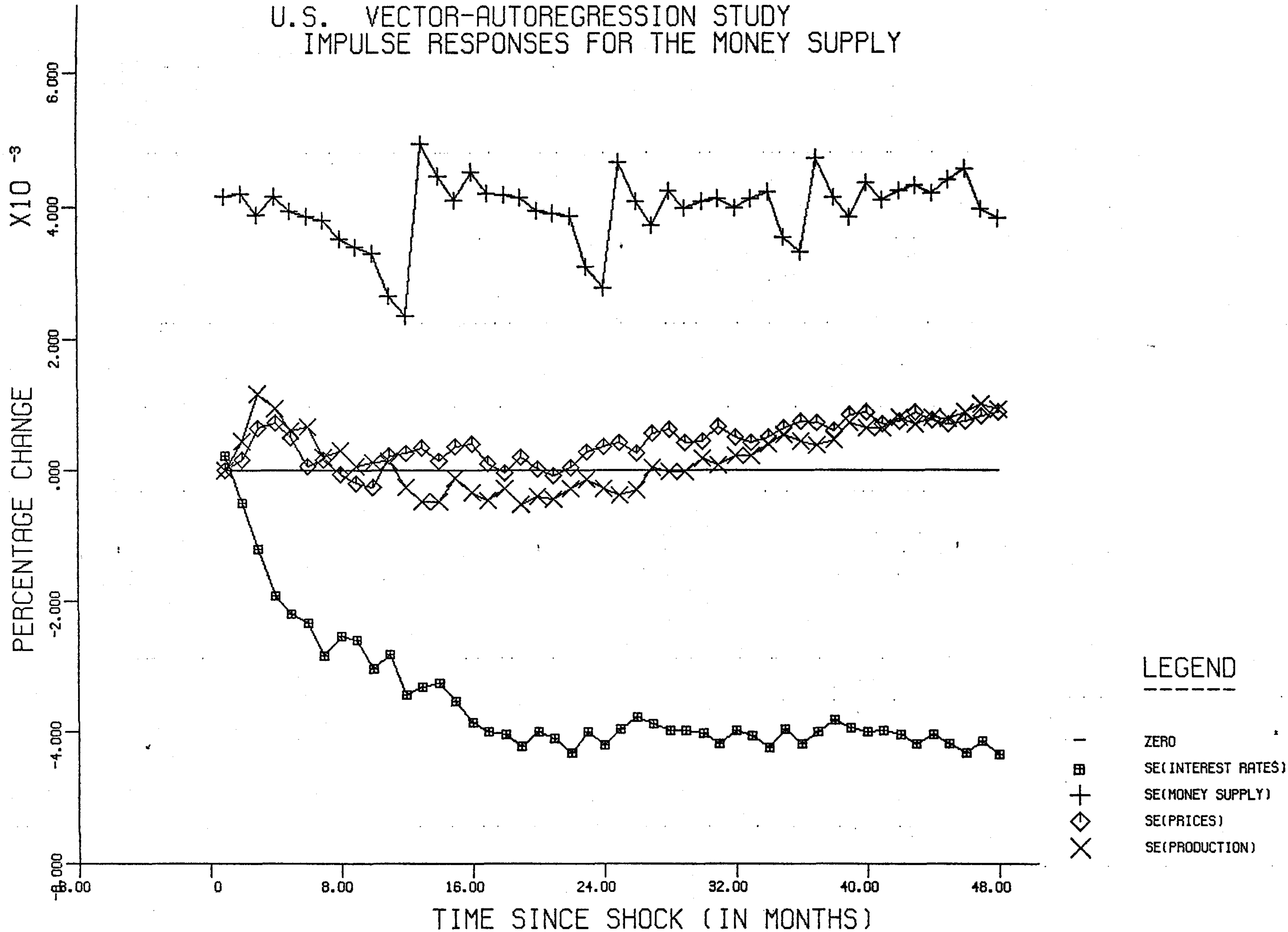

U.S. VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES FOR THE MONEY SUPPLY
X10 -3
PERCENTAGE CHANGE
6.000
4.000
2.000
.000
-2.000
-4.000
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (IN MONTHS)
LEGEND
ZERO
SE(INTEREST RATES)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

FIGURE US-3

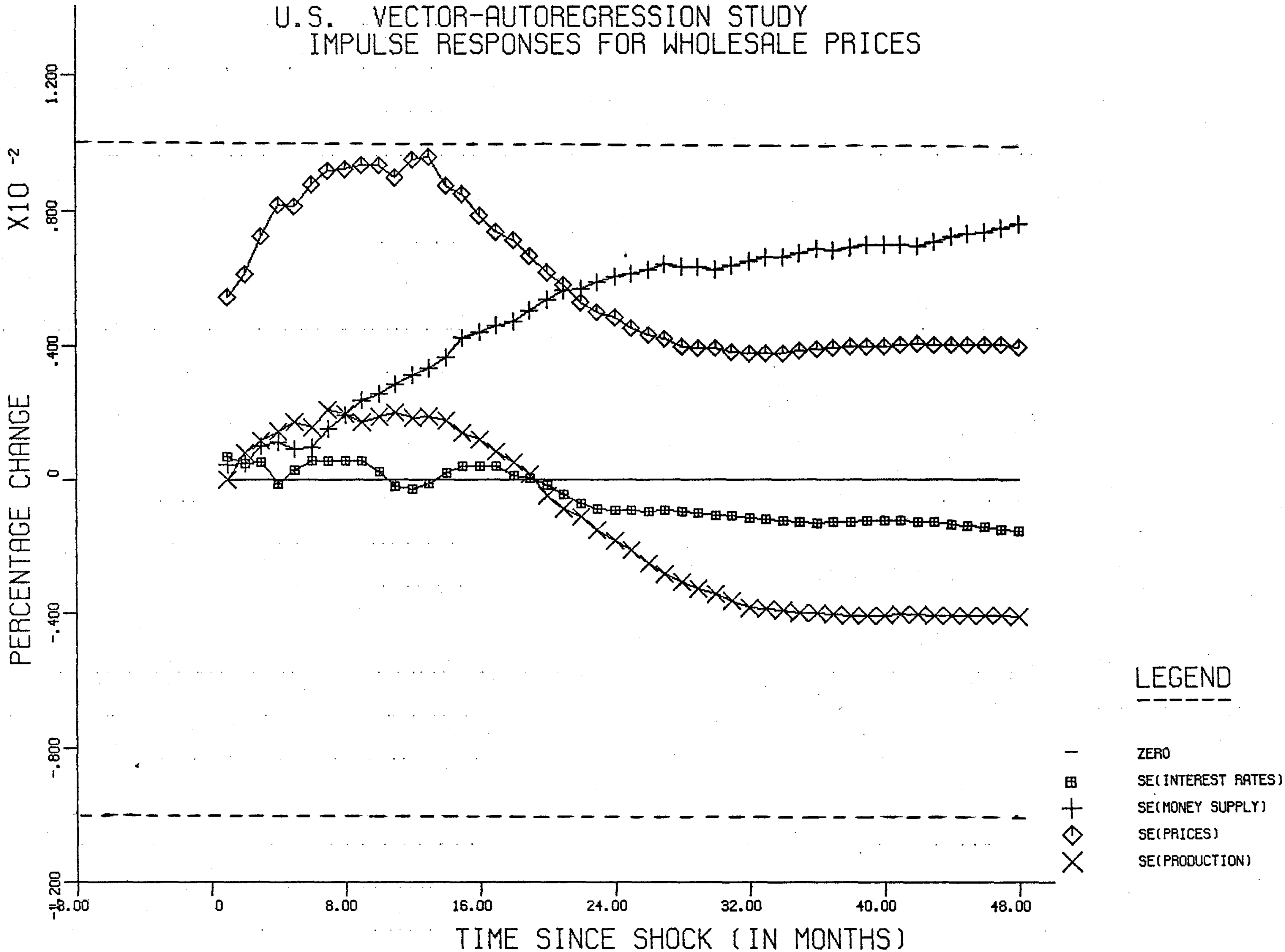
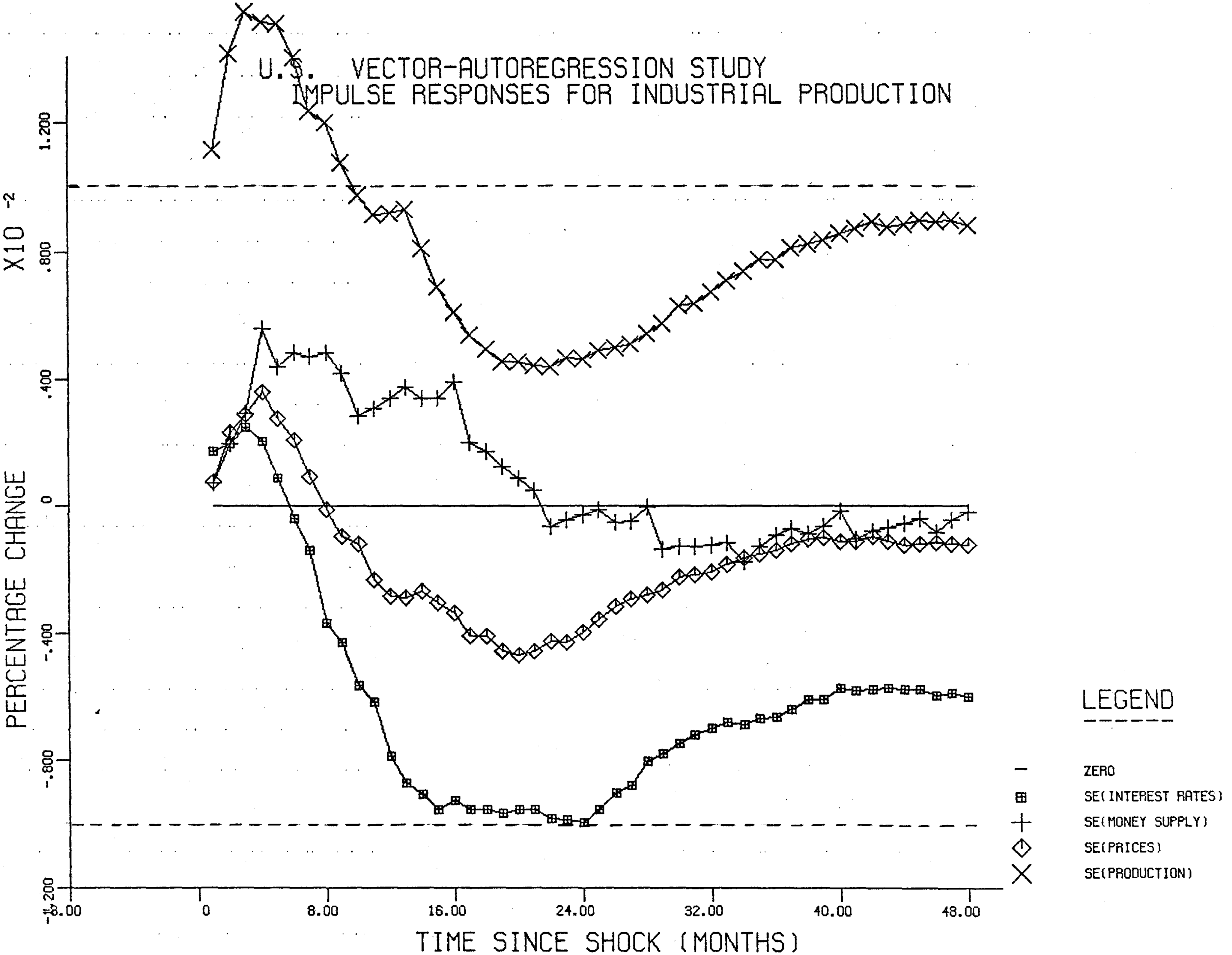
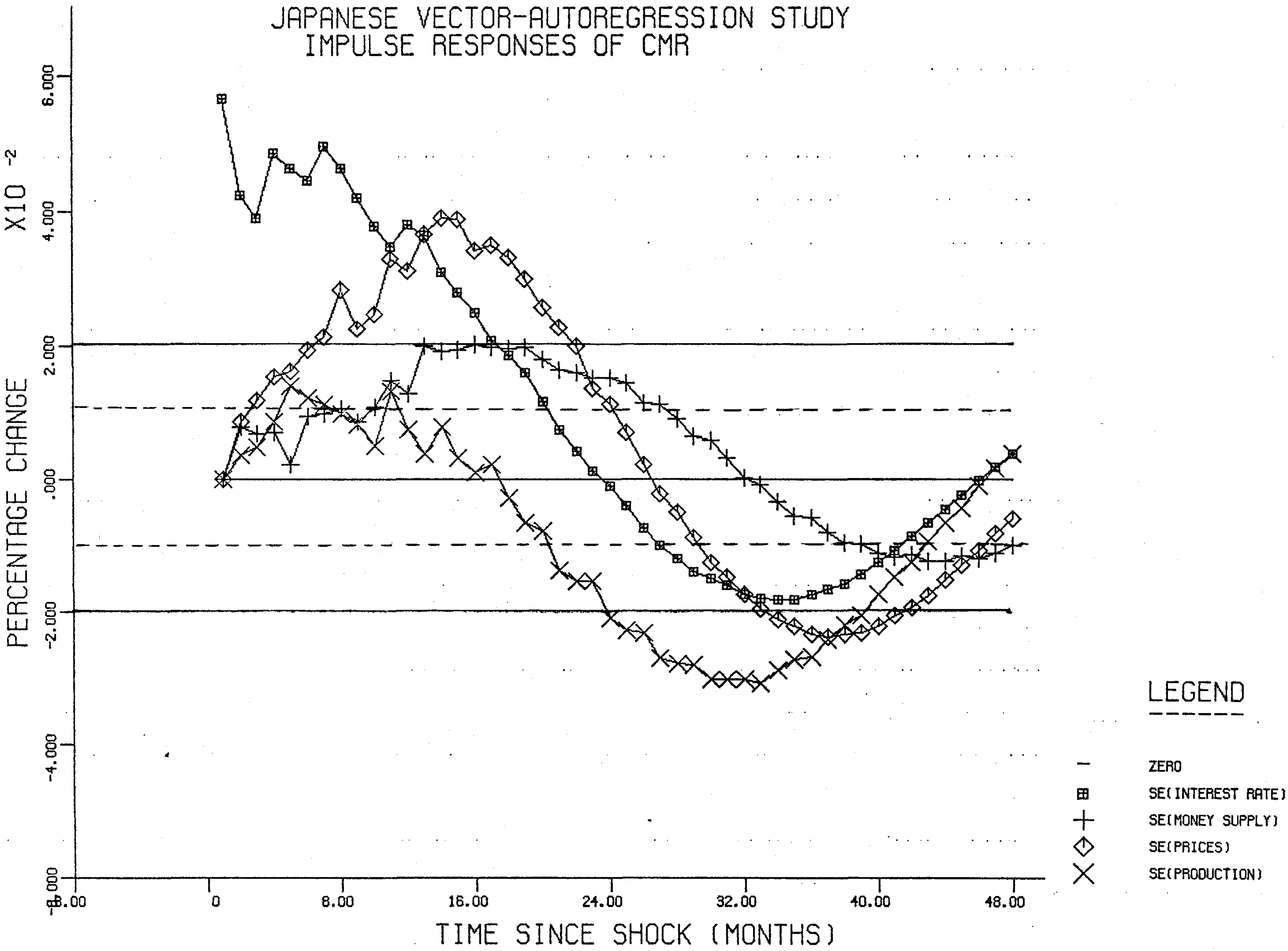

U.S. VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES FOR WHOLESALE PRICES
X10 -2
PERCENTAGE CHANGE
1.200
.800
.400
0
-.400
-.800
-1.200
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (IN MONTHS)
LEGEND
ZERO
SE(INTEREST RATES)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

FIGURE US-4



U.S. VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES FOR INDUSTRIAL PRODUCTION
X10 -2
PERCENTAGE CHANGE
1.200
.800
.400
0
-.400
-.800
-1.200
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (MONTHS)
LEGEND
ZERO
SE(INTEREST RATES)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

FIGURE JA-1



JAPANESE VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES OF CMR
X10 -2
PERCENTAGE CHANGE
6.000
4.000
2.000
.000
-2.000
-4.000
.000
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (MONTHS)
LEGEND
ZERO
SE(INTEREST RATE)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

FIGURE JA-2

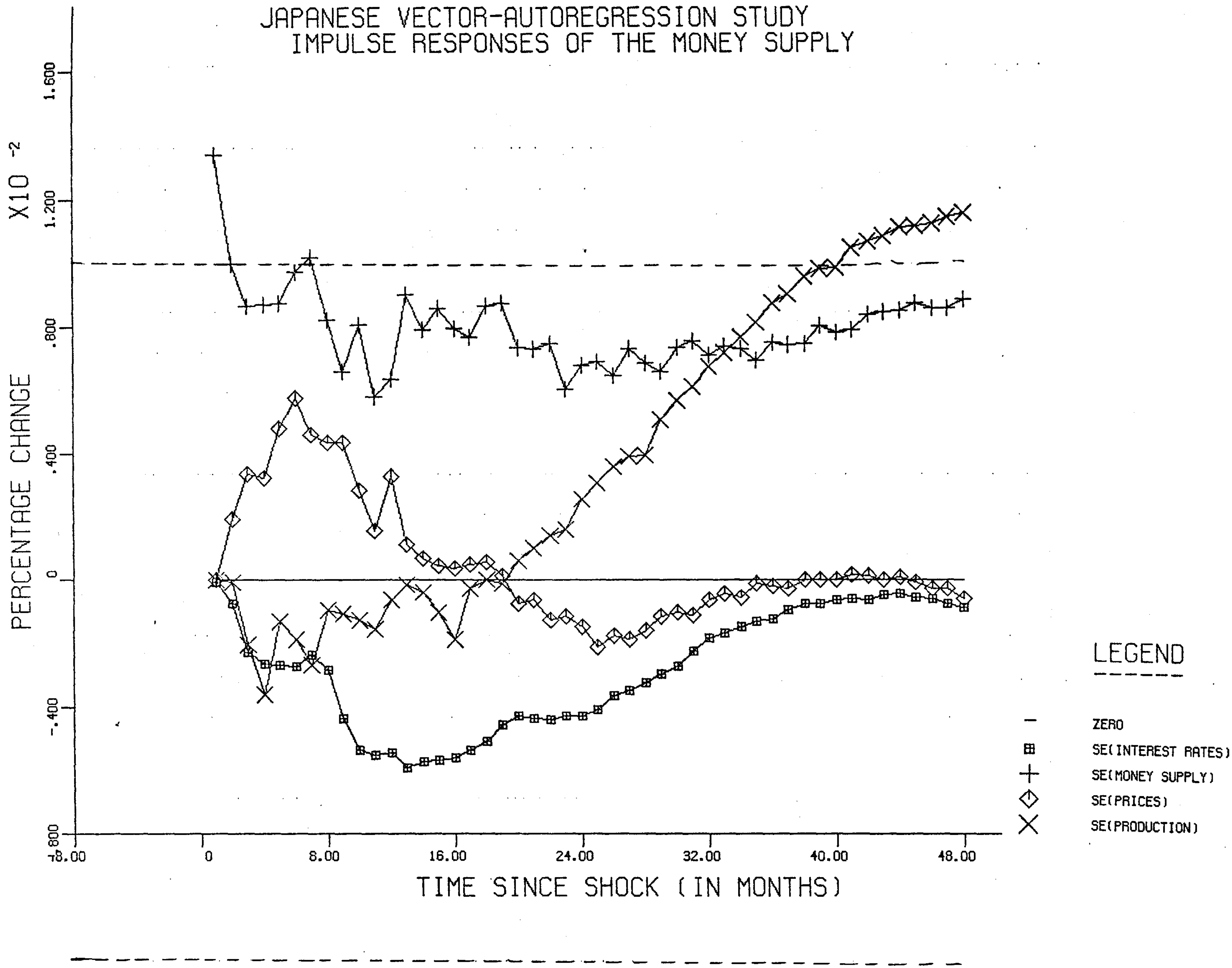

JAPANESE VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES OF THE MONEY SUPPLY
X10 -2
PERCENTAGE CHANGE
1.600
1.200
.800
.400
0
-.400
-.800
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (IN MONTHS)
LEGEND
ZERO
SE(INTEREST RATES)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

FIGURE JA-3

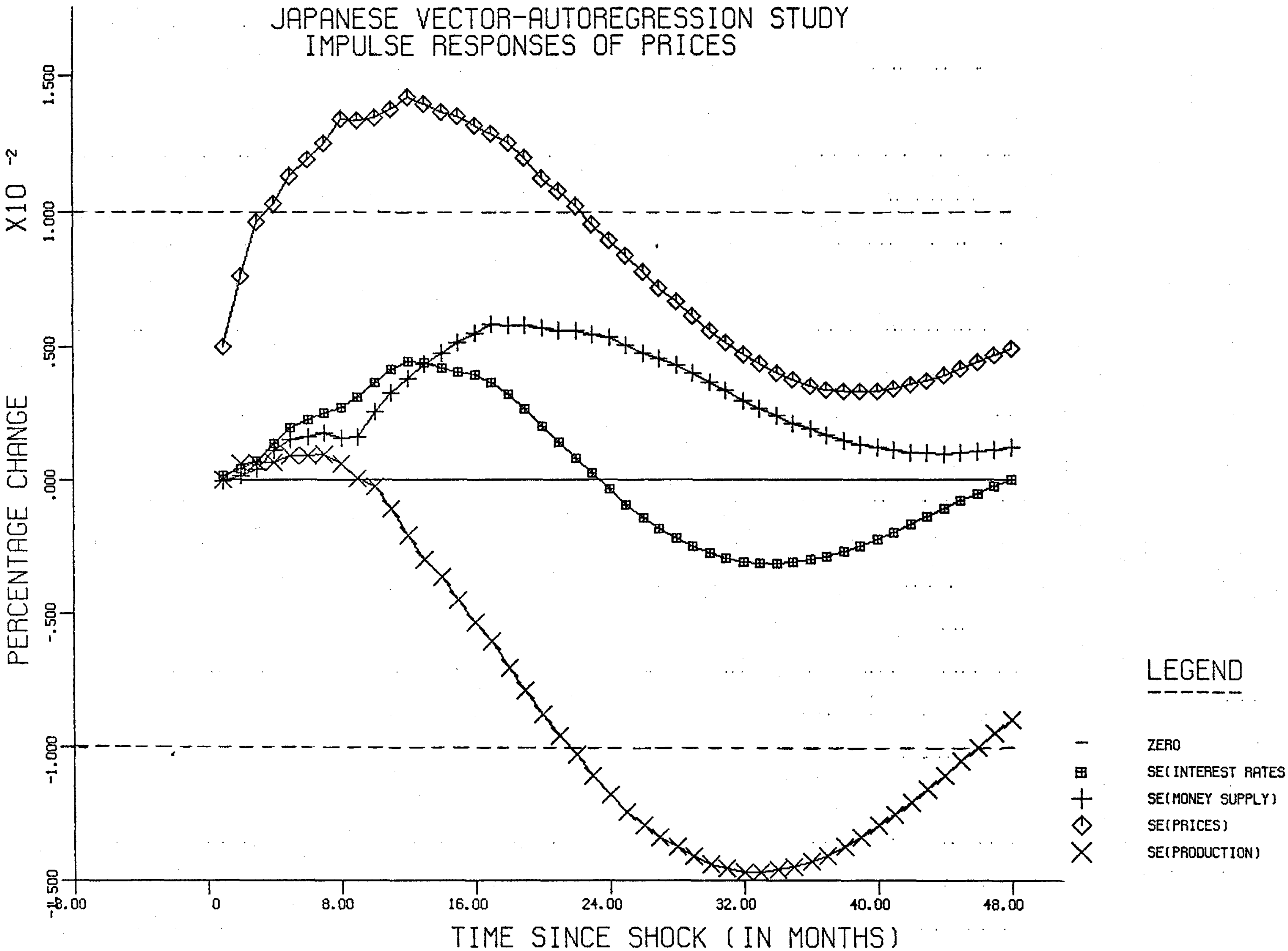
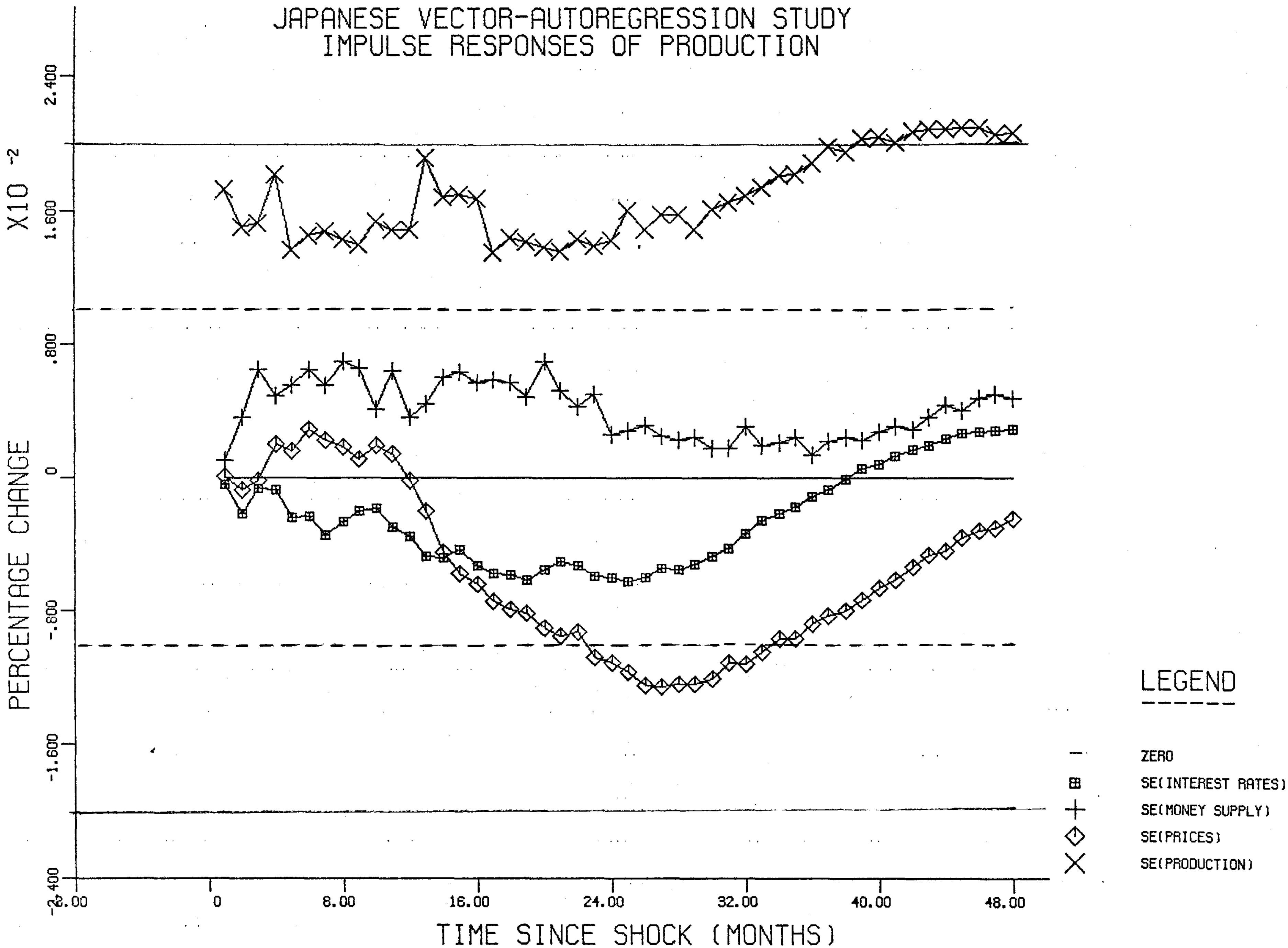
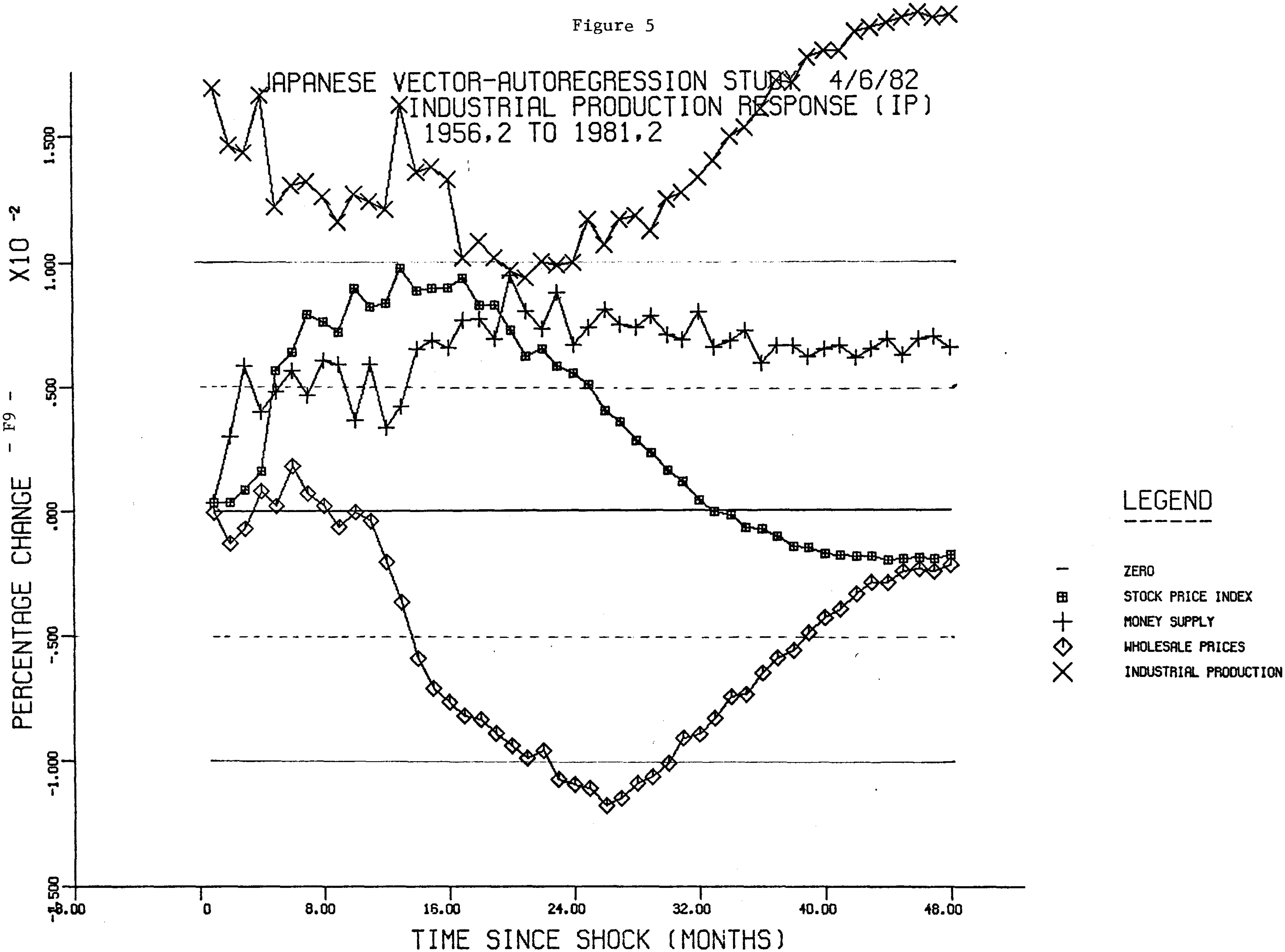

JAPANESE VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES OF PRICES
X10 -2
PERCENTAGE CHANGE
1.500
1.000
.500
.000
-.500
-1.000
-1.500
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (IN MONTHS)
LEGEND
ZERO
SE(INTEREST RATES)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

FIGURE JA-4



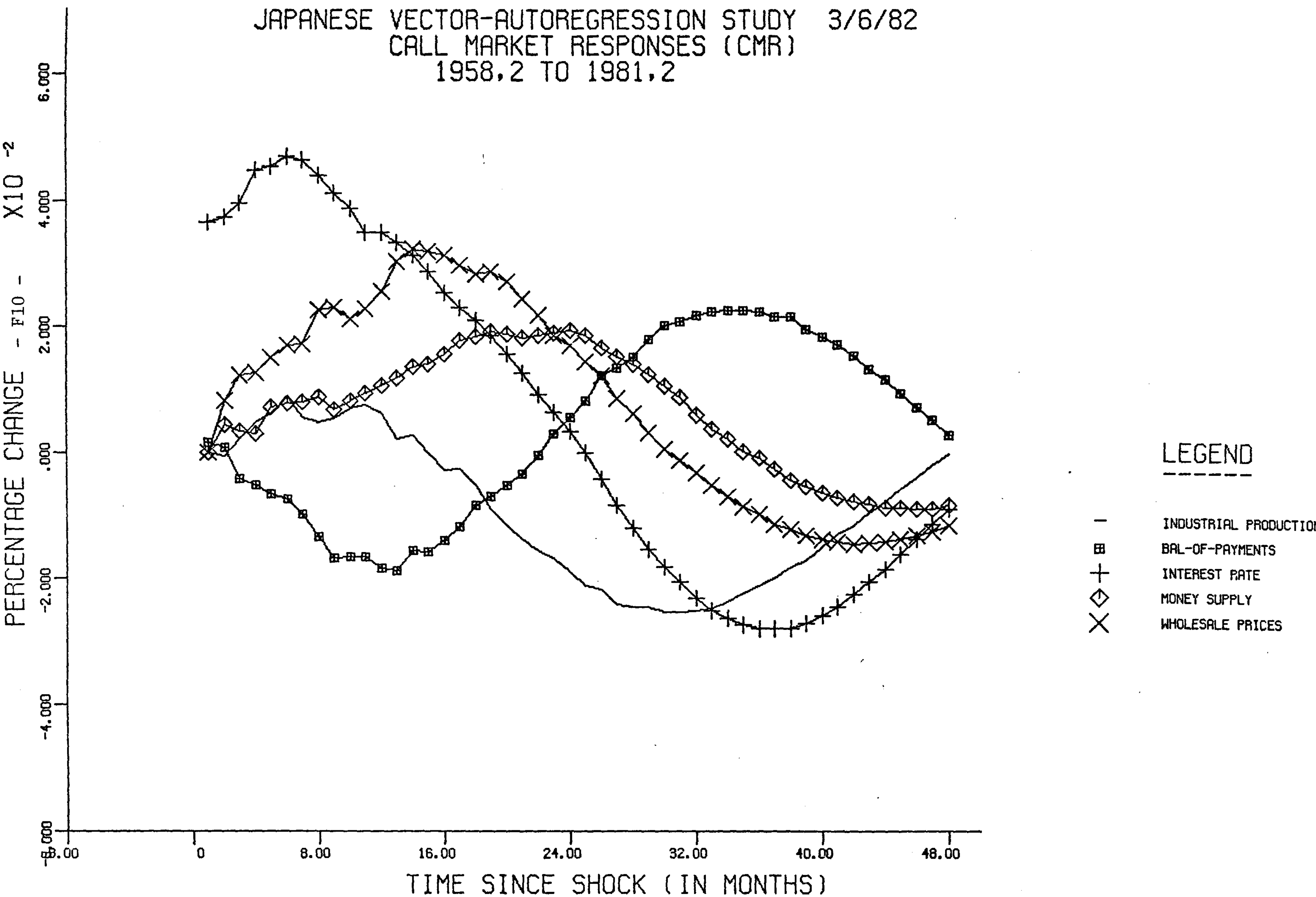
JAPANESE VECTOR-AUTOREGRESSION STUDY
IMPULSE RESPONSES OF PRODUCTION
X10 -2
PERCENTAGE CHANGE
2.400
1.600
.800
0
-.800
-1.600
-2.400
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (MONTHS)
LEGEND
ZERO
SE(INTEREST RATES)
SE(MONEY SUPPLY)
SE(PRICES)
SE(PRODUCTION)

Figure 5



JAPANESE VECTOR-AUTOREGRESSION STUDY 4/6/82
INDUSTRIAL PRODUCTION RESPONSE (IP)
1956,2 TO 1981,2
PERCENTAGE CHANGE
X10 -2
1.500
1.000
.500
.000
-.500
-1.000
-1.500
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (MONTHS)
LEGEND
ZERO
STOCK PRICE INDEX
MONEY SUPPLY
WHOLESALE PRICES
INDUSTRIAL PRODUCTION

FIGURE 6


JAPANESE VECTOR-AUTOREGRESSION STUDY 3/6/82
CALL MARKET RESPONSES (CMR)
1958,2 TO 1981,2
PERCENTAGE CHANGE - F10 - X10 -2
6.000
4.000
2.000
.000
-2.000
-4.000
-8.00
0
8.00
16.00
24.00
32.00
40.00
48.00
TIME SINCE SHOCK (IN MONTHS)
LEGEND
INDUSTRIAL PRODUCTION
BAL-OF-PAYMENTS
INTEREST RATE
MONEY SUPPLY
WHOLESALE PRICES