COMMUNICATION

An Analysis of Money and Output in the Industrial Sector in China

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The relationship between monetary aggregates and economic activity is investigated for the Chinese industrial sector for 1980–1988, a period which brackets the process of monetary reform culminating in the establishment of a full-fledged central bank in 1984. Using Granger's definition of causality, Akaike's concept of final prediction error, and Hsaio's sequential testing procedure, we find evidence suggesting that the relationship between money and industrial output may have changed. Whereas, prior to reform, bidirectional causality is detected, after reform unidirectional causality from money to output is established.

The relationship between monetary aggregates and economic activity has long attracted the attention of researchers. The reason is that potential insights on this matter are likely to have implications both for modeling and policy purposes. For example, in estimating a demand for money function, it is common to assume implicitly that output has an impact on money, but not the reverse.

This issue of exogeneity is closely linked to causality. Traditionally, monetarists have viewed changes in the money supply as the major determinant of fluctuations in nominal income, while their critics have argued that the money supply tends to react passively to variations in national income. Sims (1972, 1980), using a causality concept developed by Granger (1969), found unidirectional causality from money to nominal income using post-war U.S. data. Sims argued that if money causes income, one clearly should not estimate a demand for money equation by treating nominal income as an exogenous variable. Instead, a structural model must be posited, from which the reduced form equations can be derived.

With the growing interest in the economy of the People's Republic of China, to a great extent induced by the economic reform of the last decade, pioneering attempts have been made to extend the causality debate to China. A major reason for this interest is that causality takes on a special resonance in a centrally planned economy where the monetary authority is prone to accommodate output directives. Portes and Santorum

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(1987) and Chen (1989) have conducted earlier investigations, in both cases using a (necessarily small) annual data set. Portes and Santorum, using a sample ending in 1983, performed Granger causality tests and found bidirectional causality between two different definitions of money, M0 and M2, and real income, though the influence of money on income was only marginally significant in the case of currency (M0).[1] Chen, utilizing a 1951–1985 sample, investigated causality between money and a set of macroeconomic variables of interest. Estimating three different Bayesian VARS using three different definitions of money, each coupled with nominal income, the trade deficit, the budget deficit and generalized inflation, he found strong evidence of bidirectional money-income causality for M0 and M2. For M3 he found unidirectional causality from income to money. To summarize, the consensus was that income caused money, but that (less conclusively) money also caused income. These findings were important in that they indicated to policymakers that money might potentially serve as an effective policy instrument in China.

The present paper continues the debate but departs from previous research in two crucial ways. First, a sectoral approach is taken: causal relationships between money held by enterprises and gross industrial value (GIV) are explored. Money held in the industrial sector is reasonably proxied by bank deposits held by industrial enterprises. Though enterprises in China are allowed to hold currency, as well as deposits, strict limitations both in terms of quantity and usage ensure that the holdings of industrial deposits account for the overwhelming preponderance of total money balances in the industrial sector.[2]

One obvious advantage in focussing on the industrial sector is that GIV is an output series with monthly frequency. The additional observations relative to annual aggregate measures facilitate a more careful causality analysis.

Another advantage is related to money's special place in production. While cash balances for consumers tend to move in tandem with income,[3] for businesses they not only reflect receipts for goods and services, but also act as an input in the productive process.[4] Thus one might expect the neoclassical prior that money drives output, but not the reverse, to be even more defensible in the industrial sector. Even if the monetary authority is acting in a purely accommodating fashion, it would not be surprising to observe bidirectional causality due to the fact that our focus is on the industrial sector. In addition, as the PRC moves slowly in the direction of a market-driven economy, one might further expect this influence to become of increasing importance.

With this in mind, a second way in which this study departs from previous ones is in explicitly investigating changes in causality relationships as China's economic reform process continues. It has been observed by De Wulf and Goldsborough (1986), Feltenstein and Farhadian (1987), and Naughton (1987) that economic and monetary reform likely tended to increase the role of monetary policy. In particular, there is reason to believe that the monetary regime began to change in the mid-80s with the establishment of a full-fledged central bank in 1984. Whereas, prior to this date, policy is widely viewed as having been accommodating, it is a salient possibility that policy was less so subsequently.[5] Some background at this point on monetary reform in China is in order. The key administrative features of enterprise financing and how it related to the monetary process before 1984 can be summarized as follows. For each planning period, the central planners designated production targets for each enterprise. The fiscal authority, in line with these targets, would then decide on the amount of funds, including the need for circulating capital and wage benefits, that would be required by the enterprise to fulfil these targets. As production took place, the monetary authority supplemented these direct budget transfers by offering loans to enterprises, thus expanding the money supply. Though policy makers had supposed that this would happen only in cases where enterprises needed additional capital beyond what was planned for in order to pay for seasonal or other special transactions, the reality was otherwise. As Byrd (1983; p. 34ff.) characterized at the time, "the conditions under which credit can be granted are specified strictly and in detail; it is nearly impossible for a bank to refuse to make a loan to an enterprise that meets all the relevant conditions. Credit is granted almost automatically based on enterprise credit plans and inventories of goods. . . . The threat to withhold credit is largely empty if it brings into doubt the continued viability of a firm. Enterprises can respond to a credit crunch by delaying payments to their creditors, causing an increase in involuntary trade credit." Thus the reality was that loans were extended by the local bank branches (essentially) whenever requested and monetary policy became to essentially offer as many loans as were needed, whenever they were needed.[6]

Partly as an attempt to remedy this deficiency, in 1984 the central bank was granted the authority to administer and organize financial activities around the country, making financial policies and rules, and, most importantly, determine the level of the money supply. At the same time, the range of production targets mandated in the central plan had been substantially narrowed. Though enterprises were allowed to keep their previous credit quotas as assigned by the fiscal authority before the reform, rapid growth in industrial production and hence in loan demand made enterprises rely heavily on bank loans. Their discretionary provision enabled the central bank potentially to exert a higher degree of control over the money supply by controlling aggregate loans to enterprises. [For more details on the monetary process and reform, see Zhao (1987).]

In terms of causality, one might expect that the relationship between money and output that others have found to be bidirectional might have become unidirectional from money to output subsequent to 1984, when this monetary reform took place. In other words, China's money-income causality relationship might have become indistinguishable from that of a market economy.

The purpose of this paper is to address these issues. The causal relationship between money and output for the industrial sector in China is investigated using monthly data covering the period of January 1980 to July 1988. In Section I, the empirical model is set out. The next section details the results. Finally, Section III concludes the paper.

I. EMPIRICAL ISSUES

As discussed earlier, when one is unsure of the causal relationship among the relevant variables, a conventional econometric approach which assumes exogeneity will not be appropriate in establishing estimated structural parameters. On the other hand, we can utilize a time series approach to establish the causal relationship between enterprise money and industrial output, and subsequently perform model estimation which will not impose priors and false restrictions.

To establish causal relationships using the time series approach, we rely on Granger's notion of causality.[7] In a nutshell, X causes Y, according to Granger, if given an information set A_t that includes at least (X_t, Y_t), Y_t can be better predicted by using past observations of X_t than by not using them. The difficulty in applying the Granger concept of causality in a time series framework is the determination of optimum order of lag structure in each of the estimated equations. Here, we will utilize the concept developed by Akaike (1969a, 1969b) in his treatment of final prediction error (FPE). In fact this marriage of the Granger definition of causality and the use of FPE was first advocated by Hsiao (1979, 1981), and has been subsequently used by many researchers in causality analysis.

We can write the causal ordering of our two variables, enterprise deposits and industrial output, in terms of the constraints of a bivariate autoregressive (AR) model, namely,

$$\begin{bmatrix} m_t \\ y_t \end{bmatrix} = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} m_t \\ y_t \end{bmatrix} + \begin{bmatrix} u_t \\ v_t \end{bmatrix} \tag{1}$$

where m_t and y_t are defined as the first differences of the logarithms of the quantity of money and industrial output respectively; L is the lag operator; and the $\{u_t\ v_t\}$ are white noise innovations with constant variance-covariance matrix.

The theoretical FPE is defined as the (asymptotic) mean squared prediction error, or

$$E(p_{it} - \hat{p}_{it})^2 \tag{2}$$

where $\hat{p}_{it}$ is the prediction of p_{it} given by

$$p_{it} = \hat{\Psi}_{i0} + \hat{\Psi}^n_{i1}(L)\, m_t + \hat{\Psi}^r_{i2}(L)\, y_t + \hat{e}_{it} \tag{3}$$

and where $p_{1t} = m_t$ and $p_{2t} = y_t$; the superscripts n and r denote the order of lags in $\Psi_{i1}(L)$ and $\Psi_{i2}(L)$; and $\hat{\Psi}_{i0}$, $\hat{\Psi}^m_{i1}$, $\hat{\Psi}^r_{i2}$ and $\hat{e}_{it}$ are the least square estimates. The FPE, as operationalized by Akaike is

$$\text{FPE}_{\text{pi}}\,(n, r) = \frac{T+n+r+1}{T-n-r-1} \sum_{t=1}^{T} (p_{it} - \hat{p}_{it})^2/T \tag{4}$$

where T is the number of observations; and the chosen model associated with a particular p_i is the one that yields the smallest FPE.

By choosing the lag structure with minimum FPE, Akaike's criterion tries to balance the bias from choosing too small a lag order against the increased variance from a higher order specification. More specifically, the FPE is comprised of two components. The first component is due to the FPE of the best linear prediction for given n and r, while the second component is due to the statistical deviation of $\hat{\Psi}^n_{i1}(L)$ and $\hat{\Psi}^n_{i2}(L)$ from $\Psi^n_{i1}(L)$ and $\Psi^r_{i2}(L)$ (L). Generally, as n and r are increased, the first component decreases whereas the second component increases for a finite number of observations of money and industrial output. The procedure of selecting the minimum FPE is equivalent to applying an appropriate F test with varying degrees of significance levels. If $FPE_{pi} < (n, r)$ $FPE_{pi}(n + q, r + s)$, we choose (n, r) rather than $(n + q, r + s)$ as the orders of lags for $\Psi_{i1}(L)$ and $\Psi_{i2}(L)$. This is equivalent to choosing (n, r) of the following approximate F statistic:

$$F(q + s, T - n - r - q - s - 1)$$

$$= [Q_{pi}(n, r) - Q_{pi}(n+q, r+s)\,(T-n-r-q-s-1)/(q+s)] < 2T/(T+n+r+1) \qquad (5)$$

where

$$Q_{pi}(n, r) = \sum_{t=1}^{T} (p_{it} - \hat{\Psi}_{i0} - \hat{\Psi}^n_{i1}(L)\, m_t - \hat{\Psi}^r_{i2}(L) y_t - \hat{e}_{it})^2].$$

On the other hand, we would choose $(n+q, r+s)$ for $\Psi_{i1(L)}$, $\Psi_{i2}(L)$ if the inequality is reversed. As T goes to infinity, the critical point of the approximate F statistic approaches 2.[8]

The major difference and advantage of using the FPE statistic over the conventional hypothesis testing procedure is the choice of the significance level. The conventional choice of 5% or 1% significance level is ad hoc. The FPE decision is based on an explicit optimality criterion or minimizing the mean squared prediction error. It removes us from the ambiguities of the conventional procedures.

To review the procedure, based on Granger's definition of causality, Akaike's concept of final prediction error (FPE), and the sequential testing procedure introduced by Hsiao, we can determine the optimal lag structure of each variable in the system.[9] In short, the preferred model is the one which yields the smallest FPE.

II. DATA AND THE EMPIRICAL RESULTS

Recall that money held by industrial enterprises is proxied by industrial deposits. The latter appear in the supplementary tables in the *Monthly Assets and Liabilities* tables published by the People's Bank of China. Data on the value of industrial output can be found in the *Chinese Statistics Monthly* published by the State Statistics Bureau. The sample period covered in this analysis spans January 1980 to July 1988.

Our analysis in this study will be conducted in nominal terms only. First, there is

TABLE 1. FPEs for Univariate Autoregressive Models of Money and Output: 1980(1) to 1984(6)

*Order of Lag**	*Money*	*Output*
1	3.9719 (× 10^{-4})	3.0188 (× 10^{-3})
2	4.1987	2.2228
3	4.3218	2.3571
4	4.5865	2.4462
5	4.8441	2.5234
6	4.7814	2.6738
7	4.8655	2.8444
8	5.0410	3.0282
9	5.2733	2.9463

Note: *The maximum order of lag in the univariate analysis is set at 9 to capture any potential seasonal variations.

no monthly price index for the output variable. Second, most previous studies on the relationship between money and income [e.g., Sims (1972) and Hsiao (1979)] are based on nominal magnitudes. Third, it has been shown [e.g., Chan, Cheng, and Deaves (1991)] that published price indices in China mask true inflation and are hence unreliable.

As indicated earlier, the empirical analysis is done for two different subperiods, so as to enable us to grasp and identify any potential structural changes subsequent to the monetary reform of 1984. Thus we divide our entire sample into a pre-monetary reform subperiod stretching from January 1980 to June 1984 and a post-reform period from July 1984 to July 1988. This demarcation of the sample into pre- and post-monetary reform periods will not only allow us to avoid potentially biased results due to possible structural changes, but will also allow us to examine the causal relationship between these two variables under different economic regimes.

Univariate results for both enterprise money and industrial output for the pre-reform period are presented in Table 1. It is evident that the lag structure for money which minimizes FPE occurs for $AR(1)$, with the corresponding FPE value being 3.97196×10^{-4}. For industrial output, the minimum FPE occurs at AR(2) with a corresponding FPE of 2.2228×10^{-3}. In each case, the next step is to maintain this lag, and then to introduce the other (manipulated) variable at different lags. First, based on the univariate results, we maintain AR(1) when money is the controlled variable, and introduce different lags for industrial output as the manipulated variable. This is the sequential procedure for testing causality as introduced by Hsiao. In essence, we are trying to examine if, after introducing the manipulated variable, this bivariate process has helped to reduce the minimum FPE established under the univariate process. The results of the bivariate analysis for both money and output are presented in Table 2. It is clear from our empirical results that, by introducing industrial output in the money

TABLE 2. FPEs for Bivariate Models of Money and Output with Controlled and Manipulated Variables: 1980(1) to 1984(6)

Order of Lags of the Manipulated Variables*	*Money as Controlled Variable Set at AR(1)*	*Output as Controlled Variable Set at AR(2)*
0	4.1474 × (10^{-4})	<u>2.1937</u> × (10^{-3})
1	<u>3.5708</u>	2.3251
2	3.7784	2.3416
3	3.7958	2.4855
4	3.7312	2.5780
5	3.9691	2.7237
6	4.0424	2.6310
7	3.9161	2.4994
8	4.0338	2.6477
9	4.2863	2.6183

Note: *The manipulated variable in the money equation is output, and in the output equation the manipulated variable is money.

equation, the value of the minimum FPE (3.5708 × 10^{-4}) is lower than that of the univariate process (3.9729 × 10^{-4}). This result confirms our prior expectation that industrial output helps to explain movements in money. Similarly, when money is used as a manipulated variable to explain the movements of output, it is found that the minimum FPE falls to 2.1937 × 10^{-3} relative to the univariate result of 2.2228 × 10^{-3}.

This set of results reveals to us that during the pre-monetary reform period there is two-way instantaneous causality behavior exhibited in the money-industrial output relationship. This is broadly consistent with the results of Portes and Santorum (1987) and Chen (1989). It is, therefore, important to incorporate this finding in any modelling of these two variables. The only proper way to estimate the stochastic processes governing these two variables during this time is to treat them as a system of simultaneous equations.[10]

More important than the technical confirmation of proper estimation procedures is the economic implications associated with these results. Since it is clear from our analysis that during the pre-monetary reform period both money and industrial output were variables that had an impact on each other, it seems that the monetary authority was adopting an accommodating stance, but, at the same time, money's ability to act as an input in the productive process played an important role.

Next we turn to the post-monetary reform period. Following the same methodology as outlined for the pre-reform analysis, the minimum FPEs under the univariate analysis are 8.646 × 10^{-4} and 6.511 × 10^{-4} for the money and industrial output equations respectively. (The FPEs under different univariate lag structures are listed in Table 3.) In the bivariate analysis (reported in Table 4), it is found that using output as a manipulated variable in the money equation results in a minimum FPE of 8.655 × 10^{-4} which is greater than the minimum FPE under the univariate AR money equation. This

TABLE 3. FPEs for Univariate Autoregressive Models of Money and Output: 1984(7) to 1988(7)

*Order of Lag**	*Money*	*Output*
1	8.8810 (× 10^{-4})	6.5488 (× 10^{-4})
2	8.6461	6.5105
3	9.0076	6.7808
4	9.3758	6.7891
5	8.9898	7.0436
6	9.3633	7.2295
7	9.7611	7.4787
8	10.0088	7.7095
9	10.3453	7.8581

Note: *The maximum order of lag in the univariate analysis is set at 9 to capture any potential seasonal variations.

means that industrial output does not cause money in the Granger sense. On the other hand, the bivariate result for the industrial output equation using money as a manipulated variable produces a minimum FPE of 5.618 × 10^{-4}, which is much lower than the minimum FPE for the univariate AR industrial output equation. Thus money does cause industrial output in the Granger sense.

These results indicate that when estimating equations for money and industrial

TABLE 4. FPEs for the Bivariate Models of Money and Output with Controlled and Manipulated Variables: 1984(7) to 1988(7)

Order of Lags of the Manipulated Variables*	*Money as Controlled Variable Set at AR(2)*	*Output as Controlled Variable Set at AR(2)*
0	8.7661 (× 10^{-4})	5.9685 (× 10^{-4})
1	8.7934	6.0736
2	8.9481	5.9856
3	9.1794	6.1558
4	9.3849	6.3640
5	8.9732	5.6184
6	8.6546	5.7645
7	9.0035	5.9783
8	8.9710	5.8866
9	9.3029	5.9191

Note: *The manipulated variable in the money equation is output, and in the output equation the manipulated variable is money.

output, we need not use simultaneous equations. As for the monetary process in effect at the time, it is apparent that, subsequent to monetary reform, money is best viewed as an input in the production process. In some small way, the results show that a more traditional market-oriented economic environment did begin to materialize during the post-reform period. Therefore our results resemble previous findings for market economies when studies of the relationship between money and income at the macro level were undertaken.

III. CONCLUSION

Our study has borrowed the fairly well-established procedure of causality testing based on Granger's definition of causality, Akaike's concept of final prediction error, and Hsiao's sequential testing procedures. We show that in China during the pre-monetary reform period, industrial output and industrial money exhibit bidirectional causality. It is likely that the monetary authority's proclivity towards accommodation and the fact that industrial money can be viewed as an input in the process of production both played a role. During the post-reform period, however, the causal relationship between these two variables is established in such a way that only money affects output, but not the converse. This finding, and what it implies for exogeneity of the variables, is very similar to what we would anticipate in a market-oriented economy.

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NOTES

1. When nominal income was used in the tests, they encountered autocorrelation and misspecification problems.
2. Also, it is not possible to separate currency balances held by enterprises from those held by consumers and other agents.
3. This is, of course, the standard transactions motive. The precautionary motive reflects uncertainty in future cash transactions. The speculative motive of Keynes is viewed by most as being inconsequential in today's world with its multitude of liquid short-term interest-bearing assets.
4. This perspective has recently been taken by Sarwar, Dhaliwal, and Yanagida (1989) for the U.S. agricultural sector.
5. This is especially so prior to 1979.
6. See Li Chengrui (1981) for a description of the process.
7. Readers that are not familiar with the Granger definition of causality could refer to Granger (1969) for definitions and discussions on causality, feedback and instantaneous causality.
8. In other words, with (n, r) as the lags of the maintained hypothesis, the F-statistic for lags $(n+q, r+s)$ would be equation (5).
9. Interested readers should consult Hsaio (1979) for a detailed discussion on the sequential optimization procedure using the concept of final prediction error.
10. Thus one can use full-information maximum likelihood estimation.

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