

Supply Shocks and Inflation Targeting

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Abstract

We construct a dynamic general equilibrium model, calibrated to the Brazilian economy, in which a fraction of the firms set prices one quarter in advance. The artificial economy simulations generate series consistent with real data and with a typical estimation of a structural inflation-targeting model. We argue that these structural models specifications are incorrect for not considering supply shocks. In contrast, our model can separate supply and demand shocks effects, in addition to being (potentially) robust to the Lucas' Critique.

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Resumo

Construímos um modelo de Equilíbrio Geral Dinâmico, calibrado para a economia brasileira, em que uma fração das firmas fixa seus preços com um trimestre de antecipação. A economia artificial gera séries consistentes com os dados reais e com uma estimação típica de um modelo estrutural de metas inflacionárias. Argumentamos que as especificações destes modelos estruturais estão incorretas por não considerarem choques de oferta. Em contraste, nosso modelo pode separar os efeitos de demanda e oferta, além de ser (potencialmente) robusto à crítica de Lucas.

We construct a dynamic general equilibrium model, calibrated to the Brazilian economy, in which a fraction of the firms set prices one quarter in advance. The artificial economy simulations generate series consistent with real data and with a typical estimation of a structural inflation-targeting model. We argue that these structural models specifications are incorrect for not considering supply shocks. In contrast, our model can separate supply and demand shocks effects, in addition to being (potentially) robust to the Lucas' Critique.

1) Introduction

The recently established inflation-targeting regime in Brazil has set up economic models to use as auxiliary tools for monetary policy decision making. The most applied model — which the Brazilian Central Bank designated the “small scale structural model” and henceforth called “the structural model” — consists of econometric estimations of basic macroeconomic relations. By applying variations of this model, Taylor (1999) was able to discuss monetary policy rules that many inflation-targeting regimes around the world now consider a main component of their policymaking guidelines. A criticism to these models, however, is that they are not robust to the Lucas’ critique (Lucas (1976)). In this paper, we argue that they have an additional problem: their estimation is biased because they do not take into account the effects of supply shocks.

To provide a potential solution to both of these problems, we propose a Dynamic General Equilibrium model (DGE) in line with the real business cycle models. Our model, which is similar to that of Chari, Kehoe and McGrattan (2000), follows the recent tradition of studying monetary policy and price stickiness by using real business cycle artificial economies as laboratories.

When we calibrate our artificial economy to the Brazilian post-“Real Plan” economy, simulations are consistent with the second moments of the actual data. Additionally, estimations of the structural model in the artificial generated data produce coefficients close to those estimated in actual data. In this sense, it is a reasonably good laboratory procedure to discuss the weaknesses of the usual estimations.

We analyze the logic behind the structural Central Bank model and show that it is consistent with demand shocks only. Both demand and supply shocks, however, seem to generate real data. That implies that the usual econometric estimations are biased. In contrast, because it can separate the two types of shocks, our model can correctly estimate the desired data relationships.

We also use our model to show how the Lucas' Critique constitutes a quantitative relevant problem for the econometric estimations of the structural model. For that, we change the government policy when simulating the model and show how the parameter estimations change. This experiment suggests the importance of using micro-founded models as tools for monetary policymaking.

The paper is divided as follows. Section 2 develops the model and defines the equilibrium. Section 3 describes the calibration process. Section 4 shows the artificial economy simulations and compares them with the second moments from the actual data. Section 5 discusses the hypothesis of the structural model. Section 6, which shows how the structural model estimations compare with artificially generated data estimation, additionally accesses the quantitative importance of the estimation bias and of the Lucas' critique. A final section concludes.

2) Model

Our model is similar to that of Chari, Kehoe and Mcgrattan (2000), but with differences in the price-setting structure. In our economy, a fraction of the firms set prices with full information. The remaining fraction set prices without being aware of the contemporaneous monetary shocks. In the Chari, Kehoe, and McGrattan economic model, firms are divided into four symmetric groups that set prices once every four quarters.

This modeling choice reflects a peculiarity of the Brazilian economy. Because inflation was extremely high for many years, prices became much more flexible in the Brazilian economy than in the U.S. economy. Thus, the lags involved in the transmission of monetary policy also became shorter.

As in their paper, our economy is populated by a continuum of firms that produce heterogeneous intermediate goods using capital and labor as inputs. These goods are then used by competitive firms to produce a final good, which can be invested in or consumed by households.

Because intermediate goods are heterogeneous, the firms that produce them have monopoly power, face a downward sloping demand schedule, and set prices. Money is an argument of the utility function of households, and the monetary authority lump-sum transfers back the inflation tax.

In more detail, money is supplied by a monetary authority so that the nominal interest rate follows the process

$$i_t = (1 - r_i)i_t^m + r_i i_{t-1} + r_p (\mathbf{p}_{t-1} - \mathbf{p}^m) + r_y y_{t-1} + \mathbf{e}_{it} \quad (1)$$

where i is the nominal interest rate, \mathbf{p} is inflation, and y is the output gap (Hodrick-Prescott filtered output). The disturbance term \mathbf{e}_i , which is denoted by “demand shock”, follows a normal with zero mean and standard deviation \mathbf{s}_e .

The economy is populated by a continuum of infinitely lived households with identical lifetime preferences given by,

$$U_t = \sum_{t=0}^{\infty} \beta^t [\log(c_t) + \omega_1 \log(\frac{m_{t+1}}{P_t}) + \omega_2 \log(1 - h_t)] \quad (2)$$

Where c_t is period t final good consumption, m_{t+1}/P_t are real money balances, and h_t is the number of worked hours. Households are endowed with one unit of time to allocate for work or leisure.

A typical household begins period t with m_t units of cash and k_t units of capital carried over from the previous quarter. Its budget constraint and capital law of motion are

$$P_t (u_t k_t + w_t h_t) + m_t + b_t + T_t + \Pi_t = P_t c_t + P_t x_t [1 + \phi(x_t / k_t)] + m_{t+1} + b_{t+1} / [1 + i_t (1 - \tau)] \quad (3)$$

$$k_{t+1} = (1 - \mathbf{d})k_t + x_t \quad (4)$$

where u_t and w_t are respectively, the capital and labor remunerations, δ is the depreciation rate, m_{t+1} and k_{t+1} are the next quarter’s money and capital stocks, T represents lump-sum transfers, and Π_t is the profit of intermediate good firms. The sequence x_t represents the investments; the function $\phi(x_t/k_t)$ is convex and stands for capital adjustment costs. As usual, we assume its

functional form is $\phi(x_t/k_t) = \phi(x_t/k_t)^2$, where, with abuse of notation, ϕ in the right-hand side of the equation is a constant.

A continuum of firms produces a homogeneous final good and uses intermediate goods as input. The final good production technology is represented by,

$$y_t = \left(\int_0^1 y_t(j)^\theta dj \right)^{1/\theta} \quad (5)$$

where y_t is the amount of final good produced at time t , $y_t(j)$ is the amount of used input of the variety j , and $1/(1 - \theta)$ is the elasticity of substitution between any two varieties of inputs, $\theta < 1$. Note that these firms are competitive, the production function is homogeneous of degree one, and there is free entry.

Each intermediate good is produced by a single firm that uses the technology

$$y_t(j) = \exp(z_t) k_t(j)^\alpha h_t(j)^{1-\alpha} \quad (6)$$

where $k_t(j)$ and $h_t(j)$ represent the quantities of capital and labor used by firm j in period t . We assume that

$$z_t = \rho_z z_{t-1} + \varepsilon_{zt} \quad (7)$$

where $\rho_z \in (0, 1)$ and ε_{zt} , denoted by supply shocks, is distributed according to a normal with mean zero and standard deviation σ_z .

All firms choose prices knowing the realization of the technology shock ε_{zt} . But a fraction of firms— without generality those with name in the interval $(0, \mu)$,— set prices without knowledge about monetary shocks. The remaining firms (with name in the interval $(\mu, 1)$) set prices while having complete information about monetary shocks.

A *Recursive Equilibrium* in our economy is the allocation of capital, labor, money, and consumption for households and allocation of capital and labor for producers of intermediate goods and the prices of capital, labor, intermediate goods and final goods such that (i) taking all prices as given, households solve their problem, (ii) taking all prices as given, with the exception

of their own, intermediate good producers maximize their profits, (iii) taking all prices as given, final good producers maximize their profits, and (iv) factor prices market clear.

3) Calibration

We use the data available from 1980:1 to 2002:4. Because we are particularly interested in the period Brazil had stable prices, however, we focus on the data from after the Real Plan of 1994:3. The GDP series is seasonally adjusted data from IBGE (Instituto Brasileiro de Geografia Econômica). The Investment series was constructed using the investment rate series from IPEA (Instituto de Pesquisa Econômica Aplicada). Because we do not have a series of durable goods, they are added to the consumption series. As a measure of inflation, we use the “centered IPCA,” and as nominal interest rates, we use the “SELIC.”

Using the average inflation and nominal interest rates over the period 1994:3 to 2002:4, we calibrate $\pi^m = 2.4\%$ e $i^m = 6.1\%$ (quarterly). To obtain the depreciation rate, we use an annual capital output of 3.0 (according to Araújo e Ferreira (1999)). The investment rate average was 20%. The law of motion of capital in the steady state is

$$(i / y) = \delta(k / y)$$

which implies $\delta = 1.7\%$ (quarterly). As in Kanczuk (2002), we use $\alpha = 0.40$, which is in line with Gollin (2002). We follow Chari, Kehoe and McGrattan (2000) and choose $\theta = 0.9^1$. The Euler equation for the investment in the steady state implies

$$1 = \beta[\theta \alpha (y / k) + 1 - \delta]$$

which determines $\beta = 0.987$. The Euler equation for government bonds (which do not exist, without loss of generality) is,

$$1 = \beta[1 + i^m(1 - \tau_i)] / (1 + \pi^m)$$

¹ Although we have no information about this parameter in the Brazilian economy, our results proved to be very robust to sensitivity analysis performed on its values. See the appendix.

which determines $\tau_i = 38\%$. To calibrate w_l , we use the money demand curve,

$$\frac{(M/p)}{\omega_1 c} = \frac{1+i_t(1-\tau_i)}{i_t(1-\tau_i)}$$

and c/y and $(M/p)/y$ averages are, respectively, 80% e 22%. We obtain $\omega_1 = 0.010^2$. The Euler equation for hours worked is

$$\frac{w_2 c}{(1-h)} = q(1-a) \frac{y}{h}$$

If the fraction of available time allocated to work is $h = 1/3$, as obtained by Ellery, Gomes e Sachida (2002), we get $\omega_2 = 1.3$.

For the interest rate process,

$$i_t = (1-r_i)i_t^m + r_i i_{t-1} + r_p (\mathbf{p}_{t-1} - \mathbf{p}^m) + r_y y_{t-1} + \mathbf{e}_{it}$$

where \mathbf{p} e y are, respectively, inflation and output gap, we use Taylor's (1999) strategy and run a simple OLS regression. We observe that the only relevant coefficient is ρ_i , estimated to be 0.85 (the "t-stat" is equal to 9.9). The coefficients ρ_π and ρ_y are not statistically relevant, with "p-values" higher than 10%. The residual \mathbf{e}_i has as its standard deviation $\mathbf{s}_i = 1.3\%$.

It is worth noting that a Taylor rule that has its inflation coefficient smaller than one is classified as passive and implies explosive or indeterminate behavior in a wide gamma of models. In our environment, however, it did not present a problem.

Because we do not have a series of hours worked for Brazil, we cannot compute the Solow Residual to determine the technology process parameters. As an alternative, we follow the strategy of Correia, Neves e Rebelo (1995) of setting $\rho_z = 0.95$, and choosing σ_z so that our artificial economy output volatility matches the real data. Similarly, we choose ϕ so that the investment volatility of our economy also matches its data analog.

² As Chari, Kehoe and McGrattan (2000) point out, this parameter does not affect the results when money is separable in the utility function, as it is in our case.

Finally, we use an estimation of the “dynamic IS curve” (output gap on its lag and real interest rates) in the simulated data in order to calibrate the degree of price stickiness (value for μ). That is, we choose μ such that the IS curve estimates match their correspondents in the data, obtaining $\mu = 0.4$

The following table presents a summary of the calibrated parameters.

b	w₂	d	a	q	m	f	t_I
0.98	1.3	1.7 %	0.40	0.9	0.40	150	37 %
g^m	l^m	r_z	s_z	r_i	r_p	r_y	s_i
2.4 %	6.1 %	0.95	0.8 %	0.85	0	0	1.3 %

4) Simulations and Results: Second Moments

The first three columns of table 1 present the stylized facts of the U.S. economy (1954:1 to 2000:2) and of the Brazilian economy. For the Brazilian economy, we present statistics for two intervals: the complete data set (from 1980 on), and for the period after the Real Plan (from 1994:3 on). The first part of the table (table on the top) indicates the volatility (standard deviation) of each series. The second part shows the correlations of each series with the output series.

Notice that the real side of the economies — that is, the series of output, investment, consumption, and real interest rates — is fairly similar. Consumption is about 80% as volatile as output, whereas investment is about three times as volatile. Consumption and investment are strongly procyclical, whereas real interest rates are countercyclical. The main difference among the economies refers to the magnitude of their volatilities as a whole.

The same level of similarity does not occur for nominal variables. In fact, as Backus and Kehoe (1992) and Gavin and Fydland (1999) observe, the second moments of nominal variables

do not seem robust to different time intervals. Whereas in the U.S. inflation and nominal interest rates are procyclical, in Brazil they are countercyclical. The same happens with the price level, which in the most recent period is not correlated with output.

The following column of table 1, termed “both shocks,” shows the results of the simulation in an artificial economy. Notice that it mimics fairly well the real side of the actual data, but its consumption volatility is relatively small. Consumption and investment are closely correlated with output and interest rates are countercyclical. The behavior of nominal variables is much worse. Nominal interest rates and inflation are procyclical, whereas they are countercyclical in the data. Additionally, the volatility of money growth is more than ten times higher in the data than in the artificial economy. Interestingly, this is a corroboration of the fact that money demand is very unstable in the U.S. data and that current models are not able to satisfactorily reproduce this behavior (Prescott (1998)).

The remaining columns will be discussed in section 7.

5) Structural Model Estimation and Supply Shocks

As Taylor (1999) and Bogdansky et. al. (2000), among others, observe, structural models for inflation targeting are typically composed by three equations:

$$i_t = (1 - r_i)i_{t-1} + r_p p_{t-1} + r_y y_{t-1} + e_{it}$$

$$y_t = \phi_y y_{t-1} + \phi r_t + \varepsilon_{yt}$$

$$\pi_t = \lambda_\pi \pi_{t-1} + \lambda_y y_{t-1} + \varepsilon_{\pi t}$$

We already have used the first two equations, which were denoted by monetary policy rule and dynamic IS. The third equation — the Phillips curve — relates the output gap with inflation acceleration. Often it is estimated with a restriction that when the output gap is zero (a steady state condition) inflation becomes stable. In our specification, this implies $\lambda_\pi = 1$.

The well-known logic behind the Phillips curve is that when output is higher than its potential level, it accelerates inflation because the economic boom was due to a demand shock. In other words, when the demand curve shifts to the right, there is an increase in output and in price. Evidently, supply shocks imply a different phenomenon: when the supply curve shifts to the right output increases whereas prices decrease.

This trivial but important argument indicates that the parameter λ_y should be estimated by only having demand shocks. Equivalently, the potential output should move along with the supply curve. The output gap then would incorporate these movements and avoid the identification problem. The real challenge, sometimes acknowledged by policymakers, is to know what the potential output is.

The usual strategy is to assume there are no high frequency supply shocks. Then, a high pass filter, such as the Hodrick-Prescott filter, would solve the problem. Our argument is that this strategy is flawed: estimation is biased because of high frequency supply shocks. In a more formal language, in general one estimates the Phillips curve assuming that the residual e_{pt} is not correlated with the independent variable y_{t-1} . But supply shocks affect both and thereby makes their correlation different from zero.

In fact, the existence of high frequency supply shocks is not novel. All the real business cycle research is based on Solow residual shocks. As Lucas (2003) remarks, Aiyagary (1994) and Shapiro and Watson (1988), working from opposite directions and with very different methodologies, understood that supply shocks contribute much more than the demand shocks to high frequency output fluctuations. In the context of monetary policy rules, Woodford (2001) shows that a measure of potential output based on unit labor costs negatively correlates with the usual Hodrick-Prescott potential output. As he puts it, "...a wide variety of real shocks should affect the growth rate of potential output . . . these include technology shocks, changes in the attitudes toward labor supply, variations in government purchases, variation of households

impatience to consume and variation in the productivity of currently available investment opportunities, and there is no reason to assume that all of these factors follow smooth trends.”

The same identification problem appears in the context of the IS estimation, but in a more subtle way. The logic here is that higher real interest rates imply a lower output gap. However implicit this logic, it is again the assumption that there are no supply shocks. As the real business cycle research points out, Solow residual shocks increase the marginal product of capital, raising the equilibrium interest rates. The interest rates that should be used to estimate the IS curve should reflect these oscillations in the opportunity costs of holding productive capital. Or, as Woodford (2000) puts it, the “Wicksellian natural rate of interest,” fluctuates due to supply shocks.

6) Simulations and Results: Structural Model

Table 2 shows the estimations of the structural model for the U.S., for Brazil, and for the data generated by simulations of our artificial economy. The column “both shocks” corresponds to our benchmark simulation in which the artificial economy is perturbed by both supply and demand shocks. The columns “demand only” and “supply only” correspond to cases for which we set, respectively, σ_z and σ_i equal to zero. The great advantage of possessing an artificial economy is exactly this possibility of identifying and shutting down the desired shocks.

The first part of table 2 refers to the estimation of the dynamic IS curve. The second part refers to the estimations of the Phillips curve. Following the usual procedure, we set $\lambda_\pi = 1$, which corresponds to using the first difference of inflation as the dependent variable.

The dynamic IS curve is reasonably well estimated for the Brazilian economy, as already shown by Pastore and Pinotti (2000). For the U.S., we cannot reject the hypothesis that the interest rate coefficient is zero, but the mean value of its estimation is close to that observed for Brazil. The estimation of the IS for the “both shocks” economy is within the confidence interval

of the artificial economy. That is not really surprising, since this was the criterion used to select parameter μ .

The Phillips curve estimation tends to be sensitive to small changes of specification and time interval.³ Indeed, we cannot reject that the output gap coefficient is zero when we use the full Brazilian sample (at 10% level). But, perhaps accidentally, the “both shocks” artificial economy parameter estimates are within the confidence interval of the Post-Real Plan estimation.

We can now proceed to quantitatively assess the bias in the structural model estimation, by looking at the “demand only” column. Because the “demand only” economy does not have supply shocks, its estimations are not biased.

The coefficients on both the estimations of the IS curve and of the Phillips curve change as expected. That is, both the effect of the real interest rate on output and the effect of the output gap on inflation have greater magnitude than before. More importantly, the results prove to be very important from a quantitative point of view.

The results presented in Table 1 for the “demand only” economy are also in the way expected. Output is obviously less volatile, and interest rates become more countercyclical than before. Maybe the most surprising result is on the coefficient of lagged output in the IS curve, for which we have no intuition.

The “supply only” economy presents a behavior diametrically contrary to the “demand only” economy. The coefficients in the IS and Phillips curve estimations change in the opposite direction. The coefficient of the interest rate in the IS curve becomes very positive, reflecting the procyclicality between productivity, output, and marginal product of capital. The correlation of interest rate with output (in Table 1) also becomes positive. And the coefficient of output gap in the Phillips curve becomes close to zero.

³ Atkeson and Ohanian (2001) forcefully argue against that the conventional wisdom that the modern Phillips curve based models are useful tools to forecast inflation.

In the last column of Tables 1 and 2, we present the behavior of an economy subject to a monetary rule different from the one observed in Brazil. We choose, arbitrarily, the rule proposed by Taylor (1999), in which the process for the nominal interest rate has coefficients for the inflation and for the output respectively $\lambda_\pi = 1,5$ e $\lambda_y = 0,5$, and coefficient for the lagged interest rate equal to zero ($\lambda_i = 0$). This rule — a good approximation of the recent policy observed in the U.S., — performs well in a great variety of models.

When we estimate the structural model using data generated by the “Taylor rule” economy, we are testing for the relevance of the Lucas’ critique. If the results are quantitatively different from before, it is because agents’ reactions to policy changes are important. And this is what our results suggest. Our “Taylor rule” implies an IS curve estimation with positive interest rate coefficient and a Phillips curve with a negative output gap coefficient. If our model is correct, and if the Brazilian Central Bank changes its policy so that it conforms to a Taylor rule, the estimations of the structural model will generate weird results.

7) Conclusions

Micro-founded models calibrated to the Brazilian economy can be used as an auxiliary tool for monetary policy decision-making. Because they are potentially robust to the Lucas’ critique, many researchers believe that they will substitute the current models, which are based on econometric estimations of reduced form model equations.

In this paper, we not only suggest this is true but also argue that there is a problem with the usual model estimations. For not effectively considering supply shocks, these estimations are biased, as in any identification estimation problem. A micro-founded model is not subject to this criticism, since supply or demand shocks are identified by using theory.

Our experiments suggest that the identification problem in the estimation of usual models is quantitatively relevant. That, in turn, implies that simulations based on these structural models

may lead to incorrect conclusions and induce mistakes in monetary policymaking. Additionally, our results suggest that the Lucas' critique also is quantitatively important. That means that even if the identification problem is somehow solved, simulations based on structural models are not adequate tools for policymaking— they do not consider agents' reactions to policy changes. Results from simulations again would be misleading, since the coefficient would change the moment policy is modified.

Many improvements are, however, necessary before micro-founded models can be reliably used for policymaking. In this paper, we have shown some of their performance weaknesses, particularly about how they mimic nominal variable stylized facts. Additional work on the time lags involved in monetary transmission would also be an important progress.

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Table 1: Second Moments**Standard Deviation (%) of filtered series**

VARIABLE	U.S. 1954:1 -	BRAZIL 1980:1 -	BRAZIL 1994:3 -	BOTH SHOCKS	ONLY DEMAND	ONLY SUPPLY	TAYLOR RULE
PIB	1.6	2.7	1.7	1.7	.87	1.42	1.42
Consumption	0.81	1.9	1.3	0.74	.29	0.68	0.69
Investment	5.5	7.7	5.6	5.5	3.2	4.4	4.4
Real Int. Rate	0.43	4.9	1.4	2.7	2.7	0.43	4.0
Nom. Int. Rate	1.3	23	1.5	1.5	1.5	0.00	3.3
Inflation	0.56	20	1.1	2.5	2.5	0.42	2.2
M1 (growth)	0.87	16	8.9	.66	.66	0.02	1.2
Price	1.4	30	3.2	3.7	3.7	0.57	2.9

Correlation (contemporaneous) of filtered series with GDP

VARIABLE	U.S. 1954:1 -	BRAZIL 1980:1 -	BRAZIL 1994:3 -	BOTH SHOCKS	ONLY DEMAND	ONLY SUPPLY	TAYLOR RULE
Consumption	.83	.93	.73	.98	.99	.99	.99
Investment	.91	.89	.77	.99	.99	.99	.99
Real Int. Rate	-.23	-.29	-.09	-.34	-.77	.43	.09
Nom. Int. Rate	.41	-.21	-.33	.11	.23	-.01	-.20
Inflation	.34	-.15	-.32	.44	.99	-.42	-.47
M1 (growth)	-.19	-.18	.39	.35	.60	.99	.21
Price	-.55	-.22	-.02	.03	.29	-.99	-.94

Table 2: Structural Model Estimations

IS: Dependent Variable = Output Gap (t)

COEFFICIENT	U.S. 1954:1-	BRAZIL 1980:1-	BRAZIL 1994:3 -	BOTH SHOCKS	ONLY DEMAND	ONLY SUPPLY	TAYLOR RULE
Constant	0.00 (0.00)	0.03 (0.06)	0.05 (0.12)	0.00	0.01	-0.09	0.00
Output Gap (t-1)	0.85 (0.05)	0.58 (0.13)	0.57 (0.14)	0.44	-0.29	0.94	0.82
Real Int. Rate (t)	-0.09 (0.12)	-0.12 (0.04)	-0.05 (0.17)	-0.09	-0.17	2.35	0.13

Standard Deviation in parenthesis

Phillips: Dependent Variable = [Inflation (t) – Inflation (t-1)]

COEFFICIENT	U.S. 1954:1-	BRAZIL 1980:1-	BRAZIL 1994:3 -	BOTH SHOCKS	ONLY DEMAND	ONLY SUPPLY	TAYLOR RULE
Constant	0.00 (0.00)	0.02 (0.03)	0.00 (0.00)	0.00	0.00	0.00	0.00
Output Gap (t-1)	0.05 (0.02)	0.28 (1.14)	1.06 (0.51)	0.82	3.08	-0.02	-0.12

Standard Deviation in parenthesis

Appendix

This appendix presents some robustness tests and some additional experiments.

The first two columns of table A1 show economies with smaller and higher degrees of price stickiness. In our calibration procedure, we mentioned that we set μ in order to match the IS curve and reached a value of $\mu=0.4$. Notice that the IS curve for the economy with $\mu=.2$ has the interest rate coefficient equal to zero. And the IS curve for the economy with $\mu = .6$ presents a negative value for the lagged output gap coefficient. In contrast, the economy with $\mu = .4$ could reasonably match the IS curve

The third and fourth columns show the results for economies with $\theta = .80$ and $\theta = .95$. We mentioned that we were particularly uncertain about this parameter, since its calibration was exclusively based on U.S. studies. However, different values for this parameter imply extremely similar results.

Table 1A: Additional simulations**Standard Deviation (%) of filtered series**

VARIABLE	$\mu=.2$	$\mu=.6$	$\theta=.80$	$\theta=.95$
PIB	1.7	1.7	1.6	1.7
Consumption	.85	0.74	.78	.72
Investment	5.6	5.4	5.7	5.4
Real Int. Rate	2.8	2.6	2.7	2.7
Nom. Int. Rate	1.5	1.5	1.5	1.5
Inflation	2.7	2.1	2.5	2.5
M1 (growth)	0.65	0.66	.66	.66
Price	3.8	3.6	3.7	3.7

Correlation (contemporaneous) of filtered series with GDP

VARIABLE	$\mu=.2$	$\mu=.6$	$\theta=.80$	$\theta=.95$
Consumption	.99	.99	.98	.98
Investment	.99	.99	.99	.99
Real Int. Rate	-.08	-.58	-.33	-.35
Nom Int. Rate	.03	.22	.11	.12
Inflation	.11	.86	.43	.45
M1 (growth)	.16	.57	.34	.35
Price	-.10	.14	.02	.04

IS: Dependent Variable = Output Gap (t)

COEFFICIENT	$\mu=.2$	$\mu=.6$	$\theta=.80$	$\theta=.95$
Constant	0.00	0.01	.00	.00
Output Gap (t-1)	0.66	-0.20	0.44	.44
Real Int. Rate (t)	0.00	-0.26	-.08	-.09