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Assessing Potential Inflation Consequences of QE after Financial Crises

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Abstract

Financial crises have been followed by different inflation paths which are related to monetary policy and money creation by the banking sector during those crises. Accounting for equilibrium changes and non-linearity issues, the empirical relationship between money and subsequent inflation developments has remained stable and similar in crisis and normal times. This analysis can explain why the financial crisis in Argentina in the early 2000s was followed by increasing inflation, whereas Japan experienced deflation in the 1990s and 2000s despite quantitative easing. Current quantitative easing policies should lead to increasing and persistent inflation over the next years.

JEL codes: E52; E58; E41

Keywords: Financial crises, inflation, monetary aggregates, quantitative easing

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1. Introduction

A major issue faced by central bankers in the current environment, i.e. with short-term policy interest rates at the zero lower bound after a financial crisis, is how to evaluate the potential consequences of quantitative easing policies (QE) on future inflation. Central banks have limited experience with QE and financial crises, and economic research has largely ignored the analysis of financial sector transmission and quantities, i.e. monetary and credit aggregates, over the past 20 years. This paper assesses the potential consequences of current quantitative easing policies for inflation by analyzing the behavior of money and inflation during relatively recent episodes of financial crises, i.e. Argentina (early 2000s), Japan (1990s and early 2000s), the US (1930s) and Switzerland (early 1990s).

The analysis presented in this paper shows that historical episodes of financial crises have been accompanied by different monetary stimulus, which were function of monetary policy reaction and financial sector transmission mechanisms. This has resulted in different inflation paths after the crises. For example, the analysis can explain why the financial crisis in Argentina in the early 2000s was followed by increasing inflation whereas Japan experienced deflation in the 1990s and 2000s despite quantitative easing. The banking sector in Argentina transmitted monetary impulses with a strong expansion of money and credit aggregates after the crisis, leading to increasing inflation. In contrast, Japanese monetary aggregates decreased during the financial crisis of the 1990s, leading to disinflation and deflation. Moreover, the Japanese banking sector did not transmit the Bank of Japan quantitiative easing in the early 2000s, thus broad money and credit aggregates did not increase with the expansion of banks' reserves, and inflation remained close to zero.

The methodology, similar to Reynard (2007), is based on a long-run equilibrium analysis involving money, prices, real GDP and interest rates, and an analysis of dynamic relationship between money and price levels, accounting for equilibrium changes and non-linearity issues. The relationship is stable and similar across countries, in normal times as well as during episodes of financial crisis. The relationship between money and price levels can be characterized as follows, in a cointegrating relationship: price levels follow money levels, with lags of several years; however, when money levels decrease, price levels do not (or just barely) decrease; in that latter case, inflation remains near zero until the money level increases back above the price level, i.e. until monetary conditions are back to equilibrium. In other words, prices follow money levels in a proportional and linear way in high inflation environments, and the analysis uncovers a non-linear relationship between money and subsequent price levels that is similar across countries when inflation is close to zero. The non-linearity when inflation is close to zero needs to be accounted for to assess the effects of monetary policy at low inflation. This represents an issue for standard econometric modeling and can explain the observed weak relationship between money growth and inflation in low inflation countries.

Not only can monetary aggregates explain different inflation trends across countries and time, but persistent money movements always lead persistent changes in inflation, usually by several years. The fact that money is useful to predict persistent inflation movements and changes in inflation trends is particularly useful relative to the standard New Keynesian (NK) macroeconomic literature, where models are linearized around a given inflation steady state or exogenous trend.

Policy implications from this empirical analysis sharply contrast with interpreta-

tions of the NK framework for policy prescriptions. It is usually argued that it is sufficient to monitor inflation expectations, and that central banks can avoid accelerating inflation by quickly withdrawing reserves (or by increasing the interest rate payed on reserves) once inflation expectations start rising. The monetary analysis of this paper however shows that there has never been a situation of excess broad money (created by the banking system) which has not been followed by increasing inflation, and that the increase in inflation occurs after several years lags. Such inflation increases are persistent and occur even after money levels are subsequently reduced with restrictive monetary policy trying to fight the increase in inflation.

Section 2 presents the methodology to characterize the empirical relationship between money and inflation; section 3 compares the behavior of money and inflation during and after financial crises, as well as in normal times; section 4 assesses the potential consequences of recent QE on future inflation, and the last section concludes.

2. Characterizing the empirical money-price relationship: methodology

The starting point of the methodology used in this paper is the quantity theory of money (QT), represented by equation (1),

$$M_t \cdot V_t = P_t \cdot Y_t, \tag{1}$$

where M_t, P_t and Y_t are the money, price (CPI or GDP price deflator) and real GDP levels, respectively, and V_t is the velocity of money. Over time, with output at its potential and velocity at its equilibrium, changes in prices should be proportional to changes in the money level. However, as pointed out by Nelson (2003), Friedman (1985) noted that "[a] break in the trend of velocity [...] has been observed when-

ever and wherever accelerating inflation has been succeeded by disinflation". These equilibrium velocity movements, or opportunity cost reactions of money demand to changes in inflation environments, have also been pointed out by Wicksell (1906), Barro (1982) and McCallum (1990). This paper models equilibrium velocity as a function of interest rate to reflect changes in inflation environments.

The methodology is similar to Reynard (2007). First, the long-run relationship between the variables mentioned above, i.e. money, price, interest rate and output levels, is estimated, with unit coefficients imposed on money, price and output. This estimates the effect of interest rate on the velocity of money, i.e. a long-run money demand. The money level adjusted for equilibrium changes can then be expressed as

$$m_t^* \equiv c + m_t - y_t^* + \beta i_t^*, \tag{2}$$

where c is the regression constant, m_t is the observed money level, y_t^* is real potential GDP, β is the estimated interest rate semi-elasticity, and i_t^* is a low-frequency filtered interest rate reflecting low-frequency changes in the opportunity cost of money, i.e. equilibrium velocity changes occurring in disinflation and accelerating inflation episodes.[1] In fact, for most countries considered, this velocity adjustment accounts for the downward trend in inflation and interest rates since the 1980s.[2] All variables except interest rates are in logarithms.

As in Reynard (2006, 2007), the choice of monetary aggregate is based on the transaction concept. The monetary aggregates considered are broad aggregates representing funds readily available at no cost to buy goods and services. They represent

[1] Data sources and money demand estimations are described in the appendix.

[2] One-sided filters or the use of actual long-term interest rates yield similar results, with slightly higher variability in the adjusted money series.

the money creation by the banking sector, which is a variable function of the monetary base or central bank money depending on financial sector monetary transmission. The chosen monetary aggregates representing this concept are M2 in Argentina, Japan and Switzerland, and M2- in the US.

Thus the observed money level is adjusted by potential output to reflect the fact that when potential output increases, a corresponding increase in money is not inflationary. And it is also adjusted by the interest rate times the estimated semi-elasticity of money demand to account for the fact that, for example in a long-lasting disinflationary environment when inflation and interest rate decrease, the corresponding increase in money demand reflecting the decline in opportunity cost is not inflationary: the price level does not increase with the money level given that equilibrium velocity decreases.

The empirical strategy is thus to first impose the long-run adjustments required by the quantity theory of money, and then to analyze the dynamics between the adjusted money and price levels. For money to be useful in predicting inflation, the adjusted money and price levels should trend together and money movements should lead inflation developments. This is what the empirical analysis will confirm, in crisis as well as in normal times. Prices follow adjusted money levels in a proportional and linear way in high inflation environments, and the analysis uncovers a non-linear relationship between money and subsequent price levels that is similar across countries when inflation is close to zero.

3. Money and inflation after financial crises

This section presents the evolution of monetary aggregates and inflation during and after financial crises episodes, and compares the relationship between money and inflation in crisis and normal times. The analysis presents long and short-run relationships between money and price movements once long-run adjustments derived from the quantity theory are imposed. This will help understanding why many empirical studies have concluded against a useful link between money and inflation. The principal characteristic is that the link between money and inflation is different in high and low inflation environments, with the latter characterized by a non-linear relationship. As a result, it is difficult to empirically characterize the influence of money on inflation using standard linear econometric models.

The empirical regularities uncovered in this section show however that the link between money and inflation in financial crisis episodes has remained stable and that different inflation outcomes can be related to different monetary developments during financial crises. The section starts with the Swiss case, which is particularly interesting as inflation has been very low over the past four decades with an average of only 2%. As as a consequence, the relationship between the money and price levels that characterizes economies with inflation close to zero, as we will see for the other countries considered, can be analyzed over a long period. After a detailed description of the behavior of money and prices in the Swiss low inflation case, the section pursues to show that the same relationship holds in the other countries when inflation is close to zero, and contrasts it with the relationship in high inflation environments.

3.1. Switzerland

Switzerland is not considered in Reinhart and Rogoff's (2009) study of financial crisis episodes, where real house prices declined by an average of 35% over 6 years. However, Swiss real house prices decreased by about 25% between 1989 and 2000 (peak to trough). The Swiss case can thus also be used to assess the effects of monetary policy during and after a financial crisis.

Figure 1 displays the velocity of M2 together with the 10-year government bond nominal interest rate. There is a clear stable long-run relationship between the four variables considered, i.e. the money, price, real GDP and interest rate levels. The interest rate semi-elasticity of money demand β used to compute m_t^* is estimated at 0.09.

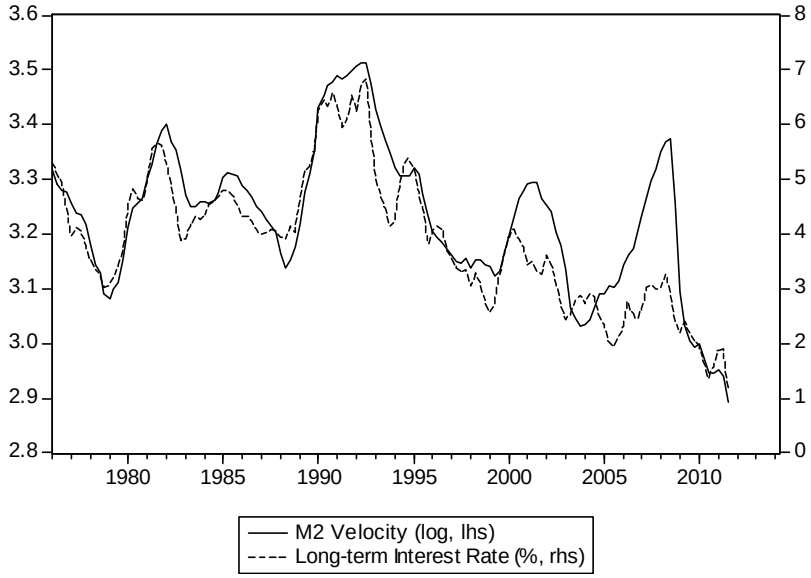

FIG. 1. Velocity and Interest Rate - Switzerland

Figure 2 displays the relationship between adjusted money (m_t^*) and price (p_t)

levels. Increases of money above price levels have been followed by proportional increases in the price level and persistent increases in inflation after a lag of about 3 to 4 years. There is however a clear non-linear pattern in the relationship between money and price levels. The price level does not decline after decreases in the money level, nor does it increase when money increases while below the price level.[3]

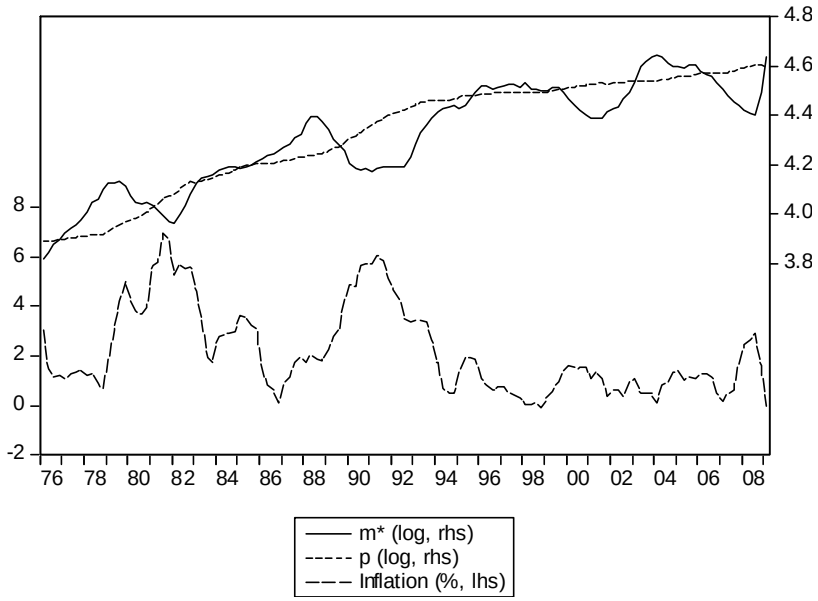

FIG. 2. Money and Prices - Switzerland

This can be seen more clearly on Figure 3, which displays excess liquidity as the difference in percentage points between m_t^* and p_t of Figure 2, together with inflation. Excess liquidity has been forwarded by 3 years on Figure 3 to see more clearly the relationship with inflation and the leading information of money.

When the money level is above the price level, i.e. when excess liquidity on Figure 3 is positive, the price level increases after a lag of about 3 to 4 years. The speed of

[3]Kugler and Reynard (2012) find econometric evidence of non-linear relationships between the money and price levels using a threshold vector error correction model.

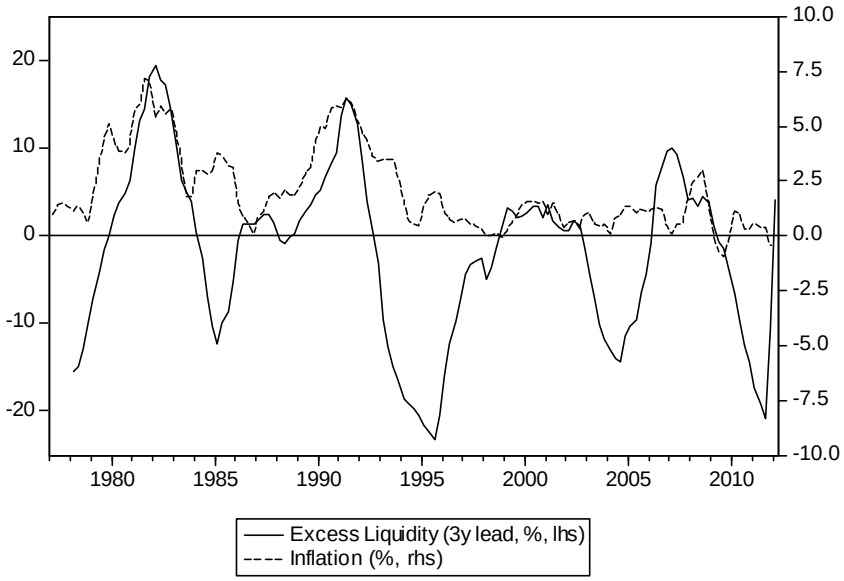

FIG. 3. Excess Liquidity and Inflation - Switzerland

upward price adjustment, i.e. inflation, has been a stable function of the amount of excess liquidity, i.e. of the distance between the money and price level. The lag from the increase in money level to the increase in price level can take several years. On the opposite side however, when the money level is below the price level, i.e. when excess liquidity is negative, the inflation rate does not turn negative. There are thus apparent downward nominal rigidities. An important fact is then that when money growth increases while the money level is below the price level (as for example around 1993), inflation does not increase. This can lead to low and insignificant effects of money growth on inflation in linear econometric models.

As we will see with the other economies considered, the non-linear relationship displayed on Figure 3 between excess liquidity and inflation has been stable across countries when inflation has been low, and contrasts with periods of high inflation

when there is a linear and proportional relationship between money and price levels.

Turning now specifically to the financial crisis episode of the early 1990s, when house prices decreased strongly in Switzerland, the money level first decreased strongly with the financial crisis and stress in the banking sector, which was followed by a decade of disinflation. Inflation remained near zero percent despite a strong increase in money growth around the mid-1990s, as the money level remained below the price level, i.e. excess liquidity was negative. There was thus no monetary stimulus transmitted through the financial sector during the housing crisis, and prices remained stable. The disinflation and stable price environment after the crisis was thus consistent with the money-price relationship in normal times at inflation rates close to zero.

3.2. Japan

Figure 4 displays the velocity of M2 together with the 10-year government bond nominal interest rate. After relatively stable but high interest rate and velocity in the 1970s, both variables declined with the decline in inflation since the 1980s. The interest rate semi-elasticity of money demand β used to compute m_t^* is estimated at 0.04.

Figure 5 displays the relationship between adjusted money (m_t^*) and price (p_t) levels. Both adjusted money and price levels have been trending together. The trend was particularly steep in the 1970s and flat since the 1990s. The case of Japan is interesting as it covers two inflation environments: inflation was relatively high in the 1970s, and close to zero since the mid-1980s. These two environments of high and low inflation can be characterized differently, the first with money growth rates, and

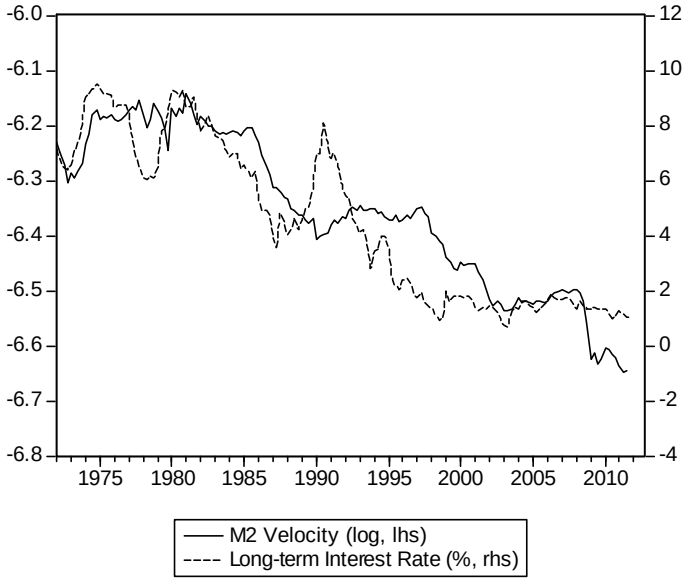

FIG. 4. Velocity and Interest Rate - Japan

the second with excess liquidity.

Figure 6 displays the growth rate of M^* with inflation. In the 1970s and up to the mid-1980s, when inflation was high, money growth is followed by corresponding inflation. The relationship is linear and one-for-one. From the late-1980s however, inflation was close to zero, and the relationship between money and prices can be characterized, as in the Swiss case, by a non-linear relationship. This can be seen on Figure 7, which displays excess liquidity as the difference in percentage points between m_t^* and p_t of Figure 5, together with inflation.

The focus on Figure 7 should be since the second part of the 1980s, as the earlier period can be well characterized by a one-for-one link between money growth and inflation, i.e. earlier positive or negative excess liquidity represent changes in money level trends and are followed by corresponding inflation swings. Since the mid-1980s

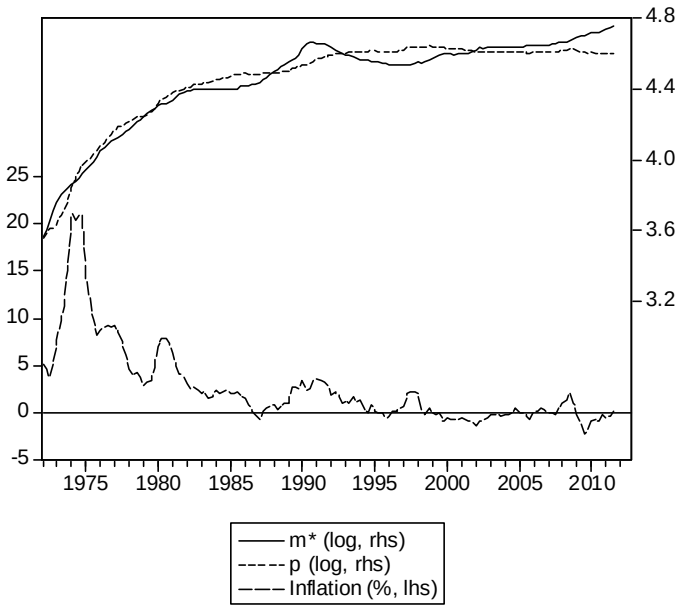

FIG. 5. Money and Prices - Japan

however, inflation has been close to zero and the relationship between money and prices has become non-linear. The relationship between excess liquidity and inflation is similar to the Swiss case where inflation has been close to zero; the proportions of the scales are the same on both the Japanese and Swiss graphs. This means that the speed of upward price adjustment to an excess money relative to prices is similar.

Inflation has usually remained close to zero as money has been significantly above the price level during only two episodes since the mid-1980s. First in the late 1980s / early 1990s, which was accompanied by a persistent but relatively small increase in inflation. And second, money picked up significantly since 2009, which given monetary policy lags should lead to higher inflation in the next years. Note two additional facts. First, there was an an increase in VAT in 1997, and second, during the mid-2000s

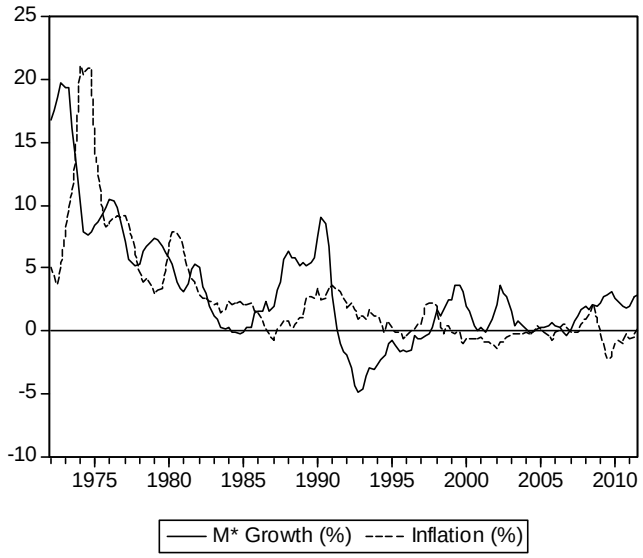

FIG. 6. Money Growth and Inflation - Japan

excess liquidity was only slightly positive, at around 3%, and prices remained stable.

Turning now specifically to the financial crisis episode of the early 1990s, in Japan as in Switzerland, the money level decreased and remained low (i.e. below the price level) during the 1990s, following the financial crisis in the early 1990s. Thus this was followed by disinflation and inflation close to zero. In the late 1990s, the money level increased but remained below the price level, thus inflation remained close to zero. During the period of quantitative easing in the early 2000s, the broad money level remained relatively stable, only slightly above the price level, and thus inflation remained close to zero. The financial sector was not in good health and thus could not participate in the money creation that should have followed the Bank of Japan QE in the early 2000s.

Recently, the money level started to increase strongly above the price level since

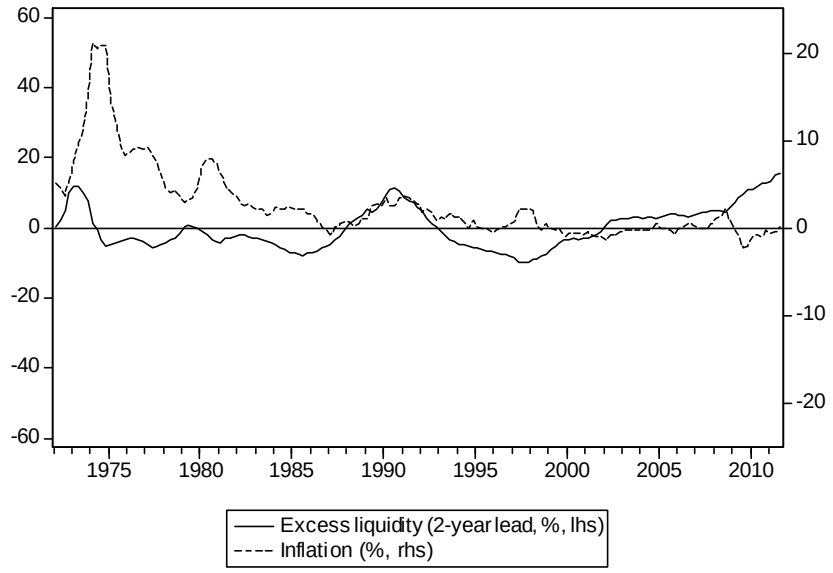

FIG. 7. Excess Liquidity and Inflation - Japan

2009. Thus in contrast to the early 1990s and early 2000s, monetary policy has been expansionary and, at the same time, commercial banks have participated to the money creation. The upward effects on inflation have not been observed yet, which is in line with the long (3 to 5 years) lags usually characterizing low inflation economies. QE should this time lead to an increase in inflation, in contrast to the money increase of the late 1990s or QE in the early 2000s, as it is the first time since the late 1980s that money grows substantially above the price level.

3.3. Argentina

In Argentina, the 10-year interest rate is not available and I did not find a stable money demand with short-term rates, so I do not make the equilibrium velocity

adjustment. Thus in this case the money level m_t^* has only been adjusted by potential output, and by a constant representing the mean of M2 velocity. Figure 8 displays the relationship between the adjusted money and price levels.

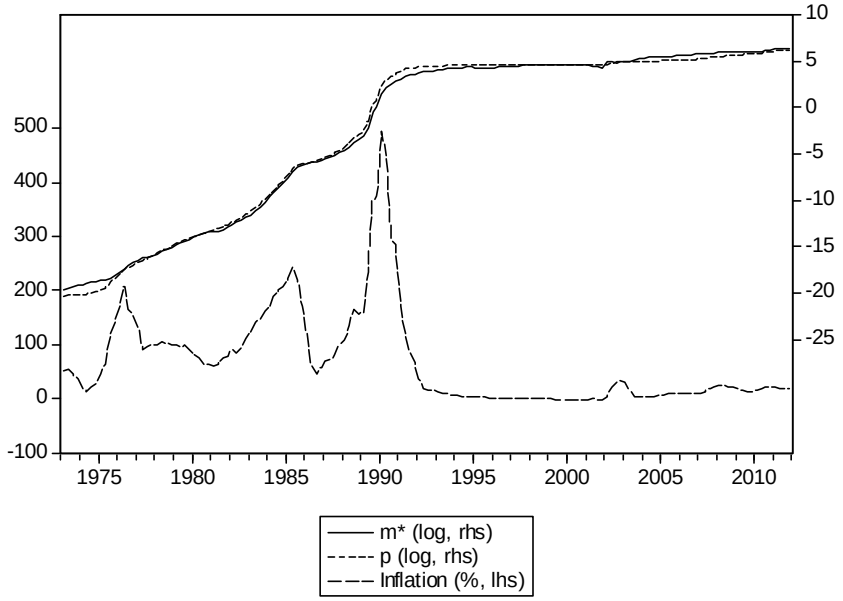

FIG. 8. Money and Prices - Argentina

As the economy has been characterized by high inflation, the proportional and linear link between money and price levels is very tight. In the early 1990s, Argentina adopted a currency board, and money growth and inflation dropped. Figure 9 shows the same graph as above (i.e. with the same scale for money and price levels) but only since the 1990s.

The same non-linear relationship as in the Swiss and Japanese cases appears when inflation is close to zero during the currency board. The money level has been below the price level during the currency board, and inflation was close to zero. The finan-

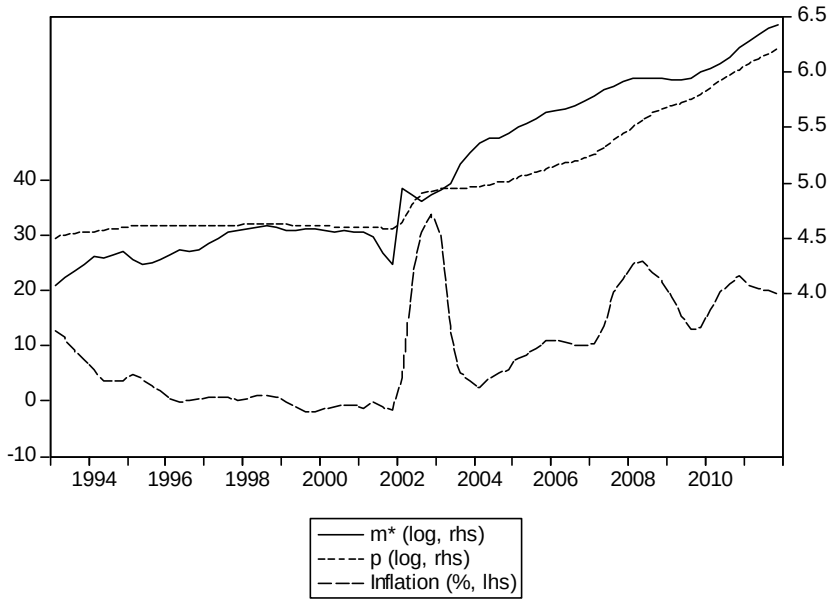

FIG. 9. Money and Prices - Argentina (since 1990s)

cial crisis started in 2001. Money supply first decreased for a short time, but then increased sharply with the "pesification" of bank accounts. When the currency board was dropped in 2002 and the pesos was devalued, the price level adjusted immediately to the previous increase in money supply. Then, after a small and brief decline, money supply increased very swiftly since 2003, and inflation followed. Contrary to Switzerland and Japan where the money supply decreased in the 1990s, in Argentina the money level increased during and after the financial crisis, and so did inflation.

3.4. US in the 1930s

Figure 10 displays the velocity of M2 and the commercial paper rate in the US for the period around the financial crisis of the 1930s. Interest rates and velocity

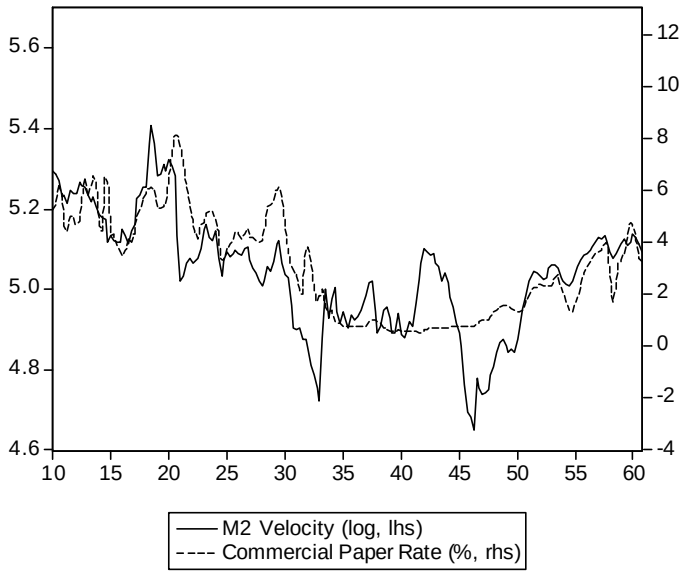

FIG. 10. Velocity and Interest Rate - US in the 1930s

decreased with the decline in inflation from the 1920s to the 1940s, and increased thereafter. The interest rate semi-elasticity of money demand β used to compute m_t^* is estimated at 0.06.

Figure 11 displays the relationship between adjusted money (m_t^*) and price (p_t) levels. Contrary to the other countries and periods considered above, there was no downward price rigidity in the US around the 1930s. Prices followed money levels proportionally, even when the money supply contracted as in the 1930s. As in Japan and Switzerland, and contrary to Argentina in the financial episodes analyzed above, during the financial crisis of the 1930s money supply contracted in the US. This was accompanied by deflation. Thus, in this episode of financial crisis, inflation can again be related to monetary developments.

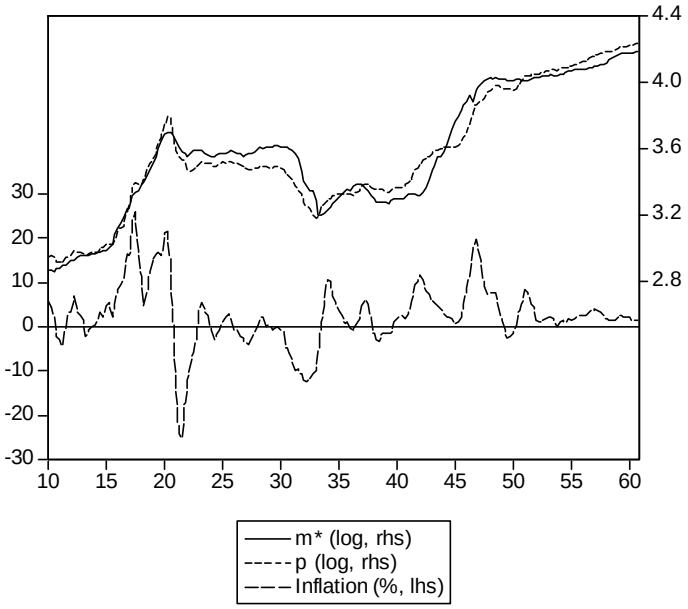

FIG. 11. Money and Prices - US in the 1930s

4. Assessing QE effects on future inflation - current US situation

This section analyzes the recent relationship between money and inflation in the US and the potential consequences of QE for future inflation. Figure 12 displays the velocity of M2- and the 10-year T-bond interest rate. Both velocity and long-term interest rate have been trending downward since the early 1980s. The interest rate semi-elasticity of money demand β used to compute m_t^* is estimated at 0.04.

Figure 13 displays the relationship between adjusted money (m_t^*) and price (p_t) levels, where the price level is the GDP deflator. Both periods of excess liquidity since the 1980s, i.e. when $m_t^* > p_t$, were followed by persistent increases in inflation. Figure 14 displays excess liquidity as the difference in percentage points between m_t^* and p_t of Figure 13, together with inflation. Excess liquidity has been forwarded by 2

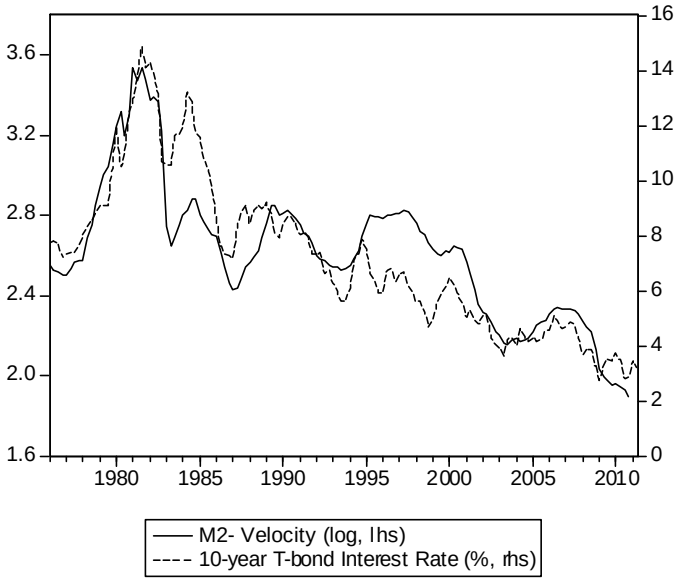

FIG. 12. Velocity and Interest Rate - US

years on Figure 14 to see more clearly the relationship with inflation and the leading information of money.

A particularity of the US case is that the non-linearity, which starts at around 0% inflation in Switzerland and Japan, generally starts higher at around 1.5% inflation in the US. There thus seems to be nominal rigidities that prevent US inflation to go much below 1.5%. It is unclear what determines that threshold.

In contrast to the crisis episodes in Japan and Switzerland in the 1990s as well as in the US in the 1930s, but similar to Argentina in the 2000s, the US money level has not decreased during the recent financial crisis. Excess liquidity was slightly negative in 2006 and 2007, but has been positive and increasing since 2009 due to an expansionary monetary policy and continued money creation by the banking system. The upward effects on inflation of the recent excess liquidity have just started, which

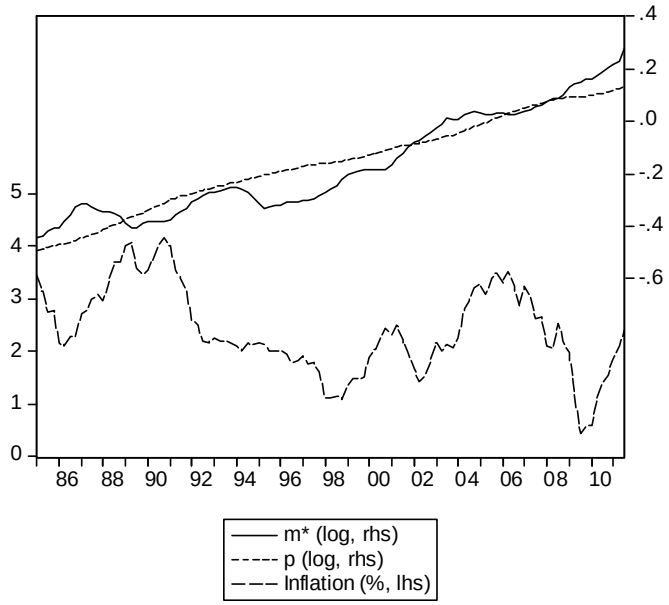

FIG. 13. Money and Prices - US

is in line with the long (3 to 5-year) lags characterizing low inflation economies. The decrease in inflation during the crisis as well as the current increase in inflation are consistent with standard relationship between excess liquidity and inflation, in crisis as well as normal times. Current excess liquidity should thus lead to a persistent increase in inflation over the next few years, to levels observed in the late 1980s and early 1990s, i.e. around 4-5%.

5. Conclusions

The analysis presented above shows that the inflation outcomes in the years following financial crises have reflected the evolution of broad monetary aggregates in response to those crises. The relationship between money and inflation is similar

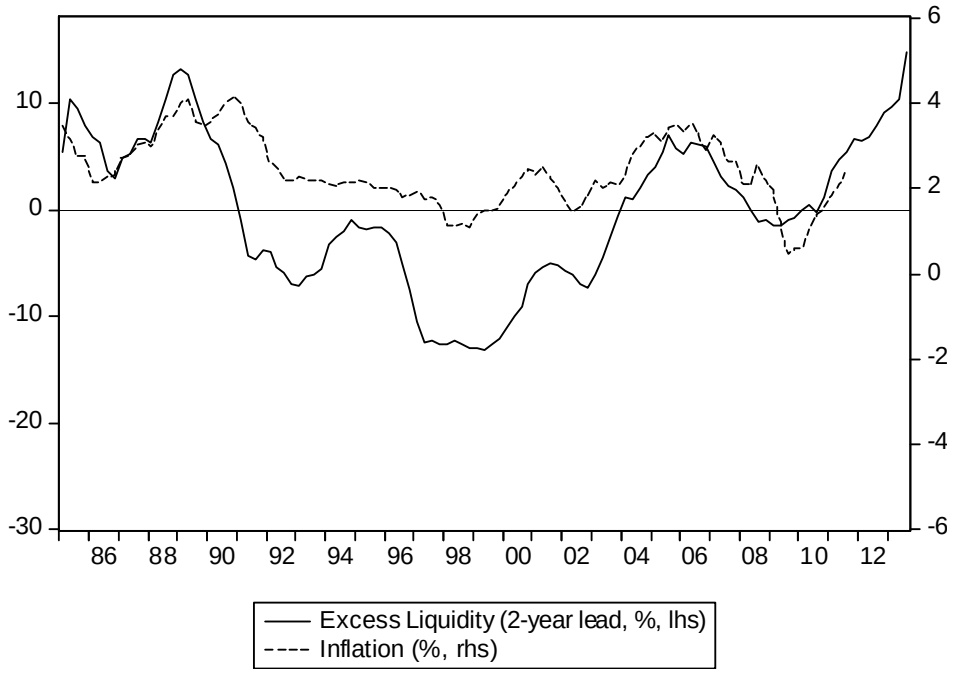

FIG. 14. US Excess Liquidity and Inflation

in financial crises as in normal times. Excess liquidity has always been followed by persistent increases in inflation. Current quantitative easing policies should lead to increasing and persistent inflation over the next years.

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Appendix 1: Data sources

Bank of Japan; FRED; IFS; Bank of Argentina; private sources for Argentina provided to me by Fernando Avalos; US data for the 1930s episode are from Balke and Gordon (1986) and were provided to me by Luca Benati.

y_t^* is computed potential output where available, otherwise HP-filtered real GDP.

i_t^* is the HP-filtered long-term nominal interest rate.

Appendix 2: Money demand estimation

The money demand or cointegrating relationships between money, price, real GDP levels and interest rate, where unit coefficients have been imposed on money, price and real GDP levels, have been estimated by OLS. Thus here an income elasticity of unity is imposed. Reynard (2006, 2007), using dynamic least squares (Stock and Watson, 1993), shows that an income elasticity not significantly different from unity is found with US and Swiss data.

Results for the different countries are relatively similar, with the following estimated interest rate semi-elasticity β and sample periods:

	β	Sample
Swiss M2	0.09	1976Q1-2011Q3
Japan M2	0.04	1972Q1-2011Q3
US M2	0.06	1910Q1-1960Q4
US M2-	0.04	1977Q1-2010Q4

Table 1. Interest Rate Semi-Elasticity Estimates