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Inflation and Interest Rates in the presence of a Cost Channel, Wealth Effect and Agent Heterogeneity

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Abstract

As far as the control of inflation is concerned, the interest rate is the most important monetary instrument. This paper examines the effectiveness of the interest rate policy in controlling inflation. The model utilized in this paper considers both demand and supply side effects of interest rate policy. These effects are used to derive not only the relevant impulse response functions but also the welfare loss to the society that arises from the supply side shocks. Based on their ability to control inflation and minimization of the overall welfare loss to the society, three policies are compared: (i) monetary policy with commitment, (ii) Taylor’s rule, and (iii) inflation targeting. We argue that, in the presence of a cost channel, it is imperative that the interest rate policy is used with restraint. Our results also suggest that ignoring the cost channel of monetary policy can lead to significant under-estimation of the social welfare loss.

Keywords: Inflation targeting; Interest rate policy; Monetary commitment; Taylor’s rule, cost channel; wealth effect; Agent heterogeneity

JEL Classifications: E47, E52, E58
1. Introduction

Monetary policy is the most popular method of controlling inflation. As interest rate is the most important instrument of monetary policy, Central Banks usually attempt to control inflation by raising the interest rate. Up until the late 1970s, high interest rates policy to control inflation mostly produced disappointing results. For instance, the US economy in the seventies experienced high and variable inflation and despite a series of upward adjustment to the interest rate, inflation rate remained high until the early eighties (see Nelson, 2004, Table 1). Thus the belief that a high interest rate policy can control inflation without adversely affecting aggregate supply may not be realistic. While increase in interest rate may reduce aggregate demand, recent studies, have also highlighted the importance of a cost channel of monetary policy (for example, see Ravenna and Walsh, 2006). A cost channel exists when marginal cost of a firm is affected by nominal interest rate.\(^1\) In the presence of a cost channel, a high interest rate policy can further exacerbate the problem of inflation, especially in developing countries. Furthermore, Ravenna and Walsh (2006) have shown that in the presence of a cost channel, the policy makers do not always face a trade-off between stabilization of inflation and the output gap.

The cost channel arises from the supply side effects. Within the context of the so-called "price puzzle", the supply-side effects of interest rate policy were highlighted in the 1990s. This puzzle arises from the observation that, contrary to conventional view, prices of goods tend to increase with tightening of the monetary policy (Rabanal, 2003). One possible explanation for this puzzle is that negative shocks to the economy are already embedded in the economy before monetary tightening and hence prices and interest rate move in tandems. An alternative explanation for this puzzle is the presence of a cost channel of monetary policy. Specifically, an

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\(^1\) The existing empirical studies, such as Barth and Ramey (2001), support the presence of a cost channel.
increase in interest rate contributes to increase in the cost of production, which leads to higher prices.

Friedman (1960) strongly argued that inflation is a monetary phenomenon and that inflation control requires restraint in monetary aggregates rather than just controlling prices and wages.\footnote{Friedman (1960) strongly argued that inflation is a monetary phenomenon and that inflation control requires restraint in monetary aggregates rather than just controlling prices and wages.\footnote{While evaluating the effectiveness of monetary policy in industrialized countries, Mishkin (2000) compared the options of monetary and inflation targeting. Mishkin argues that the policy of monetary targeting was successful in controlling inflation in Germany and Switzerland mainly due to special conditions present in those economies.} Friedman's view is based on quantity theory of money, which assumes a stable (or constant) velocity of circulation of money and full employment level of output. Taylor (1993), on the other hand, suggested a rule which is based on the view that in the event of rapid inflation, the nominal rate of interest could be increased by more than the rate of increase in inflation. It was argued that an increase in interest rate would restrict aggregate demand in general and ostentatious consumption in particular, thereby controlling the rate of inflation.\footnote{Monetary policy affects the economy through changes in (i) prices such as the interest rate, the exchange rate and asset prices and (ii) quantities such as the money supply, outstanding government bonds, etc. The interest rate channel, the credit channel and the balance sheet channel are considered as the major transmission mechanisms of monetary policy. See Bernanke and Gertler (1995) for detailed discussion.} Inflation targeting is another policy option that is currently used by a number of developed and emerging economies (e.g., Australia, Canada, Chile, Brazil, New Zealand, Poland, Sweden, Turkey, and the United Kingdom) with some success.\footnote{Schwartz (2008) suggests that inflation targeting is based on Milton Friedman's view that it can stabilize the output growth around a trend. A recent review of the literature on inflation targeting can be found in Svensson (2010).} The policy of inflation targeting can help to pin down inflationary expectations, the lack of which is regarded as one of the key factors that exacerbate inflation and destabilize the economy.\footnote{The general practice of indexation of nominal wage contracts to the past rate of inflation is viewed as an obstacle to disinflation programs because such practices can result in inflation inertia. When individuals expect a higher inflation rate than the target rate, employment falls because they demand higher wages based on their expectations concerning the rate of inflation. Higher wages tend to cause contraction in the supply of goods, which leads to further increase in inflation.}}
targeting can contribute to increase in output growth and a decrease in output volatility – something which is found to be lacking in a number of non-inflation targeting countries (see Bernanke, et al., 1999 and Truman, 2003). Inflation targeting started in New Zealand in 1990 (a developed country) but its desirability is also being seriously considered in some developing countries (see Table A.1 in Appendix). For example, Mishra and Mishra (2012) consider the desirability of inflation targeting in India. They argue that, given the rigidities in the economy and the current state of insufficient financial market integration, a policy of flexible inflation targeting suits India.

In this paper, in order to determine the right interest rate policy to deal with cost push inflation, we use a model which reflects two important features of LDC’s – interest cost of production finance and real domestic debt. Following Ravenna and Walsh (2006), we introduce a cost channel of monetary policy in a new Keynesian model. This allows us to examine the implications of the supply-side effects of changes in the interest rate. In addition, Blake and Kisanova (2004), we incorporate real debt in the model. Furthermore, as far as the price setting behaviour is concerned, firms in our model are not homogenous; some firms are forward looking whereas the rest are backward looking. This allows us to examine the sensitivity of the results to agent heterogeneity. The model is used to compare the effectiveness of three policies that can be used to control inflation: (i) monetary policy with commitment, (ii) Taylor’s rule and (iii) inflation targeting. Monetary policy commitment refers to the ability of a government to follow through on its announced policy choices. Schaumburg and Tamberlotti (2007) provide an interesting analysis of the gains from monetary policy commitment. Taylor’s rule is simply a guide concerning the interest rate manipulation. In order to derive clear analytical results, we

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6 Given the well documented superiority of the monetary commitment policy over the discretionary monetary policy, in this paper, the model was not calibrated for the latter.
focus only on the supply-side shocks to the economy. The relative performance of each of the three policies is assessed and compared by means of the relevant impulse response functions and the associated social welfare loss to the economy. Calibration of our model suggests that, in the presence of a cost channel of monetary policy, interest rate policy that is aimed to control spiralling inflation should be used with restraint. Our results also highlight the importance of the cost channel of monetary policy – ignoring this channel can lead to significant under-estimation of the social welfare loss.

The rest of this paper is organized as follows. Section 2 presents an overview of the recent trends in the inflation and interest rates in some developed and developing economies. This section also contains a review of the related literature. A theoretical model is presented in Section 3. Section 4 contains the results of model calibration and Section 5 contains some concluding remarks and policy implications.

2. Inflation and Interest Rates: An Overview and a Review of the Related Literature

In order to gain further insight into the relationship between the inflation and interest rates, we consider the recent trends in the inflation and interest rates of some major world economies.
Figure 1: Interest Rates and Inflation Rates in Selected Countries (Year 2011)

Figure 1 suggests a strong association between the inflation and interest rates. It appears that countries with high inflation rate also have high interest rate and vice versa. In the past, high interest rate policy practiced by some developed countries did produce the expected results. For example, in the UK, from the late 1980s to early 1990s, the interest rate was increased to 15%. Increase in the interest rate in the UK led to a large contraction in demand, which resulted in a decrease in both the output and employment in the early 1990s (Bank of England, 2012). The high interest rate policy effectively increased the overall burden of both the public and private debt. Would a high interest rate policy help in controlling inflation over a longer period of time is unclear. For instance, in the case of the UK (which is also true for many less developed countries), a sharp rise in energy and food prices pushed the inflation rate well above the targeted rate to a peak of 5.2% in September 2008 (Bank of England, 2012). We also note that in the case of the UK, output growth weakened in 2008 and by the third quarter of 2009, output growth fell by 6.4% from its peak reached in the first quarter of 2008.7

7 Detailed information on the UK monetary policy can be found from the Bank of England website (http://www.bankofengland.co.uk/monetarypolicy/index.htm).
Inflation targeting has been reasonably successful in a number of countries including New Zealand, Canada, Australia, the United Kingdom, Turkey and Sweden. Figure 2 shows the inflation rate and the interest rate in New Zealand.

Figure 2: Inflation and Interest Rates in New Zealand

Figure 2 shows that from 2009 onwards, despite an increase in the rate of inflation to 5.2%, in recent months, the New Zealand central bank has followed a low interest rate policy.\(^8\) Turkey is another example of a country where prudent monetary policy was successful in controlling the rate of inflation (Akyurek et al., 2011). In 2002, the Central Bank of Turkey introduced an implicit inflation targeting framework. Based on the early signs of success, in 2006, inflation targeting was explicitly introduced in Turkey. At that time Turkey was facing a number of economic problems, such as a very high rate of inflation (70% at the end of 2001), a

\(^8\) A number of studies appear to support the policy of inflation targeting. For example, Brash (2002) found inflation targeting to be effective in controlling inflation in New Zealand whereas Torres (2003) found inflation targeting to be helpful in Mexico. Amato and Gerlach (2002) considered the case of a group of developing and emerging economies. Likewise, Goncalves and Salles (2008) while examining 36 emerging markets concluded that countries that follow inflation targeting regime did far better than those that do not. On the other hand, while evaluating the effectiveness of inflation targeting in OECD countries, Willard (2012) found that the impact of inflation targeting on actual inflation rate was insignificant.
very high public debt to GDP ratio (approximately 68%), backward looking pricing and a weak banking system (Central Bank of Turkey, 2012). A well-coordinated fiscal and monetary policy helped Turkey to overcome some of these problems. Figure 3 shows the experience of Turkey with inflation targeting.

![Inflation target and realization](image)

**Fig. 3 Inflation target and realization**

Source: The Central Bank of Turkey (2012)

Figure 3 shows both the target and the actual inflation rate. The Turkish inflation rate fell from 70% in 2001 to below 10% in 2004 and since then the rate of inflation has been relatively stable (see Akyurek et al., 2011). Furthermore, during the inflation targeting period, the volatility of macroeconomic variables such as output, inflation rate and the interest rate has significantly decreased. Starting from 2001, the Central Bank of Turkey reduced the overnight interest rate from 59% to 13.75% over the first 48 months and 7% over the next 48 months. Akyurek et al. (2011) conclude that the success of monetary policy in Turkey can be attributed to a number of factors such as fiscal discipline, better communication between the central bank and general public and bank flexibility in revising the target inflation rate from time to time.

However, not all existing studies recognize inflation targeting as the principal objective of monetary policy, especially in the case of emerging economies. Mishkin (2003 & 2008), for
example, argues that inflation targeting requires monetary discipline and there is no general
greement concerning the desirability of this policy. Some economists believe that targeting
inflation is an undue economic intervention, which limits the scope of the monetary policy (see
Truman, 2003; Mitchell and Bill, 2004 and references therein). The empirical analysis of Brito
and Bystedt (2010) suggests that inflation targeting was not a suitable policy to stabilize inflation
and output growth in emerging economies. Using propensity score matching technique
involving 180 countries over the period of 1990-2007, de Mendonca and de Guimaraes (2012),
found that adoption of inflation targeting is an ideal monetary regime for developing economies.
They argue that this policy helps not only in reducing inflation but also in controlling inflation
volatility. However, they found inflation targeting to be innocuous in the case of some developed
economies.

Woodford (2012) argues that financial stability can be achieved along with flexible
inflation targeting. Furthermore, leaning against the wind or tighter monetary policy can helps in
reducing the probability of financial crises. This view however is challenged by Svensson (2012)
who argues that inflation targeting and financial stability must be dealt by two separate policies.

Inflation targeting in emerging economies in general and developing economies in particular,
especially when interest rate is used as a tool to achieve the target, can lead to serious problems.
Eichengreen, et al. (1999) argue that emerging economies seriously lack both the technical
capabilities and Central Bank independence, which are prerequisites for successful inflation
targeting. On the same subject, Batini and Laxton (2007) argue that in addition to the
independence of the Central Bank, a country needs a well-developed technical infrastructure for

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forecasting, modeling and data analysis. The success of inflation targeting also depends on the ability of the Central Bank to accurately forecast inflation and other target variables. The Central Banks need these forecasts as there is a lag between the monetary policy actions and their effect on the target variables. Svensson (2010) argues that, for inflation targeting, we need an institutional framework that is characterized by the trinity of (a) a mandate for price stability, (b) independence, and (c) accountability of the Central Bank.

A number of developed as well as developing countries have a very high level of public sector debt. Consequently, a large increase in the interest rate can lead to a significant increase in debt burden. A large debt to GDP ratio gives rise to future monetization of debt and thus seriously undermines the credibility of the tight monetary policy. A large debt to GDP ratio also leads to fiscal dominance of monetary policy (Ersel and Ozatay, 2007). A zero level of fiscal dominance implies complete independence of monetary policy. However, due to factors such as corruption, weak taxation system, banking crises and overspending, a number of developing countries are facing the problem of rising debt, which significantly reduces the independence of the monetary policy. As a result of rising debt, the use of monetary policy to control inflation may not yield the desired results. Sargent and Wallace (1981) suggest that when public debt is high and the real rate of return on government securities is in excess of growth rate of the economy, a tight monetary policy in the form of lower growth rate of money supply can result in higher rather than lower inflation. Kumhof et al., (2008) show that, in such a situation, Taylor’s

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10 Bank of England research studies reveal that it takes two full years for the changes in short-term interest to show effects on real variables.

11 A growing number of studies have considered the issue of optimal monetary policy with fiscal dominance (see for example Kumhof et al., 2008).

12 For a detailed discussion of (i) why Central Banks do not like high level of public debt and (ii) why in the presence of high public debt, a high interest rate policy may backfire, see Ersel and Ozatay (2007, p. 5 and 6).
rule becomes impractical and undesirable. They conclude that monetary policy alone cannot contrive a rescue unless a fiscal discipline is established before committing to inflation targeting. Likewise, Woodford (1996, 1998 & 2001) examined the issue of the optimal monetary policy under fiscal dominance. Woodford found that, in the presence of a dominant fiscal policy, non-explosive government debt can be guaranteed only by ensuring that the real interest rate falls when inflation rises. This result contradicts Taylor’s proposition which calls for raising the real interest rate to control inflation (see Taylor, 1993). Within the context of an open economy, Blanchard (2005) argued that if an increase in the real interest rate also increases the probability of default on debt interest payments then it would make government debt less attractive, resulting in a real depreciation of the home currency, which could further increase the rate of inflation. Blanchard suggests that in such a situation, “…. fiscal policy, not monetary policy, is the right instrument to decrease inflation…. (p. 2)".

Generally speaking, debt ridden countries also rely on IMF and the World Bank loans. However, these loans come with policy advice and conditions that can reduce the effectiveness of both monetary and fiscal policies. A weak transmission mechanism is another factor that seriously emasculates the success of the interest rate policy. For instance, there is a strong possibility that a change in interest rate may not affect the demand for money as predicted by the economic theory and thus may not have the desired impact on aggregate demand. Likewise, the speed and the size of the interest rate pass-through from policy rate to the market rate can also play a critical role. Factors such as the less competitive banking system, underdeveloped financial markets, capital controls, over liquidity, balance sheet problems (both in the banking and corporate sectors), ambiguity concerning the nature of policy changes (i.e., permanent versus temporary) can lead to a slow adjustment from the policy rate to the market rate.
In recent years, excessive printing of money combined with a significant increase in oil and food prices have contributed to a considerable increase in the rate of inflation in a number of developing countries such as China, India and Pakistan. According to International Energy Agency (IEA), if the world oil price were to remain 10% above a base forecast level for two years then there will be a 0.4% increase in the average rate of inflation in most major economies.\(^{13}\) The inflation rate may rise further if wages are indexed to the rate of inflation. Increase in the price of oil adversely affects consumers as it leads to increase in the price of a number of products. Higher oil prices tend to reduce the growth of real GDP through a decrease in planned investment and it also adversely affects both business and consumer confidence.

A relatively few theoretical studies have addressed the issue of controlling inflation in a model economy. Calvo (1992) questioned the efficacy of high interest rate policy. Calvo’s model predicts that high interest rates may jeopardize the effectiveness of the policy while giving rise to nonperforming bank loans. This study suggests that it would be optimal to aim for low rather than high interest rates. Calvo’s model, however, does not include direct supply-side effects of the interest rate.\(^{14}\) Alvarez, Lucas and Weber (2001) explored the link between the interest rate and inflation. Their model is based on the assumption that markets are segmented and that only a fraction of the economic agents participate in the money market. It is further assumed that production is fixed, velocity of circulation of money is exogenous and that quantity theory of money determines the price level. They found that that the nominal interest rate is a decreasing function of the rate of money growth and that a decrease in money growth followed by an

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\(^{13}\) For further details, see http://www.iea.org/

\(^{14}\) Myatt and Scarth (1995) is an early attempt that highlights the importance of the supply-side effects of the interest rate policy. This study, which is mainly focused on the effectiveness of fiscal policy, concludes that if the nominal interest rate is 6% or higher then fiscal spending would be contractionary.
increase in the nominal interest rate helps to reduce inflation. This study highlights the importance of a decrease in the growth of money supply to control inflation. In this paper, while taking into account the cost channel to the monetary policy, we revisit the effectiveness of the interest rate policy in controlling inflation. A cost channel is realized when a firm’s cost of production is positively related to the nominal interest rate (Ravenna and Walsh, 2006).

Within the context of developing countries, due to non-existence of well-established stock markets, firms are effectively forced to finance their spending through bank loans at the market rate of interest, which results in a considerable cost channel. In the presence of a significant cost channel, a policy of high interest rate can give rise to monopoly as only well-established firms that already have access to conventional and non-conventional means of financing may be able to remain profitable. In other words, in the presence of a cost channel, a high interest rate policy can lead to a decrease in market competition. While using industry level data for the US economy, Barth and Ramey (2001) detect a strong cost channel in the pre-1979 period. However, Rabanal (2003), while using post 1984 data, did not find a cost channel. Furthermore, Rabanal’s simulation results suggest that if firm borrows at a rate which is at least four times higher than the Fed rate only then the interest and the inflation rates move in the same direction.

In addition to the supply-side effects of interest rate and the wealth effect, the model used in this study also features expectations that are not rationally formed. The idea that all agents always form rational expectations has been under scrutiny for some time. The work of Dubey,

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15 Liosa and Tuesta (2009), Blake and Kisanova (2004) and Ravenna and Walsh (2002) are few examples where the supply side effects of interest rate are explicitly considered.

16 Orphanides and Williams (2007) reiterate the role of expectations in the success of inflation targeting. Their empirical investigation reveals that monetary policy, which works well under rational expectations, performs poorly when imperfect knowledge is introduced in the model. They developed a simple policy, which incorporates three
Geanakoplos and Shubik (1987) is one of the early attempts on this subject. In recent years, the literature on Behavioral Economics has rapidly grown. This literature also deals with consumer behavior and expectations. Mullainathan, Schwartzstein and Shleifer (2008) have highlighted the importance of coarse thinking as an alternative to complete Bayesian rationality. Following Amato and Laubach (2003), in this paper, we assume that there are two groups of firms - one group forms expectations rationally whereas the other group uses a rule-of-thumb to set prices as we explain in Section 3.

3. The Model

The model used in this paper closely follows the framework of Ravenna and Walsh (2006) and Blake and Kirsanova (2004) and therefore in this section we only provide log-linearized conditions as follows:\textsuperscript{17}

\begin{equation}
    x_t = E_t x_{t+1} - \frac{1}{\sigma} \left( R_t - E_t \pi_{t+1} \right) + \psi b_t + u_t
\end{equation}

\begin{equation}
    \pi_t = \gamma^{\text{for}} E_t \pi_{t+1} + \gamma^{\text{hoc}} \pi_{t-1} + k(\sigma + \phi) x_t + k x_t R_t + u_t
\end{equation}

\begin{equation}
    b_{t+1} = R_t - E_t \pi_{t+1} + \frac{1}{\beta} (b_t + d_t) + u_t, \text{ where } d_t = -s b_t
\end{equation}

where $x_t$ is the natural logarithm of the real output, $b$ is the real domestic debt, $R_t$ is the nominal rate of interest, $\pi_t = p_t - p_{t-1}$ is the inflation rate, $E_t \pi_{t+1} = E_t p_{t+1} - p_t$ is the expected inflation and $p_t$ is the natural logarithm of the price level.

\textsuperscript{17}For further discussion and analysis of the related issues, see Benigo and Woodford (2004) and Lam (2010).
Equation (1) is the new IS curve, also known as the forward-looking IS curve. The IS curve equation used in this paper also takes into account the wealth effect (see Blake and Kirsanova, 2004 and Smets and Wouters, 2002 for further details). Equation (2) is the aggregate supply-curve (also known as the Phillips curve). Unlike most existing studies, the aggregate supply curve used in this paper includes a cost channel. We assume that, because it is hard to raise funds through the stock market, in order to pay the wage bill, firms rely on external financing and borrow at an interest rate $R$.\(^{18}\) Within the context of this paper, an increase in nominal interest rate shifts the aggregate supply curve to the left and the resulting effect dominates the traditional contractionary demand side effect – the overall effect is further inflation. Equation (2) takes into account agent heterogeneity concerning the rate of expected inflation where firms are divided into two groups; $\gamma_{for}$ is the fraction of forward looking firms whereas $\gamma_{bac}$ is the fraction of backward looking firms.\(^{19}\) Equation (3) is the debt accumulation equation, which assumes that fiscal authorities control the real primary deficit with a feedback rule $d_t = -sb_t$ (see Blake and Kirsanova, 2004 for details). Inflation can be controlled by means of at least three policies that are highlighted in section 4.

\(^{18}\) A cost channel can be introduced in the model in more than one ways. Normally, we assume that due to non-availability of retained earnings and poor primary stock market, firms resort to borrowing from banks at the market rate of interest. Another option is to assume that labour supply depends on discounted expected real wage rate where market interest rate is used as the rate of discount (see Ali and Anawar, 2012). Ravenna and Walsh (2003) assume that production depends on the marginal cost which depends on the interest rate along with other variables. In each of the three cases, the interest rate appears as an argument in the aggregate supply equation. The empirical work of Barth and Ramey (2001) supports the presence of a cost channel. Blake and Kirsanova (2004) further extended Barth and Ramey’s work to include the wealth effect.

\(^{19}\) Parameters $k$, $\gamma_{for}$ and $\gamma_{bac}$ are linked with the structure of the model as follows:

\[
k = \left[ \omega + \nu \{1 - \omega(1 - \beta)\} \right]^{-1} \left[ (1 - \nu)(1 - \omega)(1 - \beta \omega) \right]^{-1} \beta \omega,
\]

\[
\gamma_{for} = \left[ \omega + \nu \{1 - \omega(1 - \beta)\} \right]^{-1} \beta \omega,
\]

\[
\gamma_{bac} = \left[ \omega + \nu \{1 - \omega(1 - \beta)\} \right]^{-1} \nu; \text{ where } (1 - \omega) \text{ is the fraction of firms that are not allowed to adjust their prices and } \nu \text{ is the fraction of firms that are allowed to change their prices optimally; } (1 - \nu) \text{ is the fraction of the firms that use the last period’s prices (see Amato and Laubach, 2003 for details).}

4.1 Monetary Policy under Commitment

Monetary policy under commitment refers to a policy rule that is derived based on models where economic agents (households and firms) are forward looking, i.e., their present decisions also depend on their expectations about the future conditions. Accordingly, the monetary policy is viewed as an ongoing process rather than as a sequence of unrelated decisions (McCallum, 2003, p. 4). Svensson (2010, p.3) noted that monetary policy to a large extent is about “management of expectation.” Svensson further noted that monetary policy affects the economy mostly through the private sector expectations that are based on the current monetary policy. Considering the importance of expectations, it is imperative that while setting an inflation target, the monetary authorities take into account the private-sector inflation expectations. An attractive feature of the monetary policy under commitment is that it helps the authorities to tame (or guide) the private sector expectations concerning inflation. Following the existing literature, we assume that the monetary authority acts to maximize a social welfare function (SWF) with respect to the optimal time path of inflation, output gap, domestic debt and interest rate as follows:

\[
\text{Max}_{\pi,\lambda,\beta,\lambda} [\text{SWF}] = -\frac{1}{2} E_t \sum_{j=0}^{\infty} \beta^j \left[ \frac{\pi_{t+j}^2}{\lambda_t} + \lambda_t x_{t+j}^2 + \lambda_t (\pi_{t+j} - \pi_{t+j-1})^2 \right]
\]  

(4)

---

20 This function is valid only in the presence of a rule-of-thumb. However, in case of completely forward looking expectations, the SWF reduces to:

\[
\text{Max}_{\pi,\lambda,\beta,\lambda} [\text{SWF}] = -\frac{1}{2} E_t \sum_{j=0}^{\infty} \beta^j \left[ \frac{\pi_{t+j}^2}{\lambda_t} + \lambda_t x_{t+j}^2 \right]
\]

This optimization problem assumes that the central bank is targeting zero inflation and zero output gap. A good discussion of the underlying microeconomic foundations of this SWF can be found in Amato and Laubach (2003) and Lam (2010).
where \( \lambda_x = \frac{k}{\alpha} \) and \( \lambda_x = \frac{v}{(1-v)\psi} \).

Maximization of the SWF given in equation (4) subject to three constraints, as given by equations (1) to (3), yields the following first order conditions under commitment (see Appendix for details):\(^{21}\)

\[
\pi_t = -\dot{\lambda}_x (\pi_t - \pi_{t-1}) + \lambda_x^b + \beta (E_{t} \pi_{t+1} - \pi_t) - E_t \dot{\lambda}_x^y \gamma^{bce} \beta - \hat{\lambda}_{x-1}^y \beta^{-1} - \lambda_{x-1}^b \beta^{-1} = \lambda_{x-1}^{bce} \beta^{-1} \tag{5}
\]

\[
\dot{\lambda}_x x_t = -k(\sigma + \phi) \lambda_x^x + \lambda_x^x - \lambda_{x-1}^x \beta^{-1} \tag{6}
\]

\[
(1-s)\lambda_{x}^{bce} = \lambda_{x-1}^{bce} - \psi \pi_t \beta \lambda_x^y \tag{7}
\]

\[
k_x^x \dot{\lambda}_x^x = \lambda_x^b \sigma^{-1} - \hat{\lambda}_x^b \tag{8}
\]

where \( \forall y = x, \pi, b \) and \( i = -1, 0, 1 \); \( \lambda_{x,i}^y \) are the Lagrange multipliers.

The model comprises of equations (1) to (3) and (5) to (8). Once we substitute out variables such as \( E_{t} \lambda_{x+1} \) and \( E_t x_{t+1} \) in equation (5) and elsewhere in the model, it is possible in principle to solve for reduced form solutions for four endogenous variables: \( x_t, \pi_t, b_t \) and \( R_t \). However, the reduced form solutions involve both forward and backward looking variables. As an analytical solution cannot be found, we resort to a numerical solution. The model is calibrated by making use of DYNARE.\(^{22}\) This allows us to trace the optimum time path of the variables of interest; \( x_t, \pi_t, b_t \) and \( R_t \).

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\(^{21}\) Given the superiority of monetary commitment/timeless perspective over discretionary monetary policy in forward-looking models, we restrict our discussion to the latter case. See McCallum and Nelson (2004) for further details.

\(^{22}\) Based on the specified parameter values, DYNARE derives a numerical solution to the model. After establishing the stability of the model, DYNARE solves the model for the steady state values of the relevant variables. In our model, it turns out that in the steady state \( x_t = \pi_t = R_t = b_t = SWL = 0 \), which is quite common in log-linear models. In the second stage, in response to an exogenous shock to the economy, DYNARE traces the impulse response function of the relevant endogenous variables (deviations from their steady state values).
3.2 Taylor’s Rule/Interest Rate Smoothing

In order to control the rate of inflation and output gap, the central bank may follow an interest rate policy that is based on Taylor’s (1993) rule as follows:

\[ R_t = \xi R_{t-1} + (1 - \xi) \left[ a_p (\pi_t - \pi_0) + a_y (x_t - x_0) \right] \]  

(9)

where \( \pi_0 \) and \( x_0 \) respectively are the target inflation and output levels.

The interest rate policy presented in equation (9) is in fact the case of flexible inflation targeting. This follows from the fact that monetary policy presented in equation (9) is aimed at stabilizing not only the inflation but also the output gap; where \( \pi_0 \) and \( x_0 \) respectively are the inflation and output gap targets. In his original work, Taylor suggested that \( a_p \) and \( a_y \) respectively be set at 1.5 and 0.5. The logic behind this choice is quite simple. Taylor rightly believed that a high nominal interest rate would practically slow down the economy by checking the excessive consumption and investment demand until and unless it leads to high real interest rate and that would occur if and only if the increase in the nominal interest rate is higher than the rate of inflation.

*Inflation Targeting/Strict Inflation Targeting*

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\( ^{23} \) Equation (9) is a modified Taylor’s rule. The original rule involves setting \( \xi = 0 \) and adding the steady state rate of interest (\( \bar{R} \)) to the right hand side of equation (9).

\( ^{24} \) Money growth targeting is usually considered as an alternative to inflation targeting. Svensson (2010, p. 5) argues that money growth targeting has been tried by a number of countries in the past but this policy was abandoned because the practical experience suggests that there is no consistent relationship between money growth and inflation. Svensson also notes that many small and medium-sized countries have tried exchange rate targeting as a means to stabilize inflation and the economy but these policies were also abandoned due to difficulties in defending the misaligned fixed exchange rates.
Another option for central banks is to choose an interest rate policy that is based on inflation targeting as follows:\(^25\)

\[ R_t - R_{t-1} = \alpha_r (\pi_t - \pi_o) \tag{10} \]

Equation (10) captures the essence of strict inflation targeting as the Central Bank focuses only on the inflation target and other things such as output gap are ignored. Friedman (2004, p.135) noted that in the past few decades inflation targeting has emerged as one of the most salient new development in the theory and practice of monetary policy. Inflation targeting involves anchoring inflation expectations, which is central to the success of controlling inflation. In this context Eggertsson (2012, p.103) and Woodford (2012, p.7-8), for example, observed that under credible inflation targeting, a Central Bank has the ability to react to short-term shocks without un-anchoring medium and long-term inflation expectations. Woodford also highlights the fact that, despite a serious disruption to the world financial system arising from the global financial crisis of 2008, none of the major economies fell into a deflationary spiral as was the case in 1930s. In this paper, we refer to inflation targeting and strict inflation targeting interchangeably. Equation (10) suggests that as soon as the actual inflation rate exceeds the targeted rate (\(\pi_o\)), the central bank would raise the interest rate and vice versa. The parameter \(\alpha_r\) measures the speed at which the interest rate changes to bridge the gap between the actual and the targeted inflation rate. In the existing literature, there is a considerable debate about fixed and flexible inflation targeting. Friedman (2004) believes that strict inflation targeting poses undue constraints on monetary policy and consequently monetary authorities are left with limited

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\(^25\) In the aftermath of the oil and food prices shock of 2007, International Monetary Fund (2008) found that, as compared to other options, inflation targeting was relatively more effective in anchoring inflation expectations even in the case of emerging economies.
choices to address other economic issues, such as the output gap and unemployment. On the other hand, Kuttner and Posen (2012), while comparing the US (a flexible inflation targeting country) with the UK (a fixed inflation targeting) found that the performance of both countries during the recent global financial crisis was not very different. In short, their analysis appears to reject the proposition that a strict inflation targeting restricts the scope of monetary policy.

Model Calibration

We start our calibration exercise by assuming that \( \nu = 0.5 \) i.e., 50% of the firms form rational expectations concerning inflation and the rest follow a rule-of-thumb. In addition we assume the following parameter values that are commonly used in related studies:26

\[
\begin{array}{cccccccc}
\sigma & \beta & \eta & \phi & \varepsilon & \omega & \psi & \varepsilon_s \\
1 & 0.99 & 1 & 1 & 0.005 & 0.75 & 0.3 & 0.5 \\
\end{array}
\]

Table 1: Assumed Parameter Values

Finally, in order to take into account the inertia associated with the exogenous shock to the economy, we assume that the disturbance term \( u_{2t} \) follows a stationary AR(1) process as follows:

\[
u_{2t} = \rho u_{2t-1} + e_t \quad \text{where} \quad 0 < \rho < 1 \quad \text{and} \quad e_t \sim iid(0, \sigma_e^2)
\]

Equation (11) suggests that a realization of the positive value of \( e_t \) (for example an unexpected increase in the price of oil) could lead to unfavorable impact on the supply of goods both in the short and in the medium-run before it disappears in the long-run. However, when \( \rho \) takes a value of 1, the shock would be permanent and would not abate overtime. For calibration

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26 For example, see Ravenna and Walsh (2006), Blake and Kirsanova (2004), Liosa and Tuesta (2009) and Lam (2010).
purposes, we assume that \(\rho\) takes a value of 0.95. The calibrated results are shown in Figures 4(a) to 4(d), where each figure shows the impact of a 1% supply-side shock \((u_{s,t})\) on four key variables i.e., \(R_t, \pi_t, x_t,\) and \(\frac{b_t}{x_t}\). Each of these figures contain three time paths (each associated with one of the three interest rate policy choices).
We note in Figure 4(a) that if the Central Bank follows Taylor’s rule then it would choose to increase the interest rate to mitigate the effect of a cost push shock. On the other hand, if the Central Bank adopts inflation targeting policy then it would keep the interest rate almost at its steady state level. Finally, in the case of monetary commitment, we note that the Central Bank chooses to reduce the interest rate by a relatively large margin and for a longer period of time. The policy of reducing the nominal interest rate or at least keeping it at its steady state level
makes lots of sense when the interest rate has negative supply-side effects and also when the model contains forward looking variables. In contrast, an increase in the interest rate not only depresses the aggregate demand but it also decreases the aggregate supply due to an increase in the cost of production.\textsuperscript{27} In other words, in the presence of a cost channel, increase in interest rate can decrease the aggregate supply, which can put an upward pressure on the price level. Moreover, in the presence of forward looking variables, due to an increase in interest rate, both firms and households may expect inflation in the future and hence may not significantly reduce their demand in the current period. The simulation results suggest that both monetary commitment and inflation targeting can lead to a large decrease in inflation. As shown in Figure 4(b), the economy is almost fully immune to inflation under these polices. In contrast, the Taylor’s rule does not appear to be very promising - despite a large increase in the interest rate, the rate of inflation stays at a relatively higher level. The failure of Taylor’s rule mirrors the recent experiences of a number of developing economies. For example, Argentina and Pakistan are two developing countries, where the Central Banks aggressively followed high interest rate policy without much success. On the other hand, monetary commitment and inflation targeting policies mimic the experiences of developed countries, such as New Zealand, Australia, and Canada, where the Central Banks follow a policy of inflation targeting with success. As far as the time path of the output gap is concerned, in Figure 4(c), we note that adherence to Taylor’s rule or inflation targeting works better than monetary commitment. We also analyzed the debt situation of the economy in the event of a cost-push shock. Figure 4(d), where debt-output gap ratio (in levels) is measured along the vertical axis, shows that inflation targeting and Taylor’s rule perform better than the policy of monetary commitment.

\textsuperscript{27} We assume that aggregate demand is sensitive to interest rate changes and assume that $\sigma = 1$, see table 1.
Finally, comparing the overall performance of the three policies, Table 2 shows that Social Welfare Loss (SWL), which is calculated using equation (4), associated with the policies of monetary commitment and inflation targeting is much lower than the loss associated with Taylor’s rule. These results suggest that if the Central Bank is focused on just the issue of inflation targeting then other problems such as the output gap would be automatically fixed. In short, inflation control should be the key priority. Our results mimic the experiences of those countries that follow inflation targeting, which leads to relatively less output volatility (see Bernanke, et al., 1999, Truman, 2003 and Svensson 2010).

<table>
<thead>
<tr>
<th></th>
<th>Taylor’s Rule</th>
<th>Inflation Targeting</th>
<th>Monetary Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWL</td>
<td>0.15786</td>
<td>0.000708</td>
<td>0.067625</td>
</tr>
</tbody>
</table>

Table 2: Social welfare Loss (SWL) under different policy regimes

4.4 Sensitivity Analysis

In order to determine the robustness of our results, we perform some sensitivity tests. First, we calibrated the model when monetary policy has no cost channel. To accomplish this goal we set \( z_2 = 0 \) in equation (2). In the second sensitivity test, we assumed that all firms have forward looking expectations, i.e., \( \gamma^{bac} = 0 \), \( \gamma^{for} = 0 \), and \( \lambda_x = 0 \). We also re-calibrated the model when all firms have backward looking expectations, i.e., \( \gamma^{bac} = 0 \) and \( \gamma^{for} = 0 \). Finally, in the third sensitivity test, following Kumhof et al. (2008), we simulated the model by augmenting the Taylor’s rule while taking into account the real debt as follows, where \( b_i \) is the target real debt.

\[
R_t = \xi R_{t-1} + (1 - \xi) \left[ a_x (\pi_t - \pi_0) + a_y (x_t - x_0) + a_b (b_t - b_0) \right]
\]
Some of the relatively more interesting results are reported in graphs and tables.  

Case I: No Supply-side Effects of Interest rate

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\(^{28}\) The results not reported here are available from authors upon request.
Figure 5: Impulse response to a supply-side shock under different policy regimes when monetary policy has no cost channel.

<table>
<thead>
<tr>
<th></th>
<th>Taylor's Rule</th>
<th>Inflation Targeting</th>
<th>Monetary Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWL</td>
<td>0.071759</td>
<td>0.00070</td>
<td>0.069325</td>
</tr>
</tbody>
</table>

Table 3: Social welfare Loss (SWL) under different policy regimes

Figure 5(a) above reveals that despite the absence of the cost channel of monetary policy, inflation targeting leads to no change in interest rate, whereas in case of monetary commitment interest rate is set to be reduced first but pushed back up soon after to its steady state level. Figure 5(b) confirms the success of these two policies in taming inflation. Table 4 above also reveals that both monetary commitment and inflation targeting policies help to reduce the overall welfare loss to the society. The policy that Central Bank should keep the interest rate low in the event of negative supply-side shock, despite the absence of supply-side effects of interest rate, in fact entails the importance of expected future inflation. For example, if agents observe the increase in interest rate then
they would expect more inflation in the future which would increase the inflation even further.

Case II: All firms have Forward Looking Expectations

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**Figure (a):**
- Solid line: commitment
- Dashed line: inflation targeting
- Solid line with dots: Taylor's rule

**Figure (b):**
- Solid line: commitment
- Dashed line: inflation targeting
- Solid line with dots: Taylor's rule

---
Figure 6: Impulse response to a supply-side shock under different policy regimes when all firms have forward looking expectations.

<table>
<thead>
<tr>
<th></th>
<th>Taylor’s Rule</th>
<th>Inflation Targeting</th>
<th>Monetary Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWL</td>
<td>0.06080</td>
<td>0.000697</td>
<td>0.06055</td>
</tr>
</tbody>
</table>

Table 4: Social welfare Loss (SWL) under different policy regimes

In case II, where all firms have forward looking expectations, and in case III, where all firms have backward looking expectations, we note the superiority of inflation targeting and monetary commitment in controlling inflation - both policies suggest against the use of increase in interest rate to remedy the effect of the cost push shock (see Figures 6(b) and 7(b)). The importance of the supply-side effects of interest rate and heterogeneity of the agents can be seen by examining the fall in the overall welfare loss in the case of Taylor’s rule. By comparing Table (4) and Table (5) with Table (3), we note that social welfare loss decreases in the case of Taylor’s rule, which shows that Taylor’s rule overstates the efficacy of interest rate policy. As the real world is far more complex than the model economy considered in this paper, it would be
unwise to follow a rule of thumb policy which involves raising the interest rate whenever inflation increases.

Case III: All Firms have Backward Looking Expectations.
Figure 7: Impulse response to a supply-side shock under different policy regimes when all firms have backward looking expectations.

<table>
<thead>
<tr>
<th></th>
<th>Taylor’s Rule</th>
<th>Inflation Targeting</th>
<th>Monetary Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWL</td>
<td>0.027252</td>
<td>0.000215</td>
<td>0.021074</td>
</tr>
</tbody>
</table>

Table 5: Social welfare Loss (SWL) under different policy regimes

**Case: IV  Inflation and Real Debt Targeting**

Using equation (12), we considered two cases; (i) \( a_x = 0 \) and (ii) \( a_x = 0.5 \) where we set \( a_b = 0.05 \). The results are shown in Figure 8.
(a) Interest rate vs. time with different values of $a_k$.

(b) Inflation vs. time with different values of $a_k$. 

- Dotted line: $a_k = 0.5$
- Solid line: $a_k = 0$
Figure 8: Impulse response to a supply-side shock when $\rho_t = \rho_{t-1} + \frac{1}{1-\phi} \left[ \alpha_x (\pi_t - \pi_0) + \eta_x (y_t - y_0) + \eta_h (h_t - h_0) \right]$

<table>
<thead>
<tr>
<th>Augmented Taylor’s rule</th>
<th>$a_x = 0.5$</th>
<th>$a_x = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWL</td>
<td>0.07291</td>
<td>0.00781</td>
</tr>
</tbody>
</table>

Table 6: Social welfare Loss (SWL) under augmented Taylor’s rule

Figure 8 shows that, if monetary authorities focus only on the targeted inflation rate and real debt and do not worry about the output gap then Taylor’s rule, as suggested by the Keynesian
economists, is helpful not only in controlling the inflation but it also minimizes the welfare loss (see Table 6). This result is similar to the earlier result, where the policy of inflation targeting alone resulted in not only control of inflation but the output gap was also stabilized (see Table 2 above). In other words, it seems that if the Central Bank manages to successfully control inflation then the severity of rest of the economic problems is automatically abated. Within the context of less developed (or debt ridden) countries, it makes a lot of sense for the Central Banks to focus exclusively on inflation targeting. Furthermore, the cost channel is important in the sense that ignoring this channel can lead to significant under-estimation of the social welfare loss.

5. Concluding Remarks

This paper focuses on the choices that are available to monetary authorities to control spiraling inflation. We use a model that captures two important features: the presence of a cost channel of monetary policy and the real domestic debt. Both the cost channel and national debt present important challenges to less developed economies. The model is used to evaluate the effectiveness of alternative policies that can be used to deal with the problem of inflation emanating from a temporary cost push shock. The policies considered in this paper include (i) monetary commitment, (ii) inflation targeting and (iii) Taylor’s rule.

The simulation exercise presented in this paper suggests that it is unwise to always raise the interest rate to control inflation. The supply-side effects of interest rates in fact emasculate the basic premise of the high interest rate policy to cool-off the economy in the event of a shock. In contrast, inflation targeting and the monetary commitment policies appear to be relatively more attractive in achieving the objective. In short, based on the results presented in this paper, we believe that a restraint in pursuing high interest rate policy can achieve relatively more
desirable results. This finding is consistent with the interest rate policies that were utilized by a number of Central Banks during the recent global financial crisis.

The simulation results presented in this paper suggest that in the presence of a cost channel of monetary policy, social welfare loss associated with Taylor’s rule is the highest, whereas inflation targeting leads to the least amount of social welfare loss. Ignoring the cost channel leads to a significant under-estimation of the social welfare loss from Taylor’s rule and hence the policy of monetary commitment and Taylor’s rule appear to be almost equivalent. Ignoring the agent heterogeneity also leads to gross underestimation of the social welfare loss under Taylor’s rule. Targeting of both the debt and inflation leads to gross under estimation of the social welfare loss. Furthermore, monetary commitment can lead to large fluctuations in the short-run.

Acknowledgements

This paper has greatly benefitted from very helpful comments and suggestions from two anonymous reviewers. However, the authors are solely responsible for all remaining errors.
Appendix A

Table A.1: Approximate adoption dates of inflation targeting

<table>
<thead>
<tr>
<th>Country</th>
<th>Date</th>
<th>Country</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>1990</td>
<td>Korea</td>
<td>2001</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1991</td>
<td>Mexico</td>
<td>2001</td>
</tr>
<tr>
<td>Sweden</td>
<td>1992</td>
<td>Iceland</td>
<td>2001</td>
</tr>
<tr>
<td>Finland</td>
<td>1993</td>
<td>Norway</td>
<td>2001</td>
</tr>
<tr>
<td>Australia</td>
<td>1993</td>
<td>Hungry</td>
<td>2001</td>
</tr>
<tr>
<td>Spain</td>
<td>1993</td>
<td>Peru</td>
<td>2002</td>
</tr>
<tr>
<td>Israel</td>
<td>1995</td>
<td>Philippines</td>
<td>2002</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1997</td>
<td>Guatemala</td>
<td>2005</td>
</tr>
<tr>
<td>Poland</td>
<td>1997</td>
<td>Slovakia</td>
<td>2005</td>
</tr>
<tr>
<td>Brazil</td>
<td>1998</td>
<td>Indonesia</td>
<td>2005</td>
</tr>
<tr>
<td>Chile</td>
<td>1999</td>
<td>Romania</td>
<td>2005</td>
</tr>
<tr>
<td>Colombia</td>
<td>1999</td>
<td>Turkey</td>
<td>2006</td>
</tr>
<tr>
<td>South Africa</td>
<td>2000</td>
<td>Serbia</td>
<td>2006</td>
</tr>
<tr>
<td>Thailand</td>
<td>2000</td>
<td>Ghana</td>
<td>2007</td>
</tr>
</tbody>
</table>

Source: Roger (2009)

Appendix B

The Central Bank minimizes the Social Welfare Loss (SWL) by choosing the optimal time path as follows:

\[
\begin{align*}
\text{Min}_{\pi, x, b, R} \left[ \text{SWL} \right] &= -\frac{1}{2} E_t \sum_{j=0}^{\infty} \beta^j \left[ \pi_t \pi_j + \lambda_x (\pi_t - \pi_j)^2 \right] + \\
\lambda_{x_{t+j}} & \left[ x_{t+j} - x_{t+j+1} - \sigma^{-1} (R_{t+j} - \pi_{t+j+1}) - \psi_{x_t} b_{t+j} - u_{t+j} \right] + \\
\lambda_{\pi_{t+j}} & \left[ \pi_{t+j} - \pi_{t+j+1} - \lambda_{\pi_{t+j+1}} x_{t+j} - k (\sigma + \phi) x_{t+j} - k x_{t+j} R_{t+j} - u_{t+j} \right] + \\
\lambda_{R_{t+j}} & \left[ R_{t+j} + \pi_{t+j+1} - \phi^{-1} (1 - \lambda_{x_{t+j}}) b_{t+j} - u_{t+j} \right]
\end{align*}
\]

(A.1)

where \( \forall y = x, \pi, b \) and \( i = -1, 0, 1 \); \( \lambda_{y_{t+j}} \) are the Lagrange multipliers.

After differentiating equation (A.1) with respect to \( \pi_t, x_t, b_t \), and \( R_t \), and setting the results equal to zero, we get equations (5) to (6).
References


International Monetary Fund (2008), World Economic Outlook, October 2008.


