Will the SARB always succeed in fighting inflation with contractionary policy?

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Abstract

The conventional view is that a monetary policy shock has both supply-side and demand-side effects, at least in the short run. Barth and Ramey (2001) show that the supply-side effect of a monetary policy shock may be greater than the demand-side effect. We argue that it is crucial for monetary authorities to understand whether an increase in expected future inflation is due to supply shocks or demand shocks before applying contractionary policy to forestall inflation. We estimate a standard New Keynesian dynamic stochastic general equilibrium model with the cost channel of monetary policy for the South African economy to show that whether the South African Reserve Bank should apply contractionary policy to fight inflation depends critically on the nature of the disturbance. If an increase in expected future inflation is mainly due to supply shocks, the South African Reserve Bank should not apply contractionary policy to fight inflation, as this would lead to a persistent increase in inflation and a greater loss in output. Our estimation results also show that, with a moderate level of cost-channel effect and nominal rigidities, a New Keynesian dynamic stochastic general equilibrium model with the cost channel of monetary policy is able to mimic the price puzzle produced by an estimated vector autoregressive model.

JEL codes: E52, E31, E58, E12

Keywords: Monetary policy, price puzzle, inflation targeting, New Keynesian model, Bayesian analysis

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1 Introduction

The conventional view suggests that monetary authorities should adjust the nominal short-term interest rate gradually and sufficiently to alter the real rate in the direction that offsets any movement in expected future inflation (Clarida et al., 1999). A contractionary monetary policy shock should, in principle, decrease future inflation. However, empirical evidence shows a positive and significant response of price level to positive innovations in the nominal short-term interest rate, the so-called price puzzle in the literature.

Price puzzle evidence was first noted by Sims (1992) and labeled by Eichenbaum (1992). To characterize the dynamic effects of monetary policy disturbances, Sims (1992) uses vector autoregressive (VAR) models and shows that the price puzzle emerges in most developed countries, such as France, Germany, Japan, the U.K. and the U.S. That is, a contractionary monetary policy shock leads to a sharp, persistent increase in price level. As pointed out by Eichenbaum (1992), this VAR-based empirical evidence is an obvious challenge to Keynesians, Monetarists, and Real Business Cycle Theorists. According to Sims (1992), the price puzzle arises due to the misidentification of monetary policy shocks. Monetary authorities may have more information on expected future inflation than a VAR could capture. For instance, once a commodity price index is included in the VAR, econometricians would no longer observe the price puzzle.

An alternative explanation for the price puzzle suggests that it is due to the cost-channel effect of monetary policy shocks. Barth and Ramey (2001) present aggregate and industry-level evidence that suggests a cost channel of monetary policy can potentially explain the price puzzle. Studies using general equilibrium models to explicitly analyze the cost-channel (supply-side) effect of monetary policy shocks all assume firms have to borrow funds to pay their factors of production before they sell their product[1]. As a result, an increase in the nominal short-term interest rate increases the prices of the factors of production, and hence inflation ensues.

Besides the sharp, persistent increase in price level, a contractionary monetary policy shock also leads to a significant, persistent decline in real output. This degree of amplification puzzle noted by Bernanke and Gertler (1995) implies that contractionary policy can neither forestall inflation, nor improve the short-run output/inflation trade-off if the cost channel of monetary policy is present.

This paper examines the effects of monetary policy for the South African economy from a New Keynesian perspective. In particular, we study under what circumstance the South African Reserve Bank (SARB

[1] See Christiano and Eichenbaum (1992), Christiano et al. (1997), Farmer (1984), and Farmer (1988).

hereafter) should apply contractionary policy to fight inflation[2]. To do so, we estimate a simplified version of Smets and Wouters (2007) New Keynesian dynamic stochastic general equilibrium (DSGE hereafter) model with the cost channel of monetary policy. We then compare the dynamic responses of inflation and output to a contractionary policy shock for the model with and without the cost channel of monetary policy. We argue that whether the SARB should raise the nominal short-term interest rate in an effort to forestall inflation depends on whether an increase in the expected inflation is mainly due to demand shocks or supply shocks. We show that in the presence of the cost channel of monetary policy, the nominal short-term interest rate acts as a cost-push shock: an increase in the nominal short-term interest rate raises the real marginal cost of production, and hence inflation ensues. The SARB can only succeed in fighting inflation with contractionary policy if an increase in the expected future inflation is mainly due to demand shocks, or put differently, the demand-side effect dominates the cost-channel (supply side) effect of monetary policy shocks. Our estimation results also show that, with a moderate level of cost channel effect and nominal rigidities, a New Keynesian DSGE model with the cost channel of monetary policy is able to mimic the price puzzle produced by an estimated vector autoregressive model.

The paper proceeds as follows. Section 2 presents the VAR-based empirical evidence for the South African economy. Section 3 describes the New Keynesian DSGE model with the cost channel of monetary policy. Section 4 discusses the prior and posterior parameters and the robustness of the estimation results. Section 5 presents the findings and Section 6 concludes.

2 Empirical evidence

The VAR includes three variables, and the ordering of the variables is real output, inflation, and the nominal short-term interest rate[3]. The estimated VAR contains four lags of each variable and the sample period is 1970:Q1-2010:Q4. The monetary policy shock is identified with the Cholesky decomposition of the variancecovariance matrix of the reduced-form residuals. Fig. 1 presents the impulse response functions of output, inflation, and the nominal interest rate to a contractionary policy shock. It is not surprising that the price puzzle emerges in the South African data. In response to an increase in interest rate, inflation starts

[2]The SARB is one of those central banks that adopt inflation targeting as its monetary policy. Therefore, it is important for the SARB to have a better understanding of the effects of monetary policy on inflation in particular.

[3]See Section 4.1 for the measurements of the variables included in the VAR. The data is introduced in the same way as estimating the DSGE model.

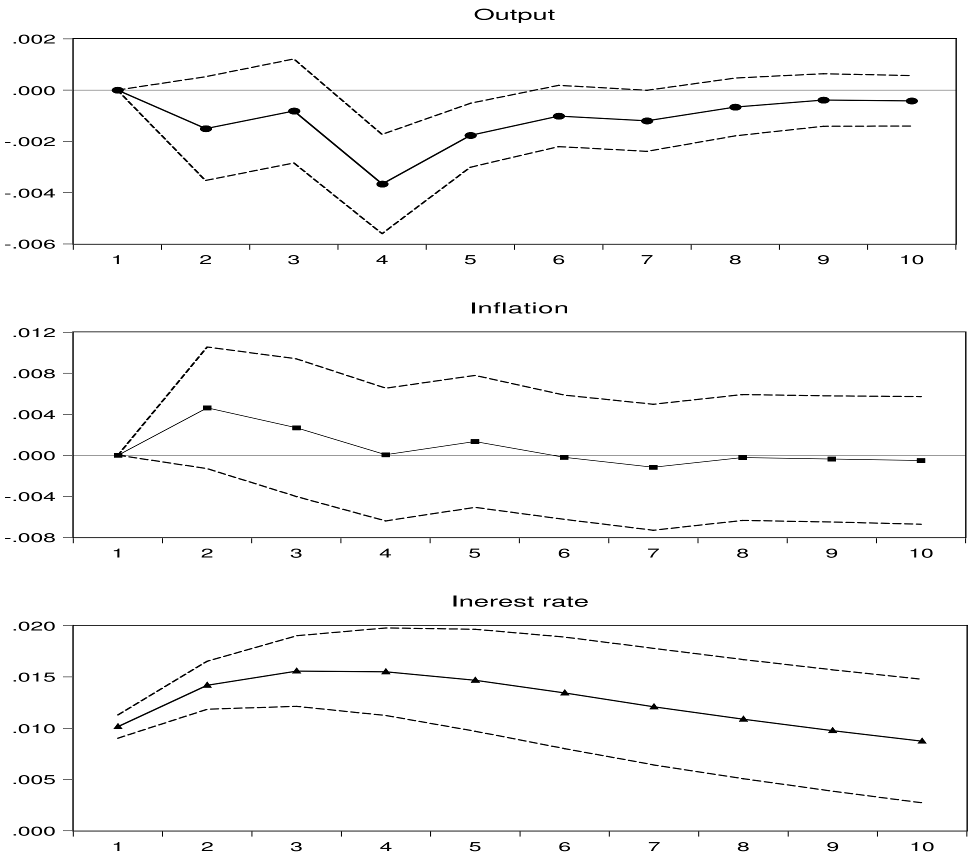

Figure 1: VAR-based empirical evidence (dashed lines represent ± 2 standard deviation bands)

increasing one quarter after the shock occurs and then starts declining slowly.

One explanation for the price puzzle is that it is due to the cost-channel (supply-side) effect dominating the demand-side effect of the monetary policy shock. That is, a monetary policy shock has an effect primarily through increases in production costs, resulting in an increase in aggregate prices. For instance, if the increase in expected future inflation is predicted to be due to an increase in the oil price, increasing the policy rate is not going to bring down future inflation. The increase in oil price would have already raised the production costs for firms. If the monetary authorities ignore the cost-channel effect of monetary policy shocks and simply increase the policy rate to fight inflation, it is no different to "throwing gasoline on fire" (Barth and Ramey, 2001). Fig. 2 plots inflation, the nominal short-term interest rate, and the (ln) oil price during the period of 2005Q1-2010Q4. It shows that monetary policy shifts are highly correlated with oil price shocks, as suggested by Hoover and Perez (1994). The patterns for inflation and the oil price over the period 2005Q1-2009Q2 are almost identical. The oil price increased gradually from 2007Q1 to 2008Q2 and dropped sharply

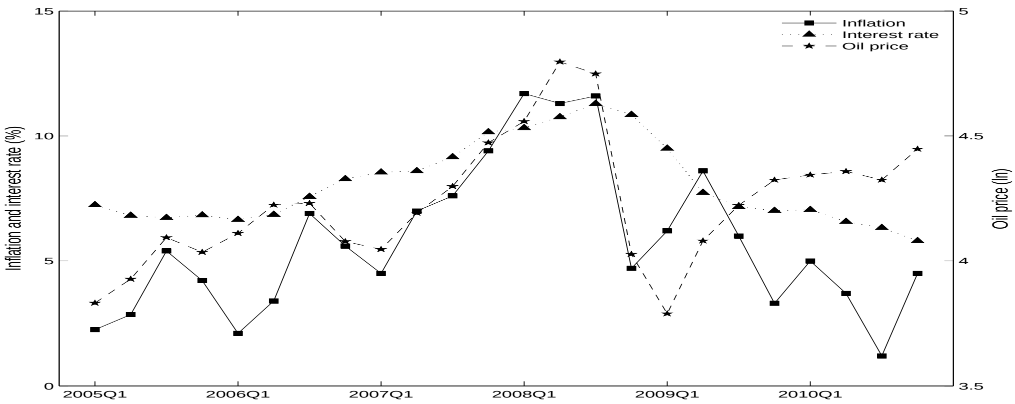

Figure 2: Inflation, interest rate, and oil price

from 2008Q3, and inflation followed in the same manner. During the period 2007Q1-2008Q2, SARB kept hiking the interest rate without any success in fighting inflation. One might argue that it was due to the policy time lags that inflation only started declining from 2008Q3. In fact, the oil price dropped sharply from 2008Q3, indicating that during the period 2007Q1-2008Q2, the persistent increase in inflation was probably due to the cost-channel effect of monetary policy shocks.

3 A model with the cost channel of monetary policy

The basic framework of the baseline model presented here is a simplified version of Smets and Wouters (2007) model. The model has many features typical of a standard dynamic New Keynesian model with nominal rigidities. The cost channel of monetary policy is introduced into the model, as in Rabanal (2007). That is, a fraction of firms have to borrow funds to pay for their wage bill before selling their products.

3.1 Households

The economy consists of a continuum of infinitely-lived households. In each period $t = 0, 1, 2, ...$, a representative household makes a sequence of decisions to maximize her expected utility over a composite consumption good C_t and leisure $1 - N_t$:

$$E \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t - hC_{t-1})^{1-\eta_c}}{1-\eta_c} - \frac{(N_t)^{1+\eta_n}}{1+\eta_n} \right] \tag{1}$$

where β is the subjective discount factor. η_c is the coefficient of the relative risk aversion of the household, and η_n is the inverse of the elasticity of work effort with respect to real wage. The habit formation parameter h measures the importance of the reference level relative to current consumption. As suggested by Fuhrer (2000), Amato and Thomas (2004), and Bouakez et al. (2005), including habit formation in household's utility function improves the short-run dynamic of the model in terms of replicating the hump-shaped response of consumption to monetary policy and other shocks.

In each time period t, the representative household carries the government bond B_{t-1} from the previous period into the current period, and receives a lump-sum transfer T_t from the monetary authority and a nominal profit or dividend payment D_t from the intermediate-good firms. In addition, the household receives its usual labor income W_tN_t, where W_t denotes the nominal wage. Therefore, in each time period, the representative household maximizes her expected utility Eq. 1 subject to the following budget constraint:

$$C_t + X_t + \frac{B_t}{P_t} \leq \frac{W_t}{P_t}N_t + \frac{B_{t-1}(1+i_{t-1})}{P_t} + \frac{D_t}{P_t} + \frac{T_t}{P_t} \tag{2}$$

Besides the intertemporal budget constraint Eq. 2, the representative household is also subject to the following capital accumulation constraint as in Christiano et al. (2005):

$$K_t = (1-\delta)K_{t-1} + \xi_{x,t}\big[1 - S\big(\frac{X_t}{X_{t-1}}\big)\big]X_t \tag{3}$$

where δ is the depreciation rate, X_t is the gross investment. The function S captures the presence of investment adjustment cost [4]. The investment shock $\xi_{x,t}$ is assumed to follow an AR(1) process:

$$\xi_{x,t} = \rho_x \xi_{x,t-1} + \epsilon_{x,t}, \qquad 0 \leq \rho_x < 1, \qquad \epsilon_{x,t} \sim i.i.d.(0, \sigma_i^2) \tag{4}$$

The linearized first-order conditions[5] are:

[4]In steady state, $S(\cdot) = 0,\ S'(\cdot) = 0,\ S''(\cdot) > 0$.

[5]A lowercase letter represents its log deviation from steady state.

$$c_t = \frac{h}{1+h}c_{t-1} + \frac{1}{1+h}E_t c_{t+1} - \frac{1-h}{(1+h)\eta_c} r_t \tag{5}$$

$$p_{k,t} = E_t \pi_{t+1} - r_t + [1-\beta(1-\delta)]E_t r_{k,t+1} + \beta(1-\delta)E_t p_{k,t+1} \tag{6}$$

$$x_t = \frac{1}{1+\beta}(x_{t-1} + \beta E_t x_{t+1} + \frac{1}{\nu} p_{k,t}) + \xi_{x,t} \tag{7}$$

Eq. 5 is the consumption Euler equation with external habit formation. It represents the intertemporal allocation of consumption, where consumption for the current period depends on a weighted average of previous and expected future consumption. Eq. 6 is the Lucas asset price equation for capital. $P_{k,t}$ is the shadow value of the installed capital, which depends on both the expected future value of capital and its return $r_{k,t}$, taking into account the depreciation rate. The investment Eq. 7, which contains both backward-looking and forward-looking components, describes the dynamics of investment. ν is the investment adjustment cost parameter, $\nu = S''(\cdot)$.

3.2 Final goods production

In the final-good sector, firms are perfectly competitive. The representative firm produces the final good Y_t using a continuum of intermediate goods $Y_{j,t}$ indexed by j ($j \in [0,1]$), according to a constant elasticity of substitution (CES) production function, as suggested by Dixit and Stiglitz (1977):

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\varphi_{p,t}-1}{\varphi_{p,t}}} dj \right)^{\frac{\varphi_{p,t}}{\varphi_{p,t}-1}} \tag{8}$$

where $\varphi_{p,t}$ measures the time-varying price elasticity of demand for each intermediate good $Y_{j,t}$. It acts as a price markup shock in the goods market. The price markup shock is assumed to be IID.

The representative firm maximizes its profit, and the first-order condition implies the demand for each intermediate good as the following:

$$Y_{j,t} = (\frac{P_{j,t}}{P_t})^{-\varphi_{p,t}} Y_t \tag{9}$$

where $P_{j,t}$ is the price of the intermediate good j, and P_t is the price for the final good. Since the final-good firms operate in a perfectly competitive market, in equilibrium the representative firm's profit should equal zero. Hence, the equilibrium market price for the final good is given as the following:

$$P_t = \left(\int_0^1 P_{j,t}^{1-\varphi_{p,t}} dj \right)^{1/1-\varphi_{p,t}} \tag{10}$$

3.3 Intermediate goods production

In the intermediate-good sector, firms are monopolistically competitive. In each time period, the representative firm produces $Y_{j,t}$ units of intermediate good j according to the following constant-returns-to-scale production function:

$$Y_{j,t} = \xi_{z,t} K_{j,t-1}^{\alpha} N_{j,t}^{1-\alpha}, \qquad 0 < \alpha < 1 \tag{11}$$

where the aggregate technology shock $\xi_{z,t}$ follows an AR(1) process:

$$\xi_{z,t} = \rho_z \xi_{z,t-1} + \epsilon_{z,t}, \qquad 0 \leq \rho_z < 1, \qquad \epsilon_{z,t} \sim i.i.d.(0, \sigma_z^2) \tag{12}$$

Households supply $N_{j,t}$ units of labor to the representative firm j. The aggregate labor demand N_t is given by the following Dixit-Stiglitz form:

$$N_t = \left(\int_0^1 N_{j,t}^{\frac{\varphi_{w,t-1}}{\varphi_{w,t}}} dj \right)^{\frac{\varphi_{w,t}}{\varphi_{w,t-1}}} \tag{13}$$

where $\varphi_{w,t}$ measures the time-varying price elasticity of demand for different types of labor. It acts as a wage markup shock in the labor market. The wage markup shock is assumed to be IID.

Staggered wages are introduced in the manner proposed by Erceg et al. (2000). Households are price setters in the labor market. In other words, wages are taken as a given by the intermediate-good firms. Following Calvo (1983), in each time period only a random fraction $1-\theta_w$ of households have the opportunity to reset their wages. This fraction is independent across households and time. In addition, the model assumes that households who cannot reset their wages simply index to lagged inflation as in Christiano et al. (2005). Therefore, the wage index $W_{j,t}$ is given by:

$$W_{j,t}^{1-\varphi_{w,t}} = \theta_w[(\frac{P_{t-1}}{P_{t-2}})^{\gamma_w} W_{j,t-1}]^{1-\varphi_{w,t}} + (1-\theta_w)(W_{j,t}^*)^{1-\varphi_{w,t}}, \qquad 0 \le \theta_w \le 1, \quad 0 \le \gamma_w \le 1 \tag{14}$$

where γ_w is the degree of wage indexation, and $W_{j,t}^*$ represents the nominal wage level chosen by those households who can reset their wages at time period t.

The intermediate-good firms face the same restriction in setting their prices. In each time period, the probability of being able to reset prices is $1-\theta_p$, and firms who cannot reset their prices also index to lagged inflation. The price index $P_{j,t}$ is given by:

$$P_{j,t}^{1-\varphi_{p,t}} = \theta_p[(\frac{P_{t-1}}{P_{t-2}})^{\gamma_p} P_{j,t-1}]^{1-\varphi_{p,t}} + (1-\theta_p)(P_{j,t}^*)^{1-\varphi_{p,t}}, \qquad 0 \le \theta_p \le 1, \quad 0 \le \gamma_p \le 1 \tag{15}$$

The linearized first-order conditions are given by:

$$\begin{aligned}
mc_t &= \alpha r_{k,t} + (1-\alpha)w_t - \xi_{z,t} && (16)\\
w_t &= \frac{1}{1+\beta}\big\{w_{t-1} + \beta E_t w_{t+1} + \gamma_w \pi_{t-1} - (1+\beta\gamma_w)\pi_t + \beta E_t \pi_{t+1} \\
&\quad - \frac{(1-\beta\theta_w)(1-\theta_w)}{(1+\varphi_w \eta_n)\theta_w}[w_t - \eta_n n_t - \frac{\eta_c}{1-h}(c_t - hc_{t-1})]\big\} + \epsilon_{w,t} && (17)\\
\pi_t &= \frac{1}{1+\beta\gamma_p}\big[\gamma_p \pi_{t-1} + \beta E_t \pi_{t+1} + \frac{(1-\beta\theta_p)(1-\theta_p)}{\theta_p} mc_t\big] + \epsilon_{p,t} && (18)
\end{aligned}$$

Eq. 16 implies that the real marginal cost is a function of the real rental rate of capital and the real wage, since capital and labor are used in producing the intermediate goods. The real wage Eq. 17 states that, under staggered wage contracts, the representative household takes into account not only past and expected future real wages, but also past, current, and expected future inflation rates. The representative household sets her real wage higher than the marginal rate of substitution, since she knows there is a possibility that she may not be able to reset her wage in the future. It is worth noting that the real wage equation contains both backward-looking and forward-looking components, which induce inertia in inflation through marginal costs[6]. The New Keynesian Phillips curve Eq. 18 implies that inflation depends on past and expected future

[6] As shown in Eq. 16, marginal cost is an increasing function of real wages, and marginal cost appears in the inflation equation Eq. 18.

inflation. It also shows that the price indexation parameter γ_p governs persistence in the response of inflation to a given shock. If $\gamma_p = 0$, Eq. 18 becomes a purely forward-looking Phillips curve. Finally, it shows that inflation is a function of the current marginal cost, and that both γ_p and θp govern the contribution of marginal cost to the persistent response of inflation. Here, we follow Gali and Gertler (1999)'s argument that, as the theory suggests, real marginal cost is a significant and quantitatively important determinant of inflation, instead of an ad hoc output gap.

3.4 Monetary authority

Monetary policy is described as a Taylor-type of interest rate rule The monetary authority adjusts its instrument, the nominal short-term interest rate, in response to the deviations of output and one-quarter-ahead expected inflation from their steady-state values:

$$i_t = \kappa_i i_{t-1} + (1 - \kappa_i)(\kappa_\pi E_t \pi_{t+1} + \kappa_y y_t) + \xi_{i,t} \tag{19}$$

To accommodate the SARB's forward-looking monetary policy, we have the one-quarter-ahead expected inflation in the Taylor rule instead of the current inflation. The monetary policy shock $\xi_{i,t}$ is assumed to follow an AR(1) process:

$$\xi_{i,t} = \rho_i \xi_{i,t-1} + \epsilon_{i,t}, \qquad 0 \leq \rho_i < 1, \qquad \epsilon_{i,t} \sim i.i.d.(0, \sigma_i^2) \tag{20}$$

3.5 Introducing the cost channel of monetary policy

Following Rabanal (2007), we introduce the cost channel of monetary policy by assuming that a fraction of firms have to borrow funds to pay their wage bill before they receive revenues from sales. As a result, the policy rate affects the marginal cost of hiring an extra unit of labor, and hence the real marginal cost of production. If the cost channel of monetary policy is present, the linearized real marginal cost Eq. 16 becomes:

$$mc_t = \alpha r_{k,t} + (1 - \alpha)(w_t + \gamma i_t) - \xi_{z,t} \tag{21}$$

The policy rate now affects the marginal cost of hiring an extra unit of labor, and hence, the real marginal cost of production, whereas γ determines the magnitude of the impact of the policy rate on real marginal cost.

This approach of introducing the cost channel of monetary policy was originally proposed by Christiano and Eichenbaum (1992). By assuming that workers must be paid in advance of production and firms have to borrow money from a financial intermediary to pay their wage bill at the beginning of the period[7], Christiano and Eichenbaum (1992) introduce an additional component into the cost of labor. That is, the marginal cost of hiring an extra unit of labor becomes the product of the real wage and the nominal short-term interest rate. The policy rate affects the real marginal cost directly, whereas real marginal cost is a significant and quantitatively important determinant of inflation, as discussed in Section 3.3. Therefore, an increase in the policy rate increases inflation through the cost channel of monetary policy.

4 Parameter estimates

The model is estimated using Bayesian estimation techniques[8]. The mode of the posterior distribution is estimated by maximizing the log posterior function combining the prior information. Bayesian estimation and evaluation techniques have become the industrial standard for empirical work with DSGE models due to the following two main advantages. First, it allows one to formalize the use of a prior information based on previous studies either at a micro or macro level. Second, it provides a framework for evaluating fundamentally misspecified models on the basis of the marginal likelihood of the model or the Bayes' factor [9].

4.1 The data

The model is estimated using quarterly data on real output (GDP), employment, real wage, inflation, and a short-term nominal interest rate over the period of 1970:1-2010:4. The data is obtained from the SARB Quarterly Bulletin. Inflation is measured by the changes in GDP deflator. Real wage is calculated by dividing nominal wage by GDP deflator, whereas the measure of the nominal wage is the "remuneration per worker in the non-agricultural sector". The short-term nominal interest rate is measured by the 3-month Treasury

[7] Which is the case for $\gamma = 1$ in Rabanal (2007).

[8] Models are estimated using Dynare developed by Michel Juillard and his collaborators at CEPREMAP.

[9] For a detailed discussion on estimating DSGE models using Bayesian techniques, see Leeper and Zha (2001); Smets and Wouters (2003); An and Schorfheide (2007).

bill rate. We detrend real output, employment and real wage prior to estimation.

4.2 Prior distributions

The prior distribution of the parameters are shown in columns 2-4 in Table 1. In the baseline model, we assume that γ follows beta distribution with mean 0.7, meaning more than half of firms (70%) need to borrow money to pay their wage bill before they sell their products.

In the utility function, the prior on habit formation parameter h is set at 0.7 with a standard deviation of 0.05, which is consistent with the literature (Boldrin et al., 2001; Rabanal, 2007). The coefficient of relative risk aversion η_c is assumed to follow gamma distribution with mean 2.1 and standard deviation 0.1, whereas the inverse of elasticity of labor supply η_n is assumed to follow normal distribution with mean 1.5 and standard deviation 0.75.

The Calvo parameters and friction coefficients of wage and price indexation are assumed to follow beta distribution, and the following prior means. The degree of wage stickiness θ_w is assumed to be 0.75, which implies that wages are fixed on average for a year. Prices are fixed on average for two quarters, i.e. $\theta_p = 0.5$. The degree of wage indexation is set at 0.5, whereas the degree of price indexation is set at 0.55.

We assume the real shock is more persistent than the nominal shocks. The persistence of the AR(1) processes is assumed to follow beta distribution with mean 0.75 and standard deviation 0.1 for ρ_x, mean 0.55 and standard deviation 0.05 for ρ_i, and mean 0.95 and standard deviation 0.02 for ρ_z. Whereas the standard deviations of the shocks are inverse-gamma distributed with a mean of 0.1.

The parameters of the monetary policy rule are assumed to follow normal distribution with standard deviation 0.05, and a mean of 0.6, 1.8, 0.25, with respect to κ_i, κ_π, κ_y.

Three parameters are fixed prior to estimation. The annual aggregate capital depreciation rate δ is obtained from the annual averaged values of $\frac{I}{Y}$ and $\frac{K}{Y}$. This yields an annual depreciation rate of 0.076, or a quarterly rate of 0.019. The capital output share α is equal to 0.26. Both δ and α are calibrated to the values that are consistent with the literature (Liu and Gupta, 2007). The discount factor β is set at 0.99 as in the literature.

Table 1: Prior and posterior distributions

	Prior distribution			Estimated posteprior mode			
				With cost channel		Without cost channel	
Parameter	type	mean	std. dev.	mean	std. dev.	mean	std. dev.
γ	Beta	0.5	0.1	0.4888	0.1011	—	—
h	Beta	0.7	0.05	0.8112	0.0355	0.8147	0.0355
η_c	Gamma	2.1	0.1	2.1946	0.1012	2.1833	0.1012
η_n	Normal	1.5	0.75	2.2414	0.5941	2.1982	0.6078
ν	Gamma	2	0.4	1.8255	0.3146	1.8003	0.3122
θ_p	Beta	0.5	0.1	0.7434	0.0132	0.6991	0.0143
θ_w	Beta	0.75	0.05	0.8201	0.0377	0.8161	0.0375
γ_p	Beta	0.55	0.15	0.1055	0.0328	0.1275	0.0367
γ_w	Beta	0.5	0.2	0.8663	0.0400	0.8019	0.0436
ρ_x	Beta	0.75	0.1	0.2522	0.0585	0.2592	0.0602
ρ_i	Beta	0.55	0.05	0.4080	0.0400	0.4271	0.0418
ρ_z	Beta	0.95	0.02	0.7459	0.0349	0.7348	0.0357
κ_i	Normal	0.60	0.05	0.6171	0.0337	0.6095	0.0339
κ_π	Normal	1.8	0.05	1.6154	0.0500	1.6268	0.0506
κ_y	Normal	0.25	0.02	0.2664	0.0195	0.2650	0.0196
ϵ_i	Inv. Gamma	0.1	Inf.	0.0385	0.0023	0.0393	0.0023
ϵ_z	Inv. Gamma	0.1	Inf.	0.0495	0.0028	0.0495	0.0028
ϵ_x	Inv. Gamma	0.1	Inf.	0.6932	0.0465	0.6897	0.0468
ϵ_p	Inv. Gamma	0.1	Inf.	0.0183	0.0011	0.0191	0.0012
ϵ_w	Inv. Gamma	0.1	Inf.	0.0310	0.0017	0.0282	0.0017

4.3 Results

The posterior mode of the parameters and the corresponding standard errors for the baseline model (a New Keynesian model with the cost channel of monetary policy) are reported in columns 5 and 6 in Table 1. The estimated parameter γ of 0.63 implies that nearly two thirds of firms have to borrow funds to pay their wage bill before they receive revenues from sales. It indicates that the cost-channel effect of the monetary policy does exist in the South African economy during the sample period.

The parameter estimates of the monetary policy rule indicate that the SARB's policy can be described as a Taylor-type of interest rate rule. That is, the SARB adjusts the nominal interest rate in response to the deviations of output and the expected inflation. The estimated inflation parameter of the Taylor rule is 1.62. Ortiz and Sturzenegger (2007) estimate a small open economy model with an augmented Taylor rule for the South African economy during the sample period of 1982-2002 and report the estimated inflation parameter of 1.11. One possible reason that the inflation parameter obtained in this study is greater than that from Ortiz and Sturzenegger (2007) is that our sample period also covers the period since the SARB started implementing inflation targeting monetary policy in 2002[10]. The estimated output parameter and

[10]We have also estimated the model with the current inflation in Taylor rule as in Ortiz and Sturzenegger (2007) and the estimated inflation parameter is 1.61.

interest rate smoothing parameter are 0.27 and 0.62, which are very close to those (0.27 and 0.73 respectively) reported by Ortiz and Sturzenegger (2007).

For the parameters that characterize the degree of price and wage stickiness, the results indicate a slightly higher degree of stickiness in wage than that in price. More Precisely, the estimated degree of wage stickiness of 0.82 implies an average 6 quarters duration of wage contracts, and a relatively high degree of wage indexation of 0.82. However, a slightly lower degree of price stickiness of 0.74 is obtained, implying an average four quarters duration of price contracts. This value is lower than that in Gali and Gertler (1999), who report a degree of price stickiness of 0.83 for the U.S economy, obtained from the single-equation estimation. We observe an extremely low degree of price indexation 0.11 from the South African data.

The model without cost channel of monetary policy is estimated using the same priors and standard deviations as those assigned in the baseline model. The estimates are very close to those from the baseline model[11], indicating our estimation results are robust.

5 The cost-channel effect of monetary policy

In this Section, we investigate the cost-channel effect of monetary policy for the South African economy. We first study the dynamic responses of inflation, output, and the policy rate to a contractionary policy shock for the model with and without the cost channel of monetary policy.

Fig. 3 shows the dynamic responses of the observable variables from the estimated model without the cost channel of monetary policy. It shows that without the cost channel of monetary policy, the impulse response function of inflation to a contractionary policy shock is inconsistent with the VAR-based empirical evidence presented in Section 2. In reaction to the monetary contraction, inflation decreases and starts reverting to its steady state three quarters after the shock occurs. This indicates that a standard New Keynesian model is not capable of mimicking the price puzzle produced by an estimated VAR. In the absence of labor market frictions, a contractionary policy shock causes a substantial decline in labor demand and investment. As a result, monetary contraction leads to a substantial decline in real wages and the rental rate of capital $r_{k,t}$, and hence, the real marginal cost of production. Therefore, inflation always declines in response to a contractionary policy shock.

Ravenna and Walsh (2006) show that in a standard New Keynesian model with the cost channel of

[11] Parameter estimates for the model without cost channel are reported in the second last column in Table 1.

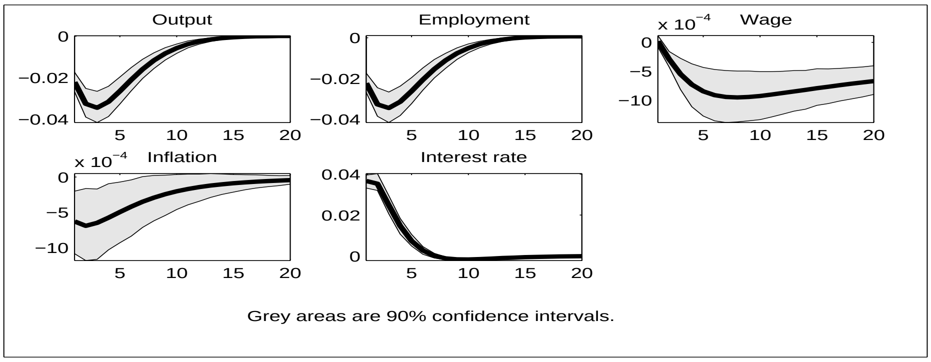

Figure 3: Impulse responses to a monetary policy shock (model without cost channel)

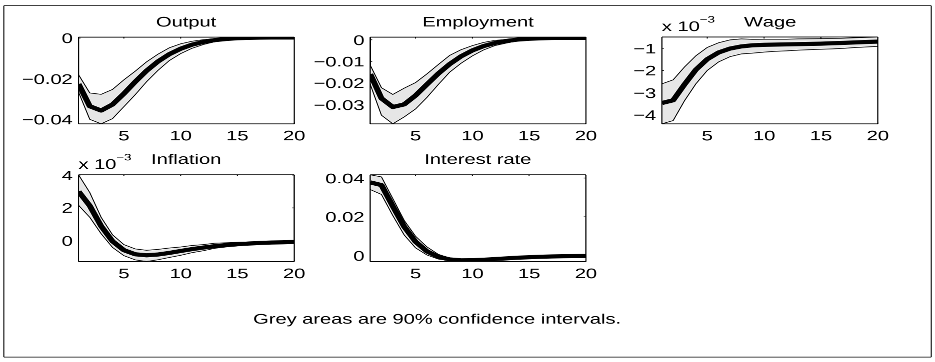

Figure 4: Impulse responses to a monetary policy shock (model with cost channel)

monetary policy, firms' real marginal cost depends directly on the policy rate. As a result, the policy rate acts as a cost-push shock, and inflation always increases in response to an increase in the policy rate through the cost channel of monetary policy. As shown in Fig. 4, the baseline model successfully mimics the price puzzle observed in an estimated VAR. It shows that, in the presence of the cost channel of monetary policy, the SARB would not succeed in fighting inflation simply by mechanically following the conventional view that a contractionary policy should, in principle, decrease future inflation.

Rabanal (2007) estimates a more elaborated DSGE model with the cost channel of monetary policy for the U.S economy and suggests that the cost channel is of little concern for the U.S economy. Rabanal (2007) finds a fairly low estimated γ (0.15) for the U.S economy. Moreover, Rabanal (2007) argues that, in addition to the full-cost-channel restriction and a high variability of the capital utilization rate, higher wage stickiness, full wage indexation, and lower price stickiness are necessary features to generate the price puzzle. Compared to the estimated results from Rabanal (2007), we find relatively high wage stickiness and wage indexation, but extremely low price indexation in the South African data. It is clearly that our estimation results are in favor of the argument of Rabanal (2007). With a moderate level of cost channel (eg. 0.49 in this study), but not necessary unlikely nominal rigidities argued by Rabanal (2007), a New Keynesian DSGE model with the cost channel of monetary policy is able to mimic the price puzzle produced by an estimated VAR.

Fig. 3 also shows that the effects of the shock on output and the policy rate. The responses of output and the policy rate to monetary contraction are consistent with the VAR-based empirical evidence. A contractionary policy shock leads to a substantial persistent decrease in output and an increase in the policy rate. As shown in Fig. 4, output and the policy rate react in the same manner to a contractionary policy shock in the baseline model.

As discussed early on, monetary policy shocks have both supply-side and demand-side effects, at least in the short run. It appears that, in the absence of the cost channel, a contractionary policy shock always leads to a persistent decline in inflation due to the usual demand-side effect: an increase in the policy rate discourages investment and decreases labor demand, and hence, results in a decline in real wage and return on capital. However, Barth and Ramey (2001) argue that the cost-channel effect of a monetary policy shock may be greater than the demand-side effect. Therefore, it is crucial for the SARB to understand whether, or to what extent, an increase in expected future inflation is due to supply shocks, before applying contractionary policy to forestall inflation.

We now conduct a further investigate, that is, to what extent the cost-channel effect dominates the demand-side effect of a monetary policy shock. In the baseline model, parameter γ controls the fraction of firms that have to borrow money to pay their wage bill before they sell their products. The policy rate affects the marginal cost of hiring an extra unit of labor, and hence, the real marginal cost of production, whereas γ determines the magnitude of the impact of the policy rate on real marginal cost. Therefore, it is possible to investigate the extent of the cost-channel effect of monetary policy by controlling the value of parameter γ.

Fig. 5 shows the impulse response functions of inflation to monetary contraction with different values for parameter γ, including the estimated $\gamma = 0.49$. In the case of $\gamma = 1$, it simply assumes that all firms have to borrow money to pay their wages bill before they sell their products, meaning the strongest cost-channel effect of monetary policy exists in the model. As the value of γ declines, the cost-channel effect becomes weaker and weaker. Based on our simulation exercises, we find that the demand-side effect of monetary policy shock starts dominating if $\gamma < 0.36$. As a result, a contractionary policy shock leads to a persistent decline in inflation, and the price puzzle disappears. Therefore, the SARB can only succeed in fighting inflation by applying contractionary policy if an increase in expected future inflation is mainly due to demand shocks.

If the cost-channel effect dominates, an increase in the policy rate increases real marginal cost immediately, and hence, inflation ensues. Inflation only starts to decline two quarters after the shock occurs. If the SARB keeps hiking the policy rate to fight inflation, as it did over the period 2007Q1-2008Q2, instead of a decline in future inflation, what the SARB would face is a persistent increase in future inflation. This is because a cost-push shock arises endogenously with the presence of the cost-channel of monetary policy in a standard New Keynesian model (Ravenna and Walsh, 2006). As a result, every increase in the policy rate exaggerates the cost-channel effect of the monetary policy shock and continuously increases real marginal cost, and hence, inflation ensues. Therefore, it is not surprising that inflation followed the same path as the policy rate in 2007 and 2008, as is shown in Fig. 2.

Fig. 6 shows that regardless of whether the cost-channel effect dominates the demand-side effect of a monetary policy shock, monetary contraction always leads to a persistent decline in output. However, as the cost-channel effect of monetary policy increases (increase in γ), monetary contraction leads to a greater decline in output. That is, in the presence of the cost channel, a contractionary policy shock has an effect primarily through production costs, resulting in a persistent decline in output and an increase in inflation.

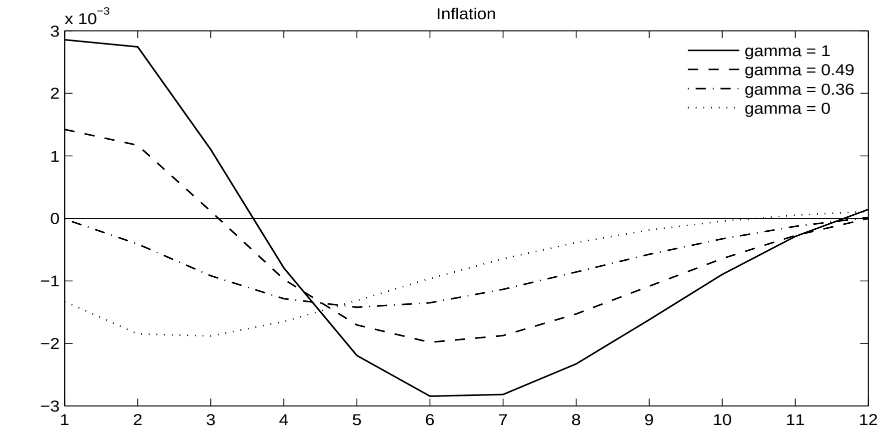

Figure 5: Policy effect on inflation: cost-channel (supply-side) effect vs demand-side effect

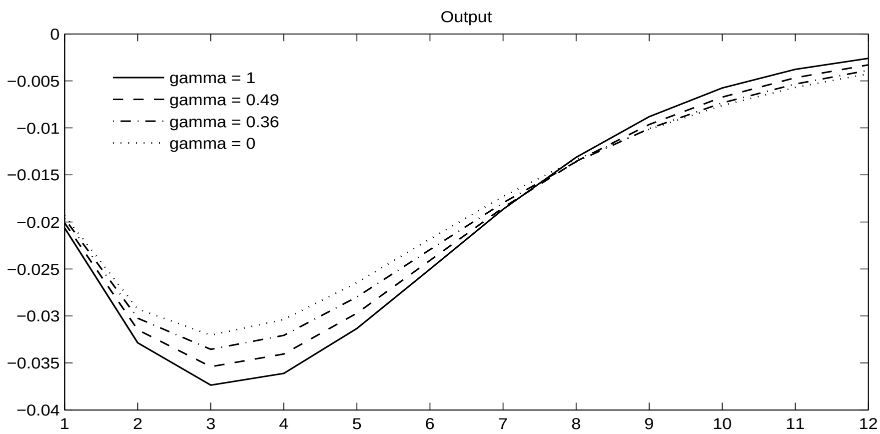

Figure 6: Policy effect on output: cost-channel (supply-side) effect vs demand-side effect

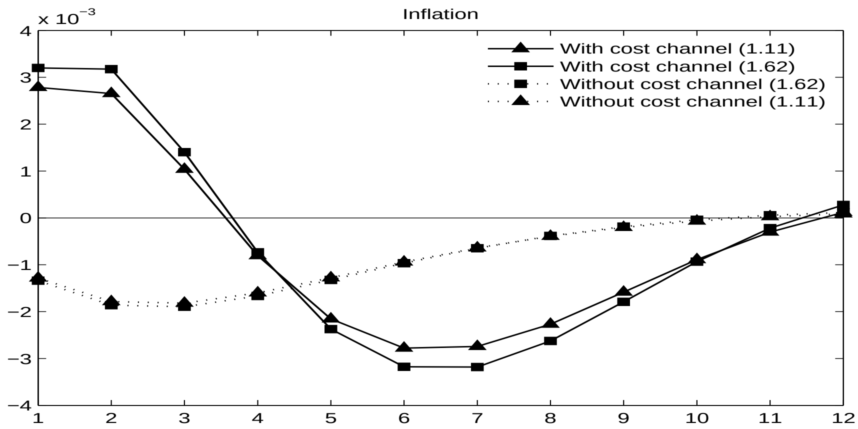

Figure 7: Cost-channel effect with different inflation parameter values in Taylor rule

The cost of fighting inflation increases as the cost-channel effect of monetary policy increases. Once the cost-channel effect starts dominating the demand-side effect of the monetary policy shock ($\gamma > 0.36$), the SARB would face an increase in inflation and a greater loss in output when implementing a contractionary policy to forestall inflation.

Finally, it is worthwhile to investigate whether a greater value of the inflation parameter in Taylor rule exacerbates the cost-channel effect of monetary policy. This exercise is motivated by the greater value of the estimated inflation parameter (1.62) in Taylor rule that we obtained in this study than that (1.11) reported by Ortiz and Sturzenegger (2007). Fig. 7 displays the response of inflation to a contractionary policy shock. Under the baseline model (solid lines), inflation increase stronger when the inflation parameter is assigned a greater value (1.62). In other words, a greater value of the inflation parameter in Taylor rule exacerbates the cost-channel effect of monetary policy. Fig. 7 also shows that, if the cost-channel effect were not present (dotted lines), inflation would decline more or less the same percentage regardless the inflation parameter in Taylor rule is assigned with 1.62 or 1.11. From this point of view, the SARB, an inflation-targeting central bank, must investigate to what extent an increase in expected future inflation is due to supply shocks before applying contractionary policy to fight inflation.

6 Conclusions

In this paper, we study the effects of monetary policy on the South African economy, specifically on inflation and output. The conventional view suggests that a contractionary monetary policy shock should decrease future inflation, whereas the empirical evidence shows a significantly positive response of inflation to the shock. Using a standard New Keynesian model with the cost channel of monetary policy, we show that the price puzzle emerges only if the cost-channel effect dominates the demand-side effect of a monetary policy shock.

Whether or not the SARB should apply contractionary policy to forestall inflation depends critically on the nature of the disturbance. In principle, if an increase in the expected future inflation is predicted to be mainly due to supply shocks, the SARB should not apply contractionary policy to forestall inflation. Otherwise, the bank would face persistent increases in inflation and a greater loss in output. What the South African economy experienced in 2007 and 2008 could be a good lesson.

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