Abstract

This paper attempts to provide an explanation of the short-run monetary non-neutrality in an economy where agents have full current information and no nominal prices are set in advance. This non-neutrality arises due to the government's setting of nominal target bands. If the current money supply is near the upper bound of the band, any increase in money supply will require the monetary authority to take immediate action to reduce it. This serves to decrease the expected rate of inflation, thus increasing the demand for real balances and production. This paper also shows that if readjustments of nominal target bands are likely to occur, then the positive effect of money on output becomes attenuated.

Key words: Nominal Target Bands, Monetary Neutrality

JEL classification: E32, E52
1. Introduction

There are many models that explain the short run money-output and inflation-output correlations. Relying mostly on imperfect information, staggered contracts, and imperfect competition, these models try to explain the existence of the output-inflation tradeoff in the short run and its non-existence in the long run.\(^1\) They also attempt to explain the fact that if the government exploits the tradeoff repeatedly -- as is the case in typical high inflation countries, the tradeoff tends to vanish even in the short run.\(^2\) Without relying on imperfect information, staggered contracts, or imperfect competition, this paper attempts to provide an explanation for the interactions between nominal and real variables in the short run. More specifically, this paper studies money-output relationships in an economy where money growth is the only source of uncertainty and the government attempts to control nominal variables within some target bands.

Governments in general have certain target bands when conducting monetary policy.

\(^1\)See Bernanke and Mihov (1998) for a recent empirical evidence for the short run liquidity effect and the long run neutrality of money. See also King and Watson (1997).

\(^2\)Lucas (1972) explains the monetary non-neutrality assuming workers’ having imperfect information about monetary shocks. See also Lucas (1996). Fischer (1977), Phelps and Taylor (1979) assume that some nominal prices are set in advance to explain the non-neutrality. Caplin and Leahy (1991) indicate that if monopolistically competitive firms change prices discretely whenever they deviate a certain amount from optimal values, the non-neutrality arises. Eden (1994) and Lucas and Woodford (1994) postulate games in which monetary shocks are gradually revealed so that these monetary shocks have real effects.
In fact, it is difficult to imagine a government conducting any policy, monetary or fiscal, without targets, even though it sometimes does not explicitly make the targets public. In the late 70’s and early 80’s, both the U.S. and the U.K. governments tried to conduct monetary policy with explicit monetary targets. In the 90’s, Canadian, New Zealand, and the U.K. governments have been conducting monetary policy with explicit inflation targets. Monetary policy with target bands is a half-way house between a k percent money growth rule and a period by period discretionary monetary policy with no necessary connection between the choices of a different period. While money supply is within a pre-specified target band, monetary policy can be directed toward other goals, such as stabilizing foreign exchange rates. When the boundary is reached, the monetary authority focuses resources on maintaining the boundaries.

This paper shows that such nominal target bands may generate monetary non-neutrality. The non-neutrality arises from agents’ expectations of future government policy interventions. More specifically, a known increase in money supply raises real output since an increase in money growth today is expected to result in a decrease in future money growth and thus future inflation. However, if a readjustment of the monetary target band is more probable than defending the existing one, then a known increase in money supply will lead to a more-than-proportional increase in the price level and a decline in production. Production decreases as the expected future rate of inflation increases.

The paper is organized as follows. Section II describes the structure of the economy. Section III studies the behavior of price, output, and the expected rate of inflation in an economy where the government controls money supply within a known target band. Section IV discusses a case where the government may readjust the nominal target bands. Concluding remarks are in Section V.

II. Structure of the Economy

Consider an infinitely lived economy with a constant population. There are many two
\( u'(0) > 0, \quad v''(0) < 0, \quad N_t \) is the amount of labor, which yields the same amount of the non-storable consumption goods. \( C_{t+1} \) is an agent’s old age consumption. The government issues fiat money, given to the old at time zero. The money demand of a young agent equals the market value of his output:

\[
P_t \text{ is the price level in period } t. \quad \text{The money demand of the agent is also equal to the market value of his consumption next period:}
\]

From (1), (2), and (3), we get young agent’s demand for real balances:

The old supply inelastically the money they have accumulated. In equilibrium, money demand equals money supplied. Thus,

\[
\text{where } M_t \text{ is the amount of money supplied. Substitution of (5) into (4) yields equilibrium real money balances:}
\]
According to (6), equilibrium real balances is a function of the rate of inflation. If uncertainty is introduced, equilibrium real money balances become a function of the expected rate of inflation. Taking a log linear approximation, denoting logarithms by lower case letters, using the approximation $E_t(P_{t+1}/P_t - 1) = E_t(p_{t+1} - p_t)$, and ignoring an unimportant constant term, we get the following first-order non-homogeneous stochastic difference equation:

$$\gamma $$

According to (6), $\gamma$ is the gradient of $u'(\cdot)^{-1}v'(\cdot)$. The restrictions imposed on $u(\cdot)$ and $v(\cdot)$ do not determine the sign of $\gamma$. However, to be consistent with empirical findings (see, e.g., McCallum (1989)), this paper considers only the cases where $\gamma > 0$, i.e., the cases where the expected rate of inflation, the negative of the rate of return on money, negatively affects equilibrium real balances.

A forward looking fundamental price solution of the first order stochastic difference equation (7) is:

According to (8), the current price is related to the current and future money supply through the interest elasticity of money.

For simplicity, we consider that monetary shock is the only source of uncertainty in this paper.

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3$\gamma$ is not a policy invariance structural parameter and thus could be affected by the way which the government implements monetary policy. However, this feature does not alter any of the qualitative results in this paper.
supply \( m_t \) follows a random walk process with no drift:

Thus, the expected money growth rate, \( E_t (m_{t+1} - m_t) \), becomes zero. Substitution of (9) into (7) yields the equilibrium price equation:

Thus, the current money supply affects the price level proportionally. According to (9) and (10), the expected rate of inflation equals to that of money growth. That is,

\[
\text{Substitution of (11) into (2) yields equilibrium output:}
\]

According to (10), (11), and (12), money is neutral: a known increase in money supply is accompanied by a proportionate increase in the price level and does not affect output. Furthermore, an increase in the current money supply \( m_t \) does not affect the expected rate of inflation.

It is well known that the solution (10) is unique in the class of forward looking prices, linear in fundamentals or state variables. In this paper, we would like to show that a particular government monetary policy may give rise in a price solution which is non-linear in fundamentals so that an increase in money supply could lead to a less than proportionate increase in the price level. To this end, we let \( p_t = p(m_t) \). Taking a second order Taylor series approximation, we get
For $h=1$, (14) becomes

Substitution of (15) into (6) yields a second order non-homogenous differential equation with

constant coefficients:

A general solution of (16) is:

where $A_1$ and $A_2$ are arbitrary constants and

The first part of the solution (17), $m$, is identical to (10); it can be also obtained from (16) by restricting $p_{mm} = 0$ -- that is, $p_t$ being linear in $m_t$. The second part consists of the term's non-linear in $m_t$. We now show that a government monetary policy with target bands may give rise to such non-linearity.

$\sigma^2 p_{mm}$. Note that this is identical to the instantaneous mean of a change in the log of the price level in a continuous time case, where money supply follows a Brownian motion process.
III. A Case of Monetary Control with Target Bands

Suppose the government controls money supply or the price level within a known target band. The government may intervene as often as necessary to maintain the band. In this case, \( m_t \) follows the random walk process (8) as long as \( p_t \in [p_l, p_h] \) or equivalently \( m_t \in [m_l, m_h] \), where \( m_l = p^{-1}(p_l) \) and \( m_h = p^{-1}(p_h) \). If the price happens to be outside of these bounds, the government instantly takes action to increase or decrease the money supply in order to keep the price within the band.\(^5\) Such a money supply process is shown by:

Thus, the monetary authority simply allows the money supply to follow the random walk process (8) until it reaches either of the boundaries of the pre-specified band, \( m_l \) and \( m_h \). Once the money supply reaches a boundary, then the monetary authority regulates it. Following Harrison (1985, p. 80), the regulators \( L_{t+1} \) and \( U_{t+1} \) in (19) increase only when the money supply reaches the lower bound \( m_l \) and the upper bound \( m_h \), respectively. Technically, the money growth is a process with reflecting boundaries, and the boundary conditions on \( p(m_t) \) are called smooth pasting conditions:

\[ \text{where } A_1 \text{ and } A_2 \text{ are arbitrary and } \lambda \text{ is defined in (18). Substituting (20) and (21) into (17) yields:} \]

\(^{5}\)The techniques of regulated Brownian motion was initially developed by Harrison (1985), and further developed and applied to many fields of economics, including investment, foreign exchange movements, and the business-cycle. See for example Bertola and Caballero (1992), Caplin and Leahy (1991), Dixit (1989), Flood and Garber (1991), and Krugman (1991). In this paper, the technique is modified to fit for a discrete time framework.
Then the equilibrium price, expected rate of inflation, and output become:

Near the lower bound, a decrease in $m$ leads to a less than proportionate decrease in the price level according to (26). According to (27), the expected rate of inflation is higher than that
of money growth, and a decrease in $m^t$ increases the expected rate of inflation. According to (28), a decrease in $m^t$ reduces output. These result from the fact that near the lower bound, a further decrease in $m^t$ implies higher probability of the monetary authority's taking action to increase in the money supply in the very near future. Thus, whether $m^t$ is near the upper bound or the lower bound, we get the same qualitative results. Finally, if $m^h$ and $m^l$, then the equilibrium price, the expected rate of inflation and output become:

(29) is identical to the linear case discussed earlier. Thus, if both the upper and lower bounds are infinitely distant, then $p^t$ is a linear function of $m^t$. That is, a known increase in the current money stock is accompanied by a proportionate increase in the price level without affecting output, and an increase in $m^t$ does not affect the expected rate of inflation. The solution (29) confirms that the previously discussed non-linearity results from the way how the government conducts monetary policy. So far this paper has discussed a case of infinitesimal government monetary interventions. In the remainder of this section, a case of discrete government monetary intervention is considered. A Case of Discrete Monetary Intervention

Now, consider a case of discrete monetary intervention policies. For simplicity, assume that the monetary authority regulates the money supply process $m^t$ only at the upper bound, $m^h$. Intervention occurs as follows: if $m^t$ reaches the boundary the monetary authority reduces the money supply by $b$ so that $m^t$ becomes the equilibrium price, the expected rate of inflation and output take the following form:
where \( \lambda \) is defined in (18). To determine \( A \), we consider what happens when \( m_t \) reaches the upper bound. At this point, the prevailing price level must equal the price level immediately after monetary intervention. Thus, according to (30),

Rearranging terms yields

Note that as \( b \to 0 \), the equilibrium price equation (30) with (34) becomes (23). This indicates that the boundary condition is essentially identical to the smooth pasting condition (20) and that the equilibrium price, expected rate of inflation and output in (30), (31), and (32) are qualitatively identical to those in (23), (24), and (25). In the following section, we study a case where the government readjusts the monetary target band stochastically.

IV. A Case of Stochastic Band Readjustments

Suppose that the government pursues discrete market intervention and readjusts the target band stochastically. Suppose further that the government intervenes at pre-specified points \( + b \) and \( - b \), where \( b \) stands for the center of the current band. More specifically, when \( m_t \) reaches either of the boundaries, say \( + b \), the government may either bring it back to the current center or declare a new monetary target band for the fundamental process with center \( b \) and unchanged width \( 2b \). Assume that the probability of the government’s defending the current band is \( \theta \) and that of declaring a new band is \( 1-\theta \). Note that \( \theta \) measures the credibility of the current monetary policy. In this case, the equilibrium
m price and output have the following form:

To determine A, consider a case where m, reaches the current boundary,  
At this moment, the prevailing price level must be equal to the weighted average of the two possible price levels immediately after the decision to defend or declare a new band is revealed, weighted according to the probabilities of the two events. That is, according to (35),

Thus, we have

According to (39), A \( \leq 0 \) if \( \theta \) is greater than ending the current band is greater than that of setting a new one; \( A = 0 \) if they are equally likely; \( A > 0 \), otherwise.

Substituting (39) into (35), (36) and (37), then differentiating them with respect to \( m \), we have:
According to (40), (41), and (42), if the government is more likely to defend the current nominal target band than to set a new one, then an increase in the money supply leads to a less than proportionate increase in the price level, a reduction in the expected rate of inflation, and an increase in output. If the probability of the government’s defending the current band and that of declaring a new band are equal, then money affects the price level proportionally and will not affect production. Finally, if readjusting the monetary band is more probable, then an increase in the money supply causes the price level to rise more than proportionally, increasing the expected rate of inflation, and decreasing production.

Thus, an expansionary monetary policy may affect output positively. This positive effect results from agents’ belief that if money supply nears a pre-announced monetary upper bound, the government is more likely to reduce money supply in the near future. However, if the policy of maintaining the current monetary target band is not credible, say due to the past behavior of the monetary authority, then an increase in the current money supply at least near the government announced upper bound will not likely be binding with regard to the government’s future actions. In this case, agents have no reason to believe that prices will decline in the future. Thus, the expected rate of inflation increases, which, in turn, gives agents less incentive to produce goods today.

IV. Concluding Remarks

This paper provides an explanation of monetary non-neutrality even when agents have full current information and no nominal prices are set in advance. This non-neutrality results from the fact that when implementing monetary policy, the government has explicit (or sometimes implicit) nominal target bands. Thus, agents expect the current government policy not to go on forever and to reverse its course in the future. Such expectations seem quite rational since after having eased monetary conditions, for example, governments typically become
concerned about when it should tighten the monetary conditions again.

Any microeconomic basis for failure of the classical dichotomy requires some kind of nominal imperfections, such as imperfect information or menu costs in nominal price adjustment. In Caplin and Leahy (1991), for example, the real effects of monetary changes stem from costs of changing nominal prices. In this paper, the non-neutrality results from the government’s having nominal target bands when implementing monetary policy. The fact that the government has nominal target bands implies that it must be costly for the government to control nominal variables, such as money supply or the price level, to meet the targets all the time. The cost may be measured in terms of real resources foregone in controlling nominal variables. More importantly, the cost must also reflect the consequences of completely foregoing other policy goals.

Appendix: Derivation of (24)

From (23), the log of the price level that will prevail in period $t+1$ expected in period $t$ can be expressed as:

From (9), the log of the money supply in period $t+1$ expected in period $t$ becomes:

Now,

Note that

since according to (17),
Substitution of (A.2), (A.3), and (A.4) into (A.1) yields:

Subtracting (23) from (A.5) yields (24).

Q.E.D.

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