MONEY AND INCOME CAUSALITY IN JAPAN UNDER THE FLEXIBLE EXCHANGE RATE REGIME: 1971 - 1983

by

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ABSTRACT

The paper examines Granger-causal relationships between money and income and its components in Japan under the flexible exchange rate regime. Through Sims's test and the Granger-Sargent test, M_2CD and both GNP and real GNP appear to be in a bidirectional feedback relationship, while the GNP deflator is unidirectionally causal to M_2CD. The findings conform to Mundell's theory and the liberalization of financial capital flows in December 1980. Analytical results are also confirmed with the impulse response based on the three-variate autoregressive model.

Money and Income Causality in Japan under the Flexible Exchange Rate Regime: 1971-1983.

Money and income causality tests caused considerable attention and various tests have been undertaken since Sims (1972). What we learned from past experience is kind of odd: test results vary depending on country and institutional setup and method employed [Feige and Pearce 1979; Williams, Goodhart and Gowland 1976; Putnam and Wilford 1978; Mills and Wood 1978; Komura 1982, 84; Ram 1984], and above all within a multivariate feedback framework money's role was downgraded in favor of interest rates [Sims 1980b]. Monte Carlo experiments indicate that the power of Granger and Sims's test is relatively weak, that is, a true causal relationship is not very well detected [Nelson and Schwert 1982; Guilkey and Salemi 1982]. Besides, it was argued that economic causal relationships could deviate from statistical leads and lags relationships [Tobin 1970; Zellner 1979; Sims 1983]. Nevertheless, it still remains true that a simple two variates causality test summarizes leads and lags relationships between money and income for a given time and place. As such, different findings across countries and periods are related to the exchange rate regime.

It was pointed out that the Japanese money and income relationship is unique in that a bidirectional relationship was observed under the fixed exchange rate regime and in that the reverse causality was detected under the flexible exchange rate regime during the period 1971:III-1980:IV. The paper reexamines the causal relationship between money and income and its components, i.e., output and price, for the extended flexible exchange

rate regime 1971:III-1983:IV, which adds the experience after the second oil shock. Two different kinds of causality tests, Sims's test (ST) and the Granger-Sargent test (GT) were used since it is often claimed that the test results vary depending on the method. The evidence indicates that there was a bidirectional causal relationship between broad categories of money M_2CD and both GNP and real GNP, though the reverse causality running from GNP to M_2CD appears weak according to GT, and that there was a reverse causality running from the GNP deflator to M_2CD. The findings correspond to Mundell's theory which asserts that monetary policy is effective under the flexible exchange rate regime since the extended period covers the period when financial capital flow is set free which is an important underlying assumption of his theory.

I. Data and Methodology

Data consists of two types of money supply, M_2+CD (M_2CD) and M_1, GNP, and its components, real GNP and the GNP deflator. M_1 includes demand deposits and currency in circulation. M_2CD covers M_1, time deposits of various kinds of banks, and negotiable certificates of deposit since May 1979[1]. Three months average of money supply outstanding at the end of the month is used as a quarterly figure. Real GNP is measured with the current price of 1975. All data are original and seasonally unadjusted with a unit of a billon yen. The sample period covers the period 1971:III-1983:IV out of which necessary filtering manipulation is made and leads and lags are taken as discussed below.

Two kinds of tests are adopted since it has been suggested that the results are dependent on the test method employed. Sims's test consists of testing the significance of future coefficients in the regression of one variable by the future, present, and past of another variable as follows. That is,

$$FY = \sum_{s=-p}^{q} a(s)FX(t-s)+C+b_1D1+b_2D2+b_3D3+cT+u(t)$$

where FY and FX are the prefiltered value of natural logarithms of money and GNP, C constant, D1,D2, and D3 seasonal dummy variables, T the time trend, a(s), b_i and c are respective coefficients, and u(t) the error term. Prefiltering is of the form $(1-kL)^2$, where L is the lag operator, i.e., LX(t)=X(t-1) and k is a parameter with a value greater than 0 and less than 1 and chosen so that the second order serial correlation of error terms be removed following Mehra. If $\Sigma a(s)$ $(s<0)$ are jointly nonsignificant, Y is expressed by X's present and past, and thus Y does not Granger cause X and X is exogenous to Y. However, if they are significant Y is Granger causal to X. By interchanging X and Y the causal relationship in the other direction is also checked. If Y causes X, while X causes Y, then there is a bidirectional relationship, i.e., a feedback relationship, between them.

Granger's test consists of examining the significance of the past of one variable besides the past of another variable in the regression of the present value of another variable. Sargent's practice in doing this is to take the first difference of the natural logarithm for both variables in order to make data stationary and to remove autocorrelation in errors. Thus, the Granger-

Sargent test is formulated as follows. That is,

$$DY = \sum_{s=1}^{m} a(s)DY(t-s) + \sum_{s=1}^{m} b(s)DX(t-s)+C+c_1D1+c_2D2+c_3D3+dT+u(t)$$

where $DY = \ell nY(t)-\ell nY(t-1)$, $DX = \ell nX(t)-\ell nX(t-1)$, C is constant, D1, D2 and D3 seasonal dummies, T trend, u(t) an error term and a(s), b(s), c_i and d respective coefficients. If $\Sigma b(s)$ is jointly significant, X is Granger causing Y and similarly the reverse relationship can be tested. For both ST and GT a different lag structure is explored since joint significance is sensitive to the lag structure.

II. Empirical Results

Table 1 summmarizes the results of ST. The third column of (i) shows that the futures of GNP are significant for 8, 6 and 4 leads at the 5 percent level and for 2 leads at the 10 percent level. The F-values of futures of M_2CD are as shown in the fourth column, significant for 8 and 2 leads at the 5 percent level and for 6 and 4 leads at the 10 percent level. Therefore, M_2CD causes GNP and GNP also causes M_2CD, that is, they are in a bidirectional feedback relationship. If we view that the highest F-value indicates the lag length until one variable's effect on another becomes the maximum, M_2CD's maximum impact is achieved in one year, while GNP's in two years. Now, looking at the fifth and sixth columns, it is seen that M_2CD and real GNP (RGNP) are also in a feedback relationship with the respective maximum effect being achieved in one year. The seventh and eighth columns show that there is only the reverse causal relationship running from

the GNP deflator (PGNP) to M_2CD with its maximum effect being achieved in one year.

Table 1-(ii) presents the results between M_1 and GNP and its components. No causal relationship is observed from M_1 to GNP, while GNP causes M_1 at the 5 percent level of significance within half a year lag. With respect to GNP's components, M_1 causes RGNP and PGNP causes M_1 respectively at the 5 percent level and with a one year lag.[2]

Table 2 lists the results of the GT for 2, 4, 6 and 8 lags. As is true for ST, M_2CD causes GNP with its maximum effect in one year, while GNP weakly causes M_2CD at the 10 percent level of significance with a one year lag. Turning to GNP's components, M_2CD and real GNP are in a feedback relationship within half a year. M_2CD and the GNP deflator are also in a feed-back relationship with M_2CD's effect on PGNP achieved in one year and the reverse effect in half a year. Table 2-(ii) shows the results for M_1. Little causal relationship is observed except a weak unidirectional causal relationship running from M_1 to GNP.

Table 3 illustrates the results of both ST and GT. As a whole, between M_2CD and both nominal and real GNP a feedback relationship is observed, though the reverse causal relationship from GNP to M_2CD appears to be weak according to GT. PGNP causes M_2CD in both tests, while M_2CD's effect on PGNP is observed only by GT. No consistent causal relationship is observed between M_1 and GNP and its components.

III. Analysis of Findings

As discussed in the introduction, money and income causality was related to the exchange rate regime. The above findings differ from Mundell's theory that monetary policy is effective under the flexible exchange rate regime and those for the period until 1980:IV. Therefore, it is necessary to analyze the underlying factors. It should be emphasized that M_1 did not show any consistent causal relationship with GNP and its components, while the broader category of money M_2CD had fairly consistent causal results as discussed above. Since M_2CD covers time deposits which are an important part of households' savings and the majority (68%) of M_2CD, its fluctuation is less volatile compared to M_1 and shows a relatively stable leads and lags relationship vis-a-vis GNP. The Bank of Japan was not bothered much with volatile movements of M_1, but watched carefully the movement of M_2CD using it as an intermediate target of monetary policy.[3] Thus it is not too surprising to find a clear causal relationship between M_2CD and GNP but not between M_1 and GNP.

Now, the following two points disturbed the theoretically expected results. First, an assumption underlying the theory was not satisfied for most of the period. Free financial capital flow was not admitted before December 1980 when a new foreign exchange rate and trade law was enacted.[4] An institutional change due to the law must have contributed to strengthening the causal relationship running from money supply to GNP.[5] Second, during the sample period there were a few exceptional real shocks such as the abandonment of convertibility and devaluation of the dollar in August

1971, and the first and second oil shock. It is very conceivable that these events disturbed ordinary money and income relationships otherwise observed.

Whether the exchange rate regime is flexible or not, the reverse causal relationship from GNP to money can result from the following two types of monetary policies. First, the Bank of Japan has traditionally followed an accomodative policy in order to supply so called growth money. Thus, the money supply tended to keep pace with GNP, with its growth rate speeding up during expansion and slowing down during recession. To the extent that such an accomodative policy is in effect GNP should be causal to money in a directly proportional manner. Second, monetary policy has pursued countercyclical measures when the economy deviates too far from its trend growth path. Thus, an excessive growth and resulting inflation led to tight monetary policy, and similarly, recesssion induced an easy monetary policy. To the extent that such a countercyclical monetary policy is in effect, a causal relationship running from GNP to money should appear to be an inversely proportional one. The sum of eight future coefficients of M_2CD in Sims's test is 0.5359, suggesting that an accomodative monetary policy was dominant on average.

On the other side of the coin, monetary policy could affect GNP in a directly proportional manner, with a tight monetary policy leading a recession and easy monetary policy followed by economic recovery. To the extent that capital flow is restricted such an effect directly affects GNP through domestic channels, while it

affects GNP indirectly through change in the foreign exchange rate to the extent that free capital flow is allowed. Whether such a causal relationship is observed or not depends on whether effective monetary policy was adopted during the sample period. The period consists of three easy monetary policy periods and two tight monetary policy periods, of which only the last easy monetary policy during August 1980 through December 1983 was accompanied by a theoretically expected exchange rate movement, i.e., depreciation of yen in this case.[6] It is interesting that the causal relationship running from M_2CD to GNP became apparent by adding this corresponding period 1981-1983 to the sample. The sum of four future coefficients of GNP in Sims's test is 0.7682, showing a directly proportional relationship.

With respect to the causal relationship between M_2CD and the GNP deflator, a consistent result in the two tests is the reverse causal relationship from PGNP to M_2CD. Such findings are consistent with the fact that monetary policy's main target was to defeat inflation during the two oil crises, reacting against inflation. It is worth noting that the effect of monetary policy on PGNP did not show up through the two tests, suggesting that the price movement self-guided its own track.

These interactions can be made explicit by estimating a three variate autoregressive model and examining the impulse responses of the respective variable against respective orthogonal innovations. The results mostly confirm the analysis in the text, as discussed in the Appendix and illustrated in Figure 1.

IV. Concluding Remarks

The paper discussed the causal relationship between money and income and its components in Japan for the period under the flexible exchange rates regime. The results are encouraging in two points. First, fairly consistent results are observed through different types of tests; Sims's test, the Granger-Sargent test, and the impulse response among the three variables while the opposite were often reported. Second, the findings endorse Mundell's theoretical implication that monetary policy is effective under the flexible exchange rate regime, if we take into consideration the institutional setup in Japan and exceptional historical events during the period. Enhanced financial capital mobility after December 1980 contributed to making monetary policy effective, while the reverse causality resulted from an accomodative monetary policy as well as exceptional exogenous shocks. Thus, two variates causality tests remain a good way to summarize the leads and lags relationship between variables, though we warn that the results be appropriately interpreted within a given institutional setup and economic environment.

Footnotes

[1] M_1 outstanding at the end of 1983 is 80.8 trillion yen of which demand deposits are 74.5% and cash currency in circulation is 25.5%. M_2CD outstanding is 268.7 trillion of which M_1 is 30.1% and time deposits are 68.0% and CD's 1.9%.

[2] All of the significance of Sims's test were confirmed by the significance of present and past values in the summary regression where one variable is regressed on another variable's present and past values, constant, dummies and time trend.

[3] The lack of consistency between M_2CD and M_1, compared to the earlier period under the fixed exchange rate regime, suggests that the public's attitude toward holding respective money has changed considerably [Komura 1984].

[4] It was pointed out that the international interest rate parity did not hold for the earlier period, while it did since around 1980 [Mutoh and Hamada 1984].

[5] This is confirmed by the fact that the causal relationship running from M_2CD to GNP was not observed under the flexible rate regime until 1980:IV.

[6]The first period of two other easy monetary policies was September 1971 through March 1973 during which the yen rate appreciated from 334.21 yen per dollar at the end of September 1971 to 265.83 yen by March 1973. The second period covered April 1975 through March 1979 when the yen rate again appreciated from 293.30 yen to 209.30 yen. However, during the last easy monetary policy period it depreciated from 219.0 yen in August 1980 to 277.30 yen by the end of October 1982 and then appreciated to 232.20 yen by the end of December 1983. On the other hand, the first of two tight monetary policy periods covered April 1973 through March 1975 when the yen depreciated from 265.50 yen per dollar to 293.80 yen. The second period was April 1979 through July 1980 which was again accompanied by declining yen: from 218.50 per dollar to 227.00.

Appendix

To examine the interaction among M_2CD, RGNP and PGNP, the three variate autoregressive model is estimated and the impulse response of respective variables against a one time shock of orthogonal innovations is analyzed, with the method by Sims [1980a]. The estimated model is formulated as follows. That is,

$$(1) \qquad Y(t) = \sum_{s=1}^{5} a(s)Y(t-s)+C+b_1D1+b_2D2+b_3D3+cT+u(t)$$

where Y(t) is a vector of natural logarithms of M_2CD, PGNP and RGNP, s=1,2,4,5, C constant, Di's seasonal dummies, T trend and u(t) a vector of innovations. Table 4 summarizes the estimated results in terms of F-statistics of predetermined variables and their marginal significance. It confirms a strong reverse causal relationship running from PGNP and RGNP to M_2CD, while M_2CD's effect on PGNP is shared with RGNP and M_2CD's effect on RGNP is overshadowed by the significant effect of PGNP on RGNP.

Figure 1 illustrates the impulse response of respective variables against a one time shock of respective orthogonalized innovations. The error term u(t) represents innovations which is part of the current value of Y(t) that is not predicted by the past information of Y's and deterministic terms. Innovations are orthogonalized according to the Wold causal chain since error terms are correlated to each other and a part of the error is explained by the other errors. The nature of this feedback system can be described by impulse responses of each variable against a one

time shock of the orthogonalized part of 1SD innovations. Though there are six different impulse responses due to different ordering, the following features show up through them.

1. Regardless of the order the relationship between PGNP and RGNP is definite: price increases always cause a decline in real GNP reflecting a supply shock and an increase in real GNP causes an initial small decline in price and later increases in price after one year.

2. Between M_2CD and RGNP, an increase in real GNP always causes accomodative expansion in M_2CD, while M_2CD's expansion causes an initial relatively small increase in real GNP and its later decline if M_2CD is placed before RGNP in the order of orthogonalization. Otherwise, an initial increase in RGNP is very limited and overshadowed by later decline.

3. With respect to the M_2CD and PGNP relationship, an increase in M_2CD always causes an initial decline and a later increase in the price deflator. On the other hand, a price hike triggers a decline in M_2CD, representing a counter inflationary tight monetary policy if PGNP is placed before RGNP. Otherwise, M_2CD tends to oscillate.

Figure 1 illustrates the impulse response when the error terms are orthogonalized in the order of M_2CD, PGNP and RGNP. The results come closest to the interpretation discussed in the text. A one time shock of 1 standard deviation (SD) of M_2CD has an immediate stimulative effect on RGNP which achieves the maximum of 0.36SD in two quarters, though RGNP declines during the sixth and eleventh quarters. It also affects PGNP in a directly proportional

manner after one year with its maximum of 0.51SD achieved in seven quarters. The one time price shock of 0.98SD causes an immediate adverse effect on both RGNP and M_2CD. The maximum effect on RGNP is -1.09SD achieved in two quarters and that on M_2CD is -0.52SD in four quarters. Finally a shock in RGNP of 0.88SD causes an accommodative increase in M_2CD whose maximum is 0.99SD achieved in six quarters. It also triggers a price increase after one year which achieves the maximum of 0.98SD in two and one-half years. It is noted that some of the results of the impulse responses depend on the specific ordering here adopted: the error of M_2CD is exogenous and gets into the errors of both PGNP and RGNP and the orthogonalized error of PGNP in turn gets into that of RGNP. Such an ordering corresponds to a view that the real sector is contemporaneously affected by monetary and price shocks, while the broad category of money is contemporaneously independent of either price or real shocks. It is interesting that such an ordering most closely matches the interpretation given in the text of the bivariate Granger-Causality tests.

References

Feige, Edgar L. and Douglas K. Pearce, "The Causal Relationship Between Money and Income: Some Caveats for Time Series Analysis," Review of Economics and Statistics 61 (November 1979): 521-33.

Granger, C.W.J., "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," Econometrica 37 (July 1969): 424-38.

Guilkey, David K. and Michael K. Salemi, "Small Sample Properties of Three Tests for Granger-Causal Ordering in a Bivariate Stochastic System," Review of Economics and Statistics 64 (November 1982): 668-80.

Komura, Chikara, "Money, Income and Causality: The Japanese Case," Southern Economic Journal 49 (July 1982): 19-34.

------, "Money, Income and Causality in Japan - Supplementary Evidence: A Reply," Southern Economic Journal 50 (April 1984): 1219-23.

Mehra, Y.P., "Money, Wages, Prices and Causality," Journal of Political Economy 85 (December 1977): 1227-44.

Mills, Terry C. and Geoffrey E. Wood, "Money-Income Relationships and the Exchange Rate Regime," Federal Reserve Bank of St. Louis Review (August 1978): 22-27.

Mundell, Robert, International Economics. New York: Macmillan, 1968.

Mutoh, Takahiko and Koichi Hamada, "International Short-Term Capital Flow and the Foreign Exchange Rate: Japan," Economic Studies Quarterly 35 (August 1984): 97-115.

Nelson, Charles R. and G. William Schwert, "Test for Predictive Relationships Between Time Series Variables: A Monte Carlo Investigation," Journal of the American Statistical Association 77 (March 1982): 11-18.

Pierce, David A., "Relationships - and the Lack Thereof - Between Economic Time Series, with Special Reference to Money and Interest Rates," Journal of the American Statistical Association 72 (March 1977): 11-26.

Putnam, Bluford H. and D. Sykes Wilford, "Money, Income, and Causality in the United States and the United Kingdom: A Theoretical Explanation of Different Findings," American Economic Review 68 (June 1978): 423-27.

Ram, Rati, "Money, Income and Causality in Japan - Supplementary Evidence: Comment," Southern Economic Journal 50 (April 1984): 1214-18.

Sargent, Thomas J., "A Classical Macroeconometric Model for the United States," Journal of Political Economy 84 (April 1976): 207-37.

Sims, Christopher A., "Money, Income and Causality," American Economic Review 62 (September 1972): 540-52.

----, "Macroeconomics and Reality," Econometrica 48 (January 1980a): 1-48.

----, "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered," American Economic Review 70 (May 1980b): 250-57.

----, "Is there a Monetary Business Cycle?" American Economic Review 73 (May 1983): 228-33.

Tobin, James, "Money and Income: Post Hoc Ergo Propter Hoc?" Quarterly Journal of Economics 84 (May 1970): 301-17.

Williams, David, C.A.E. Goodhart and D.H. Gowland, "Money, Income and Causality: The U.K. Experience," American Economic Review 66 (June 1976): 417-23.

Zellner, Arnold, "Causality and Econometrics," in: Three Aspects of Policy and Policymaking: Knowledge, Data and Institutions, Carnegie-Rochester Conference Series on Public Policy vol. 10, Amsterdam: North-Holland, 1979, 9-54.

TABLE 1

F-VALUES OF FUTURE COEFFICIENTS IN SIMS'S TEST

(i)

Lag Form	Degrees of Freedom[a]	M_2CD on GNP		GNP on M_2CD		M_2CD on RGNP		RGNP on M_2CD		M_2CD on PGNP		PGNP on M_2CD	
		F-ratio	k[b]	F-ratio	k	F-ratio	k	F-Ratio	k	F-ratio	k	F-ratio	k
4 future 8 past	(4,18)	1.52	0.60	0.50	0.60	0.40	0.45	3.00**	0.05	0.24	0.40	5.18**	0.95
8 future 4 past	(8,18)	2.58**	0.60	5.57**	0.60	1.19	0.65	0.54	0.05	1.10	0.65	1.51	0.95
6 future 4 past	(6,22)	2.88**	0.60	2.20*	0.30	1.76	0.65	0.83	0.40	1.59	0.65	1.11	0.95
4 future 4 past	(4,26)	3.74**	0.60	2.60*	0.30	3.09**	0.65	1.24	0.40	1.99	0.65	2.54*	0.60
2 future 4 past	(2,30)	3.17*	0.60	5.00**	0.30	1.43	0.65	0.40	0.40	2.22	0.65	2.03	0.60

(ii)

Lag Form	Degrees of Freedom	M_1 on GNP		GNP on M_1		M_1 on RGNP		RGNP on M_1		M_1 on PGNP		PGNP on M_1	
		F-ratio	k	F-ratio	k	F-ratio	k	F-Ratio	k	F-ratio	k	F-ratio	k
4 future 8 past	(4,18)	2.64	0.60	0.69[c]	0.20	1.99	0.50	0.83[c]	0.05	0.67	0.45	4.11**	0.80
8 future 4 past	(8,18)	1.12	0.60	2.03[d]	0.25	1.26	0.50	0.47	0.40	0.72	0.45	1.35	0.80
6 future 4 past	(6,22)	1.19	0.60	2.27*[d]	0.20	2.00	0.50	0.46	0.40	1.02	0.45	0.95	0.80
4 future 4 past	(4,26)	1.94	0.60	2.23*	0.30	3.65**	0.50	0.34	0.40	1.16	0.45	0.95	0.80
2 future 4 past	(2,30)	1.23	0.60	4.58**	0.30	0.97	0.50	0.13	0.40	2.27	0.45	0.64	0.80

** significant at the 5 percent level

* significant at the 10 percent level

(a) Degrees of freedom for the F-test are shown in parentheses respectively for the numerator and the denominator.

(b) The second-order filtering of the form $(1-kL)^2$

(c) There remains an autocorrelation of 10 percent significance in the error term.

(d) There remains an autocorrelation of 5 percent significance in the error term.

TABLE 2

F-VALUES IN THE GRANGER-SARGENT TEST

Direction of Causality		L=2[a] (2,38)	L=4 (4,32)	L=6 (6,26)	L=8 (8,20)
(i)	M_2CD to GNP[b]	0.51	3.17**	2.25*	2.19*
	GNP to M_2CD	1.43	2.20*	1.48	1.30
	M_2CD to RGNP	4.53**	2.17*	1.44	0.96
	RGNP to M_2CD	3.64**	1.98	1.68	0.75
	M_2CD to PGNP	2.80*	2.75**	1.96	1.59
	PGNP to M_2CD	4.98**	2.23*	1.82	1.20
(ii)	M_1 to GNP	1.23	2.06	2.38*	1.58
	GNP to M_1	1.07	1.25	0.58	0.31
	M_1 to RGNP	2.10	1.53	1.13	0.69
	RGNP to M_1	1.36	1.26	0.82	0.36
	M_1 to PGNP	1.85	1.60	1.45	0.91
	PGNP to M_1	1.49	0.95	0.48	0.62

(a) The number in "L=" indicates the lag length in quarters of the two explanatory variables. The numbers in the parentheses below show the degrees of freedom of F-test for the numerator and the denominator, respectively for the column.

(b) The expression "M_2CD to GNP" means that GNP is regressed on its own lagged values and on the lagged values of M_2CD, and the F-test consists of verifying whether the coefficients of lagged M_2CD are jointly significant.

** significant at the 5 percent level

* significant at the 10 percent level

TABLE 3

A COMPARISON OF THE CAUSAL RELATIONSHIP BETWEEN THE GRANGER-SARGENT TEST AND SIMS'S TEST

Granger	Sims	Granger	Sims
$M_2CD \underset{\leftarrow\cdot\cdot}{\overset{\longrightarrow}{}}$ GNP	$M_2CD \underset{\Longleftarrow}{\Longrightarrow}$ GNP	$M_1 \cdot\cdot\rightarrow$ GNP	$M_1 \longleftarrow$ GNP
$M_2CD \underset{\longleftarrow}{\overset{\longrightarrow}{}}$ RGNP	$M_2CD \underset{\longleftarrow}{\overset{\longrightarrow}{}}$ RGNP	M_1 RGNP	$M_1 \longrightarrow$ RGNP
$M_2CD \underset{\longleftarrow}{\overset{\longrightarrow}{}}$ PGNP	$M_2CD \longleftarrow$ PGNP	M_1 PGNP	$M_1 \longleftarrow$ PGNP

$\Longrightarrow$ F-ratio is significant at the 5 percent level at least for two types of specification.

$\longrightarrow$ F-ratio is significant at the 5 percent level at least for one type of lag specification.

$\cdot\cdot\rightarrow$ F-ratio is significant at the 10 percent level for one type of lag specification.

TABLE 4

F-STATISTICS AND SIGNIFICANCES IN THE THREE VARIATE AUTOREGRESSIVE MODEL

Explanatory* Variables	Dependent Variables		
	M_2CD	PGNP	RGNP
M_2CD	14.95[a]	1.33	0.08
	(0.00)	(0.28)	(0.99)
PGNP	7.73	12.70	2.98
	(0.00)	(0.00)	(0.04)
RGNP	4.09	1.27	4.01
	(0.01)	(0.31)	(0.01)
$\bar{R}^{2}$[b]	0.9998	0.9982	0.9954

*Explanatory variables include a constant, three seasonal dummies, and trend besides M_2CD, PGNP and RGNP. Correlation coefficients of errors are −0.42 between PGNP and RGNP, 0.29 between M_2CD and RGNP, and −0.19 between M_2CD and PGNP.

[a]Joint F-statistics of 1, 2, 4, and 5 lags. The marginal significance level is shown in parentheses.

[b]The degree-of-freedom adjusted coefficient of determination.

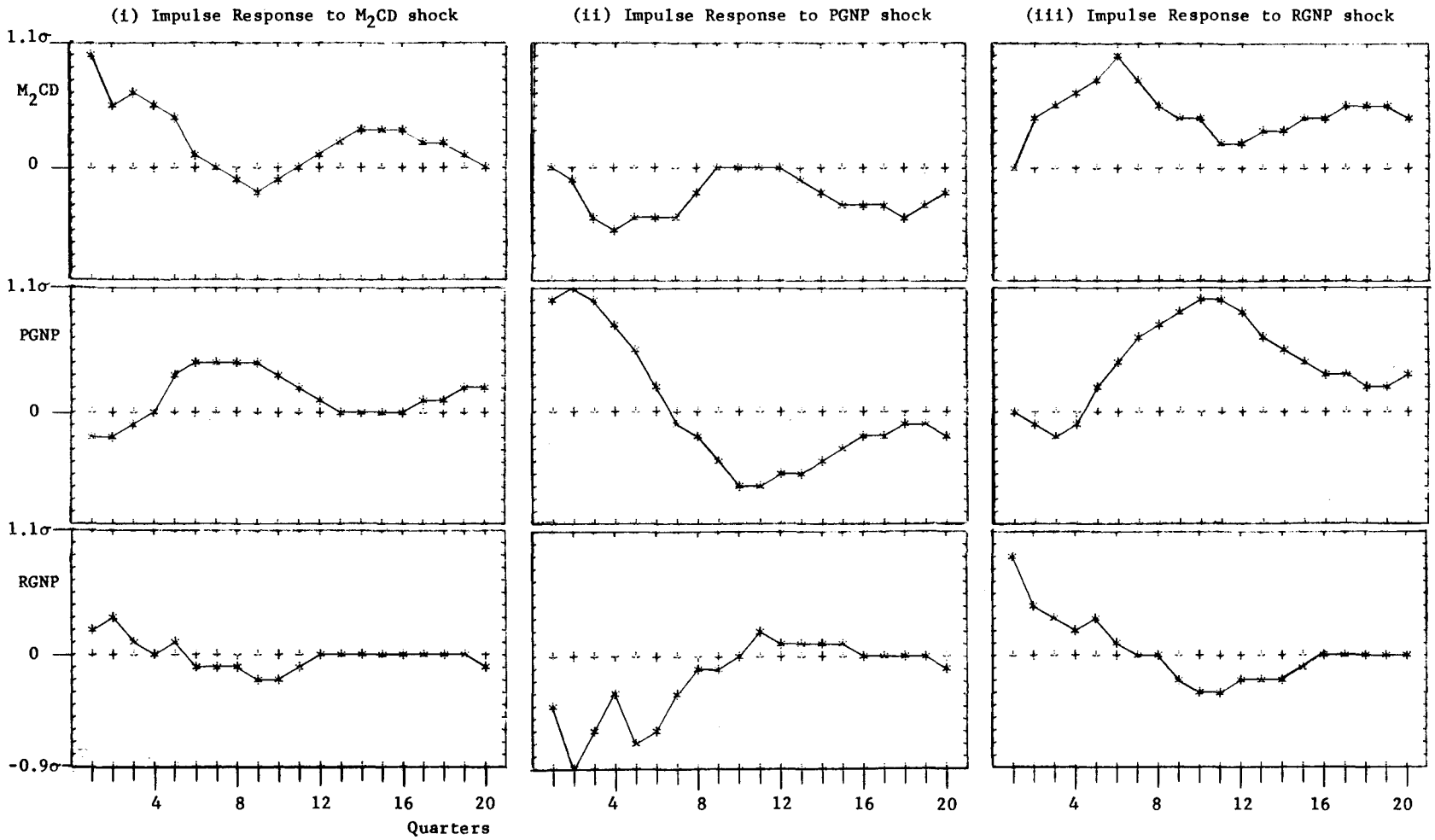

FIGURE 1

IMPULSE RESPONSES TO RESPECTIVE ORTHOGONAL INNOVATIONS