Engle, R.F. and Granger, C.W.J. (1987), 'Co-integration and error-correction: representation, estimation and testing', *Econometrica* 55, 1251–1276.

Godfrey, L.G. and Poskitt, D.S. (1975), 'Testing the restrictions of the Almon lag technique', *Journal of the American Statistical Association* 70, 105–108.

Himarios, D. (1989), 'Do devaluations improve the trade balance? The evidence revisited', *Economic Inquiry* XXVII, 143–168.

Johansen, S. (1988), 'Statistical analysis of cointegration vectors', *Journal of Economic Dynamics and Control* 12, 231–254.

Johansen, S. and Juselius, K. (1990), 'Maximum likelihood estimation and inference on cointegration – with applications to the demand for money', *Oxford Bulletin of Economics and Statistics* 52, 169–210.

Krugman, P.R. and Baldwin, R.E. (1987), 'The persistence of the U.S. trade deficit', *Brookings Papers on Economic Activity* 1, 1–43.

Mann, C.L. (1986), 'Prices, profit margins and exchange rates', *Federal Reserve Bulletin* 933–948.

Miles, M.A. (1979), 'The effects of devaluation on the trade balance and the balance of payments: some new results', *Journal of Political Economy* 87, 600–620.

Nelson, C. and Plosser, I.C. (1982), 'Trends and random walks in macroeconomic time series', *Journal of Monetary Economics* 10, 139–162.

Osterwald-Lenum, M. (1990), 'Recalculated and extended tables of the asymptotic distribution of some important maximum likelihood cointegration test statistics'. Institute of Economics, University of Copenhagen.

Philips, P.C.B. (1987), 'Time series regression with unit roots', *Econometrica* 55, 277–301.

Reynolds, B.L. (1987), 'Trade, employment, and inequlaity in postreform China', *Journal of Comparative Economics* 11, 479–489.

Rose, A.K. and Yellen, J.L. (1989), 'Is there a *J*-curve?', *Journal of Monetary Economics* 24, 53–68.

Said, E. and Dickey, D.A. (1984), 'Testing for unit roots in autoregressive moving average models of unknown order', *Biometrika* 71, 599–607.

Schwert, G.W. (1987), 'Effects of model specification on tests for unit roots in macroeconomic data', *Journal of Monetary Economics* 20, 73–103.

World Bank (1990), *China: Between Plan and Market* Washington: World Bank.

Economics of Planning **26**: 243–270, 1993

Towards Estimating the Demand for Money in China

GANG YI
Department of Economics, Indiana University, 425 University Blvd., Indianapolis, IN 46202-5140 U.S.A.

Abstract

The demand for money in China is estimated separately for the periods before and after the economic reform. Besides the traditional transactions demand variable, the expected rate of inflation (as a measure of the opportunity cost of holding money) and the monetization process are also incorporated into the demand function. The preliminary results show that the demand for money in China has changed in response to the institutional changes during the economic reform. Adding the monetization and inflation expectation variables into the money demand function has enhanced significantly its explanatory power.

1. Introduction

There are a number of articles in the recent literature that discuss various aspects of the monetary and banking systems in China: money demand (Chow, 1987; Szapary, 1989), inflation (Feltenstein and Farhadian, 1987; Perkins, 1988; Yi, 1990b), liquidity overhang and monetization (Feltenstein and Ha, 1991). The present paper estimates the demand for money in China using annual data for the period 1952–1989 and quarterly data for the period 1983–1989. The objective is to find money demand models that would be capable of reflecting the profound institutional changes in the money and banking sector during the economic reform in the 1980s.

The value which this paper adds to the literature is the following. First, the important characteristics of the demand for money in China are discussed. These 'Chinese characteristics' originate from the unique aspects of the Chinese system: a centrally planned, underdeveloped economy. Second, it is shown that the demand for money has changed profoundly during the reform. The monetization process, the establishment of the central bank, and the rapid growth of the private sector provide enough evidence to justify that the demand for money should be estimated separately for the periods before and after the reform. Third, the money demand functions are derived for the semi-reformed economy. Besides the traditional transactions demand variables (Chow, 1987), the expected rate of inflation (as a measure of the opportunity cost of holding money) and the monetization process are also incorporated into the

demand function. As a result, the explanatory power of the money demand equation has increased significantly. Although this paper focusses on China only, the problems addressed here are quite common to other centrally planned and/or developing economies.

Section 2 of this paper discusses some important characteristics of the demand for money in a centrally planned, developing economy. Section 3 argues that the money demand function has changed in response to the institutional changes during the reform. Section 4 explains the data set used in this paper. Section 5 derives the money demand functions and presents the estimation results. Section 6 offers a brief summary.

2. Some problems related to the demand for money in China

In macroeconomics the demand for money is derived from utility and profit maximization of economic agents. In the case of China some assumptions of the maximization process might be questionable. In this section we address some important issues related to the money demand in China. These problems are either deeply rooted in a centrally planned system or in the intrinsic aspects of a developing economy.

2.1. The lack of financial securities

The concept of demand for money is well defined when people have alternative ways to invest or store their wealth. In the West the demand for money means people's willingness to hold money instead of bonds, stocks, real estate and other types of investment. In China most of these investment alternatives are either unavailable or insignificant, except that most farmers invest a large proportion of their wealth in constructing houses in rural areas. Financial and real estate markets in China are at a very primitive stage. By the end of 1989 the total amount of bonds (including government bonds, key project bonds, local enterprise bonds and all other bonds) was 110.5 billion yuan. The total amount of outstanding stocks (the book value, not the market value) was 4.16 billion yuan. The sum of bonds and stocks was only about 10% of M2, which was 1092.0 billion yuan at the end of 1989 (*Statistical Yearbook of China*, 1990). Obviously, cash and bank deposits are the primary ways to hold financial assets for consumers and firms. However, bonds and equity stocks appear to be gaining as a percentage of the total financial asset holdings.

Does the concept of demand for money make sense, in the face of few other financial securities? To answer this question let us assume, for simplicity, that only two assets exist: money and commodities–no securities (this assumption is close to the reality in China and other centrally planned economies). In these circumstances the traditional theory of demand for money–such as the transactions and precautionary demand for money–are still valid. A typical consumer faces the decision of how to allocate his wealth between money and consumer goods. The transaction demand for money is a function of income and the precautionary demand is a function of the interest rate or some other measure of the opportunity cost of holding money. The fact that money is the only financial asset does not spoil the analysis as long as people have consumer goods as an alternative. The lack of financial securities becomes problematic when consumer goods are not available and there are forced savings.

2.2. Are there forced savings and a monetary overhang in China?

Feltenstein and Ha (1991) have estimated the extent to which the price level was repressed in China and have shown that the decline in observed income velocity of money was due to involuntary savings by households. They constructed a 'true' price index, by which they were able to demonstrate that the 'true' velocity of money is statistically constant. By the end of 1988 the true price index was 114 percent higher than the official index, assuming that the two were equal at the beginning of 1979. They concluded that there was a monetary overhang in China in the sense that excess money was being held by households over the nominal value of transactions. Consequently there were repressed inflation and forced savings.

The results derived by Feltenstein and Ha are not surprising, except for the fact that the monetization factor is not significant. If we do not believe the official price index, and postulate that the 'true' price is higher, we would get similar results. However, other studies indicate that it is premature to conclude that there is a persistent shortage in the consumer goods market in China (Portes and Santorum, 1987).

Here we argue that, although forced savings existed to different degrees over the period under study, we are leaning in the direction of not using the forced saving argument to explain the bulk of the changes of the broad money for two reasons. First, before the reform, the money supply was tightly controlled. The low incomes, combined with high job security, gave households little incentive to save. People did not have much to save to begin with, even if they wanted to. The average saving rate as a percentage of households' income was less than 5% on average for the period before the reform (Qian, 1988; Bei, 1989). Notice that the domestic saving rate as a percentage of the national income was very high: 27.8% on average for the period 1952–1978. Most of the savings were directly from the government. There was hardly any 'monetary overhang' before the reform, except for the period 1959–1961, and the price level was frozen stable. Second, since the economic reform started

in 1979, household saving has become more and more important. At the same time, the consumer goods markets have been in a relatively good shape; it is hard to argue that the bulk of the rapidly increase of the household savings are forced. In this regard one observation is worth mentioning here: since the economic recession and sluggish market started in the third quarter of 1989, most consumer durable goods became available at 1988 prices or lower, but the demand was still stagnant until the first quarter of 1991. The official inflation rate for 1990 was only 2.1%. Household savings have soared continuously in the 1989–1990 period. It is safe to say that these savings are voluntary rather than forced. This suggests that whether the savings are forced or not largely depends on people's expectations of the future price level.

2.3. *Which price index should be used: official or market?*

Generally speaking, the demand for money refers to the demand for real money balances. We then have to consider the problem of which price index should be used to convert nominal money into a real balance. Some different conclusions in the literature (e.g. Feltenstein and Ha, 1991; Szapary, 1989) can be explained as the results of using different price indices.

There are many price indices in China; among them the general retail price index and the free market price index are commonly used. For convenience, we adopt the terms which are widely used in the literature–calling the former the official price index (OPI) and the latter the market price index (MPI)–although both of them are calculated and published by the State Bureau of Statistics, an official organ under the State Council.

The OPI is calculated as a weighted average of the official prices, negotiated prices, and market prices. The advantage of the official price index is that it is calculated on a broad basis. For example, in 1988 the official general retail price level was calculated from samples drawn from more than 14 000 grassroots markets of 420 counties or cities over the entire country. The samples contained almost every important retail commodity, and the final general retail index was computed by four rounds of weighted averages at different levels (*People's Daily*, 4/7/1988). However, there is no doubt that the official price index underestimates the price level for the following reasons. First, the weights used in the OPI are biased in favor of the state-owned commerce. The bulk of the OPI is calculated from the official prices, a great proportion of which are prices under the rationing system that do not reflect the true price level faced by the consumers. Second, in the sampling process, the local government agencies that are in charge of selecting samples from grass roots markets have the incentive to underreport their price level because the inflation rates of provinces and cities are computed at the same time. Local governments want to show that they have done a good job in controlling the inflation in their localities. This observation is supported by many independent studies from different angles (Feltenstein, Lebow and Van Wijnbergen, 1990).

Obviously, the advantage of the market prices is that they are determined by demand and supply. However, there are two shortcomings of the free market price index. First, it is not as broadly based as the official price index. Most commodities in well-established, large-scale free markets are agricultural and light industrial products. Second, it tends to overestimate the price level due to the coexistence of the government-run commerce. For example, suppose that there are 100 color TVs available, and 90 are distributed through the government-controlled commerce at a low price plus a rationing coupon. The remaining 10 are sold in a free market. Then it is easy to see that the free market price is higher than the price in the scenario wherein all 100 TVs were sold in the free market, which would be the ideal case for measuring the true price level. Although both official and market price indices have their own limitations, at least they provide two polar cases.[1] The real price level should be somewhere in between. A natural alternative is to create a mixed price index, which is a weighted average of the two price indices. Of course the weights are different from time to time. Generally speaking, at the early stage of the reform, the official price index should be given a larger weight. As the reform progresses, the market price index should be more and more important. A mixed price index is constructed in Appendix A.

When we estimate the demand for money of China we should keep the above 'Chinese characteristics' in mind. Furthermore, it is also necessary to consider the institutional changes brought by the economic reform in the 1980s, which will be discussed in the next section.

3. The changes in the money and banking sector during the reform

In this section we argue that the demand for money in China has changed significantly in the 1980s due to the economic development and institutional changes during the reform. Consequently, the demand for money function should be estimated separately for the period before and after the reform. So far, many systematic econometric studies have been made of the Chinese economy at the aggregate level. While all of them revealed some truth, they have a common shortcoming–their econometric models are not estimated separately for the periods before and after the reform.[2] If the above claim is valid, then we have to reconsider the econometric results that pool the data in both periods. This is a typical example of Lucas' (1976) critique. It shows that it is crucial to take economic development and institutional changes into full account in building economic models.

Although a book could be written to document the profound changes of the economic system during the reform, as far as the demand for money is concerned the following three points are important to consider. They are the monetization process, people's inflation expectations and the establishment of the central bank. Let us discuss them in order.

3.1. *The monetization process in China*

In a developing country like China the economy can be decomposed into two parts: monetized and nonmonetized. When we consider the demand for money in China there is an extra demand for money caused by the monetization process, besides the regular transaction and precautionary demand. The term 'monetization' refers to the process in which the proportion of economic activities conducted by money (using money as the medium of exchange) increases. As an economy develops not only does the total output increases, so too does the proportion of the monetized economy. Consequently, money supply should increase not only in proportion to the growth of the economy, but also to accommodate the newly monetized sectors. With this in mind, we can define the real total national income as $y = \lambda y + (1 - \lambda)y$, where λ is the proportion of the monetized economy. Subsequently, the appropriate version of the exchange equation for the partially monetized economy should be

$$MV = \lambda yP \tag{1}$$

where M is nominal money supply, V is the income velocity and P is the general price level. Taking the natural log of Equation (1) and differentiating, we get

$$\dot{M} + \dot{V} - \dot{y} - \dot{\lambda} = \dot{P} \tag{2}$$

where all the dot notations in (2) represent the growth rates of the corresponding variables.

If we assume that the velocity is constant (i.e., $\dot{V} = 0$), then the price level increases only when $\dot{M} > \dot{y} + \dot{\lambda}$; that is, when the money supply growth is greater than the sum of the income growth and the growth rate of the monetized economy. The decrease in income velocity in China can be explained, at least partially, by the monetization process. If we neglect the monetized process, the velocity is

$$V = Py/M \tag{3}$$

For China it is easy to show (using the data in Appendix B) that the income velocity defined by (3) decreased rapidly during the period

1978–1989. With the monetization taken into account, the velocity becomes

$$V^* = (P\lambda y)/M \tag{4}$$

Since $0 < \lambda < 1$ and is increasing, the income velocity defined in (4) has not decreased as rapidly as is calculated by (3).

The monetization process depends primarily on two factors—the degree of economic development, and the institutional or structural change of the economy. In the case of China, both of these factors are changing. There are many alternative ways to estimate λ, the proportion of the monetized economy. Unfortunately none of them is very systematic. After all, in a developing country the economic growth and monetization are interwoven together. It is difficult to have a precise measure of the monetization process.[3]

Yi (1991) presents a detailed, sector-by-sector analysis of the monetization process in China. His results suggest that the Chinese economy was monetized rapidly during the period 1979–1985, as the introduction of the responsibility system in the agricultural sector, and the proliferation of private businesses and township and village enterprises engendered an extraordinary demand for currency. Consequently, most of the excess money was absorbed by the newly monetized economy and inflation was moderate in this period. However, since 1985 the monetization process has slowed down significantly. The economy could no longer absorb the excess money. The excess money supplies above and beyond the growth rate of the real GNP have mainly resulted in inflation.

3.2. *Estimating inflation expectations*

In a traditional money demand model the interest rate serves as an explanatory variable to measure the opportunity cost of holding money. The interest rates in China have not reflected the opportunity cost of holding money because they were fixed at an arbitrary level that was below market equilibrium rates. One alternative is to use the expected rate of inflation as a measure of the opportunity cost of holding money.

Figure 1 shows the natural log of the official and market price indices for the period 1952–1989. From Figure 1 we can see that the official retail price level had been virtually frozen during the period 1952–1978. The market price level was also relatively stable before the economic reform, except for the period 1960–1963. It is fair to say that the inflation rate was extremely low before the reform. Since the economic reform started, the Chinese economy has been haunted by rampant inflation.

A detailed discussion on inflation in China is available in Perkins (1988), Naughton (1991), and Yi (1990b). Here it is worth emphasizing

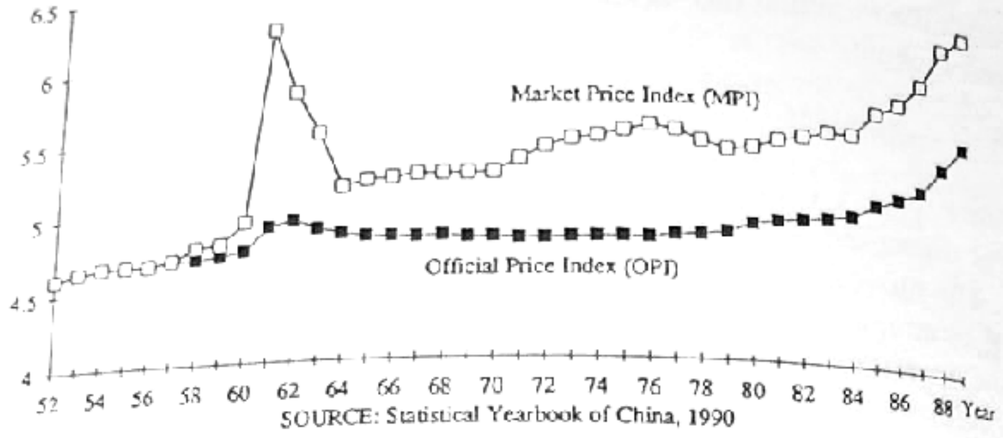


Fig. 1. The log of the official and market price indices (1952 = 100).

two points. First, inflation is not only an economic problem but also a political problem in China. The older generation (who are now policy makers) still vividly remember the hyperinflation in the period of 1947–1949, which certainly contributed to the demise of the Nationalist government. While a 20% inflation rate may be acceptable for some developing countries, it is definitely not in China. Second, inflation and inflation expectations significantly influence the demand for money of households and firms. In 1988 inflation (officially 18.5%) in China caused panic buying and hoarding by both households and firms, which resulted in a dramatic decrease in bank deposits (2.6 billion yuan) during August of 1988.

Since the interest rate has been virtually fixed and inflation expectations are an important factor that influence the demand for money, it would be natural to include the inflation expectation as an explanatory variable in the money demand equation. However, there is no consensus on how people form their inflation expectations, even in the most developed economies of the West–let alone in China, where the economic mechanism is mixed and keeps changing. Yi (1990a) has classified different expectations hypotheses into three general categories: *ad hoc* expectations, rational expectations, and autoregressive process expectations. He estimates and evaluates various ways of forming inflation expectations using annual data from China and concludes that the rational expectation model and the second-order autoregressive process out perform other expectation hypotheses in terms of prediction errors. He also finds that the static expectation (Turnovsky, 1977)

$$\pi_t = P_{t-1} \tag{5}$$

also performs fairly well in terms of prediction error, where π_t is the expected rate of inflation and P_{t-1} is the expected rate of inflation and P_{t-1} is the actual inflation rate in the previous period.

3.3. *The establishment of the central bank*

The establishment of the central bank and the reserve system in 1984 brought fundamental changes to the money and banking sector in China. Before the reform the money supply was basically endogenously determined. Money was an accounting tool to accommodate the physical allocation of resources. After the establishment of the central bank and the reserve system the money supply process has gradually become a money creation mechanism through the multiplier effect. The central bank tries to tune the macroeconomic condition by controlling the money supply. It is obvious the central bank's control through monetary policy works only when households' and firms' demands for money are responsive to the change of policy instruments (such as interest rate). These changes have certainly influenced the money demand in China. Before the estimation of the money demand equation we will first describe the data set to be used in the next section.

4. Data

The amount of economic information available from China has increased exponentially in recent years. However, due to the difference in economic systems and the statistical measures, the Chinese economic data need to be explained before econometric modeling. There are roughly three main sources of data: Chinese official sources, the International Monetary Fund (IMF), and data sets collected by different authors. As far as the money and banking sector is concerned, examples of authoritative publications of the first type are *Statistical Yearbook of China*, and *Almanac of China's Finance and Banking*; an example of the publications from the second source is *International Financial Statistics*; examples of the third source are Chow (1987), Chen (1989). Given the multiplicity of data sources and their disparate measurement techniques, it is common to see different authors use different measures for the same variable in both Chinese and Western literature. In this section we define and explain the data set used in this paper. While experts may not agree with our definition, at least it is clear how the variables used in this paper are defined and measured.

Figure 2 illustrates th natural log of the real per capita broad money, M2, deflated by the official and market price indices, respectively. M2 is calculated from the balance sheet of the consolidated (government) banks published by *Almanac of China's Finance and Banking* by the following formula:

M2 = (All deposits + Currency in Circulation − the central government's deposits)

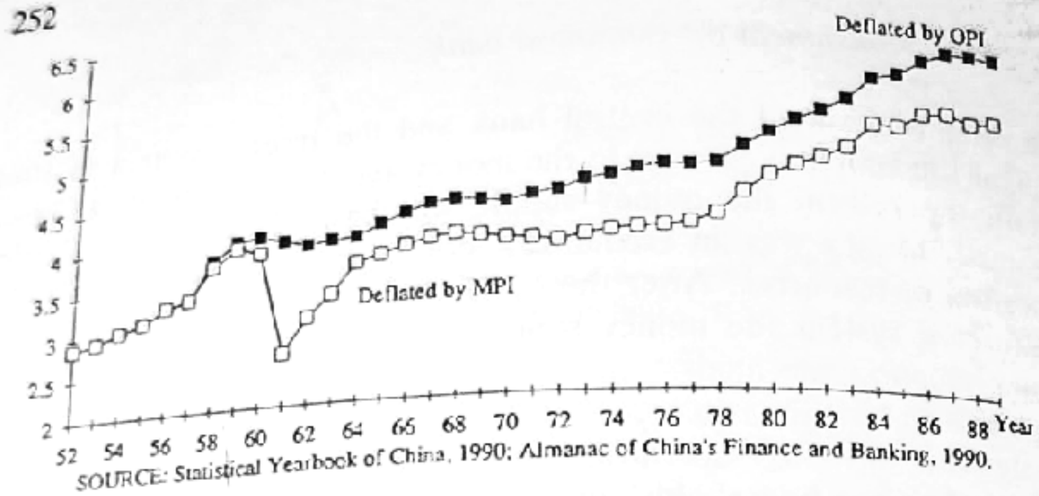


Fig. 2. The log of the real per capita M2 (in 1952 yuan).

Notice that M2 does not include the financial activities of rural savings and loan co-ops. The advantage of this M2 measure is that data are available from 1952. Other measures of broad money might be the 'money plus quasi-money' series published by IMF in *International Financial Statistics*. The problem with the IMF broad money series is that it has been available only since 1977. Another M2 series is published by *Almanac of China's Finance and Banking*, but it has reported data only since 1985.

Figure 3 displays the natural log of the real per capita national income, deflated by the official and market indices, respectively. Per capita national income will be used as an explanatory variable in the money demand equation to measure the transaction demand for money. An alternative measure would be per capita gross national product (GNP), which is available since 1978.

The proportion of urban population is shown in Figure 4 and will be used as a proxy of the monetization process. Figure 5 demonstrates the nominal seasonally adjusted per capita M2 and retail sales for the period 1983,1–1989.4. The seasonal effect is eliminated by dividing the original

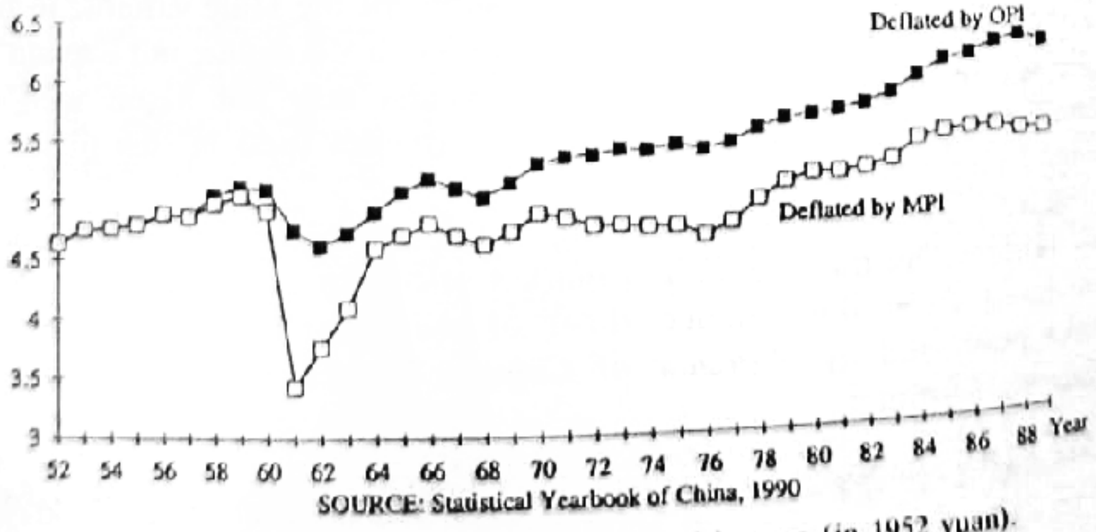


Fig. 3. The log of the real per capita national income (in 1952 yuan).

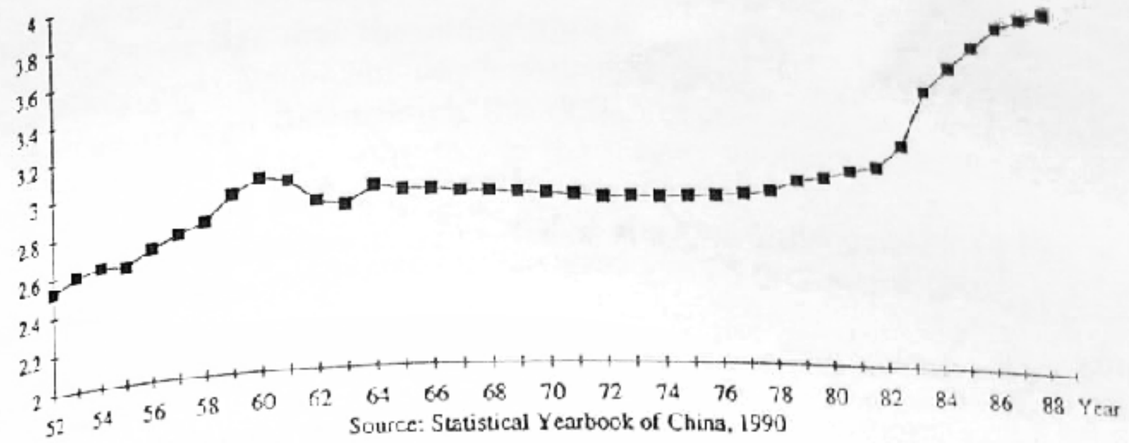


Fig. 4. The log of the percentage of urban population 1952–1989.

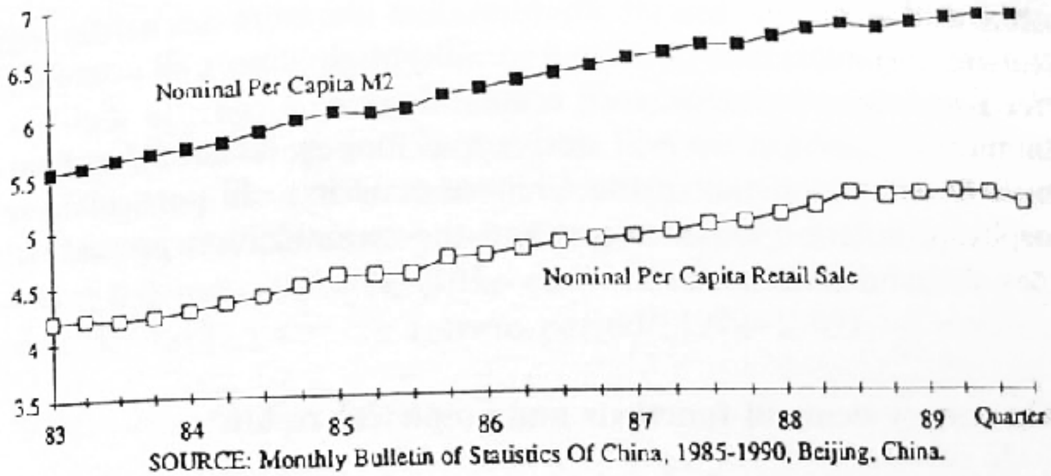
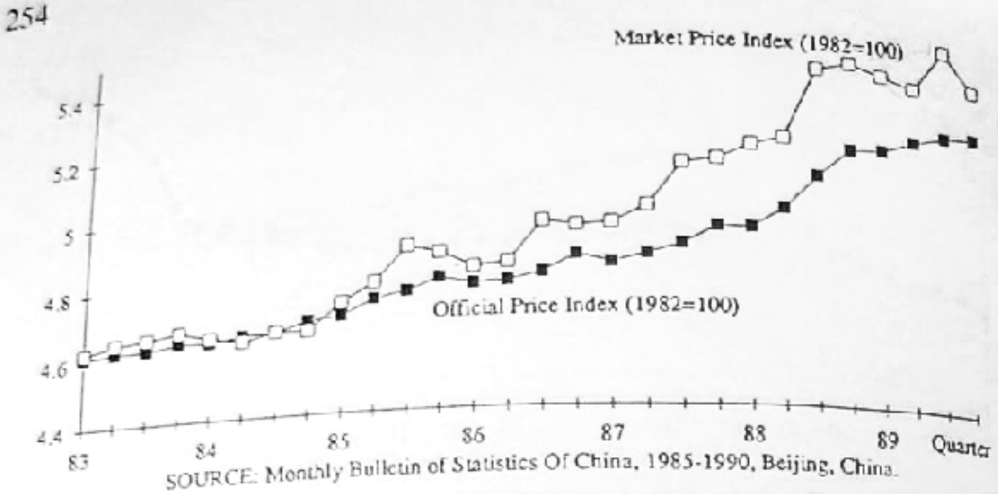


Fig. 5. The log of the nominal per capita M2 and retail sales, seasonally adjusted quarterly data, 1983.1–1989.4.

series by the seasonal index (Newbold, 1984), which are 98.84, 97.83, 97.57, 105.75 for the M2 series, and 102.47, 97.36, 93.86, 106.31 for the retail sales, respectively. The retail sales is used in the money demand equation for the price 1983.1–1989.4, because quarterly data on national income are not available and the estimation of quarterly national income is an *ad hoc* and tedious process due to the calculations of the added value of the agricultural sector. Figure 6 provides the log of the quarterly official and market price indices for the period 1983.1–1984.4. All the data used in Figures 1–6 are provided in Appendix B.

Although significant progress has been achieved in the data collecting process, the limitations of data are still obvious and remain one of the most difficult obstacles of empirical research on China. The data used in this paper are the best data available and their definitions are given explicitly. Problems such as seasonal effects, nonstationary series, conversion from the monthly data to quarterly data have been carefully addressed, and will be discussed in detail in the next section when the empirical results are presented. Notice that the implication of potential



SOURCE: Monthly Bulletin of Statistics Of China, 1985-1990, Beijing, China.

Fig. 6. The log of the official and market price indices (1982 = 100).

problems due to the use of an imperfect measure of a true variable (errors in variables) is applicable here, although almost all economic data suffer from these problems to a certain degree.

In the next section we will derive the money demand functions that reflect the characteristics of the Chinese economy. In particular, we will incorporate inflation expectations and the monetization process into the money demand functions.

5. The money demand functions and empirical results

'The important consideration for money theory and policy is whether the demand for money can be treated as a reasonable stable function of a fairly small number of variables and whether this function can be empirically specified with reasonable accuracy'. Friedman (1966) made the above eminent comment twenty-five year ago, the main point of which can still serve as the guideline of estimating the money demand in China today.

In the next section we first discuss alternative money demand models based on the theoretical exposition of the previous sections. Then we estimate the money demand functions by using annual data for the period of 1952–1989 and quarterly data for the period 1983–1989.

5.1. Deriving the money demand models

The discussion of Section 2 suggests two points. First, the lack of financial securities does not spoil the analysis of the money demand, provided that people have consumer goods as an alternative. Second, there has been no persistent forced saving for the period under study. Consequently we assume, by and large, that the money demand is equal to the money supply. Therefore, the models discussed below are more or less equilib-

rium models rather than disequilibrium models.[4] The discussion of Section 3 indicates that the monetization process and inflation expectations were most significant developments during the reform and played important roles in determining the demand for money in China. These two factors will be incorporated in the money demand models in such a way that they can be estimated.

With these discussion in mind, let us start with the simplest version of the exchange equation:[5]

$$MV = Py \tag{6}$$

or alternatively,

$$m = (1/V)y = kY \tag{7}$$

where y is the real national income, $m = (M/P)$ is real money balance and $k = (1/V)$ is the Cambridge k. Notice that the exchange equation is true for both aggregate and per capita data. If k is constant, then it is easy to show that the income elasticity for real money balance is equal to 1. To test whether the income elasticity is equal to unity or not, we have our first model, which is derived by taking the natural log of equation (7) and adding a dummy variable at the end to distinguish the before reform period (1952–1978) from the reform period (1979–1989).

$$\textit{Model I}: \quad \ln(m) = C + \ln(y) + D \tag{8}$$

where ln is the natural log, $C = \ln(k)$, and D is the dummy variable. If we believe that the modified exchange Equation (1) is more appropriate, then we have

$$\textit{Model II}: \quad \ln(m) = C + \ln(y) + \ln(\lambda) + D \tag{9}$$

Equation (9) is similar to Equation (8), except that it has an additional variable, λ, which is the proportion of the monetized economy.

The most difficult task of estimating Equation (9) is to find a proper λ. There are two ways to tackle this problem. The first is to estimate λ. Because the monetization process is very complicated and many factors have been involved, it is extremely difficult to find an estimator that could mimic the entire monetization process of the whole country. Even if there is an acceptable formula it would be a formidable task to estimate it due to the data availability problem. The second way is to find an observable variable that can reasonably approximate λ. It is plausible to use the percentage of the urban population (UP) to approximate the monetization process, since it is generally accepted (Yi, 1991) that urbanization is highly positively correlated with the monetization process. However, one difficulty is that the term 'urban' was redefined in 1984. Therefore, the urban population series published in *Statistical Yearbook of China* is not

really consistent. Nonetheless, it is still one of the better proxies, since other series suffer from more or less the same problem. For simplicity we will use the percentage of urban population to approximate λ in this paper. Alternative measures that could represent the monetization process are the total volume of transactions in free markets, the number of free markets, the total retail sales by farmers to city dwellers, etc. The total value of transactions in free markets has also been used as a proxy of the monetization process in the money demand equation and the result of the estimation is qualitatively the same.[6]

We can regard Equations (8) and (9) as the conditional probability of the dependent variable given independent variables. In other words, there is an unobservable stochastic error term attached to each model.

5.2. *The estimation method*

In a provocative study, Nelson and Plosser (1982) find evidence that most macroeconomic time series behave like random walks. Plosser and Schwert (1978) also argue that with most economic time series it is usually better to work with differenced data rather than data in level. They show that the risk associated with an underdifferenced model is much larger than that of an overdifferenced model. To investigate whether the data used in this paper are random walks some kind of unit root test should be performed. From both visual inspection of the data plots and the reform experience in China, it is obvious that the structure of demand for money has changed since the reform. Perron (1990) suggests a test for a unit root in a time series with a changing mean, which allows a one-time change in the structure of the series at a time T_B: notice that $(1 < T_B < T)$, when T is the sample size. Part A of Table 1 reports the results of the Perron test. In our study the break point is chosen to be 1978, when the reform started. Hence, the ratio between T_B and T, λ, is equal to 0.73. The critical value (Perron, 1990) for $T = 50$ and $\lambda = 0.70$ at the 5 percent significance level is -3.39 for the distribution of t_α. Looking at t_α in Part A of Table 1, it is clear that we cannot reject to null hypothesis that there is a unit root for all the series under consideration at the 5 percent significance level. The standard Dickey–Fuller (1981) test is biased toward nonrejection of the hypothesis of a unit root when the full sample is used and there is a structural change. The correct way of using the Dickey–Fuller test is to test a series in which no structural changes is assumed. Part B of Table 1 provides the F statistic of the Dickey–Fuller test for the periods 1952–1978 (annual data) and 1983.2–1989.4 (quarterly data), respectively. Once again, the standard Dickey–Fuller test for the separate periods fails to reject the null hypothesis that the time series have a unit root. Recall that the critical values of the Dickey–Fuller test

Table 1. Testing for unit roots.

Part A: Perron's ful sample unit root tests with changing mean for 1952–1989 annual data.

Series (y_t)	$\hat{\mu}$	t_μ	$\hat{\gamma}$	t_γ	$\hat{d}$	t_d	$\hat{\alpha}$	t_α
M2O	0.38	2.94	0.16	2.64	0.03	0.36	0.92	−2.65
M2M	1.14	2.83	0.45	2.68	−0.10	−0.39	0.69	−2.74
NIO	0.51	1.47	0.09	1.34	−0.03	−0.28	0.90	−1.42
NIM	2.42	3.32	0.35	2.52	−0.12	−0.41	0.48	−3.31
ln(*UP*)	0.18	1.42	0.08	2.57	−0.03	−0.55	0.94	−1.37

Note: M2O = log of the real per capita M2 deflated by official price index; M2M = log of the real per capita M2 deflated by market price index; NIO = log of the real per capita national income deflated by official price index; NIM = log of the real per capita national income deflated by market price index; ln(*UP*) = log of the percentage of urban population.

The regression is: $y_t = \mu + \gamma D_t + d D(TB)_t + \alpha y_{t-1} + \Sigma_{j=1}^{k} c_j \Delta y_{t-j} + v_t$

where $D_t = 0$ if $t \leq T_B$ and 1 otherwise; T_B equals the year 1978 (the 27th observation), in which the change occurred; $T = 38$; $D(TB)_t = 1$ if $t = (T_B + 1)$ and 0 otherwise; $\Delta y_{t-1} = (y_{t-1} - y_{t-2})$ and $k = 1$. All the t statistics are for testing the null hypothesis that the parameter is equal to zero except t_α, which is the t statistic for testing the null hypothesis that $\alpha = 1$. The critical value for the distribution of t_α for $\lambda = 0.7$, $T = 50$ at the 5 percent significance level is -3.39 (Perron, 1990).

Part B: F statistics of the Dickey–Fuller test.

1952–1978 Annual data					
Time series	M2O	M2M	NIO	NIM	UP
$F(2, 21)$	4.16	6.25	7.02	4.16	2.89

1983.1–1989.4 Quarterly data					
Time series	M2O	M2M	NIO	NIM	UP
$F(2, 22)$	1.81	3.36	2.78	2.45	4.77

Note: The critical values for the Dickey–Fuller test are higher than the regular F test. The 5% critical values are 7.24, 6.73 for sample sizes equal to 25 and 50, respectively.

are higher than the commonly used F test. The 5% critical values are 7.24 and 6.73 for sample sizes equal to 25 and 50, respectively.

The results in Table 1 mean that we cannot reject the null hypothesis at the 5% level that they are random walks for all the time series data described above. On the contrary, the evidence strongly suggests that most time series under consideration behave like random walks (the estimated coefficient for the time trend is close to zero and the first order correlation coefficient is close to one). Since a random walk does not have a finite variance, a regression of one against another can lead to spurious results. The Gauss–Markov theorem would not hold and ordinary least squares (OLS) would not yield a consistent parameter estimator.

To mitigate the nonstationary nature of the data set, we use the general differencing approach (Box–Jenkins, 1976, transfer function model), which is analogous to generalized least squares (GLS). Harvey (1981) calls this method the two-step full transform method. For expository

purposes, we can rewrite the two money demand models, Equations (8) and (9), in the standard matrix form

$$y = X\beta + \epsilon \tag{10}$$

where y is the dependent variable, X is the design matrix, β is the parameter, ϵ is the error term and is assumed to have the first-order serial correlation structure. In the first step ordinary least squares (OLS) is applied to Equation (10) and the estimated error terms are obtained by $\hat{\epsilon} = y - Xb$, where b is the OLS estimate of β. The first order correlation coefficient of the error terms is estimated by an iteration process until it converges from the following equation

$$\hat{\epsilon}_t = \rho\hat{\epsilon}_{t-1} + v_t \tag{11}$$

where v_t is white noise. In the second step, the variance–covariance matrix of ϵ, $\sigma^2 W$, is computed and the GLS estimator

$$\hat{\beta} = (X'W^{-1}X)^{-1}X'W^{-1}y \tag{12}$$

is obtained. The GLS estimates, and the estimated first order correlation coefficient, $\hat{\rho}$, are reported in Tables 2, 3 and 4. The t-ratios of the regression coefficients are given in parentheses. If the estimated $\hat{\rho}$ is close to unity, then the above procedure and the first differencing approach should yield similar results. For all GLS estimates obtained in this paper, we can reject the null hypothesis that the residual term is non-stationary at the 5% significance level. In other words, it is highly likely that the residual terms for all the final money demand models are stationary.

5.3. *The demand for money, 1952–1989*

Table 2 summarizes the regression estimation results for the two models discussed above by using the annual data for the period 1952–1989. Each model is estimated by using the official, market and mixed (Appendix A) price indices as the deflator, respectively.

The following points can be observed from Table 2. First, Model I provides the first step approximation by using income as the only explanatory variable. In Model I the coefficients of income elasticity are close to unity, indicating that the growth of the real per capita income and the per capita money demand have increased at the same pace. The dummy variable, D, in Model I is significantly different from zero, suggesting that the demands for money are different for the periods before and after the reform.

Second, if we add the monetization factor into the model, then the income elasticity decreases (from about unity in Model I to about 0.75 on

Table 2. Estimation of money demand and function from annual data, 1952–1989.

Part A: Estimation of Model I (Equation 8)

Dependent variable	C	$\ln(y)$	D	R_2	DW	$\hat{\rho}^a$
M2O	−2.269	1.235	0.273	0.722	1.268	0.805
	(−2.59)	(7.42)	(1.95)			(7.91)
M2M	−0.397	0.864	0.419	0.791	1.322	0.793
	(−0.92)	(9.89)	(3.25)			(7.63)
M2W	−0.944	0.981	0.360	0.718	1.311	0.808
	(−1.46)	(7.88)	(2.68)			(8.01)

Part B: Estimation of Model II (Equation 9)

Dependent variable	C	$\ln(y)$	$\ln(UP)$	D	R^2	DW	$\hat{\rho}$
M2O	−2.365	0.719	0.949	0.185	0.814	1.285	0.802
	(−3.24)	(3.76)	(3.96)	(1.55)			(7.72)
M2M	−2.427	0.792	0.810	0.188	0.882	1.356	0.803
	(−4.65)	(11.76)	(5.01)	(1.75)			(7.75)
M2W	−2.327	0.752	0.869	0.164	0.824	1.340	0.826
	(−3.88)	(7.60)	(4.64)	(1.47)			(8.41)

Notation in Table 2: C = intercept; M2O, M2M and $\ln(UP)$ are defined as in Table 1; M2W = log of the real per capita M2 deflated by the mixed price index; $\ln(y)$ = log of the real per capita national income; D = dummy variable, $D = 0$ for the period 1952–1978, $D = 1$ for 1979–1989; R^2 = coefficient of determination of the transformed (GLS) model; DW = Durbin–Watson test for the transformed (GLS) model. The t-ratios of the regression coefficients are in parentheses.

[a] $\hat{\rho}$ = the estimated first order correlation coefficient from the original (untransformed) data. $\hat{\rho}$ is used to estimate the variance–covariance matrix of the error term, which is used in the generalized least squares (GLS) estimation.

Table 3. Estimation of money demand function from annual data: 1952–1978.

Dependen: variable	C	$\ln(y)$	$\ln(UP)$	R^2	DW	$\hat{\rho}$
M2O	−6.606	0.899	2.129	0.809	1.202	0.496
	(−5.99)	(4.82)	(4.76)			(2.74)
M2M	−5.137	0.772	1.805	0.840	1.332	0.581
	(−4.90)	(9.67)	(5.17)			(3.42)
M2W	−6.145	0.834	2.078	0.815	1.168	0.529
	(−5.57)	(6.71)	(5.30)			(2.99)

Notation in Table 3 is the same as in Table 2.

average in Model II). This is quite natural since part of the money demand increase is explained by the monetization process. Here, the percentage of urban population is used as a proxy of the monetization process. The estimated urban population elasticity in Model II suggests that 1% increase in the percentage of the urban population would cause a 0.81% to 0.95% increase in demand for real money, depending on which price index is used.

Table 4. Estimation of money demand function from quarterly data: 1983.1–1989.4.

Dependent variable	C	$\ln(rs)$	π	$\ln(UP)$	R^2	DW	$\hat{\rho}$	$\chi^2_{(4)}$
M2O	1.152	0.657	−.004	0.530	0.932	1.552	0.660	7.63
	(3.16)	(5.03)	(−1.97)	(5.08)			(4.12)	
M2M	1.015	0.822	−.002	0.355	0.927	1.400	0.429	7.13
	(2.62)	(6.94)	(−1.96)	(5.18)			(2.26)	
M2W	1.231	0.653	−.004	0.511	0.933	1.507	0.605	6.87
	(3.13)	(4.64)	(−2.12)	(5.07)			(3.57)	

Notation in Table 4: $\ln(rs)$ = log of the real per capita retail sales; π = expected rate of inflation; the remaining notation is the same as in Table 2. Notice that the 5% critical value for χ^2 distribution with four degree of freedom is equal to 9.49.

Third, from Table 2 we see that the parameters estimated by the official price index and the market price index serve as two polar cases of the estimation. It is logical to infer that the 'true underlying parameter', if there is one, would lie somewhere in between. The parameters estimated by using the mixed price index are usually in between the two polar cases, although not always.

Fourth, it is not surprising to see that the dummy variable in Model II has lower t-ratios than those of Model I. One explanation might be that in Model I, the dummy variable mitigates the misspecification bias of omitting a true (monetization) variable. Part of the variations due to the monetization process are captured by the dummy variable in Model I. Nonetheless, the dummy variables in Model II are all significant at the 15% level, suggesting again that the demands for money are different before and after the reform. In summary, the two models in Table 2 together shed light on the long-run money demand trend in China.

Another way to confirm that the demand for money has changed during the reform is to apply a Chow (1960) test to MOdel I and Model II, using 1952–1978 as the first period and 1979–1989 as the second period. We have conducted the Chow test: the F statistic for Model I is 23.0 with (2, 34) degrees of freedom; the F statistic for Model II is 22.5 with (3, 32) degrees of freedom. In both cases the null hypothesis that the demands for money are the same for the two periods is rejected. Next, we will estimate the demands for money for the two periods separately.

5.4. *The demand for money, 1952–1978*

Table 3 reports the estimation results of the demand for money (Model II) for the period 1952–1978. A comparison with the estimation result for the entire period 1952–1989, yields the following two points from Table 3. First, the estimated income elasticity in Table 3 is quite similar to that in Table 2. The intercepts in Table 3 are much smaller (bigger in absolute

value) compared to those in Table 2. Second, the estimated elasticity of the percentage of urban population in Table 3 is much greater than that in Table 2. The economic interpretation is that the percentage of urban population series had first increased rapidly in the period 1952–1960 and had remained fairly stable for the period 1961–1978. This pattern fits the per capita M2 series very well, up to a constant, keeping other variables fixed. This constant is the estimated elasticity of the urban population. The high value (approximately equal to 2) of the elasticity of urban population explains the rapid growth of per capita M2 in the period 1952–1960. It was true that for a 1% increase in urban population, there was a roughly 2% increase in per capita M2, keeping other variables constant in the period 1952–1960. For the period 1961–1978, the urban population series had little variation, coinciding with the fact that the monetization process was frozen during this period. The main explanatory power of the variation of M2 came from the per capita national income series for the period 1961–1978. These patterns can be seen by comparing Figures 2, 3 and 4.

5.5. *The demand for money, 1983.1–1989.4 (quarterly data)*

The money demand functions in Tables 2 and 3 ignore the measure of the opportunity cost of holding money. As we discussed before, interest rates in China have been strictly controlled and virtually fixed at a level that was far below the equilibrium level. Consequently, interest rates could not reflect the opportunity cost of holding money. One alternative is to use inflation expectations as a proxy of the measure of the opportunity cost of holding money. However, as the economic system changes, the way that people form their inflation expectations also changes. It is hardly convincing to estimate inflation expectation from 1952–1989 due to drastic institutional changes after 1978. In fact, there was very little inflation before 1978, except in the period 1959–1961.

Fortunately, we have quarterly data for the period 1983.1–1989.4 (in Figures 5 and 6), thanks to a series of publications of economic information in the 1980s, including periodicals such as *The Monthly Bulletin of Statistics of China* and *China Finance*.

If we use the last period's actual inflation rate as the expected rate of inflation in the money demand function as an explanatory variable to measure the opportunity cost of holding money, we have

$$\ln(m) = C + \ln(rs) + \pi + \ln(UP) \tag{13}$$

where (rs) is retail sales in real term, which is a proxy of income variable, π is the expected rate of inflation defined by Equation (5), and UP is the

percentage of urban population. Again, the stochastic error term attached to the end of Equation (13) is omitted.

Equation (13) deserves more discussion. The retail sales, rs, is used because quarterly national income data are not available.[7] The static expectation is chosen in Equation (13) for the following reasons. First, using the static expectation for this period is intuitively plausible. Inflation is a new phenomenon for P. R. China. Most people (including a lot of government officials) do not understand the mechanism of inflation very well. They are pretty 'naive' in the sense described by the static expectation. Second, the empirical evidence (the panic buying behavior in 1988 and massive saving behavior in 1989 and 1990) in China support the static expectation formulation. The static expectation mimics the public's inflation expectation reasonably well in terms of the mean squared error of prediction, especially when we consider the quarterly data. Third, it is simple. We would like to use the simplest approach to convey the main points of the paper without falling into the complications of how the inflation expectations are formed. For instance, if one uses adaptive or extrapolative expectations, then the question is why adaptive and why extrapolative? If one uses rational expectation, then the question is how to select the model; why use this model selection criterion instead of another one? Fourth, the static expectation makes sense by itself in the money demand equation. It says that people's demand for money of this quarter depends (inversely) on the actual inflation rate of the previous quarter.[8] Equation (13) is estimated by the GLS method and the result is summarized in Table 4.

Equation (11) assumes that the error term is a first-order, autoregressive process. For the quarterly data, we also concern the possibility of higher-order serial correlations. Breusch (1978) and Godfrey (1978) propose some simple tests for higher order of serial correlations in a fairly general setting. These tests are derived from the Lagrange Multiplier (LM) principle. The LM test is conducted for the residuals terms estimated by GLS for the quarterly data 1983–1989. Because of the limited degree of freedom in our sample, we believe that going back four quarters is sufficient. The possible error structure is

$$\epsilon_t = \rho_1\epsilon_{t-1} + \rho_2\epsilon_{t-2} + \rho_3\epsilon_{t-3} + \rho_4\epsilon_{t-4} + \upsilon_t \tag{14}$$

We are interested in testing the null hypothesis $H_0 : \rho_1 = \rho_2 = \rho_3 = \rho_4 = 0$. The test statistic is distributed as a chi-square distribution with four degree of freedom (see Maddala, 1992, for a detailed discussion of the testing procedure). The χ^2 statistics are summarized in last column of Table 4, from which we cannot reject the null hypothesis (the critical value of the χ^2 distribution with four degree of freedom is 9.49). In other words, the LM test result does not indicate that higher order serial correlation is a problem for the quarterly data.

The remaining results in Table 4 are self-explanatory. If we use the mixed price index case as an example, the estimated elasticity for per

capita retail sales is 0.65, the estimated elasticity for urban population is 0.51, and as the expected inflation rate increases, the per capita demand for real balance of money drops by a small fraction. It is worth mentioning that the coefficients of the inflation expectation variable have the right sign (negative) and are significant at 5% level for all three cases, although they are quite small in magnitude.

The parameter estimates in Table 4 seem plausible. The result that the coefficients of the inflation expectation variable are highly significant in all three cases indicates that inflation expectations have played an important role in the money demand. On the other hand, the small magnitude of these coefficients reflects the fact that although the inflation expectation is a significant factor that influences the money demand, it is still a small one compared to the transaction demand and the monetization process.

6. Conclusion

Both the theoretical analysis and statistical evidence (Chow test) indicate that the demand for money in China has changed significantly before and after the economic reform. Consequently, the demand for money is estimated separately for the two periods. The results of the Dickey–Fuller test indicate that most time series data used in this paper behave like random walks or have random walk components. An appropriate differencing transformation must be performed before the money demand equation is estimated. In this paper the general ρ-differencing is used on the original data and the final money demand equation is estimated by GLS. for all the GLS estimates obtained in this paper we can reject the null hypothesis that the residual term is non-stationary at the 5% significance level. The LM test results do not indicate that higher-order serial correlation is a problem for the quarterly data used in the paper.

The monetization process and the inflation expectations are incorporated in the money demand functions in this paper. Since the economic reform started, the introduction of the responsibility system in the agricultural sector and the astonishing growth of the township and village enterprises and private businesses have engendered an extraordinary demand for currency. The monetization process is certainly an important factor in estimating the demand for money. The preliminary results of this study indicate that including a monetization variable in the money demand function has increased its explanatory power significantly.

The expected rate of inflation provides a feasible alternative to estimating the opportunity cost of holding money. However, there is no consensus on how to estimate the inflation expectations empirically. One way to mitigate this problem is to estimate Equation (13) by using inflation expectations calculated from different expectation models and see how robust the result is. In our investigation the estimated coefficients

of the inflation expectation variable are statistically significant for various expectation formations. These results strongly suggest that the inflation expectation is a significant factor that influences the money demand, although its magnitude is still small compared to the influence of the transactions demand and the monetization process.

The result of this paper has clear policy implications. First, it suggests that the growth rate of money supply should accommodate both the GNP growth and the monetization process. Each important reform step is associated with a monetization consequence. In the past, the introduction of the responsibility system in the rural area and the change of the investment scheme for the fiscal allocation method to bank loans caused extraordinary demand for money. The future reform of the housing sector and increasing the size of the stock and bond markets will certainly have monetization consequences: perhaps different ones. The central bank should anticipate the demand for money changes caused by a reform step and formulate its monetary policy accordingly. Second, a low inflation, consistent monetary policy is clearly preferable since the inflation expectations are very important in determining the money demand, and a high inflation expectation would cause instabilities in the economy. Maintaining a low level of inflation is particularly difficult when the central government has a huge deficit. Disciplines in the money supply require a more developed financial market, expecially the bond markets, and a relatively independent central bank. Third the control over interest rates should be gradually released so that interest rates could be used in the money demand equation to reflect the true opportunity cost of holding money in the future. Without market equilibrium interest rates, it is impossible for the financial market to function properly. A market interest rate is also a necessary condition for an effective and feasible reform in the housing sector.

As its title suggests, the present paper should be regarded as a first step towards estimating the money demand in China. Future research is needed in the area of the monetization process and how to estimate the proportion of the monetized economy with more accuracy. More sophisticated econometric techniques (error correction models and the cointegration approach) are worth exploring with this data set. The autoregressive conditional heteroscedasticity (ARCH) and generalized ARCH (Engle, 1982) models are also attractive if one believes that the variance is time dependent for the period 1983–1989.

Acknowledgements

I am grateful to Dwight Perkins, Barry Naughton, Robert Dernberger, Hang-Sheng Cheng, Bruce Sun and Gene Chang for helpful comments. Special thanks to the Editor of *Economics of Planning* and three anonymous referees for constructive suggestions. Any remaining errors are mine.

Notes

1. From Figure 1 it is clear that the price level measured by the market price index is always higher than that measured by the official price index since 1957. However, this is not true for the inflation rate. The inflation rate measured by the MPI is not necessarily always greater than that measured by the OPI.
2. For example, Chow (1987) estimates the demand for money in China by using the data for 1952–1983; in Feltenstein and Farhadian (1987), the money supply and repressed inflation are estimated for the period 1954–1983; Chen (1989) examines the causal relationship between the monetary and other macroeconomic variables for the period 1951–1985; Portes and Santorum (1987) estimate the excess demand in China by using the sample period 1955–1983.
3. Yang, *et al.* (1988) estimated the percentage of the monetized economy in China for the period 1978–1986. Their estimations of the percentage of the monetized economy are 82.4 for 1978, 83.0 for 1979, 83.1 for 1980, 83.2 for 1981, 82.2 for 1982, 82.8 for 1983, 84.1 for 1984, 85.3 for 1985, 85.6 for 1986. These percentages are estimated without taking intangible assets into account. No details are provided on how these numbers were calculated.
4. There is only one observation for money, we assume that it is the money supply as well as the money demand.
5. Chow (1987) uses a similar model based on the quantity theory of money except he does not have the monetization and inflation expectation variables in his model. For a detailed discussion on the general functional forms of a money demand equation, see Hendry and Ericsson (1991) and Friedman and Schwartz (1991).
6. If one agrees that estimating λ is not feasible due to the availability of data, then using an observable variable to approximate the monetization process is the only alternative. The disadvantage of using this approach is that, no matter which variable is selected, it can only mimic part of the monetization process and some important aspects would be left out. Here we choose the percentage of urban population as the proxy, without claiming that it represents the entire monetizaion process. What we can say, at least, is that including the percentage of urban population in the money demand equation makes sense by itself: urbanization creates a demand for money.
7. Because agricultural products still account for a large proportion of the national income and their production cycle is a year, estimating the quarterly national income is tedious and less rewarding. We therefore use retail sales to approximate the transaction demand for money.
8. Alternative ways to estimate the expected rate of inflation have been also tried (e.g. second-order autoregressive process, rational expectation models selected by information model selection criteria (Hsiao, 1981)), the results are very similar to those presented in Table 4. Readers are encouraged to use other expectation formulations to check the robustness of the estimation.

Appendix A: An example of a mixed price index

Determining the price index that provides the best estimate of the real inflation level is quite controversial. Some authors suggest using the urban cost of living index because it includes

the official, market, and negotiated price indices. However, we think that the urban cost of living index does not give the market price index enough weight. Consequently, it is very close to the official price index (only slightly higher).

Feltenstein and Ha (1991) estimate a 'true price index' from the model for the period 1978–1988. During the period 1952–1989 there were too many political movements and institutional changes and that makes any systematic modeling approach less attractive. Therefore, we adopt a year-by-year fine-tuning approach to construct the mixed price index. The dividing lines of periods are determined by the major economic institutional changes (usualy caused by political movements), the weights are estimated according to the share of the planned and market economy in each period. At the same time, we also consider the scope of black markets (transactions not recorded) and the difference between the official and market price indices, which reflects the degree of the repressed inflation. Here we construct an ad hoc mixed price index, which is a weighted average of the official and market price indices. The weights are as follows.

Table A1. Weights of the mixed price index

Period	Official price	Market price	Note
1953–57	0.60	0.40	First five year plan
1958–59	0.80	0.20	Great leap forward
1960–62	0.70	0.30	famine period
1963	0.75	0.25	Adjustment period
1964–66	0.80	0.20	Socialist education
1967–76	0.90	0.10	Cultural revolution
1977–78	0.85	0.15	Transition period
1979–89	0.75	0.25	Economic reform

In Table A1, for those periods when economic data are available, the weights are estimated to reflect the share of the planned and market economy. For example, scattered data on the spending pattern of consumers and firms can be found from Liu (1980), *The Great Ten Years*, and Cheng (1982) for the period 1952–1957 and Yang, *et al.* (1987) for the period 1978–1985. For those periods when economic data are not available the weights are estimated based on historical knowledge. For instance, during the cultural Revolution period (1966–1976), free markets were critized as 'capitalism' and the number and size of free markets were reduced significantly in that period. Consequently, a 90-to-10 split is assigned between the official and market price indices.

As argued in the paper, the official price index tends to underestimate the true inflation level whereas the free market index tends to overestimate it. The true price index, which was unobservable, should lie somewhere in between. The mixed price index constructed above is merely a proxy of the underlying latent variable. Although it is a fact that almost all economic variables are measured with errors, we would like to warn readers that the consequence of a latent variable (in the errors in variables context) in standard econometric analysis is applicable here (see, e.g. Maddala, 1992, Chapter 11).

It is very easy to criticize this mixed price index. For example, within each period, there were subperiods; the weights are estimated to represent a national average, but a particular region might be quite different. Notice that we are not promoting this mixed index as 'the true index', rather, it is just one way of estimating the true inflation level. In the estimation of the money demand equations, we see that the parameter estimated by using the mixed price index are usually (but not always) between those estimated by the official and market price indices.

Appendix B. Data

Table B1. Annual data of money supply, price indices and national income (M0, M1, M2 and NI are in billion yuan; population is in millions).

Year	M0	M1	M2	OPI(%)	MPI(%)	NI	UP(%)	POP
1952	2.75	9.65	10.13	100.0	100.0	58.9	12.5	574.82
1953	3.94	10.96	11.37	103.4	103.9	70.9	13.3	587.96
1954	4.12	12.24	13.24	105.8	106.3	74.8	13.7	602.66
1955	4.03	13.26	14.59	106.9	106.1	78.8	13.5	614.65
1956	5.73	15.94	17.50	106.9	105.9	88.2	14.6	628.28
1957	5.28	17.81	19.77	108.5	108.9	90.8	15.4	646.53
1958	6.78	28.93	31.32	108.8	117.5	111.8	16.2	659.94
1959	7.51	36.01	39.17	109.7	119.0	122.2	18.4	672.07
1960	9.59	37.18	40.91	113.1	136.6	122.0	19.7	662.07
1961	12.57	41.01	43.98	131.5	491.8	99.6	19.3	658.59
1962	10.65	41.06	43.62	136.5	319.6	92.4	17.3	672.95
1963	8.99	40.72	43.66	128.4	241.2	100.0	16.8	691.72
1964	8.00	39.77	43.47	123.7	167.8	116.6	18.4	704.99
1965	9.08	45.42	49.76	120.4	173.2	138.7	18.0	725.38
1966	10.85	51.94	56.63	120.0	175.3	158.6	17.9	745.42
1967	12.19	58.08	62.97	119.1	178.2	148.7	17.7	763.68
1968	13.41	61.66	66.69	119.2	178.2	141.5	17.6	785.34
1969	13.71	60.98	65.92	117.9	178.1	161.7	17.5	806.71
1970	12.36	59.73	65.11	117.6	178.1	192.6	17.4	829.92
1971	13.62	65.35	71.49	116.7	193.8	207.7	17.3	852.29
1972	15.12	68.53	75.49	116.5	209.6	213.6	17.1	871.77
1973	16.61	79.26	87.03	117.2	220.7	231.8	17.2	892.11
1974	17.66	85.01	93.68	117.8	224.8	234.8	17.2	908.59
1975	18.26	92.30	101.75	118.0	233.8	250.3	17.3	924.20
1976	20.40	98.40	108.46	118.3	243.1	242.7	17.4	937.17
1977	19.54	99.56	110.73	120.8	237.2	264.4	17.6	949.74
1978	21.20	103.02	115.91	121.6	221.6	301.0	17.9	962.59
1979	26.77	129.17	145.81	124.0	211.6	335.0	19.0	975.42
1980	34.62	153.80	184.29	131.4	215.8	368.8	19.4	987.05
1981	39.63	183.81	223.45	134.6	228.3	394.1	20.2	1000.72
1982	43.91	207.05	258.98	137.2	235.8	425.8	20.8	1015.90
1983	52.98	239.27	307.50	139.3	245.7	473.6	23.5	1027.64
1984	79.21	324.54	414.63	143.2	244.7	565.2	31.9	1038.76
1985	98.78	365.91	488.43	155.8	286.8	704.4	36.6	1050.44
1986	121.84	435.24	626.16	165.1	310.0	789.9	41.4	1065.29
1987	145.45	530.82	766.45	177.2	360.5	936.1	46.6	1080.73
1988	213.40	645.22	928.89	210.0	469.7	1177.0	49.6	1096.14
1989	234.40	673.80	1092.0	247.2	520.7	1312.5	51.7	1111.91

Source: *Almanac of China's Finance and Banking*, 1990, Beijing, China; *Statistical Yearbook of China*, 1990, Beijing, China and *Almanac of China's Prices*, 1988, Beijing, China.

Notation in Table B1: M0 is defined as currency in circulation by the end of the year; M1 is equal to M0 plus demand deposits of firms, institutions and passbood saving deposits of households; M2 equals M1 plus term deposits of households; OPI = official general retail price index (1952 = 100); MPI = free market price index of consumer goods (1952 = 100);

NI = national income in current price; UP = percentage of urban population in total population. POP = total population at the end of year.

Table B2. Quarterly data for the period 1983.1–1989.4 (M2, Rsale are in billion yuan, and population is in millions).

Quarter	M2	Rsale	OPI(%)	MPI(%)	UP(%)	SAM2	SARS	OPIC[a]	MPIC[b]
1983.1	255.1	68.9	100.7	101.8	21.4	258.5	67.2	100.7	101.8
1983.2	260.3	66.3	101.2	104.0	22.1	266.1	68.1	101.2	104.0
1983.3	273.5	63.2	101.4	104.8	22.8	280.9	67.3	101.4	104.8
1983.4	309.4	73.3	102.7	106.2	23.5	291.6	69.0	102.7	106.2
1984.1	300.9	74.5	101.6	102.0	25.6	304.9	72.7	102.3	103.8
1984.2	310.8	75.0	102.6	98.2	27.7	317.7	77.0	103.8	102.1
1984.3	336.4	76.7	102.7	99.5	29.8	345.5	81.7	104.1	104.3
1084.4	401.2	94.4	104.3	97.9	31.9	378.1	88.8	107.1	104.0
1985.1	397.4	98.8	105.6	108.1	33.0	402.7	96.4	108.0	112.3
1985.2	388.8	94.1	108.5	115.8	34.2	397.4	96.7	112.7	118.3
1985.3	401.7	91.5	110.0	125.2	35.4	412.6	97.5	114.6	130.6
1985.4	489.3	118.6	110.7	122.8	36.6	461.1	111.6	118.6	127.7
1986.1	480.7	117.1	107.5	108.6	37.8	487.2	114.3	116.1	121.9
1986.2	511.0	117.5	103.5	104.1	39.0	522.3	120.7	116.6	123.1
1986.3	544.1	119.8	104.0	105.8	40.2	558.8	127.6	119.1	138.1
1986.4	628.9	140.1	105.5	106.6	41.4	592.6	131.8	125.1	136.1
1987.1	633.7	138.3	105.2	112.4	42.7	642.2	135.0	122.2	137.0
1987.2	659.8	138.1	107.3	116.6	44.0	674.4	141.9	125.1	143.6
1987.3	709.6	141.3	108.1	117.8	45.3	728.8	150.6	128.8	162.7
1987.4	772.0	164.2	108.4	121.1	46.4	727.5	154.5	135.6	164.8
1988.1	779.4	170.2	110.8	125.6	47.4	789.9	166.1	135.4	172.1
1988.2	837.6	174.3	114.6	122.3	48.1	856.2	179.0	143.4	175.6
1988.3	881.7	190.3	122.6	132.7	48.9	905.5	202.8	157.9	215.9
1988.4	928.9	209.2	126.3	134.0	49.6	875.3	196.8	171.3	220.9
1989.1	928.6	208.7	127.1	124.5	50.1	941.1	203.7	172.1	214.2
1989.2	961.3	203.3	123.9	118.7	50.7	982.6	208.8	177.6	208.4
1989.3	1000.9	195.5	115.2	109.1	51.2	1027.9	208.3	181.9	235.6
1989.4	1092.0	202.9	107.4	96.0	51.7	1029.0	190.9	184.0	212.1

Source: *The Monthly Bulletin of Statistics of China*, State Statistics Bureau, Beijing, 1985–1990, various issues, *Almanac of China's Economy*, Beijing, 1984–1990.

Notation in Table B2: M2 = money supply measured by M2; Rsale = total retail sales; OPI = official general price index (the same period last year = 100); MPI = free market price index (the same period last year = 100); UP = percentage of urban population; SAM2 = seasonally adjusted M2; SARS = seasonally adjusted retail sales; POP = total population. The seasonal index calculated for M2 is 98.84, 97.83, 97.57, 195.75. The seasonal index calculated for retail sales is 102.47, 97.36, 93.86, 106.31.

[a] OPIC–quarterwise continuous official price index, which is constructed by multiplying the OPI of year i by the quarterwise continuous price index of year $(i-1)$. The quarterwise continuous price index of the base year (1982) is equal to 100.

[b] MPIC = quarterwise continuous market price index.

References

Almanac of China's Economy (1984–1989) Beijing, China.

Almanac of China's Financial and Banking (1989, 1990) Beijing, China.

Almanac of China's Prices (1988), Beijing, China.

Bei, Duoguang (1989), *An Analysis of Fund Circulation in China*, Sanlian Press, Shanghai, China.

Box, G.E.P. and Jenkins, G.M. (1976), *Time Series Analysis: Forecasting and Control*, Revised Edition, San Francisco, Holden-Day.

Breusch, T.S. (1978), 'Testing for autocorrelation in dynamic linear models', *Australian Economic Papers* 17, 334–355.

Chen, Chien-Hsun (1989), 'Monetary aggregates and macroeconomic performance in mainland China', *Journal of Comparative Economics*, 13(2), 314–324.

Cheng, Chu-yuan (1982), *China's Economic Development*, Westview Press, Boulder, Colorado

Chow, Gregory C. (1960), 'Tests of equality between sets of coefficients in two linear regressions', *Econometrica* 28, 591–605.

Chow, Gregory C. (1987) 'Money and price level determination in China', *Journal of Comparative Economics* 11, 319–333.

Dickey, David A. and Fuller, Wayne A. (1981), 'Likelihood ratio statistics for autoregresive time series with a unit root', *Econometrica* 49(4), 1057–1071.

Engle, R.F. (1982), 'Autoregressive conditional heteroscedasticity with estimates of the variance of U.K. inflation', *Econometrica* 50, 987–1007.

Feltenstein, Andrew and Farhadian Ziba (1987), 'Fiscal policy, monetary targets, and the price level in a centrally planned economy: An application to the case of China', *Journal of Money, Credit, and Banking* 19(2) 137–156.

Feltenstein, Andrew and Ha, Jiming (1991), 'Measurement of repressed inflation in China: The lack of coordination between monetary policy and price controls', *Journal of Development Economics* 36, 279–294.

Feltenstein, Andrew, Lebow, David and Van Wijnbergen, Sweder (1990) 'Savings, commodity market rationing, and the real rate of interest in China', *Journal of Money, Credit, and Banking* 22(2), 234–252.

Friedman, Milton (1966), 'Interest rates and the demand for money', *The Journal of Law and Economics*, IX, 85.

Friedman, Milton and Schwartz, Anna (1991), 'Alternative approaches to analyzing economic data', *The American Economic Review*, 18(1), 39–49.

Godfrey, L.G. (1978) 'Testing for higher order serial correlation in regression equations when the regressors include lagged dependent variables', *Econometrica* 46, 1303–1310.

Hendry, David and Ericsson Neil (1991), 'An econometric analysis of U.K. money demand in monetary trends in the United States and the United Kingdom by Milton Friedman and Anna J. Schwartz', *The American Economic Review* 18(1), 8–38.

Hsiao, C. (1981) 'Autoregressive modelling and money-income causality detection', *Journal of Monetary Economics* 7, 85–106.

International Financial Statistics, International Monetary Fund, Washington, D.C., various issues.

Liu, Hongru (1980), *The Issues of the Socialist Money and Banking*, The Press of Financial Economics of China, Beijing.

Lucas, Robert E. (1976), 'Econometric policy evaluation: A critique', in K. Brunner and A. Meltzer, (eds.), *The Phillips Curve and Labor Markets*, *Journal of Monetary Economics*, Suppl. 1976, 19–46.

Monthly Bulletin of Statistics of China (1985–1989), various issues, State Statistics Bureau, Beijing, China.

Maddala, G.S. (1992), *Introduction to Econometrics*, 2nd edition, Macmillan Publishing Company, New York.

Naughton, Barry (1991), 'Why has economic reform led to inflation?', *American Economic Review*, Papers and Proceedings, May, 207–211.

Nelson, Charles R. and Plosser, Charles I. (1982), 'Trends and random walks in macroeconomic time series', *Journal of Monetary Economics* 10, 139–162.

Newbold, Paul (1984), *Statistics for Business and Economics*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
Perkins, Dwight H. (1988), 'Reforming China's economic system', *Journal of Economic Literature* XXVI, 601–645.
Perron, Pierre (1990), 'Testing for a unit root in a time series with a changing mean', *Journal of Business & Economic Statistics* 8(2), 153–162.
Plosser, Charles I. and Schwert, G. William (1978), 'Money, income, and sunspots: Measuring economic relationships and the effects of differencing', *Journal of Monetary Economics* 4, 637–660.
Portes Richard and Santorum Anita (1987), 'Money and the consumption goods market in China', *Journal of Comparative Economics* 11, 354–371.
Qian, Yingyi (1988), 'Urban and rural household saving in China', *IMF Staff Papers*, December, pp. 592–627.
Statistical Year book of China (1983, 1987, 1988, 1989) Beijing, State Statistics Bureau.
Szapary, Gyorgy (1989), 'Monetary policy and system reforms in China,' Working paper, International Monetary Fund, Washington, D.C.
The Ten Great Years (1959), State Statistics Bureau, Beijing.
Turnovsky, Stephen (1977), *Macroeconomic Analysis and Stabilization Policy*, Cambridge University Press.
Yang, Guansan, Yang Xiaodong and Xuan Mingdong (1987), 'The public response to price reform', in Bruce Reynold and M.E. Sharp (eds.), *Reform in China, Challenges and Choices*, pp. 59–73.
Yang, Zhongwei *et al.* (1988), 'Diagnosis of the inflation of china', *Jingji Yanjiu* (Economic Research) 3–11.
Yi, Gang (1990a), 'Inflation and price instability: AN empirical study of the People's Republic of China', *China Economic Review* 1(2), 155–165.
Yi, Gang (1990b), 'The price reform and inflation in China, 1979–88', *Comparative Economic Studies* Winter, 28–61.
Yi, Gang (1991), 'The monetization process in China during the economic reform', *China Economic Review* Spring, 75–95.

Economics of Planning **26**: 271–274, 1993

Rejoinder

In my rejoinder I will react first to Professor Sachs' statements about real wages and the standard of living.

I agree with Sachs that statistical changes in real wages do not mean much for the real standard of living if incomes cannot be used to purchase goods, and in a socialist country at official prices. According to him there were extreme shortages of consumer goods at official prices in Poland; apparently he has 1989 in mind because this is the base year with which comparisons are made. It is true that there were shortages at official prices, but they were not as extensive as Sachs suggests. (I was in Poland in 1989 and made enquiries about this.) There was a shortage primarily of meat and cheese, if we confine ourselves to food. Meat (and if I am not mistaken also cheese) was rationed. In August 1989, prices for food were more or less freed and rationing was abolished. In the beginning the situation was worse than before the freeing of prices and many economists criticized the government move. In October the situation started to improve; domestic food stocks became increasingly larger than sales and the inflation rate declined from month to month (*Życie Gospodarcze* 1989, Nos. 44, 46, 48, and 52–3, in all issues p. 1). In November there was already a stabilization of prices for some goods, such as meat and butter, etc. (*Życie Gospodarcze* nos. 52–53, p. 1). This was the situation when the Balcerowicz program was introduced, which produced a huge decline in real wages in 1990.

Further on in his reply Sachs maintains that '. . . there is absolutely no evidence of any sharp drop in real consumption after price liberalization.' He tries to back up his statement by maintaining that the consumption of meat[1] and fruits and ownership of durable goods have increased. In addition, according to him, if the time lost in queuing, increase in product variety and quality are considered, the '. . . average consumption levels in Poland were higher in 1991 than in 1989'.

In my opinion, in order to make a judgment about the effect of a decline in real wages it is not enough to examine the consumption of meat and fruit and ownership of durable goods. People use their incomes to pay rents, utilities, to buy food, clothing, footwear, furniture, etc., and they tend to save a portion. Without a proper examination of structural changes in individual groups of consumer goods and of savings one cannot make a judgment about what the effect of the decline in real wages really was. For example expenditures for clothing and footwear, which made up 18.6% of employee's households budget in 1989, declined to 10.9% in 1990 (*Rocznik Statystyczny* 1990, p. 201 and *Rocznik Statystyczny* 1991, p. 209). In order to be able to maintain the previous