# Measuring Monetary Policy for A Small Open Economy: Turkey

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**Abstract**

Empirical research on the effect of monetary policy in open economies faces several abnormalities like "liquidity puzzle", "price puzzle" and "exchange rate puzzle". In this paper, a new monetary policy tool – spread between the Central Bank's interbank interest rate and the depreciation of the domestic currency – is introduced to address these three abnormalities within the small open economy setting. A recursive system is used to identify monetary policy shocks and to assess the effect of these shocks on the economy. Our empirical evidence from Turkey suggests that tight monetary policy is associated with a decrease in income and prices and the appreciation of the currency in the short run. For prices and the exchange rate, the effect is permanent; but for income the effect is transitory.

Key words: Monetary Policy and Small Open Economy.
JEL codes: E50, E52 and E43.

# 1 Introduction

There has been great deal of work on developing the monetary models of business cycles. There have also been extensive studies on constructing the empirical measure of exogenous monetary policy shocks. Most of these studies perform their analysis for developed countries (see Christiano, Eichenbaum and Evans (1999) and references cited therein). However, central bankers of developing countries, while also small and open economies, face additional challenges. Two of these challenges are related: the problem of currency substitution and the central bank's incentive to monitor its foreign exchange reserves closely. Therefore, construction of a model for developing countries may differ from the ones of developed countries. On currency substitution, the public may avoid using domestic currency, preferring foreign currency to guard themselves against inflation. Agents like to hold more of their wealth in foreign currency than in domestic currency if the interest rate is lower or the depreciation of the domestic currency is higher. On the level of foreign exchange reserves, the central bank also closely monitor its foreign exchange reserves eliminating either the risk of speculative attack or the balance of payment crisis. Reserves also increase as the domestic interest rate increases (due to either capital inflow or the decreasing foreign exchange demand of domestic residents) and decrease as the return on the foreign exchange increases. Hence, this paper uses a new measure to monitor monetary policy when the interest rate and the exchange rate are used simultaneously. In particular, this paper argues that the extend to which interbank interest rate exceeds the depreciation rate of the local currency (spread) can be used as an indicator of the stance of a central bank's monetary policy. Using spread as an indicator of a central bank's monetary policy does not mean that the central bank controls both of these instruments simultaneously, but rather the central bank may control one of the two and merely watch the other. However, even in this case, spread might be used as an indicator of monetary policy. This measure is also robust in the case of central bank's switching between pure exchange rate targeting and interest rate targeting. Here, the central bank may cut the liquidity provided to the public by raising interest rates at a given level of depreciation rate, or it may keep domestic interest rates stable and buy Turkish lira (TL) from the public by selling foreign currency at a lower rate.

Measuring the stance of monetary policy is not an easy task. If the monetary policy is reacting to the state of the economy, then it is unlikely to influence the economic performance in the current period. However, the part of the monetary policy that is exogenous (the part that does not respond to the state of the economy) is likely to influence the economic performance. In order to identify the exogenous monetary policy, disturbances are important. Recent research has used two well known paths to identify these exogenous monetary policy disturbances: monetary aggregates and interest rates. However, each of these paths has its own problems. The first problem is that the empirical evidence suggests that innovation in monetary aggregates is associated with rising (rather than decreasing) interest rates – *liquidity puzzle* (Leeper and Gordon (1992)).

The second problem is that once interest rate measure is integrated into the specification, monetary aggregates no longer cause output in Granger's sense (Sims (1980) and Litterman and Weiss (1985)). This encouraged Bernanke and Blinder (1992) and Sims (1992) to use the innovation in interest rate as a measure of monetary policy change. However, this created additional challenges. When the tight monetary policy is identified with positive interest rate innovations, it seems that prices increase rather than decrease – *price puzzle* (Leeper and Gordon (1992) and Sims (1992)). Sims (1992) Sims and Zha (1996) and Christiano, Eichenbaum and Evans (1996a) suggest including commodity prices to account for this puzzle. The third puzzle suggests that positive innovation in interest rates is associated with impact depreciation of the local currency rather than appreciation – *exchange rate puzzle* (Sims (1992) and Grilli and Roubini (1995)).

This paper uses Turkish monthly data from 1986:05 to 2000:10[1] to show that tight monetary policy is associated with the decrease in income and prices, and the appreciation of the domestic currency, showing its effect within two months, but the effect of monetary policy is not persistent for income. Turkey offers a unique environment for assessing the stance of the monetary policy. First, Turkey has been experiencing a high and persistent level of inflation without running into hyperinflation since the mid-1970s (the average annual inflation is 52.3% for the period between 1975 and 2000, and 61.6% for the period that is considered in this study). This allows us to assess relationships between money aggregates and macroeconomic variables easier than would otherwise be detected. Second, the Central Bank is actively involved in monetary policy setting most of the sample period considered either by influencing interbank interest rates or by setting the exchange rate. Third, Turkey has relatively well developed and liberal financial markets especially money, foreign exchange and bond markets without any heavy regulations that prevent the proper working

[1]The data set is ended in 2000:10 to avoid the beginning of a period that that has a series of financial crises starting with November 22, 2000 and continuing with February 22, 2001.

of the market mechanism for the sample period under consideration. All these allow us to assess the effect of monetary policy and the economic outcomes associated with it. The next section discusses the operating procedures of the Central Bank of the Republic of Turkey. Section 3 deals with the identification of the model. Section 4 discusses the identification of the monetary policy and the last section is the conclusion.

## 2 Operation of the Central Bank of the Republic of Turkey

Every morning the Central Bank of the Republic of Turkey (CBRT) announces the exchange rate for a set of currencies to buy and sell with a close margin and the discount window for Turkish lira to commercial banks with a wide margin for the period that this paper considers. In May 1981, CBRT adopted the crawling peg exchange rate regime in which the exchange rates of TL are set daily. In February 1990, Turkey applied to the International Monetary Fund (IMF) for the full convertibility of TL. In its 1993 annual report, the IMF identified the exchange rate regime of the CBRT as "Turkey follows a flexible exchange rate policy under which the exchange rate for the Turkish lira against the U.S. dollar is determined in daily fixing sessions held at the Central Bank." With the adaptation of the Year 2000 Disinflation Program, the CBRT announced a predetermined daily exchange rate path on a sliding 12-month horizon. This is the policy implemented for the sample that we consider till February 22, 2001 when CBRT let the exchange rate be determined by the market and allowed the depreciation of the domestic currency on the same day by 61%.

The Central Bank also hosts the interbank market where commercial banks can trade Turkish liras with overnight and overweek options. Moreover, the CBRT can also engage in open market operations. The daily depreciation of the exchange rate for the whole month does not change much within any given month, whereas the interbank interest rate may fluctuate widely. Commercial banks and the public could be holding foreign currency in preference to TL. If the public sees that the return of TL (interbank interest rate) exceeds the return of foreign currency (depreciation), then they have incentive to hold Turkish liras. If the public sees that the return of money decreases relative to depreciation of the foreign currency, then they have incentive to hold foreign currency. In the 1990s, the Central Bank showed no major weakness in regard to the foreign exchange reserves it used. Therefore, the CBRT could use its foreign exchange reserves as a tool to determine its monetary policy. In the first half of the 1990s, the CBRT followed the guidelines of a policy to issue Turkish liras parallel to the increase in its foreign exchange positions, being aware of the financing needs of the public sector. In this regard, one of the constraints of the CBRT was to stabilize the value of the TL against foreign currencies and to eliminate any potential attack on foreign exchange reserves. As stated by the Governor in his speech on January 28, 1992; *" ...we aimed to have the depreciation rate of TL follow a stable path and to keep the level of foreign exchange reserves constant."* Also it was stated by the governor in various speeches that the CBRT actively used the Open Market Operation tool in reducing the volume of TL which was issued as the result of foreign exchange reserve accumulation. Here, the CBRT could be using both of these instruments simultaneously in Pool (1970) sense, or the CBRT could set either of those instruments by watching the other. The role of depreciation the CBRT attributed to this development became more formal by the beginning of the year 1996 as the Governor of the CBRT once publicly announced this proposition that

> "*... the exchange rate basket (1 US dollar and 1,5 Deutsche marks) will be increased steadily and in parallel with the inflation rate. The stability of exchange rate policy enables the market to have a clear view of the increase in the monthly exchange rate basket by following the rates announced for surrender requirements. This offers the markets a parameter to help them shape their expectations accurately. In short, the exchange rate basket and the interest rates which are determined in accordance with this basket provide an important packet of information concerning the equilibrium of the nominal variables in the economy.*" Gazi Erçel April 1, 1998.

Therefore, it can be argued that the Central Bank may increase the interbank interest rate relative to the depreciation rate in order to tighten the monetary policy. The Central Bank may decrease the interbank interest rate relative to the depreciation rate to loosen its monetary policy stance.

In this paper, we used interest spread as an indicator of monetary policy. To measure the monetary policy of the CBRT, some of its balance sheet items could be used. The CBRT has announced its monetary program at various times in the past. The very first program that they announced was for the year 1990, when the CBRT limited credit to the public sector. In the beginning of 1998, the CBRT announced its Reserve Money target; and after the second half of 1998, the CBRT announced its Net Domestic Asset target. There were some problems with these targets. Limiting credit to the public sector did not mean that the resources of the CBRT not used to finance the public sector. The financing continued indirectly since the government forced government owned banks to give credit to the public sector at a lower than market interest rate. Public banks could finance themselves from the CBRT or financing of Treasury was realized by means of CBRT's extending funds to the banking system through the open market as was the case in 1999 (this was one of the reasons for the February 22, 2001 financial crisis (see, Uygur (2001)).

Even though the CBRT announced its Reserve Money target for the first six months of 1998, it claimed that forecasting Reserve Money Demand was difficult under variable inflation (especially when the level of inflation had been decreasing). The Governor announced that "*... Another important issue (with respect to reserve money) is that during disinflation, estimating the rate of re-monetization of an economy following period of high inflation is very difficult. Policy simulations with regard to money demand applications implicitly assumes that de-monetization and re-monetization are systematic process. However in practice these elasticities are not same*". Hence, monetary aggregates are not measured as targets to control inflation.

Hence, CBRT switched to Net Domestic Asset (NDA) targeting in June 1998. This variable was only available after the second half of 1998 for both policy makers and the public. The Governor of the CBRT publicly claimed that this target had been announced to give credibility to the monetary policy of the CBRT and the CBRT would not monetize the government debt (Monetary Program: December 9, 1999). More importantly, the Governor publicly declared that the CBRT cared more about the interest rate than NDA target and they did not even need to announce the NDA target to set up monetary policy (Yeni Yüzyıl: August 10, 1998). Therefore, innovation in NDA is not used as an indicator of monetary policy in this paper.

## 3 The Identification of The Model

The identification of the effect of the monetary policy is not a simple task. The reason for this is that the action of the Central Bank also depends on both the state of the economy and the intention of the Central Bank for the setting up the monetary policy. In order to isolate the effect of Central Banks' policy activities per se, identification of the components of the Central Banks' policy that are not reactive to other variables is crucial. In order to solve this identification problem, some assumptions are required and those assumptions will be discussed below.

The monetary policy shocks will be identified with the error terms in the regression equation specified as

$$S_t = f(\Omega_t) + \varepsilon_{st} \tag{1}$$

where $S_t$ is the policy instrument, $\Omega_t$ is the information set available to the Central Bank at time $t$, $f(.)$ a linear function, $\varepsilon_{st}$ is the monetary policy shock which is uncorrelated and orthogonal to each element of $\Omega_t$. In order to justify the $\varepsilon_{st}$ as exogenous monetary policy shocks, equation 1 is interpreted as the reaction function of the Central Bank. In addition to the orthogonality condition, is also assumed that $\varepsilon_{st}$ does not affect any variables in $\Omega_t$. We measure the dynamic response of a variable to monetary policy shock by using the coefficients in the regression of the variable on current as well as the lagged value of the fitted residuals in equation 1.

An asymptotically equivalent way of writing this procedure is fitting a $p^{th}$ order vector autoregressive model

$$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} ... + A_p X_{t-p} + u_t \tag{2}$$

where $X_t$ and $u_t$ are $k$x1 vectors and $u_t$ is the residual term which is serially uncorrelated and has a variance-covariance matrix of $V$. Here we assume that $u_t$ is related to underlying economic shocks $\varepsilon_t$ by

$$u_t = B\varepsilon_t \tag{3}$$

where $\varepsilon_t$ is a $k$x1 vector that consists of the orthogonalized residuals for $k$ variables including $\varepsilon_{st}$ and we assume $B$ is a lower triangular matrix and the variance covariance matrix of $\varepsilon_t$ is diagonal.

Here we assume that $S_t$ is one element of $X_t$ vector. If $S_t$ is the $l^{th}$ element of $X_t$, then $\Omega_t$ includes $X_{it}$, $i = 1, ...l - 1$ and $X_{it-1}$, $i = l + 1, ...p$. The ordinary least square method is used to estimate $A_j$'s in equation 2 and once we assume $B$ is a lower triangular matrix, we can use $V = BB'$ to identify $B$ matrix. Lastly, the impulse response functions can be computed by using the estimates of equations 2 and 3. Here, we measure the monetary policy instrument, $S_t$ is this spread between the interbank interest rate minus the depreciation of the basket where the basket is the combined TL value of 1 US Dollar plus 1.5 Deutsche Mark.

The vector $X_t$ includes income ($y$), the logarithm of the wholesale price index ($p$), the logarithm of the commodity price index in local currency ($cp$), the logarithm of the exchange rate basket ($ex$), the spread between the interbank interest rate and the depreciation of the basket ($spread$) and the logarithm of money ($m$). In this paper, three income measures are used: the logarithm of industrial production, the private sector capacity utilization rate and the logarithm of the number of housing permits given by local authorities.[2] M1 + Repo is also taken as the measure of money. There are

[2] Here, the capacity of utilization rate of the private sector is used rather than total capacity utilization rate because the capacity utilization of the government is more likely determined by political decisions rather than current economic environment. The public considers the capacity utilization rate of the private sector to be more representative of the economic conditions than total capacity utilization (see for example, Aslanoglu (2001)).

two reasons to include Repo to money supply aggregates: (1) most of the repo was overnight hence this money aggregate was liquid; (2) agents prefer to repo their savings rather than open deposit accounts since the repo rates are considerably higher. The Repo/Total Demand Deposit rate was 9.54 and the Repo/Total TL Dominated Deposit excluding Repo was 0.47 in 2000:10. Hence, the change in interest rates was more likely to affect repo than other components of M1. On commodity prices, Sims (1992) notes that central banks may use commodity prices as an indicator of inflation when they set up their reaction. Hence, commodity prices are also included in the $X_t$ vector.

In order to identify the monetary policy shocks, the variables in $X_t$ are ordered as ($y_t$, $p_t$, $cp_t$, $ex_t$, $spread_t$, $m_t$). This way of ordering is consistent with our basic identifying assumption that monetary policy setup does not have any contemporaneous effect on income and prices, but income and prices do affect the Central Bank's policy reaction.

The way that the six macroeconomic variables are ordered may incorporate extreme information assumption – policy maker knows the current level of industrial production and prices. One approach to avoid this is to use quarterly data. However, using quarterly data suggests that the monetary policy shocks do not affect the output level in the current period, and this may not be true either. Not allowing output level and prices to be affected by the current period is more reasonable for the monthly data than the quarterly data. Moreover, it is more reasonable to assume that the Central Bank sets its monetary policy monthly than quarterly. Because of the narrow time span that the data is available, we are forced to use monthly data than the quarterly data. However, Geweke and Runkle (1995), Bernanke and Mihov (1998), Christiano, Eichenbaum and Evans (1996b) and Christiano et al. (1999) also show that the inference they gather with quarterly data is valid for the inferences they gather with the monthly data.

The data set used to estimate the model includes observations from 1986:05 to 2000:10. However, when the income measure is taken as the capacity utilization rate, the data set starts from 1991:02 and when the income measure is taken as the number of housing permits given by local authorities, then the data set starts from 1991:01. The order of VAR is one suggested by Hannan-Quinn and Shwarz information criteria. When the regression analysis was performed, each equation had 12 monthly dummies to account for seasonal changes, 3 dummies for the 1994 financial crises: one for the month when the crisis occurred (April 1994), one dummy before (March 1994), and one dummy after (May 1994). Repo figures are not available before November of 1995, hence a dummy period till 1995:11 is also included. All the variables used here enter into VAR specification in logarithm level variables except the spread where it is entered as a rate. One could argue for including the level variables in their first difference or in Vector Error Correction form. Johansen $\lambda - trace$ and

$\lambda - max$ tests cannot reject the presence of cointegration for the system. Hence, we estimate the system in logarithmic levels (see, Sims, Stock and Watson (1990)). The lag orders of the VAR system of 3, 6, 9 and 12 are also considered. As the lag order above 6 is considered, even if it is not statistically significant, *price puzzles* were present. This may mean that the results presented in this paper are not robust against alternative specification. Alternatively, it may mean that because of the narrow time span, the high lag order over-specified the model.

## 4 The Effect of Monetary Policy Shocks

In this section, the effect of monetary policy shocks on various aggregates will be analyzed. However, before moving onto this analysis the chronological stance of the monetary policy, which is suggested by the specification that is used in this paper, will be focused on. Figure 1 plots the cumulative sum of spread innovation when the industrial production is taken as the income measure. Here, downward movements represent monetary easing, and upward movements represent monetary tightness. Figure 1 suggests that, during the period from 1986:05 to 1987:12, loose monetary policy could be observed. In that period, Turkey had a set of elections which made it likely that the government would implement loose monetary policies [Sayan and Berument (1997) and Ergun (2000) give the political business cycles in Turkey]. These elections are: local elections for the empty seats in Parliament on September 28; municipality elections on June 8, 1987; the Constitutional Referendum on September 8, 1987; general elections on November 29, 1987. It is quite likely that the Central Bank also adopted loose monetary policy on those days because of its low independence from government (see Berument and Neyapti (1999)). The second Özal Government got the confidence vote from Parliament on December 30, 1987 and this could be the date that indicates the beginning of the tight monetary policy, which was implemented until October 1989, except for the period that precedes the municipal elections on March 26, 1989. In mid-1989 another municipal election was scheduled for June 1990: loose monetary policy can be seen from the graph. After June 1990, tight monetary policy was implemented. Once Prime Minister Özal took the office of president, Mr. Mesut Yılmaz was elected to be the leader of the Motherland Party and became Prime Minister in June 1991. He then called an early election on November 7, 1991 and from the figure loose monetary policy can easily be observed till election day. As a result of the election, Mr. Yılmaz lost the Prime Ministry and Mr. Demirel formed the new cabinet. Figure 1 also suggests that tight monetary policy was implemented until April 1993 when the President Özal died and Mr. Demirel took the office of the Presidency. When Ms. Çiller became the Prime Minister on

June 13, 1993, she publicly announced that she would like to decrease interest rates to boost the economy and loose monetary policy clearly be observed in the figure till the April 5 financial crisis in 1994.

[Insert Figure 1 Here]

A stand-by agreement was signed with the IMF in June 1994; however, the agreement was abandoned in September 1995 due to the call for another early election. For the 1996-1997 period, the CBRT publicly announced that the purpose of the monetary policy was to stabilize the financial markets rather than control increasing inflation. Parallel to that, Figure 1 shows the execution of loose monetary policy till April 1997. Tight monetary policy started to be implemented after Moody's credit rating institution decreased its grade from BA 3 to B 1 for Turkey's external debt. When the Russian financial crisis hit in August 1998, the tight monetary policy continued till the third quarter of 1999. After that, loose monetary policy was adopted: the CBRT loosened its monetary policy after the Marmara Region Earthquake on August 17, 1999 which cost around 18,000 lives. It is interesting to note that loose monetary policy continued even with the implementation of the exchange rate based disinflation program after December 1999. This is what is expected from any exchange rate based disinflation program compared to a monetary based disinflation program (see Agenor and Montiel (1999)). To sum up, the identified monetary policy and the developments of political and economic events coincide well.

In this sub-section whether the estimated impulse responses to monetary policy shocks match with the expected movements of macroeconomic variables. First, what the economic theory suggests will be presented; and second, how these theoretical implications match with the estimated impulse responses to examine the validity of the proposed empirical model.

## 4.1 Monetary Contraction and Macroeconomic Variables

With monetary contraction, initially interest rates increase and monetary aggregates fall. However, after the initial rise in interest rates, they may decrease due to deflationary pressure from monetary contraction. Next, with the monetary contraction, price level declines and the output level does not increase. However, it is plausible that after monetary contraction, output level decreases or price level increases. However, as long as the monetary policy is exogenous– monetary policy does not systematically respond to anything like inflationary pressure, excess liquidity demand and shocks from the rest of the world– then output level and prices should not increase.

The system that is used here also includes world export commodity prices in domestic currency and the exchange rate. A monetary contraction is not expected to decrease world export commodity prices since Turkey is too small a country to influence commodity prices. On the other hand, under a flexible exchange rate, it is expected that currency will appreciate in the short run with the adoption of the tight monetary policy. Moreover, even for a small country, appreciation of the domestic currency may decrease the world export commodity prices in terms of domestic currency.

## 4.2 Empirical Results

In this subsection, a set of empirical evidence on the validity of the specification being proposed will be presented.

### 4.2.1 Spread as a Measure of Monetary Policy

Here, the effect of tight monetary policy - positive innovation in spread - will be discussed. The first column of Figure 2 shows impulse response functions of industrial production, prices, commodity prices, exchange rate, spread and money obtained when there is one standard deviation innovation in spread. The middle line shows the point estimates, the other two lines show 5% confidence intervals.[3] Some of the observations are important to emphasize here. First, the innovation in spread is not persistent. After the third month, the innovation in spread disappears. Second, the effect of monetary policy is transitory on output but persistent in prices.

Tight monetary policy as measured with positive innovation in spread has a transitory effect on output. Output level decreases for first 5 months even if this is significant in the first two months. The rise in spread is associated with a drop in industrial production with output following a hump-shaped pattern. This is parallel to the open economy version of the Fuhrer and Moore model (Fuhrer and Moore (1995a) and Fuhrer and Moore (1995b)) as presented in Walsh (1998) (pp, 472-4), and consistent with the evidence on the US (see Bernanke and Blinder (1992), Sims (1992) and Christiano et al. (1996a)). The second row of column one suggests that the tight monetary policy permanently decreases the price level.[4] This clearly eliminates the *price puzzle* as discussed by Sims (1992). Tight monetary policy also permanently decreases commodity prices and exchange rate initially – the decrease in exchange rates (appreciation of currency) presents evidence that

[3] These are computed by using the Monte Carlo method with 500 draws from the estimated asymptotic distribution of the VAR specification and its covariance matrix as described by Doan (2000).

[4] Figure 2 suggests that with the innovation in *spread*, prices decrease (in a diverging way). We also calculated the impulse responses at longer time spans, in which the decrease in price level stabilizes and is not statistically significant after 40 months.

eliminated the *exchange rate puzzle.* The evidence on exchange rates is parallel to Eichenbaum and Evans (1995), Koray and McMillin (1999) and Kim and Roubini (2000). One standard deviation increase in spread does not persist and ends after the second month. The innovation in spread does last only three periods and then cuts off. This may indicate that the monetary policy of the CBRT is not persistent. However, it may also mean that uncovered interest rate parity holds for a given level of foreign interest rate and the CBRT cannot or does not deviate from it. This is parallel with what the Governor declared on April 1998. As discussed before, higher spread decreases money, but this is not statistically significant.

[Insert Figure 2 Here]

Column 2 of Figure 2 repeats the same analysis by using the capacity utilization rate of the private sector rather than industrial production. The results are practically parallel but decrease in price level and decrease in exchange rate are not statistically significant after $10^{th}$ month. The last column uses the logarithm of housing permits as a measure of income. There is no qualitative difference from the one when the capacity utilization is taken as a measure of income. Importantly, parallel to the overshooting model, when capacity utilization and housing are taken as income measures, domestic currency starts to depreciate after four months of appreciation (see, Koray and McMillin (1999)). The same thing cannot be observed when industrial production is taken as an income measure. Hence, the specification used in this paper to identify the monetary policy is on a parallel with what the theory suggests and does not produce well-known puzzles.[5]

#### 4.2.2 Money Aggregate as a Measure of Monetary Policy

Traditionally, monetary policy has been identified with various money aggregates like M0, M1 or M2. Earlier literature, in particular, followed that pattern (see for example Barro (1977) and Mishkin (1983)). In this part, we will try to identify the monetary policy by examining the implied response functions to one standard deviation to $m$ as reported in Figure 3. Column 1 uses the industrial production as a measure of income. Increase in money aggregate increases the industrial production by 24 months and it is statistically significant in the first 9 months. An increase in money supply increases prices and decreases spread. These are parallel to the properties of the

[5]The impulse response functions are also estimated for two different sets of sub-samples: 1986:05-1997:12 and 1998:01-2000:10; 1986:05-1994:03 and 1994:06-2000:10. For the second period of each sub-sample, some of the *puzzles* are observed. One may argue that there is sub-sample instability in the estimates. However, this set of results from the second period of sub-samples might be due to the shortness of the sample period used in identifying the monetary policy.

expansionary monetary policy and also parallel to the suggestions of Figure 2. Importantly, a decrease in spread as money increases suggests that there is no *liquidity puzzle* here. One may also like to see the effect of the interbank interest rate with the innovation on money aggregate. The calculated interbank interest rate (Spread + Depreciation) also suggests that there is a drop in the interbank interest rate for 2 months in a statistically significant fashion (not reported here). On the other hand, an increase in money decreases both the commodity prices and exchange rate persistently, and that is not what is expected by the expansionary monetary policy.

[Insert Figure 3 Here]

Columns 2 and 3 repeat the same analysis by using capacity utilization and housing as measures of income. Even if the behavior of prices, commodity prices, spread and money are qualitatively similar. An increase in money decreases the income and appreciates domestic currency immediately when housing is used as a measure of income. When capacity utilization is used as a measure of income, an increase in money appreciates the currency after the $4^{th}$ month. When the innovation to money is used as a measure of the monetary policy, we cannot say that the results are robust and give estimates on exchange rates as economic theory suggests.

#### 4.2.3 Effect on Real Exchange Rate

It is also of interest to analyze the behavior of the real exchange rate with the tight monetary policy. Following Kim and Roubini (2000), we perform VAR analyses with the real exchange rate rather than the nominal one in order to save from degree of freedom. Both the overshooting model (see, Dornbusch (1976)) and flexible price models with liquidity effects (see, for example Grilli and Roubini (1996)) suggest that tight monetary policy is associated with a transitory drop in income and persistent depreciation in nominal and real exchange rates after the initial appreciation. Hence, the appreciation in the real exchange rate will be transitory and the real exchange rate will return to its pre-shock level after all the prices are re-adjusted. Figure 4 shows how the real exchange rate behaves with innovation in spread. The figure suggests that with the positive innovation in spread, the TL appreciates initially and the magnitude is statistically significant for the first four months when industrial production is used as a measure of income. When capacity utilization and housing are used as a measure of income, the real exchange rate appreciation is statistically significant for two months.

[Insert Figure 4 Here]

Figure 4 also shows that over time, prices adjust and real appreciation reverses itself to real depreciation and the real exchange rate returns to its pre-shock level. This means that the reverting behavior of the real exchange rate is consistent with the long-run implication of the overshooting and the liquidity models (Koray and McMillin (1999)).

#### 4.2.4 An Additional Puzzle: Forward Discount Biased Puzzle

If the uncovered interest rate parity holds, then an increase in the domestic interest rate should lead to persistent depreciation rather than appreciation – *forward discount biased puzzle* (see, Eichenbaum and Evans (1995) and Kim and Roubini (2000)). After the initial appreciation period of four moths, Figure 2 suggests that currency starts to depreciate when the income measure is capacity utilization and housing but not for industrial production. Figure 4 suggests that real appreciation ends and real depreciation starts after the third month for the three income measures. The empirical evidence provided here suggests that "*forward discount biased puzzle*" is not present in the specification used in this paper.

#### 4.2.5 Other Money Aggregates

Here M1 plus Repo were used as money aggregates. It might be necessary to use broader money aggregates. Hence M2 plus Repo (M2R) is also used as a money aggregate. The evidence is also robust. Increase in spread decreases income temporarily but decreases prices and exchange rates permanently. However, the increase in spread tends to increase M2R rather than decrease it. (These results and the results on the other impulse response functions from now on are not reported but available from the author upon request).

#### 4.2.6 Excluding Commodity Prices from the Information Set

Sims (1992) suggested including the commodity prices to VAR setting in order to account for the price puzzle. He also notes that prices tend to increase after a measure of contraction. The reason for this is that the information set based on $\Omega_t$ did not include information about future inflation, whereas this information could be available to policy makers. In other words, the information set that is an indicator of future inflation but not a policy variable might be missing. Sims (1992), Christiano et al. (1996b) and Sims and Zha (1996) show that including the current and past values of commodity prices often eliminates the price puzzle.

In this paper, the commodity prices are also excluded from the VAR setting. When the commodity prices are excluded the price puzzle could not be observed in either of the cases which use different measures of income. Hence, one may argue that a six variable VAR model might be overspecifying the system. However, the reason for not observing the price puzzle could be that the volatility of commodity prices is high due to exchange rate volatility rather than a change in the relative prices of inputs. Another reason for having a high level of inflation for the period that is considered, could be that the effect of an increase in commodity prices does not provide enough volatility to observe the price puzzle. Kibritcioglu and Kibritcioglu (1999) and Berument and Tasci (2000) show that a 20% increase in oil prices increases the price level by 1.4%. Hence, the commodity prices were retained in the VAR specification as the sixth variable.

#### 4.2.7 The Effect of the Rest of the World

Turkey is a small open economy. Therefore, the state of the economy can be affected by policies in the rest of the world. Sims (1992) argues that shocks to foreign monetary policy are captured better with the orthogonalized shocks to foreign interest rates rather than with the orthogonalized shocks to money aggregates. Hence, the Federal Funds Rate is included in the VAR setting as the first variable. The empirical evidence suggests that Federal Funds Rate is not affected by the aggregates of the Turkish economy. This also is consistent with the small open economy assumption of Turkey. Moreover, the effects of Turkish Monetary Policy on macroeconomic variables are virtually identical to the one reported in Figure 2. This is parallel to Kim (1999). The author is not aware if there is any single empirical study which assesses the effects of a tight monetary policy on a country's domestic interest rate, output and prices simultaneously. However, the predictions of our specifications are not always at odds with the literature. Here, positive innovation in the Federal Funds Rate decreases output (consistent with Kim (2001)), increases prices initially when capacity utilization and housing are used as income measures and appreciates the domestic currency. Lastly, spread increases (consistent with Cushman and Zha (1997) and Kim and Roubini (2000)) and serves to increase money aggregates. Most of our results are parallel to the empirical evidence prior but on exchange rate.

#### 4.2.8 Impulses With Re-ordered Variables

Christiano et al. (1996b) discuss the importance of the ordering of the variables in the VAR setting. If income, prices, commodity prices and exchange rates precede the spread, then this type of ordering imposes the extreme information assumption; the CBRT observes these variables at the current time period before it sets the spread. The spread is also used as the first variable when the monetary policy of the CBRT affects all those variables at the current period. The empirical evidence is still robust. However, as the lag order is increased the price puzzle is observed. Hence, it is not necessary to change the basic specification scheme.

#### 4.2.9 Evidence from Forecast Variance Decomposition

The impulse response functions assess the dynamic effects of monetary policy shocks. On the other hand, the forecast error variance decomposition analysis assesses how the monetary policy shocks contribute to the volatility of various economic aggregates. There are two reasons for the importance of the latter. First, it helps to assess whether monetary policy shocks have been an important independent source of impulses to the business cycles. Second, it helps the identification strategy, which assumes that monetary aggregates are mostly exogenous shocks to money.

[Insert Figure 5 Here.]

[Insert Figure 6 Here.]

Figures 5 and 6 report the percentage of variance in the first 36 step-ahead forecast errors variance in income, prices, commodity prices, exchange rate, spread and money which are attributable to spread and money, respectively.

It is first necessary to assess the impact of monetary policy (spread). Regarding the effect of monetary policy on income, it has a statistically significant impact on industrial production and housing but not on capacity utilization, However, these all have small magnitude: Monetary policy shocks are not the dominant source of income fluctuations, which is parallel to Kim (1999) and Kim and Roubini (2000). For the three income measures considered, there is no statistically significant variation of prices accounted for by the spread. Importantly, a big variation of spread is also explained by itself. This supports the identification strategy, which assumes that spread is exogenous and not explained by prices and output.

Second, the results that are obtained for money are considered in Figure 6. This is statistically significant that a small fraction of variability on income is accounted for by money. However, an important fraction of prices can be accounted for by money. As forecast steps increase, the size of explanatory fractions stabilizes. In addition, a big fraction of money is explained by money itself. However, as the time horizons increase, this fraction decreases. In brief, the volatility of income is more likely to be attributable to money aggregate than the spread, and money is more likely to affect prices than output. Nonetheless, it is important to recognize that even if monetary policy shocks have played a small role in income and prices, it does not mean that the systematic component of monetary policy shocks played a small role.

Although the specification used in this paper addresses a number of the above puzzles, there are some limitations. Firstly, the recursive structure imposed here is unrealistic – the Central Bank is unlikely to know what the industrial production and prices in the current period will be – it is likely that the Turkish economy is less recursive. Secondly, there is still limited evidence on the forward discount bias puzzle. Lastly, as the lag order of the VAR system increases above 6, even if it is not statistically significant, price puzzle is present.

An alternative approach to be followed in order to identify the monetary policy is to impose spread as an identifying assumption within structural VAR framework. This would allow the effect of interbank interest rates on the macroeconomic performance to be observed.[6] An attempt has been made to impose that constraint and estimate the model. When the constraints are imposed, the impulse response functions were not robust. The casual observation of the likelihood function suggests that a possible reason for unrobustness was that local maximums were captured instead of the global maximum.

# 5 Conclusion

In this paper, a measure of monetary policy for a small open economy is introduced to address a number of empirical anomalies about the effect of monetary policy in a small open economy. A recursive identification scheme is used to (1) identify monetary shocks successfully, and (2) solve puzzles and anomalies in regard to the effect of monetary policy.

For the four puzzles addressed here, innovation in money aggregate seems to decrease the difference between the interbank interest rate and the depreciation rate (spread): there is no *liquidly puzzle*. A positive innovation in spread decreases prices: there is no *price puzzle*. Domestic currency appreciates with a tight monetary policy: there is no evidence of *exchange rate puzzle*. Lastly, after the initial appreciation, currency depreciates in real terms with a tight monetary policy: there is some support for the *no forward discount biased puzzle*.

The recursive system that we used in this paper produced impulse response functions that are not inconsistent with widely accepted views on the qualitative impact of a monetary policy shock on various macroeconomic variables. The absence of the four puzzles discussed above also suggests that the proposed macroeconomic variable used here as an indicator of monetary policy and the recursive identification scheme are not at odds with economic theories.

[6]See, for example Cushman and Zha (1997). They imposed real demand function as the identifying assumption where one could impose *spread* instead.

Tight monetary policy has a transitory effect on output; output falls for a short period of time in a statistically significant fashion. Having eliminated the exchange rate puzzle, the model given here distinguishes the Fisherian effect of interest rates from the tight monetary policy indicator. Here, the qualitative inferences on the effect of monetary policy are on a parallel with the different specification models used in previous studies (See, Sims (1992), Eichenbaum and Evans (1995), Grilli and Roubini (1995) and Kim and Roubini (2000)).

This paper imposes additional importance on the identification of monetary policy for a small open economy. Policy makers from small open economies have additional challenges that are not present in developed economies like the threat of currency substitution or the level of foreign exchange rate reserves. Hence, identifying the *spread* as the indicator of monetary policy for Turkey suggests the interesting possibility that the same variable could be used as an indicator of monetary policy for other small open economies.

There are several issues which are not addressed here. Inclusion of fiscal policy could produce a more complete picture of the behavior of prices and output. There are some periods when the CBRT used money aggregate targeting (January 1998-June 1998) and periods that targeted Net Domestic Assets (July 1998-November 2000). Furthermore, the behavior of the Foreign Reserves of the CBRT is not modeled. The level and behavior of foreign exchange reserves are important and closely monitored by the public and the CBRT. These are the areas to be dealt within future research.

Figure 1: Implied Stance of Monetary Policy: Accumulated Summation of Spread Innovations.

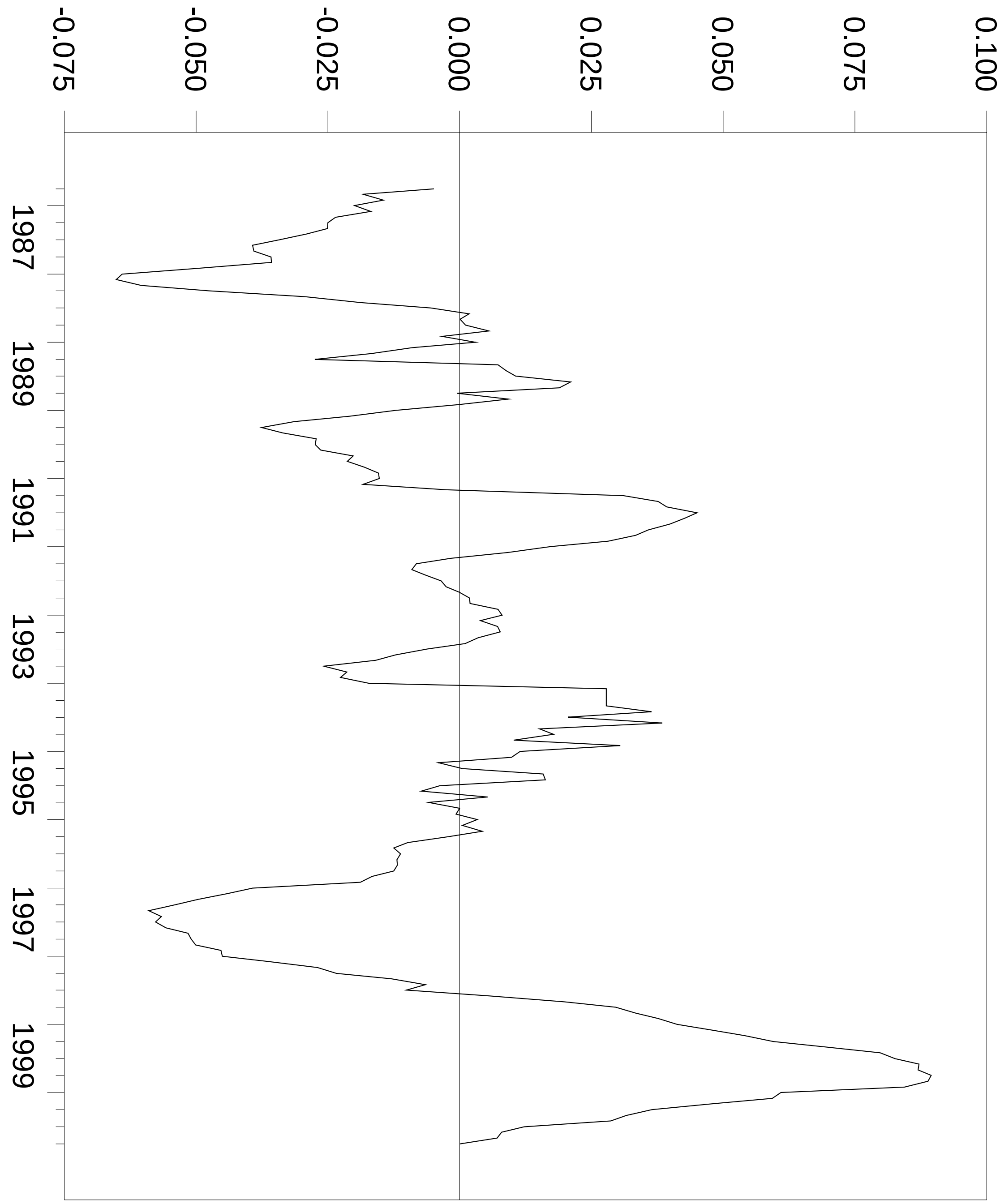


Figure 2: Effects of Spread.

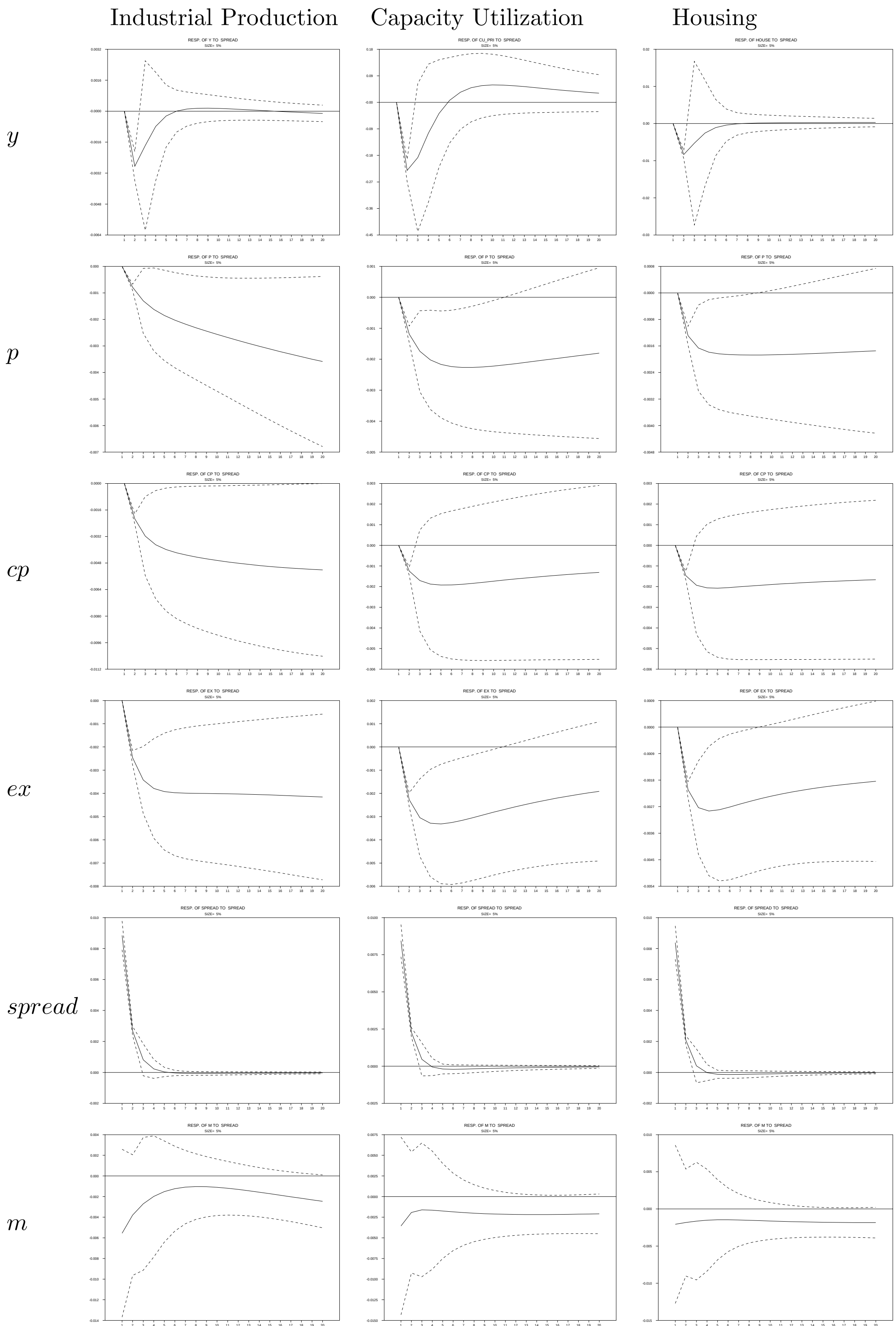


Figure 3: Effects of Money.

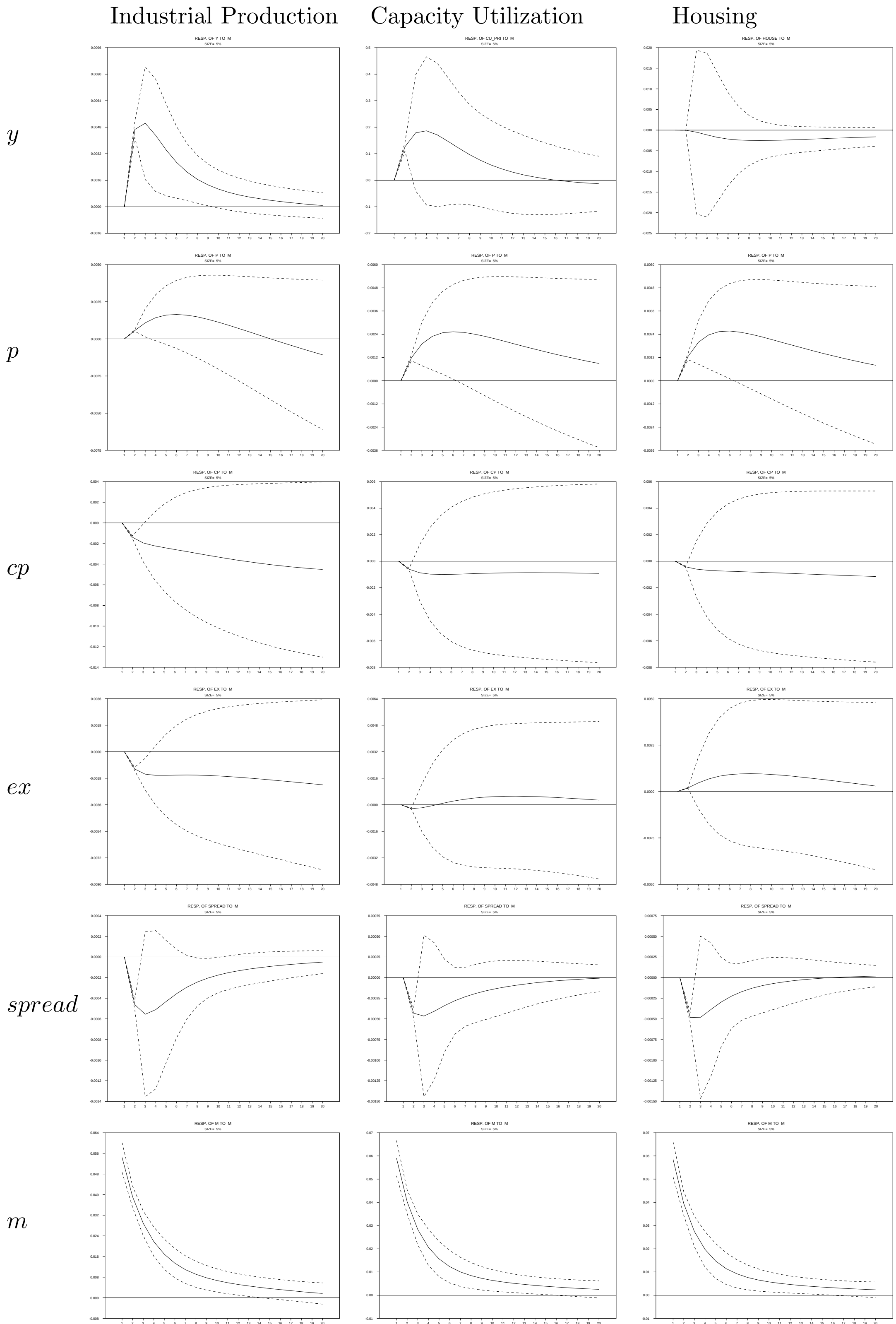


Figure 4: Effects of Spread on Real Exchange Rates.

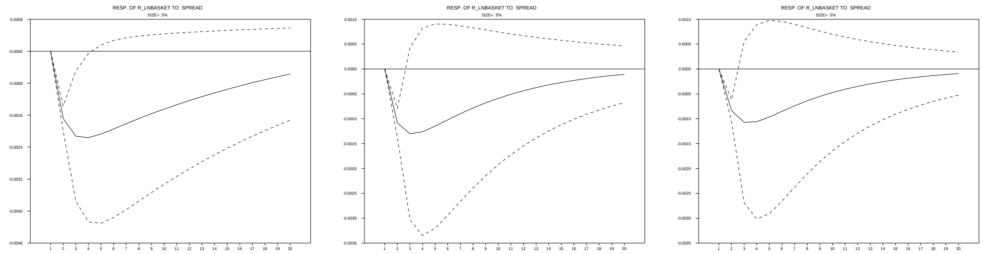


Figure 5: Forecast Error Variance Decomposition of Spread.

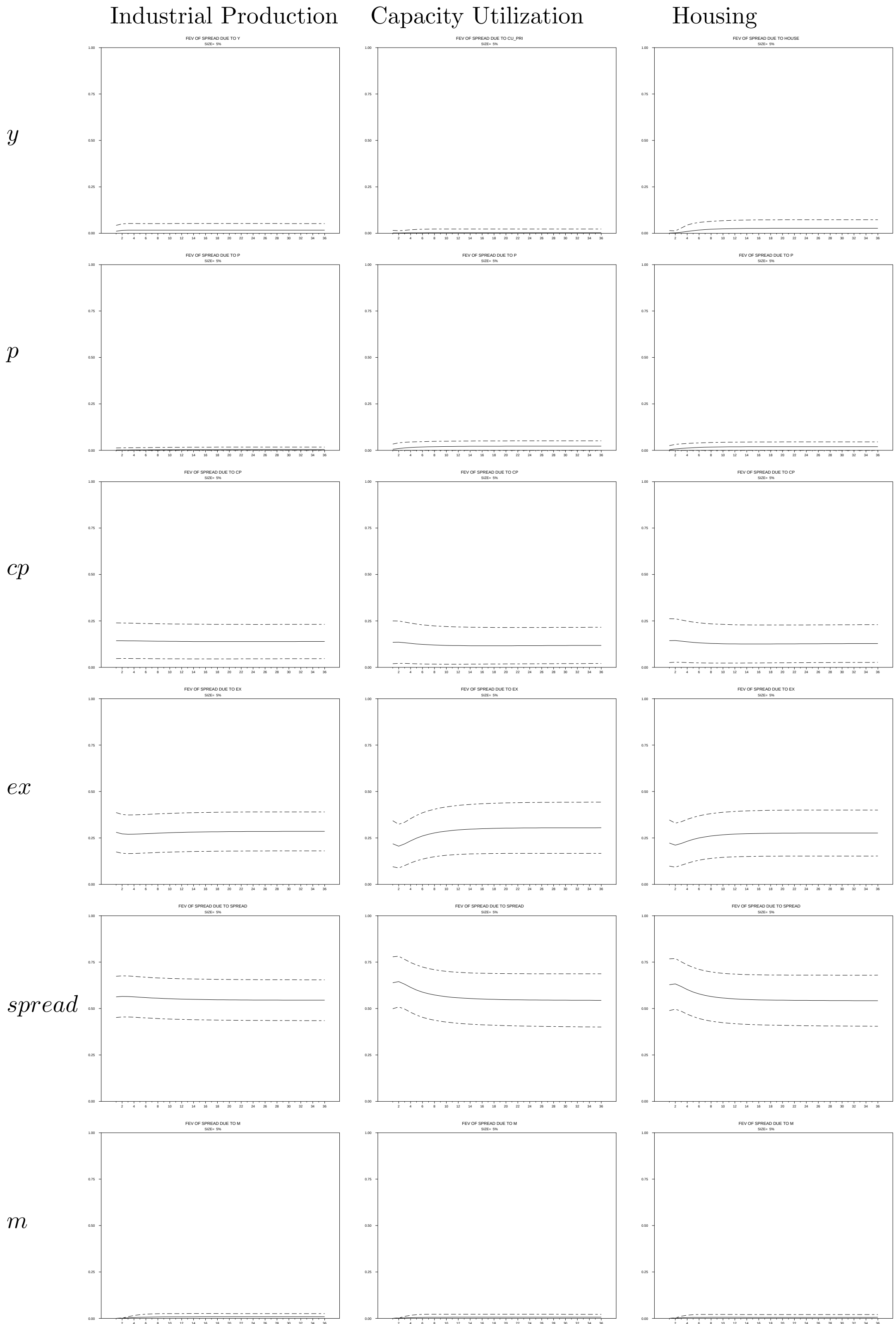
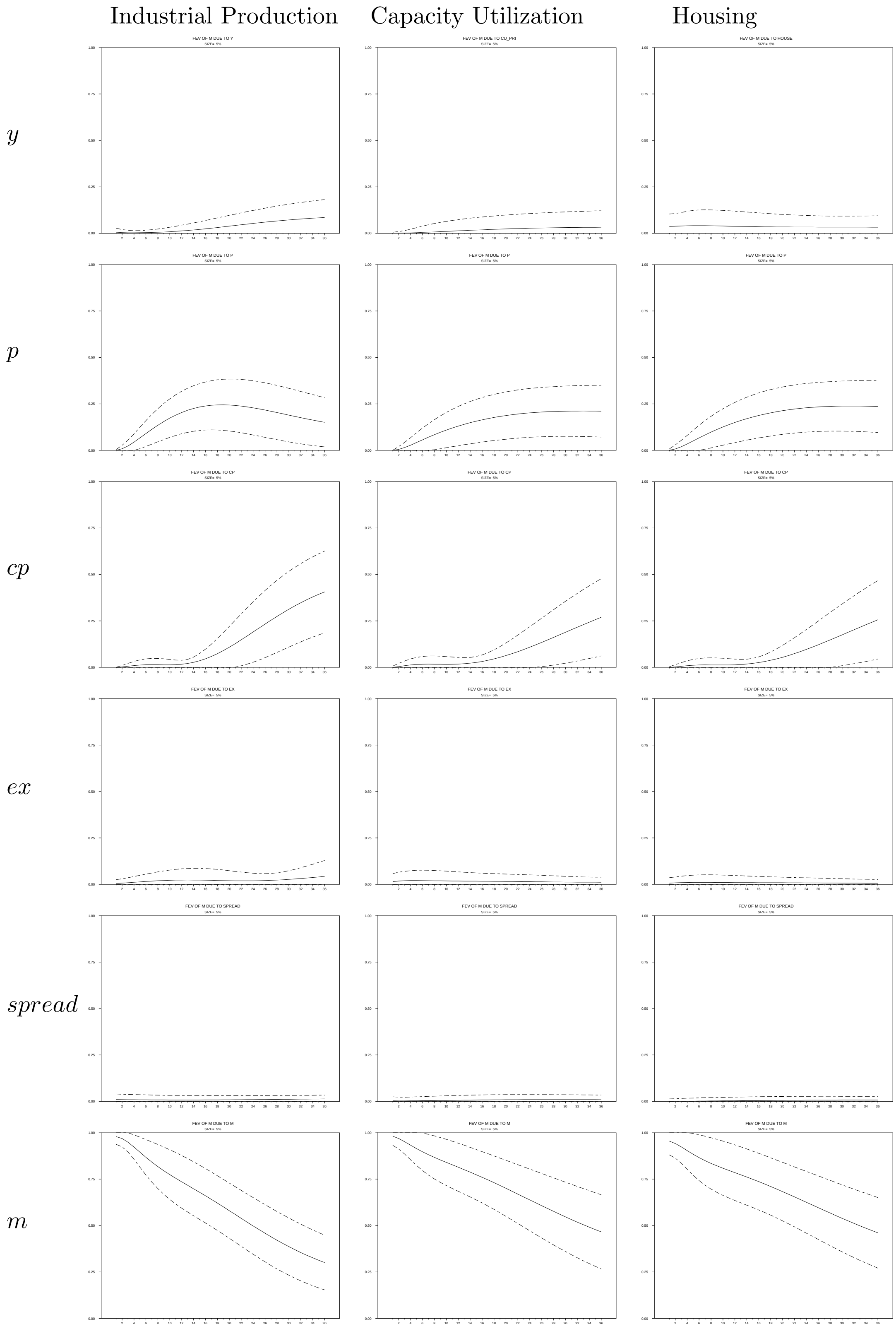


Figure 6: Forecast Error Variance Decomposition of Money.



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