



Price deflation, money demand, and monetary policy discontinuity: a comparative view of Japan, China, and the United States

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Abstract

In this paper we review the history of deflation in China, Japan, and the United States, and summarize the stylized empirical facts regarding deflation and key real and monetary variables in these economies. Based on a review of the institutional background of deflation in these economies, we argue that deflation in China is largely supply-led, whereas deflation in Japan is demand-led. We discuss the adverse effects of demand-led deflation, and argue that deflation is not simply inflation in reverse. Based on these adverse effects, we explain the basis of a discontinuity in the monetary policy process, and contrast the discontinuity process with the 1930s-era liquidity trap concept. We then provide empirical evidence on an important link in the discontinuity process: the effect of demand-led deflation on money demand. We consider a variety of money demand function estimates for Japan, China, and the United States in order to illustrate that deflation in Japan may have indeed contributed to a discontinuity in monetary policy by shifting the demand for money upward, and we then suggest several implications for central bank policy in a deflationary environment.

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1. Introduction and stylized empirical facts

Price deflation has characterized both China and Japan in recent years, and deflation was a prominent characteristic of the economic and financial distress experienced by the United States during the 1930s. While the deflation experience of China and Japan since

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Table 1
Average inflation rate in comparison economies (annual average percentage)

Country	1975:Q1– 1979:Q4	1980:Q1– 1984:Q4	1985:Q1– 1989:Q4	1990:Q1– 1994:Q4	1995:Q1– 1997:Q4	1998:Q1– 2002:Q4
United States						
Deflator	7.1	6.5	3.1	2.9	2.0	1.6
CPI	8.1	7.4	3.6	3.6	2.7	2.3
Japan						
Deflator	5.2	3.0	1.3	1.5	–0.3	–1.3
CPI (1981–)		2.2	1.0	2.0	0.6	–0.4
WPI	3.7	3.1	–1.5	–0.3	–0.6	–1.0
China						
Deflator	0.9	2.4	8.1	10.9	7.0	–0.9
CPI	1.2	3.3	11.9	10.1	9.2	–0.3

Source: See footnote 6.

the mid-1990s, which we show in Table 1, is on a much smaller scale than the deflation of the 1930s, the fact that deflation has reappeared raises a number of issues and rekindles old debates of the 1930s regarding monetary policy liquidity traps.

The deflation experience of China and Japan is markedly different in terms of its effect on real and monetary variables. China has experienced low inflation and most recently deflation, and yet, real GDP growth has been high, as Fig. 1 demonstrates. In contrast, Japan's disinflation and deflation process has been associated with stagnant or declining real GDP. Fig. 2 illustrates that nominal interest rates have fallen in China, but remain meaningfully above zero, while Fig. 3 shows that real interest rates have remained at about 2% since 1999. In contrast, growth in Japan has been stagnant (Fig. 1), nominal interest rates have approached zero (Fig. 2), while at the same time real interest rates have increased (Fig. 3). As Fig. 4 shows, the ratios of money supply (both M1 and M2) to GDP (the k ratio) have risen rapidly in China and Japan in the 1990s. The growth of the k ratio in China is probably reflecting rapid income growth more than deflation, while in Japan the growth of the k ratio largely reflects deflation, since income has been stagnant or declining. As Fig. 5 shows, the deposit expansion multipliers for M2 in China and Japan also illustrate divergent behavior in the presence of deflation.¹ China's M2 multiplier has increased while Japan's has decreased.

For the United States, which we include as a benchmark case because of the general absence of deflation in the postwar period, nominal interest rates have declined in the 1990s due to disinflation, but they remain higher than nominal rates in Japan. Real interest rates since 1999 have averaged about 2%. Furthermore, the k ratio has remained relatively stable and while the M2 multiplier declined in the early 1990s, it has stabilized since 1996.

Thus, there are considerable differences between the recent deflation experiences in China and Japan, and considerable differences with economies where deflation is not present. The

¹ Because China's monetary base is not available, the deposit multiplier in China is approximated by the M2/Currency ratio, which tracks closely with the deposit expansion multiplier in the U.S. and Japan. M2 for Japan includes CDs

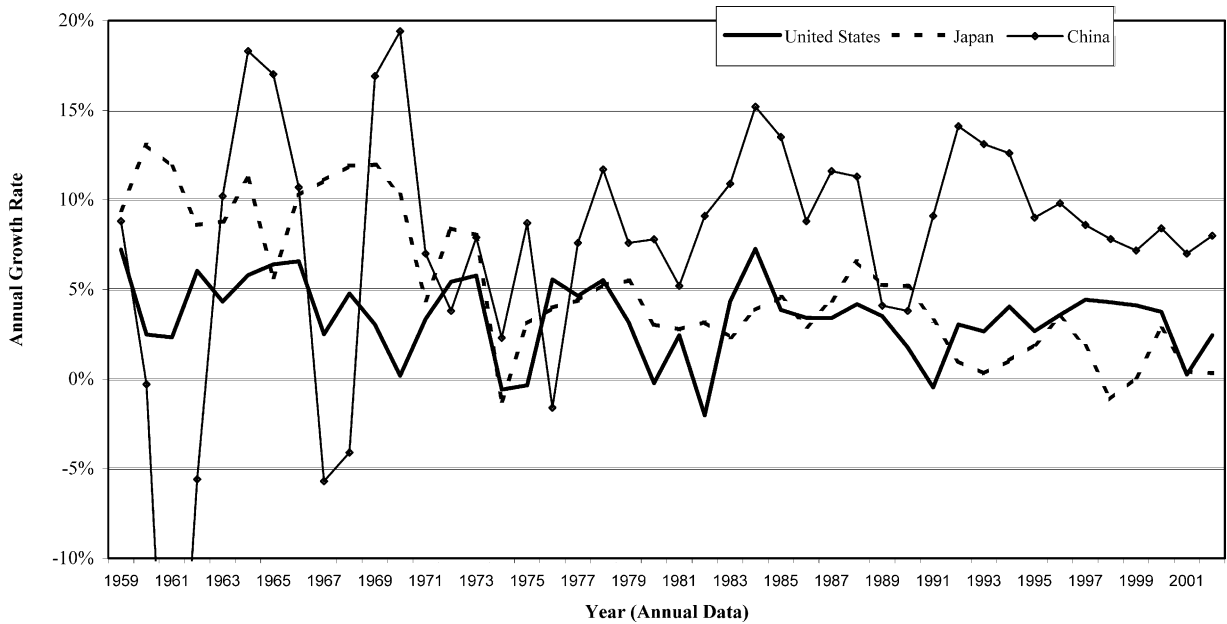


Fig. 1. Real GDP growth in the U.S., Japan, and China.

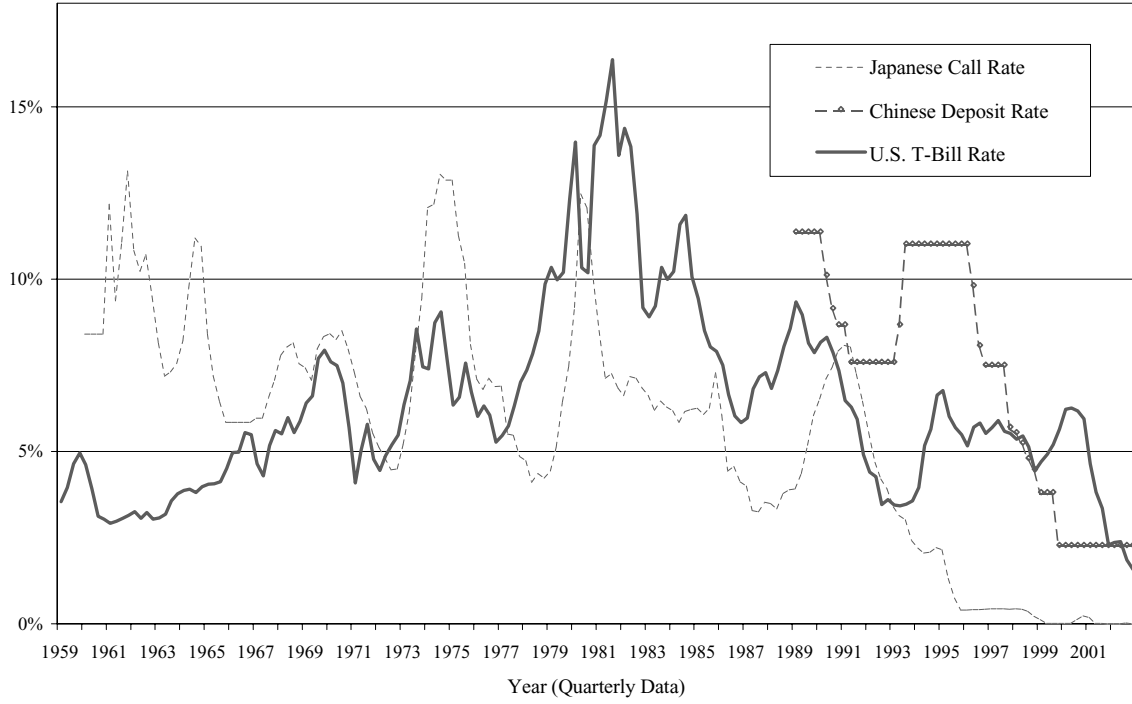


Fig. 2. Nominal interest rates in the U.S., Japan, and China.

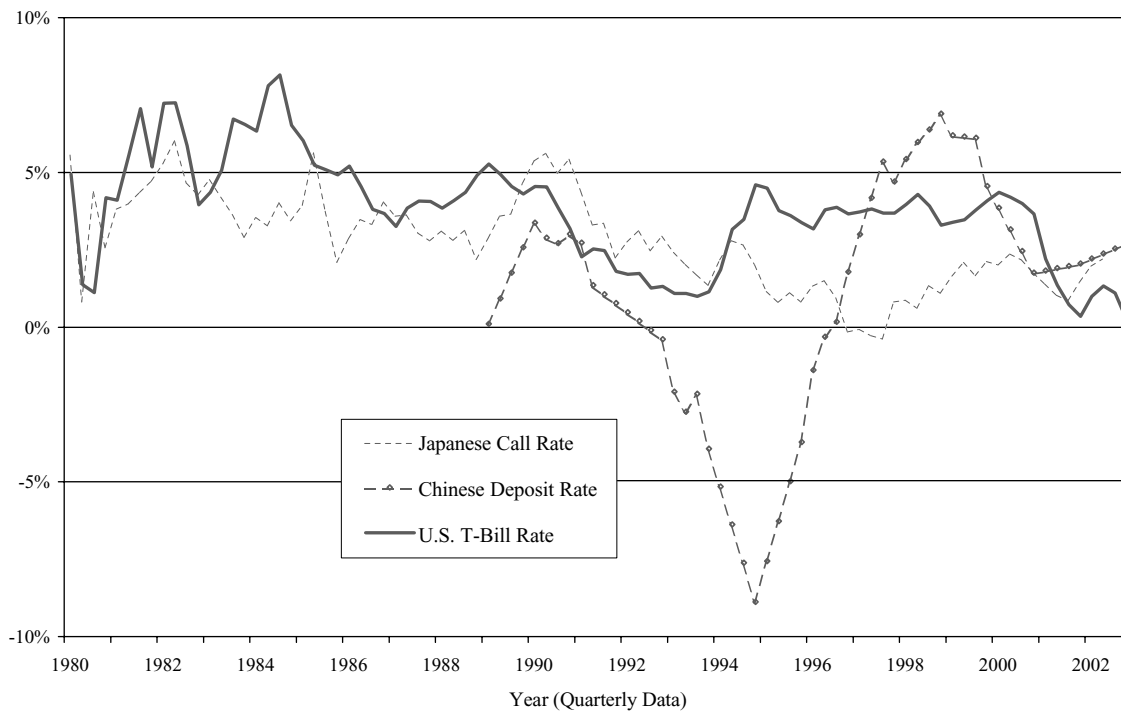


Fig. 3. Real interest rates in the U.S., Japan, and China.

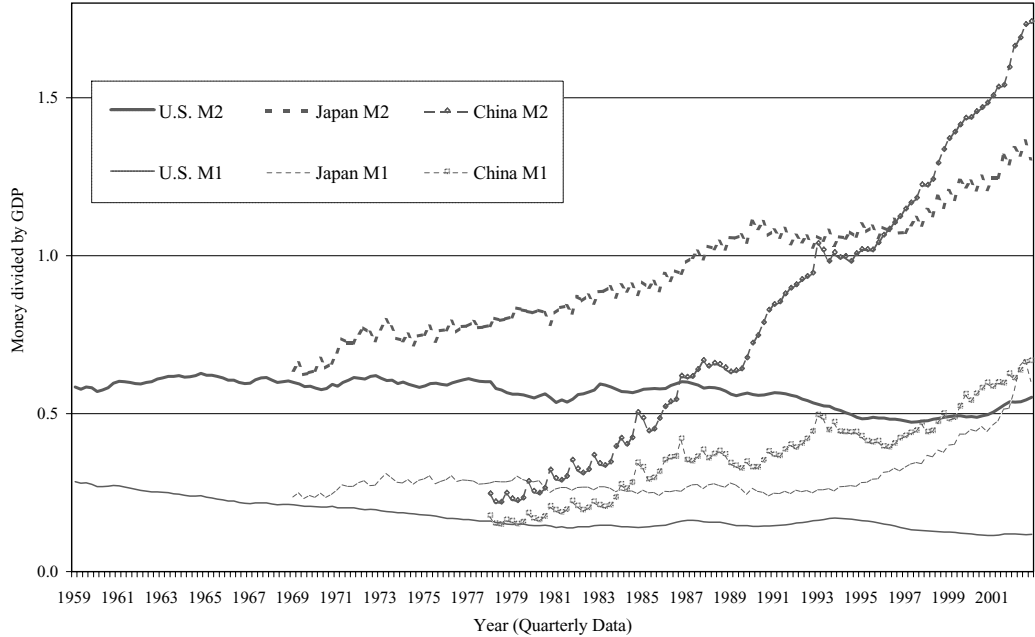


Fig. 4. Money supply/GDP ratios in the U.S., Japan, and China.

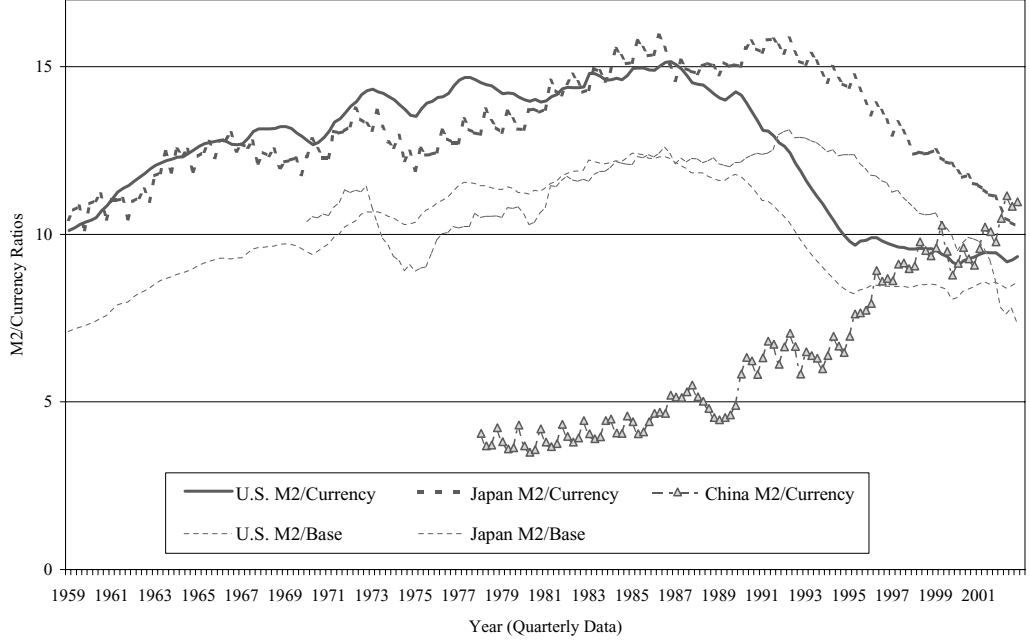


Fig. 5. Deposit expansion multipliers.

objective of this paper is to investigate the differing impacts of deflation in China and Japan, with specific emphasis on the effect of deflation on money demand and its implication for the conduct of monetary policy.

This comparative study accepts the view that deflation in China is supply-led, while deflation in Japan is demand-led. Two considerations suggest this to be a reasonable operating assumption. First, deflation in Japan has been associated with low and/or declining real GDP, while deflation in China has been associated with high rates of real GDP growth. Second, there exists considerable empirical and analytical research supporting this assumption that deflation in Japan is induced by monetary policy (e.g., Cargill, Hutchison, & Ito, 2000; Hetzel, 2003; McCallum, 2003; Posen, 1998). The Bank of Japan, however, has argued that deflation is not the outcome of monetary policy and that monetary policy has been expansionary (e.g., Okina, 1999). Others in the Japanese government have also suggested that nonmonetary forces are behind the deflation (see Noland & Posen, 2002). The consensus view, however, is that deflation in Japan is demand-driven, and has largely been caused by inappropriate monetary policy.² In contrast, Lin (2000) argues that deflation in China has been the product of over-supply rather than a slowing of aggregate demand. Reforms in the 1990s have generated significant increases in productivity in China, thus contributing to both increasing real GDP and declining prices.

Though deflation has many effects, this paper focuses on the differential impact of deflation on money demand. The empirical evidence suggests that the impact on money demand in China has been neutral, while the impact of deflation in Japan has been to shift money demand upward. Combined with other effects of deflation, the upward movement in Japanese money demand contributes to a discontinuity in monetary policy.

The remainder of the paper consists of five sections. Section 2 reviews some institutional background of the recent price behavior in China and Japan, with most of the discussion focused on China since deflation in Japan has been widely documented. Section 3 distinguishes between deflation and inflation and argues that, in general, a deflation rate of a specific magnitude has a greater adverse impact on the economy and monetary policy than an inflation rate of the same size. Section 4 outlines the process whereby deflation generates a discontinuity for monetary policy and distinguishes this discontinuity from the 1930s liquidity trap concept. Section 5 presents a range of estimates of money demand in China, Japan, and the United States using both quarterly and annual data. A concluding section summarizes the main points of the paper and draws policy implications for central bank policy.

2. Recent deflation in historical perspective

Prior to World War II, deflation was common and at times had a severe impact on both real and financial sectors in many countries (Burdekin & Siklos, 2004). After the end of the war, inflation gradually replaced deflation as the major macroeconomic concern, as central banks were no longer constrained by adherence to a rigid fixed exchange rate regime. Though it

² Many of these issues are discussed in a special issue of the Bank of Japan's *Monetary and Economic Studies* (2001).

relied on fixed rates and was linked to gold, the Dollar-reserve arrangement of the Bretton Woods system allowed the United States to gradually inflate its price level as it generated balance of payments deficits that backed up the currencies of other nations. Furthermore, countries were willing to frequently devalue their currencies whenever deflation became a concern, and the shift to flexible exchange rates after 1973 removed the last major binding international constraint on monetary expansion.

The United States has not experienced a significant deflationary period since the Great Depression, in spite of the occasional dramatic fall in equity prices, though by 2002 inflation rates were at their lowest levels in almost four decades. This has also been the case for much of the rest of the world. Countries that have experienced deflation since 1973 have tended to be small economies relying on a single primary export, or otherwise very dependent on trade, and maintaining a unilateral fixed exchange rate against a major trading partner's currency, so that the exchange rate was unable to compensate for declines in relative demand. There are at least two notable exceptions: Japan and China.

Japan's postwar growth rate after 1945 was spectacular. Real per-capita GDP grew by an average of 8% per year from 1948 to 1973. Following a short but turbulent period from late 1973 to 1974 partly caused by the jump in world oil prices, Japan's growth rate of real per-capita GDP returned to an average of 3.6% from 1975 to 1990 (Maddison, 1995). Despite impressive economic growth, Japan maintained a moderate inflation rate during the 1950s and 1960s and a very low inflation rate after 1975 through the early 1990s. In the 1990s, however, Japan's macroeconomic performance deteriorated. Real per-capita GDP growth fell to an average of less than 1% per year in the face of a declining rate of population growth.³ The stagnant economy has been characterized by a rapid deceleration in the inflation rate. As measured with the GDP deflator, price deflation began in earnest after the mid 1990s; using the Wholesale Price Index, however, price deflation appears to have begun a decade earlier, even as asset prices were beginning to rise dramatically.

Like Japan, China did not experience inflation during the first part of the postwar period, but unlike Japan, China experienced very unstable economic growth. Prior to the start of economic reform in 1978, China's centrally-planned economy relied on administered prices that did not reflect market conditions, and the banking system primarily served as a means to manage the spending of state-owned enterprises (SOEs) and to collect individual savings for state use. Prices were thus relatively stable, though inflation was repressed (and thus hidden) by government policy and shortages were increasingly common. GDP growth varied wildly, especially as a result of the disastrous Great Leap Forward period in 1958–1961 and the adverse outcomes of the Cultural Revolution in 1966–1969.

Once market reform commenced, SOEs were gradually allowed more control over production, pricing, and profits. The SOEs were pushed away from state budgetary grants towards loans from the newly-created state-owned commercial banks, but a failure to reduce pressure from local and provincial cadres led to rapid credit expansion in spite of low returns on SOE investments.⁴ China experienced a rising inflation rate, though rapid growth in money demand as the Chinese began to save large portions of their income helped

³ In fact, Japanese population is projected to decline after 2007.

⁴ See Parker (1995), for evidence of these low returns.

China's inflation from approaching the rates seen in other post-socialist economies. Industrial reforms made it possible for SOEs to compete with each other in once-monopolized sectors, and new rural township and village enterprises began to eat away at the SOE share of industrial output.

In 1988, official price inflation (as measured by the GDP deflator) rose to double digits, and the resulting social disruptions contributed to the Tian'anmen protests the following year. In 1989–1991 the government stepped back from reform and attempted to restrain demand from the non-state sector. This conservative policy successfully reduced the inflation rate but it also slowed the economy, failed to improve the profitability of the SOEs, and induced the migration of millions of farmers to the cities. As a result, the Communist Party changed direction, and by 1994 it was pushing new reforms to create the so-called "Socialist Market Economy." In the first half of the 1990s, M2 grew by over 30% per year on average, and the inflation rate (as measured by the GDP deflator) rose to almost 20% per year. This lending spiral led to an increasing and increasingly recognized bad debt problem, and by 1995 China's four major commercial banks had a negative net worth (Lardy, 1998, p. 119).

In the early 1990s, vice-premier Zhu Rongji took over the economic portfolio, including responsibility for the People's Bank of China and the lending policies of the state-owned commercial banks. Under Zhu's economic policies, the government succeeded in cutting the rate of money growth in half, and after the middle of the decade inflation began to fall rapidly. These policies continued once Zhu became premier in 1998. Pressure was put on the banking sector to reduce bad debt ratios, and further reforms were pushed through in the hope of making SOEs leaner, more competitive, and less dependent on government support or implicitly subsidized loans from the state banks.

As these reforms accelerated, and after the Asian financial crisis led to a slowdown in the growth rate of China's exports, China began to experience price deflation. The GDP deflator fell by a total of 4.3% from 1997 to 2002. China's retail price index fell by a total of 7% over the same period, though by the end of 2002 consumer prices slowed their rate of decline to only 0.4% less than the previous year's price level (China Daily, 2003). After the Fifteenth Communist Party Congress of 1997, government policy shifted towards maintaining China's rapid growth, primarily through expansionary fiscal policy, in order to make it possible to shut down increasingly more insolvent SOEs without excessive increases in the urban unemployment rate.

China's deflation was not accompanied by slower growth, however. Between 1995 and 2002, real GDP grew at an average rate of 8% per year. While Rawski (2001) argues these growth rates are overstated, in part due to large unsold inventories produced by the SOEs, it is unchallenged that China's economy nonetheless continued to grow rapidly during the deflation. This growth has been driven by both a high savings rate that has financed capital accumulation, even if much of it is not well invested, and by improvements in average productivity, driven not by the improvement of SOE performance, but by the reallocation of labor from agriculture to rural industries and an increasingly competitive market-oriented, export-focused economy (Lardy, 1998). As in Japan in the 1990s and the United States in the 1930s, China's deflation was preceded by a steep decline in asset prices, but the immaturity and small size of the Chinese markets make it extremely unlikely that this decline was a causal factor (Lin, 2000).

Thus, China provides a recent case study of actual deflation along with Japan and suggests that Japan is not an outlier. In addition to China, inflation rates in many other countries have significantly decelerated during the 1990s. The average annual inflation rate for the OECD economies was 5.6% in the late 1980s, but only 1.8% by the late 1990s, and these official inflation rates likely overstate the degree of price increases due to the well-known upward biases in price indexes. The implication to be drawn from this discussion is that inflation is no longer the macroeconomic problem it was in the first part of the postwar period, and that there is reasonable evidence that deflation has become something more than economic history.

3. The peculiar effects of price deflation

Cargill and Parker (2003a) discuss the adverse effects of deflation as contrasted with inflation. The effects of deflation depend on whether deflation is demand-led or supply-led. Demand-led deflation adversely affects the economy without exception, but supply-led deflation caused by increased productivity can be accompanied by increased output at least for some period of time. In the following discussion of five effects of deflation, demand-led deflation is emphasized.

- (1) Deflation occurs less frequently than inflation, and contracts are likely to be adjusted more slowly to price declines, so that the real effects on the economy are more pronounced. The asymmetric probability distribution of inflation and deflation based on the historical record suggests that downward movements in prices will be resisted more than upward movements, and thus the well-known effects of price stickiness render the economy more susceptible to deflation than inflation.
- (2) Anticipated deflation leads to a higher real rate of interest as nominal interest rates approach zero, which decreases investment spending if investors expect deflation to continue.
- (3) Deflation increases the real burden of servicing debt that is fixed in nominal value, and increases the probability of debt default and a falling deposit expansion multiplier. This is a variation of Fisher's (1933) "debt-deflation" process described 70 years ago, where deflation increases the real burden of servicing debt and thus debt default.
- (4) Anticipated deflation may reduce current consumption due to the asymmetric effect on future prices and the real interest rate, as consumers wait for cheaper prices in the future.⁵ This is consistent with deflation's potential impact on money demand. Of course, once the price deflation is over, consumers would be willing to spend more on now-cheaper goods, so it is the expectation of deflation rather than deflation itself which can lead to more deflation.
- (5) Deflation may be different from inflation, because central bank responses may be asymmetric, at least in exchange rate regimes that are explicitly or implicitly pegged. In the prewar gold standard, for example, central banks could improve the quality of their reserve assets by sterilizing gold inflows with bond sales, thus counteracting the return

⁵ Cargill and Parker (2003b) present a simple two-period utility maximizing model to illustrate this point.

of a balance of payments surplus to equilibrium. What emerged was a neo-mercantilist prisoner's dilemma among central banks, each vying for a larger share of a fixed amount of gold. In the absence of a gold standard, central bank responses in countries with unilateral rather than multilateral pegs may be asymmetric in a different way: inflation causes a balance of payments deficit and forces the central bank to depreciate the currency, but deflation, which causes a balance of payments surplus, does not necessarily force appreciation.

In his classic study of hyperinflation, Cagan (1956) found that money demand decreases with higher inflation rates, because the public anticipates further price increases of such large magnitudes that it substitutes commodities for money. The higher the expected inflation rate, the greater the portfolio shift from money to commodities. Though Cagan dealt with episodes of hyperinflation, the basic point is that expectations of price changes influence the balance between money and commodities. Deflation can have a similar effect in that expectations of declining prices provide an incentive to shift from commodities to money. The deflation in Japan is not of the same magnitude as the inflations studied by Cagan, but the basic point of the effect of expectations on money demand remains. Given other aspects of the deflation process (nominal interests bounded from below by zero), deflation of a specific rate will have larger effects on portfolio behavior than inflation of the same rate.

These considerations together suggest that even a low deflation rate over a period of time, such as that experienced by Japan since 1995, can have adverse effects on the economy even if deflation is perfectly anticipated. The combined effect of these adverse effects can generate a discontinuity for monetary policy in the sense that monetary policy, even though it does not lose the ability to stimulate aggregate demand, is required to become increasingly aggressive and nontraditional if it is to reverse the downward movement in prices. In this type of discontinuity, the central bank is not necessarily unable to reverse the process, nor is it assumed that fiscal policy is superior to monetary policy, as in the 1930s-style liquidity trap concept.

The type of discontinuity suggested involves the following heuristic steps. Restrictive monetary growth generates disinflation followed by deflation. Deflation lowers nominal interest rates to essentially zero and increases real interest rates, thereby reducing aggregate demand. Deflation increases the real burden of servicing outstanding debt fixed in nominal value and the larger the amount of debt outstanding, the larger the increase in the real burden. This then leads to increased bankruptcy and problems for the banking system and reduces the willingness to lend, which in turn, is reflected by a decline in the money multiplier. Deflation reduces real consumption as increasing real interest rates provide incentives to shift resources from consumption to saving. Finally, deflation increases the demand for money.

There are clearly many elements in this process that need to be worked out in a formal theoretical model; however, the purpose here is to outline the process in order to assess the empirical results on money demand. An increase in the demand for money is an important part of the process.

An important feature of the discontinuity is that monetary policy encounters increasing difficulty in reversing the process the longer deflation is permitted to continue. Restrictive monetary policy generates deflation, which in turn reduces aggregate demand contributing

to further deflation. Deflation reduces the money multiplier, thereby inhibiting the effect of an easy monetary policy. Deflation increases money demand, thereby reducing the effect on aggregate demand of easy monetary policy. Once such a process takes hold, central banks need to aggressively reverse the downward price trend and reestablish anticipations of price increases.

It is important to emphasize that this type of discontinuity is different from the liquidity trap of the 1930s, despite frequent references to Japanese deflation and monetary policy in terms of liquidity trap language (Krugman, 1999, 2000). The phrase “liquidity trap” in this context is misleading, because the liquidity trap of the 1930s is different from the discontinuity outlined above. The liquidity trap is induced by non-monetary forces, whereas the discontinuity process is the product of central bank failure to prevent deflation. The liquidity trap cannot be circumvented by conventional monetary policy, whereas the discontinuity process can be reversed by aggressive monetary ease. Thus, there is no contradiction between the evidence cited by other researchers (e.g., Hetzel, 2003) that Japan is not in a liquidity trap and the evidence presented in this paper that Japan is experiencing a discontinuity in its monetary policy process.

This point has been emphasized by a number of researchers. Krugman (1999, 2000), who is generally regarded as the first to bring back the liquidity trap⁶ terminology, did not think that the Bank of Japan was in a classic liquidity trap. The solution was for the Bank of Japan to commit to an aggressive monetary expansion sufficient to reverse price anticipations. Krugman suggested an inflation target framework to accomplish this task, as did Cargill et al. (2000) and others. Meltzer (1999), repeating an argument advanced by Brunner and Meltzer (1968), argued that the liquidity trap of the 1930s variety was a theoretical impossibility. Others have stressed the same point. Uhlig (2000) argued that a liquidity trap cannot exist in an open economy, because banks should then be willing to lend abroad at higher interest rates, which in turn should lead to higher domestic interest rates. This has been seconded by McCallum (2000), who argued that the foreign exchange market should provide monetary stabilization even when nominal interest rates fall to zero. However, McKinnon (1999) argues that relatively low nominal interest rates could be sustainable with expectations of continued domestic currency appreciation, as implied by the interest rate parity condition; this requires the expectation, however, that the higher growth rate in the money supply is temporary.

There are many elements to the discontinuity in the monetary policy process generated by demand-led deflation. We have already illustrated the different pattern of movements in the money multiplier in Japan, where it has declined along with deflation, and in China and the United States, where it has increased and stabilized, respectively. Considering China and Japan and the assumed source of deflation, differences in movements in the money multiplier are not surprising. Real interest rates in Japan are increasing, while they are stable in China and the United States. Cargill and Parker (2003b) provide empirical evidence that consumption in Japan has fallen in response to deflation.

⁶ As pointed out by Orphanides (2004), Keynes did not hold much regard for the possibility of liquidity traps, and generally held the view that aggressive monetary policy would be able to stimulate the economy. It was the interpreters of Keynes who popularized the concept of the liquidity trap, and emphasized the impotence of monetary policy and the relative power of fiscal policy.

4. An empirical analysis of deflation and money demand

This section investigates how deflation may have affected money demand in Japan and China relative to the United States, a country currently without deflation. China and Japan are suitable case studies, since both economies represent recent deflation experiences and the source of deflation differs in each economy. We have already reviewed the behavior of monetary variables, including real and nominal interest rates as well as the relationships between money, GDP, and the monetary base to highlight the stylized differences between China and Japan as well as the base case of the United States. This section estimates simple money demand equations for each country for both quarterly and annual data.⁷

4.1. Deflation and money demand with quarterly data

In order to test whether deflation has an impact on money demand in addition to the effect of disinflation, and to see if there is a difference between demand-led and supply-led deflation, we estimate a simple money demand function for the United States, Japan, and China, using quarterly data for the past several decades. Since the United States has experienced almost no deflation during this time, we use it as a baseline. We then consider whether deflation has any additional impact on money demand in Japan, where deflation has been demand-led and nominal interest rates have hit their lower bound, and in China, where deflation has been primarily supply-led and nominal rates are still positive.

In testing the stability of Japanese money demand, Bahmani-Oskooee (2001) begins with a traditional money demand equation:

$$\ln m_t = a + b \ln y_t + ci_t + e_t,$$

where m is real M2 money stock, y is real GDP, i is the nominal interest rate, and the parameters are signed as $a > 0$ and $b < 0$.⁸ Fujiki, Hsiao, and Shen (2002) use a similar money demand equation, but suggest a stock adjustment process to the preferred stock m^* :

$$(\ln m_t - \ln m_{t-1}) = \gamma(\ln m_t^* - \ln m_{t-1}) + u_t.$$

This then leads to the solution:

$$\ln m_t = \beta_m \ln m_{t-1} + \beta_y \ln y_t + \beta_i i_t + \beta_0 + e_t,$$

⁷ For the United States, all data used here were gathered from the St. Louis Federal Reserve Bank's Federal Reserve Economic Data (FRED II) website <http://research.stlouisfed.org/fred2>. For the interest rate, we used the one-year T-Bill rate. For Japan, GDP data were gathered from the website of the Economic and Social Research Institute <http://www.esri.cao.go.jp/index-e.html>, a cabinet office of the government of Japan, and monetary data were gathered from the Bank of Japan <http://www.boj.or.jp/en/stat.f.htm>. For the interest rate, we used the overnight collateralized call rate. For China, we used monthly information from the People's Bank of China to update monetary data from Yu and Tsui (2000), and prior quarterly data were available from the IMF's *International Financial Statistics*. Annual GDP data are available in the *China Statistical Yearbooks*, and this was updated using information from the University of Michigan's China Data Center, thanks to assistance from Shuming Bao. As quarterly Chinese GDP data are reported cumulatively, rather than in annual equivalents, and decomposition of these numbers is beyond the scope of this paper, we extrapolated quarterly GDP data from the annual figures by a smoothing procedure, in order to parallel the available monetary data.

⁸ See Table 2 for a definition of variables.

Table 2

Variables used in estimations

$\ln m$	Natural log of real M2 in the U.S. and China, and M2 + CD in Japan
$\ln y$	Natural log of real GDP
i	Nominal interest rate (one-year Treasury Bill rate in the U.S., overnight collateralized call rate in Japan)
π	Quarterly inflation rate for GDP Deflator
D	Dummy variable, one if $\pi < 0$, zero otherwise
π^d	Deflation rate, $D \times \pi$, so $\pi^d \leq 0$
gap	Residual of simple regression of $\ln y$ on a constant and a time variable

Source: See footnote 7.

where the coefficients are functions of the original parameters and the adjustment speed γ . In finite samples the coefficients may be biased, and the variables tend to have unit roots. Hence, the authors also specify the relationship in first differences as:

$$\Delta \ln m_t = \beta_m \Delta \ln m_t + \beta_y \Delta \ln y_t + \beta_i \Delta i_t + \beta_0 + v_t.$$

We begin by estimating both the level equation and the difference equation, using quarterly data for the United States, Japan, and China, with two additions. First, we add a variable for the inflation rate, measured simply as $\pi_t = P_t/P_{t-1} - 1$. Though the expected inflation rate is implicitly part of the nominal interest rate, Cagan’s hypothesis would suggest that inflation has an additional effect. Second, we estimate the effect of deflation on money demand in two ways: by using a dummy variable D_t for the presence of deflation, where D_t equals one if $\pi_t < 0$ and zero otherwise; and by using the variable $\pi_t^d = D_t \pi_t$ to capture any additional asymmetry between inflation and deflation. For the sake of comparison, we estimate all three versions:

$$\begin{aligned} \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln y_t + \beta_i i_t + \beta_p \pi_t + \beta_0 + e_t \\ \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln y_t + \beta_i i_t + \beta_p \pi_t + \beta_0 + \delta_d D_t + e_t \\ \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln y_t + \beta_i i_t + \beta_p \pi_t + \beta_0 + \delta_{di} \pi_t^d + e_t. \end{aligned} \tag{1}$$

Since real money may be non-stationary,⁹ and the lagged dependent variable may thus capture most of the interesting variation, we also estimate:

$$\begin{aligned} \Delta \ln m_t &= \beta_m \Delta \ln m_{t-1} + \beta_y \Delta \ln y_t + \beta_i \Delta i_t + \beta_p \Delta \pi_t + \beta_0 + e_t \\ \Delta \ln m_t &= \beta_m \Delta \ln m_{t-1} + \beta_y \Delta \ln y_t + \beta_i \Delta i_t + \beta_p \Delta \pi_t + \beta_0 + \delta_d \Delta D_t + e_t \\ \Delta \ln m_t &= \beta_m \Delta \ln m_{t-1} + \beta_y \Delta \ln y_t + \beta_i \Delta i_t + \beta_p \Delta \pi_t + \beta_0 + \delta_{di} \Delta \pi_t^d + e_t. \end{aligned} \tag{2}$$

In the level equations (e.g., equation set 1 above), we use the iterative Cochrane-Orcutt method to estimate an AR(1) term, where significant. If additional asymmetries between inflation and deflation are present in either set of equations, then we would expect that $\delta_d > 0$ and $\delta_{di} < 0$.

⁹ In estimates not included in this paper, we are able to reject the hypothesis of simple unit roots for Chinese money data, though we cannot reject it in the case of the augmented Dickey-Fuller test with trend. For the U.S. and Japan, however, we cannot reject the hypothesis of unit roots in either the simple or augmented cases. Thus, we include the money demand equation in first differences to determine whether the presence of unit roots affects the sign and significance of the coefficients for deflation.

Next, we consider the problem of simultaneity, since money, income, interest rates, and the inflation rate are all functions of each other. We attempt to address this problem first by using lagged values of $\ln y$, i , and π , and so we estimate the following three equations:

$$\begin{aligned} \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln y_{t-1} + \beta_i i_{t-1} + \beta_p \pi_{t-1} + \beta_0 + e_t \\ \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln y_{t-1} + \beta_i i_{t-1} + \beta_p \pi_{t-1} + \beta_0 + \delta_d D_t + e_t \\ \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln y_{t-1} + \beta_i i_{t-1} + \beta_p \pi_{t-1} + \beta_0 + \delta_{di} \pi_t^d + e_t. \end{aligned} \quad (3)$$

Then we use the two-stage approach suggested in Cargill and Meyer (1974), by regressing $\ln y$, i , and π on the past four lagged values of all three variables, and then use the resulting current predicted values to re-estimate the three equations. We continue to treat current deflation as an exogenous variable, since we presume that the simultaneity issue is already addressed in the inflation rate variable. So, we estimate:

$$\begin{aligned} \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln \hat{y}_t + \beta_i \hat{i}_t + \beta_p \hat{\pi}_t + \beta_0 + e_t \\ \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln \hat{y}_t + \beta_i \hat{i}_t + \beta_p \hat{\pi}_t + \beta_0 + \delta_d D_t + e_t \\ \ln m_t &= \beta_m \ln m_{t-1} + \beta_y \ln \hat{y}_t + \beta_i \hat{i}_t + \beta_p \hat{\pi}_t + \beta_0 + \delta_{di} \pi_t^d + e_t. \end{aligned} \quad (4)$$

These last two sets are estimated in levels in spite of the possible presence of unit roots, because in the first differences there is little correlation between current and lagged values, and we again adjust for autoregression where significant.¹⁰ Thus, we must be cautious about reading too much into the coefficient estimates, for unfortunately there is no perfect and easy way around both the simultaneity and stationarity problems in this framework.

In a simple money demand equation, we would expect that $\beta_y > 0$ and $\beta_i < 0$, though the simultaneity problem might affect this when using current values. But even lagged terms may not have the predicted values if, for example, monetary authorities respond to recent income growth by tightening the money supply. If $\beta_p < 0$, then this might imply that higher (lower) inflation leads to less (more) money demand, but it could also indicate that the central bank is tightening the money supply in response to rising inflation.

Our results using quarterly data for the United States from 1960 to 2002, shown in Table 3, are what we would generally expect. In all four sets, for all three equations in each, we find statistically significant expected signs for β_y and β_i , and the parameter on the lagged dependent variable is significant and of an appropriate magnitude. We also find the expected signs for β_p , indicating that the inflation rate has the additional Cagan effect, though in sets (3) and (4), both of which rely on lagged values, the coefficient is insignificant. The effect of deflation is insignificant in sets (1) and (2), and significant in sets (3) and (4). However, because the United States experienced only one quarter of decline in the GDP deflator since 1960, these results cannot be interpreted as anything more than a mere indicator of a possible effect.

As Bahmani-Oskooee (2001) pointed out, Japanese money demand estimates have a reputation for instability, and our results in Table 4 may be consistent with this instability. Using quarterly data from 1970 to 2002, we find that the income coefficient is usually negative and/or statistically insignificant. The nominal interest rate has the expected negative and statistically significant coefficient. The inflation coefficient is usually negative and significant,

¹⁰ The standard errors for the estimated variables in this two-stage approach are not asymptotically efficient, but the procedure more easily allows estimation of the autoregression effect.

Table 3
 Quarterly money demand regression results for the United States, 1960–2002

Parameter	(1) Levels		(2) Differences		(3) Lags		(4) Two-stage	
	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat
β_m {lag money}	0.779	16.35	0.740	14.32	0.593	10.43	0.614	11.15
β_y {ln GDP}	0.155	3.79	0.103	1.79	0.105	1.85	0.136	2.54
β_i {nominal <i>i</i> }	-0.268	-4.83	-0.252	-4.33	-0.444	-6.90	-0.431	-6.63
β_p {inflation}	-1.117	-7.03	-1.096	-6.96	-0.085	-0.50	-0.131	-0.45
β_0 {constant}	0.339	5.15	0.001	1.89	0.741	7.21	0.671	6.98
ρ {AR(1)}	0.936	34.68			0.986	77.95	0.985	74.53
Adj. R^2	0.9997		0.6348		0.9997		0.9997	
ln <i>L</i>	419.40		640.73		404.74		407.16	
β_m {lag money}	0.779	16.29	0.745	14.20	0.587	10.45	0.610	11.20
β_y {ln GDP}	0.156	3.79	0.102	1.75	0.111	1.97	0.142	2.69
β_i {nominal <i>i</i> }	-0.267	-4.81	-0.254	-4.35	-0.449	-7.08	-0.428	-6.67
β_p {inflation}	-1.108	-6.81	-1.116	-6.93	-0.131	-0.78	-0.213	-0.73
δ_d {dummy}	0.001	0.25	<i>-0.002</i>	-0.62	0.010	2.37	0.010	2.27
β_0 {constant}	0.339	5.14	-0.001	-0.20	0.756	7.36	0.677	7.12
ρ {AR(1)}	0.936	34.57			0.987	79.26	0.985	74.64
Adj. R^2	0.9997		0.6334		0.9997		0.9997	
ln <i>L</i>	419.43		640.93		407.66		409.79	
β_m {lag money}	0.779	16.29	0.739	14.26	0.587	10.45	0.610	11.20
β_y {ln GDP}	0.156	3.79	0.104	1.79	0.111	1.97	0.142	2.69
β_i {nominal <i>i</i> }	-0.267	-4.81	-0.251	-4.31	-0.449	-7.08	-0.428	-6.67
β_p {inflation}	-1.108	-6.81	-1.088	-6.73	-0.131	-0.78	-0.213	-0.73
δ_{dp} {deflation}	-0.788	-0.25	-0.773	-0.25	-7.790	-2.37	-7.391	-2.27
β_0 {constant}	0.339	5.14	0.001	1.89	0.756	7.36	0.677	7.12
ρ {AR(1)}	0.936	34.57			0.987	79.26	0.985	74.64
Adj. R^2	0.9997		0.6327		0.9997		0.9997	
ln <i>L</i>	419.43		640.76		407.66		409.79	

Notes. Bold indicates statistical significance of 10% or less; italics indicate an unexpected sign. The AR(1) coefficient ρ is excluded from the difference estimations.

except in set (3), while the effect of deflation is usually of the predicted sign, and it is significantly different from zero in both sets (3) and (4). The effect of deflation does not appear to be large, however. Using the deflation dummy, we find that the presence of price deflation leads at most to approximately a 5% increase in money demand. Weighting the deflation dummy by the deflation rate, a 1% deflation rate seems to lead to less than a 2% increase in money demand. This suggests that in Japan the demand for money has a tendency towards a deflationary discontinuity, and the instability in the other coefficients may even support the argument that deflation has made Japanese money demand less stable and predictable.

For China, a number of researchers in the past decade (i.e., Hafer & Kutan, 1993; Hasan, 1999; Xu, 1998; Yu, 1997; Yu & Tsui, 2000) have examined the relationship between money, income, and prices. These efforts have focused on establishing causality and cointegration, and have not given any particular consideration to deflation. Nor have any of these papers used the nominal interest rate in their estimations, perhaps because the credit market is still state-regulated and dominated by the big four state banks, or perhaps because consistent nominal interest rate data have not been available for long.

Table 4
 Quarterly money demand regression results for Japan, 1970–2002

Parameter	(1) Levels		(2) Differences		(3) Lags		(4) Two-stage	
	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat
β_m {lag money}	1.013	48.55	0.805	11.71	0.807	12.30	0.963	26.93
β_y {ln GDP}	-0.068	-2.06	-0.169	-1.90	0.284	2.83	0.011	0.19
β_i {nominal <i>i</i> }	-0.134	3.50	-0.414	-2.83	-0.311	-2.38	-0.149	-2.10
β_p {inflation}	-0.882	-30.90	-0.780	-21.53	0.534	8.44	-0.870	-23.57
β_0 {constant}	0.012	0.51	0.003	2.38	0.235	3.16	0.066	1.66
ρ {AR(1)}					0.241	2.83	0.273	3.23
Adj. R^2	0.9996		0.8412		0.9973		0.9993	
ln <i>L</i>	285.96		392.23		159.14		243.72	
β_m {lag money}	1.010	45.13	0.739	10.26	0.940	26.56	0.978	30.72
β_y {ln GDP}	-0.064	-1.80	-0.186	-2.13	0.060	1.10	<i>-0.009</i>	-0.18
β_i {nominal <i>i</i> }	-0.136	-3.28	-0.345	-2.36	-0.153	-2.26	-0.143	-2.28
β_p {inflation}	-0.848	-13.46	-0.665	-11.66	-0.036	-0.66	-0.612	-7.99
δ_d {dummy}	0.002	0.52	0.006	2.57	0.053	14.91	0.018	3.91
β_0 {constant}	0.013	0.52	0.005	3.28	0.061	1.51	0.039	1.09
ρ {AR(1)}					0.095	1.09	0.207	2.41
Adj. R^2	0.9996		0.8480		0.9990		0.9993	
ln <i>L</i>	286.09		395.60		225.22		251.04	
β_m {lag money}	1.013	48.36	0.782	11.10	0.954	27.34	0.987	31.21
β_y {ln GDP}	-0.068	-2.05	<i>-0.151</i>	-1.69	0.023	0.43	<i>-0.028</i>	-0.56
β_i {nominal <i>i</i> }	-0.133	-3.47	-0.424	-2.90	-0.123	-1.85	-0.144	-2.32
β_p {inflation}	-0.873	-15.56	-0.834	-15.46	-0.147	-2.35	-0.655	-10.09
δ_{dp} {deflation}	-0.023	-0.19	<i>0.150</i>	1.36	-1.881	-13.57	-0.537	-4.11
β_0 {constant}	0.011	0.49	0.004	2.50	0.048	1.20	0.031	0.89
ρ {AR(1)}							0.201	2.34
Adj. R^2	0.9996		0.8423		0.9989		0.9994	
ln <i>L</i>	285.98		393.19		217.64		251.73	

Notes. Bold indicates statistical significance of 10% or less; italics indicate an unexpected sign. The AR(1) coefficient ρ is excluded from the difference estimations or if its asymptotic *t*-value is less than one.

Table 5 reports estimates of a simple money demand relationship for China, using quarterly data for Chinese M2 (money and deposits), though quarterly GDP and deflator figures are estimated from annual data. Like other researchers, we drop the nominal interest rate. We do not find our money demand equations to be a good fit. In the level equations, money is significantly related to its lagged value, and the coefficients for income and inflation are of the expected sign, but statistically insignificant. For the difference equations in set (2), however, all coefficients are insignificant and usually of the opposite sign. The coefficients for deflation, too, are insignificant and of the opposite sign in all cases. We are thus unable to find any evidence that deflation has had an asymmetric effect on money demand in China.

4.2. Deflation and money demand with annual data

Because the United States did experience deflation during the Great Depression, a period for which we do have annual data, we estimate equation sets (1) and (2) for the United States

Table 5
Quarterly money demand regression results for China, 1985–2002

Parameter	(1) Levels		(2) Differences		(3) Lags		(4) Two-stage	
	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat
β_m {lag money}	0.967	19.83	0.152	1.28	0.960	20.65	0.960	20.35
β_y {ln GDP}	0.045	0.51	<i>-0.179</i>	-0.33	0.057	0.69	0.056	0.67
β_p {inflation}	-0.399	-1.52	0.072	0.10	-0.401	-1.54	-0.429	-1.52
β_0 {constant}	0.062	4.50	0.038	2.89	0.065	4.27	0.065	4.49
Adj. R^2	0.9988		-0.0183		0.9988		0.9988	
ln L	61.63		150.94		61.70		61.60	
β_m {lag money}	0.967	19.68	0.154	1.29	0.960	20.49	0.960	20.20
β_y {ln GDP}	0.044	0.51	<i>-0.220</i>	-0.40	0.058	0.69	0.057	0.67
β_p {inflation}	-0.428	-1.45	0.076	0.11	-0.430	-1.48	-0.456	-1.45
δ_d {dummy}	-0.003	-0.22	-0.001	-0.30	<i>-0.003</i>	-0.23	<i>-0.002</i>	-0.20
β_0 {constant}	0.063	4.47	0.038	2.86	0.066	4.22	0.065	4.42
Adj. R^2	0.9988		-0.0323		0.9988		0.9988	
ln L	61.65		150.99		61.73		61.62	
β_m {lag money}	0.966	19.68	0.152	1.27	0.958	20.40	0.958	20.09
β_y {ln GDP}	0.047	0.53	<i>-0.177</i>	-0.33	0.062	0.74	0.061	0.72
β_p {inflation}	-0.462	-1.59	0.061	0.08	-0.461	-1.61	-0.490	-1.58
δ_{dp} {deflation}	1.098	0.51	0.190	0.06	<i>1.092</i>	0.51	<i>1.029</i>	0.48
β_0 {constant}	0.064	4.49	0.038	2.86	0.067	4.24	0.066	4.44
Adj. R^2	0.9988		-0.0336		0.9988		0.9988	
ln L	61.77		150.94		61.84		61.73	

Notes. Bold indicates statistical significance of 10% or less; italics indicate an unexpected sign. Nominal interest rates are not included due to missing data. The AR(1) coefficient ρ is excluded from the difference estimations or if its asymptotic *t*-value is less than one.

after 1929. We do not estimate sets (3) and (4), because lags of a year or more are too great to have any significant effects on current money. We include Chinese and Japanese annual data for comparison. We estimate three equations for each set, the first with no deflation variable, the second using the deflation rate $\pi_t^d = D_t \pi_t$, and the third where we include the product of π_t^d and two related variables, the GDP gap (estimated as the residual of a simple regression of ln y on a time trend) and ln i , where the natural log is used to capture the effects of small changes in the nominal interest rate as it approaches (but never reaches) zero. We would expect the coefficients on both these products to be positive, since we are considering the coexistence of deflation ($\pi_t^d < 0$) with recession (gap < 0) and/or low nominal interest rates (ln $i < 0$).

The results are shown in Table 6. For the United States, both sets of equations show a good fit, with statistically significant coefficients of the expected sign. The inflation rate has a significant and negative effect, consistent with the Cagan effect. Of particular interest is the positive and significant coefficient on the product of π_t^d and the GDP gap; though the coefficient on the product of π_t^d and ln i is positive, it is not statistically significant at the 10% level. So there is some evidence here that deflation may have had an additional asymmetric effect during the Great Depression.

For Japan, the money demand equation appears to be a better fit with annual data, where the coefficients on income, the nominal interest rate, and the inflation rate are all statistically

Table 6
Annual money demand regression results

Parameter	United States 1930–2002				Japan 1960–2002				China 1985–2002			
	(1) Levels		(2) Differences		(1) Levels		(2) Differences		(1) Levels		(2) Differences	
	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat	Estimate	<i>t</i> -stat
β_m {lag money}	0.605	8.64	0.508	5.77	0.719	8.52	0.750	4.95	0.701	1.96	0.424	1.25
β_y {ln GDP}	0.352	5.82	0.299	4.17	0.308	2.39	0.341	2.05	0.477	0.77	0.139	0.23
β_i {nominal <i>i</i> }	-0.853	-3.00	-1.030	-3.49	-0.592	-2.81	-0.609	-2.98				
β_p {inflation}	-0.698	-5.65	-0.663	-5.42	-0.635	-4.23	-0.690	-3.81	-0.500	-2.13	-0.444	-1.65
β_0 {constant}	0.652	6.55	0.006	1.36	0.388	4.79	-0.004	-0.50	0.237	3.99	0.073	1.59
ρ {AR(1)}	0.822	12.25			0.680	5.94			0.512	2.46		
Adj. R^2	0.9984		0.5369		0.9993		0.7694		0.9978		0.0714	
ln <i>L</i>	72.56		154.39		64.47		99.00		8.44		29.79	
β_m {lag money}	0.555	7.95	0.508	5.91	0.671	6.78	0.723	4.55	0.650	1.70	0.418	0.36
β_y {ln GDP}	0.403	6.51	0.385	5.08	0.374	2.55	0.390	2.17	0.552	0.84	0.173	0.63
β_i {nominal <i>I</i> }	-0.935	-3.36	-1.071	-3.74	-0.585	-2.70	-0.613	-2.91				
β_p {inflation}	-0.633	-4.11	-0.627	-4.19	-0.596	-3.76	-0.663	-3.50	-0.519	-1.98	-0.431	-1.45
δ_{dp} {deflation}	2.595	2.18	2.392	1.99	-0.144	-0.01	-4.096	-0.22	<i>20.892</i>	-0.77	<i>16.023</i>	0.71
δ_{dpg} {defl. \times gap}	3.524	2.22	3.645	2.41	6.438	0.20	12.308	0.38	<i>-14.255</i>	-0.78	<i>-14.302</i>	-0.73
δ_{dpi} {defl. \times ln <i>i</i> }	0.362	1.36	0.310	1.16	0.580	1.07	0.479	0.87				
β_0 {constant}	0.721	7.22	0.003	0.61	0.429	4.63	-0.004	-0.59	0.249	3.62	0.071	1.41
ρ {AR(1)}	0.853	13.89			0.660	5.62			0.557	2.76		
Adj. R^2	0.9986		0.5809		0.9993		0.7561		0.9976		-0.0323	
ln <i>L</i>	77.83		159.63		65.31		99.64		8.90		30.31	

Notes. Bold indicates statistical significance of 10% or less; italics indicate an unexpected sign. Nominal interest rates are not included in Chinese estimations due to missing data. The AR(1) coefficient ρ is excluded from the difference estimations.

significant in both sets of equations, and of comparable magnitude with those for the United States. The coefficients on deflation are of the expected sign, but not statistically significant. The effect of deflation on Japanese money demand thus seems not to be comparable with that experienced by the United States during the Great Depression; but if Japan continues to experience deflation in the future, this effect may become more significant.

For China, the coefficients for income and the inflation rate now have the expected sign, though only the inflation rate coefficient is statistically significant. The coefficients on the lagged dependent variables are significant in the level equations, but not in the difference equations. As with the quarterly data, the coefficients on the effect of deflation are insignificant and of the opposite sign. There is thus still no evidence that deflation has affected money demand, a result consistent with the argument that China's deflation has been largely supply-driven.

Keeping in mind the difficulties of estimating money demand for China and Japan, the differential impact of deflation on money demand in China and Japan may nonetheless be a meaningful reflection of the differing sources of deflation. In China, price deflation is most likely a supply-led phenomenon, since output continues to increase and nominal interest rates remain reasonably above zero, so there should be no tendency for a deflationary discontinuity. In contrast, Japan's deflation is most likely demand-led, since output is stagnant or declining and nominal interest rates are close to zero.

5. Summary and policy implications

The empirical results suggest that money demand is influenced by the presence of demand-led deflation. Japan's demand for money estimates are consistent with the presence of an independent effect by the deflation process that commenced in 1995, though the evidence is not strongly significant. The evidence for Japan is not as dramatic as for the United States in the 1930s, but nonetheless the money demand functions do show sensitivity to deflation. In contrast, the money demand functions for China suggest that deflation has no measurable effect on money demand at any reasonable level of confidence. The difference between China and Japan (and the United States in the 1930s) can be attributed to the fact that deflation in China is supply-led, due to increased competition and productivity, while deflation in Japan is demand-led due to restrictive monetary policy. The resulting differential effect of deflation in China and Japan is also reflected by movements in the real rate of interest and the money multiplier.

Japan appears to be experiencing a discontinuity in the monetary policy process. Deflation has been accompanied by slow or declining real GDP, increasing real interest rates, a declining money multiplier, and a tendency for the demand for money to shift upward.

The policy implications are obvious. First, central banks should be as concerned, if not more concerned, with deflation than they have been in the past, for small rates of deflation may have a significantly greater impact than equivalently small rates of inflation. Second, once deflation begins, central banks need to pursue aggressive and nontraditional monetary policy to reestablish positive price anticipations by the public. Third, the longer the central bank postpones these actions, the more difficult it will become to reverse the process. This is not the place to discuss the issues of central bank independence/dependence and inflation

targeting, but clearly there is a growing recognition that deflation is a serious problem in Japan and may become a serious problem elsewhere (see [Federal Reserve System, 2003](#)). This in turn has motivated a discussion that further institutional redesign of central banks along inflation (or price-path) targeting lines, as originally suggested by [Simons \(1936\)](#), may be required to ensure price stability, and prevent deflation as well as inflation.

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