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ASSESSING INFLATION TARGETING IN LATIN AMERICA WITH A DSGE MODEL

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Resumen

En este documento se evalúa el impacto de las metas de inflación utilizando como grupo de tratamiento y control únicamente a países latinoamericanos. Para determinar si el desempeño de las economías cambia bajo metas de inflación, se estima un modelo de equilibrio general dinámico y estocástico pequeño. Los resultados muestran que los bancos centrales con metas de inflación parecieran ser ligeramente menos tolerantes a la inflación que los bancos centrales sin metas de inflación. Sin embargo, este resultado no se ha reflejado expectativas inflacionarias más prospectivas entre los agentes económicos.

Abstract

In this paper we assess Inflation Targeting with a unique treatment and control group of strictly Latin American countries. We estimate a small Dynamic Stochastic General Equilibrium model to determine whether economic behavior within an economy fundamentally changes under Inflation Targeting. We find that although Inflation Targeting central banks appear to be if anything, slightly more aggressive in responding to inflation than Non-Inflation Targeting central banks, this has not resulted in more forward looking inflation expectations by economic agents.

We would like express our gratitude to Viv Hall for his valuable suggestions and assistance. For technical assistance we thank Phillip Liu. For accommodating the completion of this paper, we thank the Central Bank of Chile and Klaus Schmidt-Hebbel. E-mail: John.McDermott@rbnz.govt.nz; petemaximum@gmail.com.

1 Introduction

Inflation Targeting (IT) has become a topic of much attention since the New Zealand parliament passed the Reserve Bank of New Zealand Act (RBNZ Act) in December 1989. The RBNZ Act specifies that the New Zealand government is responsible for setting an inflation target which must be made public and in writing, while the RBNZ is granted operational independence to decide how that inflation target will be achieved.

Following the lead of New Zealand, a growing number of countries have chosen to adopt the IT framework. According to the IMF (2005) some twenty-one countries (eight industrial and thirteen emerging market) were Inflation Targeters (ITers) in 2005. Latin America has followed, if not led this trend. The Central Bank of Chile began to gradually adopt features of the IT framework as early as 1990, Mexico did so since 1995, while Brazil, Colombia, and Peru fully adopted IT between 1999 and 2002.

Latin America, a region that exhibited the highest inflation rates in the world, has pursued a number of stabilization strategies since the early 1990s. Stabilization has been achieved under different monetary and exchange rate regimes, from dollarization to IT under floating exchange rates (Corbo and Schmidt-Hebbel 2001). As such, Latin America provides an interesting case study for assessing the effect of IT on emerging market economies.

We adopt a definition of IT as specified by Truman (2003) whereby IT demands a numerical inflation target and the formal recognition of price stability as the principle objective of monetary policy. Additionally, the IT framework requires a time horizon by which the target must be achieved and an ongoing review process to evaluate the success of a central bank in meeting its target obligation. [1]

McMenamin (2008) finds that although inflation levels, volatility and persistence have generally been reduced under IT, there is no robust statistically significant difference between the inflation performances of Latin American ITers and NITers.[2] In this paper we investigate whether inflation dynamics and economic behavior in an economy fundamentally change under IT compared with different monetary regimes. Specifically, we want to determine whether Latin American central banks behave differently under IT. Do they place different weights on offsetting inflation and output stability? Do they adhere to the Taylor principle?

This empirical analysis is conducted with the use of a theoretical model. The application of a theoretical model to the IT debate has only very recently begun to occur (see Caputo, Liendo and Medina 2007, Mello and Moccero 2007). To our knowledge, such a model has not been used to assess the *relative* effect of IT, i.e. one has not simultaneously been applied to both a treatment group of ITers

[1] Consequently, Chile and Mexico are not classified as ITers until all components of the IT framework are met, in 1999 and 2001 respectively.

[2] McMenamin (2008) IT sample: Brazil, Chile, Colombia, Mexico and Peru. NIT sample: Argentina, Bolivia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Uruguay, Venezuela.

and a control group of NITers. This is the major contribution of this paper. We employ a small Dynamic Stochastic General Equilibrium (DSGE) model to determine whether economic behavior within an economy fundamentally changes under IT relative to a Pre-IT adoption period and a control group of NITers. In addition, we use modern Bayesian methods of estimation and employ recent economic data. A large number of papers have used different econometric approaches to address similar issues (Corbo et al. 2002, Neumann and von Hagen 2002, Mello and Moccero 2007). Our decision to estimate a DSGE model using Bayesian methods was made with the intention to provide complementary evidences to these issues by employing an alternative approach.

The rest of the paper is divided into seven sections. Section 1 describes our methodology, including the model, our estimation technique, and the data. Section 2 presents the baseline model estimates for each Latin American IT country. Section 3 presents the results of various extensions, these include: estimating the model for IT Transition samples, excluding periods of high inflation from the Pre-IT adoption samples, and adding fiscal balances as an explanatory variable. In Section 4 we test how sensitive the posterior estimates are to the specified priors. In Section 5 we estimate the baseline model for the NITers. Section 6 presents impulse response functions for each country to a unit inflation shock, from this we conduct a test for the Taylor principle. Section 7 concludes the paper.

2 Methodology

2.1 The Model

We adopt the small closed economy DSGE model specified in Cho and Moreno (2006). The model omits several potentially relevant features, most notably the foreign sector and the exchange rate. The model does not incorporate factors such as trade and financial integration or levels of dollarization that may be relevant for our Latin American sample. We acknowledge the potential misspecifications that may result from these omissions. However, we have selected this particular model in spite of these limitations in order to heighten the chances of identifying the model. Our primary interest is the dynamics of inflation expectations and the behavior of central banks under alternative monetary regimes. If we crowd the model with too many complexities in an attempt to more fully represent reality, we risk learning nothing. Hence we employ the following small model and make only slight variations in order to improve identification and test robustness.[3]

The model contains the key features of any New Keynesian set up; Calvo pricing, a forward looking investment savings (IS) curve, a forward looking

[3] Recent papers such as Cochrane (2007) have argued that there is an inherent lack of identifiability of Taylor rule parameters in new-Keynesian models. Like a number of papers that employ DSGE models to estimate central bank behaviour, our paper may too fall prey to such criticism. However, contention over this issue lies outside the realm of focus of this paper.

Phillips curve, and a Taylor rule. It incorporates monopolistic competition and sticky prices. As shown by Woodford (2003) the set of simultaneous equations can be formulated with explicit micro-foundations as a general equilibrium model. The first two equations are shown below:

$$\pi_t = \delta E_t \pi_{t+1} + (1-\delta)\pi_{t-1} + \lambda y_t + \varepsilon_{AS,t} \quad (1)$$
$$y_t = \mu E_t y_{t+1} + (1-\mu) y_{t-1} - \phi(r_t - E_t \pi_{t+1}) + \varepsilon_{IS,t} \quad (2)$$

Equation (1) is the aggregate supply (AS) equation. It is a generalization of the supply specification originally developed by Calvo (1983). The variable π_t represents inflation at time t, y_t represents the output gap, and $\varepsilon_{AS,t}$ is a cost push shock in the Phillips curve at time t. The supply shock is assumed to be independently and identically distributed with homoskedastic variance σ^2_{AS}. E_t is the rational expectations operator conditional on the information set at time t which comprises π_t, y_t, r_t and all the lags of these variables. The Phillips curve is represented by the parameter λ; the weight on forward looking inflation expectations is represented by the parameter δ and inflation persistence is measured by $(1-\delta)$ (Cho and Moreno 2006).

Equation (2) is the demand or IS equation. It is based on a representative agent´s intertemporal utility maximization with external habit persistence. Endogenous persistence of the output gap is underpinned by an assumption of habit formation in the representative agent´s utility function. The weight on expected output is measured by the parameter μ_t. The IS equation includes a monetary policy channel whereby the real interest rate $(r_t - E_t \pi_{t+1})$ has a depressing impact on the output gap; this is measured by the parameter ϕ. The demand shock $\varepsilon_{IS,t}$ is again assumed to be independently and identically distributed with homoskedastic variance σ^2_{IS}.

The baseline model is closed with the monetary policy rule formulated by Clarida, Gali, and Gertler (1999):

$$r_t = \rho r_{t-1} + (1-\rho)[\beta(E_t \pi_{t+i} - \pi^T) + \gamma y_{t+i}] + \varepsilon_{MP,t} \quad (3)$$

The monetary policy reaction function (MRF) describes the behavior of the central bank. The variable r_t represents the quarterly nominal interest rate which is a function of three variables; the degree of interest rate smoothing (r_{t-1}) measured by the parameter ρ, inflation deviations from the (average) inflation target (π^T) measured by β, and changes in the output gap (y_{t+i}) measured by γ. The monetary policy shock $\varepsilon_{MP,t}$ is again assumed to be independently and identically distributed with homoskedastic variance σ^2_{MP}.[4]

[4] For the analysis which follows (unless otherwise specified) the nominal interest rate is responsive to lagged inflation and lagged output (i.e. i=-1). There is no theoretical reason for doing this but that we find our results are more robust with this specification. This specification is suggested in Canova (2007).

2.2 Data

CPI data was attained from the IMF's *International Financial Statistics* (*IFS*) publication and seasonally adjusted using the X12 method.[5] We measure quarterly inflation as the quarterly percentage change in consumer prices. For observations of ITers in the Post-IT sample, π_t measures the quarterly deviation of quarterly inflation from the average quarterly inflation target π^T. For observations of ITers in the two Pre-IT samples and of NITers in all three samples, π_t measures the quarterly deviation of quarterly inflation from $\overline{\pi_j}$, the average quarterly inflation rate over sample period j.[6] We obtain quarterly observations of annual interest rates from the IMF's *IFS* publication. The nominal interest rate (r_t) is the deviation of the seasonally adjusted quarterly interest rate from the mean quarterly interest rate of the respective Pre-IT or Post-IT sample period.[7] For Brazil, Chile and six NITers we use market interest rates rather than discount rates because of insufficient data (see Appendix B Table 1). Despite their differences, the market and discount interest rates of these countries are highly correlated (see Appendix B Figure 1). There is a positive correlation of 0.86 between Brazil's annual discount rate and its money market rate. For Chile we use the deposit rate which has a high correlation of 0.86 with the discount rate. For Honduras we use the lending rate which has a correlation of 0.88 with the discount rate.

For the IT countries we use quarterly GDP data taken directly from *IFS*.[8] For the NITers, because of limitations in data availability, we convert annual GDP data into quarterly data using a low to high quadratic-match sum frequency converter.[9] The output gap (y_t) is calculated for all countries (except Brazil) using the Baxter-King filter.[10] This procedure has the disadvantage of reducing the data set to estimate the output gap. To utilize all observations we employ earlier GDP data and use an AR(1) model to forecast output up until 2010q1. We then use the Baxter-King frequency filter to calculate the output gap for the combined output data set.[11] Appendix B Table 1 presents the CPI , interest

[5] The exceptions are the hyperinflation countries; Brazil, Bolivia, Nicaragua and Peru, for whom this adjustment was dysfunctional. See Appendix B Table 1 for the specific consumer price indices used.

[6] Where j is either the Pre-IT (A), Pre-IT (B) or Post sample.

[7] We convert the annual interest rates into quarterly rates by multiplying the annual rate for each quarter by 0.25. We seasonally adjust using the X12 method.

[8] Brazil's quarterly GDP was obtained from *ipeadata*, the Brazilian economic and regional database provided by the Institute of Applied Economic Research (see www.ipeadata.gov.br).

[9] EViews provides a variety of interpolation methods for converting data from a low to a high frequency. We employ a local quadratic method where the sum is matched to the sourced annual data. The method fits a local quadratic polynomial for each observation of the (annual) low frequency series, then uses this polynomial to fill in all observations of the high frequency (quarterly) series associated with the period. See Eviews 6 User Guide 1 p108 for further explanation.

[10] For Brazil, because of the lack of available output data prior to 1980, using the Baxter-King method would sacrifice the entire Pre-IT (A) sample to generate the output gap. To remedy this, we calculate the output gap as quarterly deviations from the natural rate of output which is calculated by applying the Hodrick-Prescott filter to the seasonally adjusted, logged GDP data.

[11] Colombian quarterly GDP data was not available prior to 1994. This limited our Pre-IT

rate and output data used for the following analysis as well as sample date specifications. Appendix B Figure 7 plots the seasonally adjusted inflation rate, seasonally adjusted interest rate, and the output-gap used in estimation for each country.

We take a cross-sectional analysis of ITers and NITers by creating Pre-IT and Post-IT adoption samples (as in Ball and Sheridan 2005, IMF 2005, and Vega and Winkelried 2005). We measure changes of inflation dynamics and central bank behavior in the five Latin American IT countries (Brazil, Chile, Colombia, Mexico and Peru) relative to a control group of seven Latin American NITers (Bolivia, Costa Rica, Guatemala, Honduras, Nicaragua, Paraguay and Uruguay). Our control group was chosen specifically to be composed of Latin American countries. Countries were excluded on the basis of data constraints and the incompatibility of specific monetary and exchange rate regimes with the MRF specified in our model, e.g. dollarized economies and those with currency boards.

For the ITers we break the sample into four groups; Pre-IT (A), Pre-IT (B), Transition and Post-IT. Pre-IT (A) is the larger of the Pre-IT samples, it includes observations from approximately 1980q1 until the date of IT adoption.[12] The Pre-IT (B) sample is the eight years prior to IT adoption. This sample allows us to observe how economic behavior has changed within the Pre-IT period. The Post-IT sample for each country begins at the respective date of adoption and ends at approximately 2006q3. Only Chile and Mexico, who undertook a gradual transition to IT, have Transition samples (Truman 2003). Chile´s Transition sample includes observations between 1990q3 and 1999q4; Mexico´s Transition sample is between 1994q4 and 2001q1.

For the NITers, the sample period is broken into three similar sub-groups: Pre (A), Pre (B), and Post.[13] Each of these samples are as described for the respective IT samples except that the "date of adoption" for all NITers is taken to be the median IT adoption date (1994q4).

2.3 Estimation Technique: A Bayesian Approach

We use a Bayesian method of estimation to obtain the parameter estimates for the DSGE model. The Bayesian approach allows the user to treat model and parameter uncertainty explicitly. The method does not presume that one´s model is correct but rather seeks a model with the highest posterior probability by using observations to infer the probability that the hypothesis (prior) might be true. Unlike Maximum Likelihood estimation for example, Bayesian inference is in terms of probabilistic statements rather than classical hypothesis testing procedure (Liu and Nicolaisen 2005). Other authors to have estimated New

sample to only five years. To resolve this we use annual GDP data from 1980 until 1994 acquired from *IFS* and use the Eviews frequency converter.

[12] See Appendix B Table 1 for the dates of IT adoption and the sample period for each country.

[13] Because of data constraints there is no Pre (A) sample for Nicaragua, Paraguay or Uruguay.

Keynesian macroeconomic models using Bayesian techniques include Smets and Wouters (2003), Justiniano and Preston (2004), Lubik and Scorfheide (2005) and Liu and Nicolaisen (2005).

Using the Bayesian approach, one´s conjecture about the parameter θ is contained in the posterior distribution. For a particular model i, the posterior density of the model parameter θ may be written as:

$$p(\theta \mid Y^T, i) = \frac{L(Y^T \mid \theta, i)p(\theta \mid i)}{\int L(Y^T \mid \theta, i)p(\theta \mid i)d\theta} \tag{4}$$

The objective of the Bayesian approach is to find a model i that maximizes the posterior probability given by $p(\theta \mid Y^T, i)$. Where $p(\theta \mid i)$ is the prior density, and $L(Y^T \mid \theta, i)$ is the likelihood conditional on the observed data Y^T.

The likelihood function can be computed using the state-space representation of the model together with the measurement equation linking the observed data and the state vector. The Markov Chain Monte Carlo (MCMC) method is used to obtain estimates as posterior draws.[14]

We use the Metropolis Hasting algorithm, which generates a random walk using a proposal density and a method for rejecting proposed moves, to generate the Markov Chain (MC). This is described fully by Lubik and Schorfheide (2005).

Given the data and the prior specifications, we generate 100,000 draws of MC using the method described. The Chain is generated using Dynare to estimate the model.[15]

2.3.1 Priors

The choice of priors were to some extent based on our preconceived beliefs about the economy, others were chosen arbitrarily. Accordingly, we are aware of the potential bias in our method and conduct robustness test later in the chapter. The same prior means, variances and distributions were used for all sample estimates to enhance the comparability of the posteriors estimates (see Appendix B Table 2).

Some prior distribution choices reflect the required restrictions imposed on parameters such as non-negativity or interval restrictions. A Beta distribution was chosen for parameters that are constrained between zero and one. A Normal distribution was chosen for unconstrained parameters, and an Inverse Gamma distribution was selected for shocks and parameter values greater than zero.

3 Estimation Results for ITers

For Brazil, the weight on forward looking inflation expectations, given by δ, is estimated to be much lower in the Pre-IT samples than under IT. Accordingly,

[14] The reformulation of the NK model into the state equation is provided in Appendix B: Model Application.

[15] The Dynare programme was provided by Phillip Liu (2007).

given $(1-\delta)$, this reflects higher inflation persistence prior to the adoption of IT. Of initial surprise is the extremely large Pre-IT (A) and Pre-IT (B) β estimates, i.e. the long-run responsiveness of the Central Bank of Brazil to inflation. Both Pre-IT β estimates are well above those estimated for the Post-IT sample. In addition, interest rate persistence is lower in both Pre-IT samples than under IT indicating greater aggressiveness to inflation and output in the short-run given $(1-\rho)$. We are unsure whether these estimates fairly represent the Central Bank´s behavior over the whole Pre-IT sample. The posterior distributions of β and ρ suggest that the Pre-IT (A) estimates are based on few observations. We suspect that these are skewed toward the Central Bank´s behavior during hyperinflation when one would expect the nominal interest rate to be changed frequently and in large magnitudes. We investigate this issue further in Section 3.2.

We estimate that inflation expectations are predominantly forward looking in Chile for both Pre-IT sample periods and that inflation persistence is only slightly reduced under IT. Given ρ, the Central Bank of Chile´s short-term responsiveness to inflation is increased considerably Post-IT, its long-term responsiveness remains approximately the same as it is estimated to be for the Pre-IT samples. We are concerned about the similarity of the posterior distributions of β and γ to their prior distributions. We suspect that these estimates merely reflect their respective priors.

Colombia, like Chile, has also proven to be very adept at keeping inflation persistence low both before and after adopting IT. Our estimates show that this may be attributable to the high responsiveness of the Central Bank of Colombia to inflation fluctuations throughout the sample periods. However, more aggressive monetary policy under IT has not lead to a greater anchoring of inflation expectations. Inflation persistence is estimated to have increased in Colombia under IT in comparison to both Pre-IT samples. Marquez (2004) identifies disinflation and moving inflation targets as possible culprits for high inflation persistence estimates. Because Colombia has been a "converging ITer" throughout the Post-IT sample, we expect that this has been the case here.[16]

Mexico appears to be a great success story for IT. Not only has its inflation performance improved, it appears that better monetary policy may be largely credited with this success. However, we continue to have concern over the similarity of the Post-IT MRF estimates to their respective priors. In Section 4 we check for the robustness of these posterior estimates to a different prior specification.

More so than any other country, Peru has exhibited a huge improvement in its inflation performance in the Pre-IT (B) sample. This achievement has been accompanied by much more aggressive monetary policy. Post-IT, the common attributes of IT are present; forward looking inflation expectations and low inflation persistence. As in Chile and Colombia, much of these gains appear to have been achieved before the adoption of IT.

[16] "During target convergence, inflation targets are adjusted downward, typically for calender years." Mishkin and Schmidt-Hebbel (2007 p296)

Generally speaking, one observes that for most of the ITers, the mean posterior estimates of λ often reflect the prior. We detect no distinctive trend that suggests IT has made any impact on the slope of the Phillips curve. Bernanke, Laubach, Mishkin and Posen (1999) find that the adoption of IT does not significantly alter the real economic cost of disinflation. Our model has also poorly described the IS equation. The parameter μ is extremely volatile and it is impossible to comment on how IT has contributed to such dramatic changes in the dynamics of output; there is no common trend to these changes.

There exists a weak trend suggesting that the monetary policy channel may have strengthened in the IT countries, though this is not convincingly attributable to IT. In all of the IT countries the effect of the real interest rate on aggregate demand is increased. In Colombia and Peru the increase occurs by the Pre-IT (B) sample, in Brazil and Mexico it occurs Post-IT, and in Chile ϕ remains at 0.02 for each sample. As mentioned, the Phillips curve parameter λ remains approximately constant. We cannot be sure that these estimates do not reflect the priors.

Turning to the MRF, estimates of β have increased for four out of five of the ITers throughout the sample periods. Estimates of γ are generally reduced throughout the samples but the posterior distributions indicate that there is little explanatory value in these estimates. Most notably we observe large reductions in the parameter ρ. There is a consistent trend that indicates a reduction in interest rate smoothing and accordingly, an increase in short-term central bank aggression toward inflation. Although these changes often begin before IT is adopted, central banks are estimated to be most aggressive Post-IT; this is the case for all IT countries except Brazil.

Corbo, Landerretche and Schmidt-Hebbel (2002) show that inflation aversion increased in developing IT countries but not in industrial ones in the 1990s. In addition, they find that IT central banks actually reduced their responsiveness to inflation and output. They claim that this reflects a gradual increase in credibility which allowed central banks to achieve their inflation objectives with smaller changes in the policy variable. We do not detect such a credibility gain.

Cespedes and Soto (2005) give an opposite view of the effect that IT has on interest rate responsiveness. Using a New Keynesian Phillips curve they propose that:

> "when central bank credibility is low, a central bank that is concerned with the sacrifice ratio during a disinflationary process may be less aggressive in implementing its monetary policy in order to avoid large output losses. As it gains credibility, the central bank may fight inflation deviations from target strongly." (Cespedes and Soto 2007, p548).

Cespedes and Soto (2007) confirm this hypothesis for the case of Chile after the full adoption of IT.[17] We also find an increase in the responsiveness of the

[17] Cespedes and Soto (2007) estimate a similar MRF to our own. They estimate an increase in an equivelant parameter β from 0.35 in the period 1991q1-1997q4 to 1.84 Post-IT (1998q1-

Central Bank of Chile (though not by nearly as much as that estimated by Cespedes and Soto (2007)) and the other Latin American IT central banks. We have not detected a reduction in the cost of disinflation. However, given the difficulty that our model exhibits identifying the parameters ϕ and γ, we do not reject this argument. Further investigation into this area may prove to be profitable but is outside the scope of this paper.

Mello and Moccero (2007) estimate a very similar New Keynesian model as that of Cho and Moreno (2006) for Brazil, Chile, Colombia and Mexico using monthly data between 1996q1 and 2006q2.[18] Like us, they estimate very small reductions in inflation persistence after the adoption of IT in Brazil, Chile and Mexico, and an increase in inflation persistence in Colombia. Their estimates of δ are typically lower than our own and range between 0.49 and 0.60; this difference reflects their use of monthly data. Eight out of nine of their δ estimates are significant to the one percent level. They find that "the output gap does not enter the Phillips curve in a statistically significant manner and the ex-ante real interest rate does not appear to be a powerful determinant of the output gap" (Mello and Moccero 2007 p10). They estimate the parameter μ to be between 0.40 and 0.56 for each country, but they do not find any trend in the directional change of this parameter.

In contrast to our findings, Mello and Moccero (2007) estimate that monetary policy has become more persistent over time. Pre-IT estimates of ρ range between 0.03 and 0.30 although none are significant. Significant Post-IT estimates of ρ range between 0.55 and 0.65 for Brazil, Chile and Colombia.

The most notable differences between our results and those of Mello and Moccero (2007) are our estimates of β and γ. Their Pre-IT and Post-IT estimates of β range between -0.12 and 0.30, they are frequently non-significant.[19] They estimate that the Latin American central banks have not been responsive to changes in output; their estimates of γ range between -0.02 and 0.01. We have found much higher estimates for γ and β but we suspect that these may reflect the priors. Nonetheless, the Mello and Moccero (2007) estimates indicate that under IT no Latin American central bank has come close to following the Taylor principle.

The essential finding of Mello and Moccero (2007) is that IT has been associated with greater responsiveness to changes in expected inflation in Brazil and Chile, but that lower interest rate volatility in Brazil, Colombia and Mex-

2005q4). The first estimate is significant to the 1 percent level while the latter is significant to the 10 percent level. The equivilant estimate of ρ is 0.63 in both periods, it is significant to the 10 percent level.

[18] The model used by Mello and Moccerro (2007) is slightly different in that they include an exchange rate variable into the MRF. Their model is thus structural rather than theoretical. The exchange rate variable is estimated to be a significant determinant of the nominal interest rate only in Mexico Pre-IT and in Brazil and Mexico Post-IT. They measure the expected values of the model by using one period ahead values in the relevant variables, they use Maximum Likelihood to estimate the model.

[19] Mello and Moccero (2007) Post-IT β estimates for Brazil and Chile are 0.19 and 0.11 respectively, both are significant to the 5 percent level. Brazil´s Pre-IT β estimate is 0.54, it is not significant.

ico owes more to the benign economic environment than to changes in policy settings. We are interested in how such estimates compare with Latin American countries that did not adopt IT. We investigate this in Section 5.

4 Extensions

4.1 Including IT Transition Periods

Here we analyze the gradual adoption of IT in Chile and Mexico. Because Mexico maintained monetary aggregate controls and Chile maintained exchange rate controls during their Transition periods to IT, we do not classify them as ITers until they abandon these alternative targets (1999q4 and 2001q1 for Chile and Mexico respectively (Truman 2003)). This is because neither central bank had announced that price stability be *the* principle objective of monetary policy. The posterior estimates for the Transition periods are displayed in Appendix B Table 3b, the prior and posterior distributions are presented in Appendix B Figure 2.

For both Chile and Mexico we estimate that inflation expectations became more forward looking during the Transition periods. This contradicts estimates by McMenamin (2008) who, using a univariate approach, estimates very high inflation persistence during both these samples corresponding to disinflation. The DSGE model has not estimated high persistence during these periods, both countries´ δ estimates are approximately the same for the Transition periods as for the Post-IT periods.

Mexico exhibits a very large increase in the estimated value of δ during its Transition period, from 0.50 Pre-IT (B) to 0.71. This indicates that 88 percent of the estimated increase in δ that occurred between the Pre-IT (A) and Post-IT samples was achieved before IT was fully adopted. This is a surprising result particularly given that Mexico´s inflation history would suggest that the Central Bank of Mexico initially possessed very low credibility. During Chile´s Transition period, δ increases to 0.79. This indicates that expectations were more forward looking during the Transition period than under IT. We suspect that these estimates of δ predominantly reflect the correlation of inflation to expected inflation which is generated by the Kalman filter (see Appendix B Figure 6).

During their respective Transition periods, both central banks are estimated to have become more responsive to inflation. Estimates of β indicate that both were approximately as responsive to long-run inflation during this period as under IT. Both exhibit reductions in interest rate smoothing during the Transition period relative to their Pre-IT estimates. Under IT, given $\beta(1-\rho)$, it appears the central banks of Chile and Mexico are at their most aggressive.

Surprisingly, the DSGE model has estimated that most of the gains attributed to IT, i.e. anchoring inflation expectations and reducing inflation persistence, were achieved during the IT Transition periods.

4.2 Excluding High Inflation

Our posterior estimates for Brazil and Peru in the Pre-IT (A) period were not well identified. Large error terms and extremely narrow confidence intervals illustrate this.

Figures 1 (a,b) plot the adjusted data that we used for estimating the model in the Pre-IT (A) sample periods for these two countries. Where (y) is the quarterly output gap, (i) the quarterly deviation of inflation from its Pre-IT (A) sample mean (48.6 and 33.1 percent per quarter for Brazil and Peru respectively), and (r) is the deviation of the quarterly nominal interest rate from its Pre-IT (A) mean (1847.6 and 206.1 percent per quarter respectively).

Figure 1a
Brazil: Pre-IT (A) Data

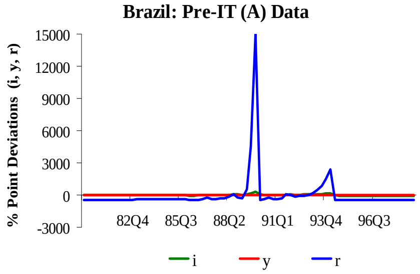
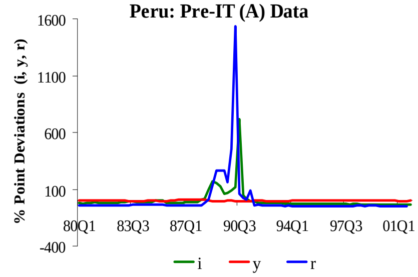


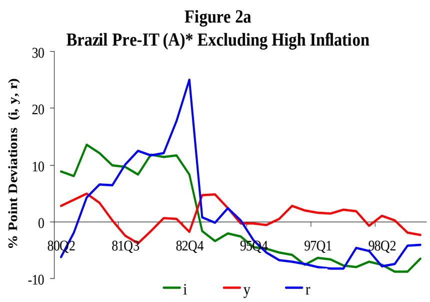
Figure 1b
Peru: Pre-IT (A) Data

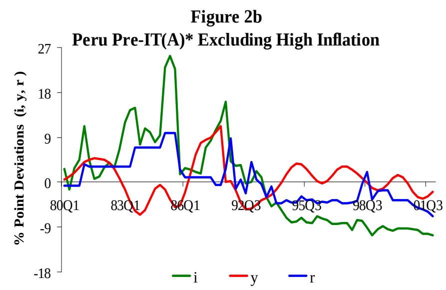


In both countries during periods of hyperinflation, the nominal interest rate explodes. For Brazil in 1990, in one quarter alone the nominal interest rate is raised approximately 15,000 percentage points above the sample mean. For Peru we observe a similar rise in the nominal interest rate when inflation peaks. The problem is not only the magnitude of the values and the difficulty of the model to explain them, it is that the model attempts to describe these phenomena at the expense of the rest of the observations in the sample. It appears that it is these observations that are responsible for Brazil´s high Pre-IT β estimates.

The estimates of β and ρ that we have estimated for Brazil and Peru Pre-IT (A) reflect the response of these central banks during bouts of hyperinflation. The estimates do not adequately reflect the behavior of these central banks over the full Pre-IT (A) sample period. Under IT, despite a fall in the Central Bank of Brazil´s responsiveness to inflation, we estimate a large increase in forward looking inflation expectations and a reduction in inflation persistence. Because the hyperinflation observations dominate our results without giving any useful explanation about the central banks´ behavior over the majority of the Pre-IT (A) sample, we experiment with excluding these periods.

Cagan (1956) defines hyperinflation as inflation over 50 percent per month. According to this definition, Brazil experienced only a very short period of hyperinflation, from December 1989 to March 1990. However, it is not just inflation over 600 percent per annum that distorts the regular behavior of central banks. A fairer comparison of policy behavior and inflation between the Pre-IT and Post-IT samples is to compare moderate inflationary environments. We adopt a definition of high inflation as inflation above 100 percent per annum (Fischer, Sahay and Vegh 2002). Accordingly, for Brazil we exclude observations between 1983q1 to 1994q3, for Peru we exclude the period between 1988q1 to 1991q2.





*Brazil Excludes (1983q1, 1994q3), Peru Excludes (1988q1, 1991q2)

Figures 2 (a,b) display the adjusted data for the Pre-IT (A) sample after excluding high inflation, we refer to these samples as Pre-IT (A)*. Again inflation (i) and the nominal interest rate (r) represent deviations from the mean Pre-IT (A)* value. For Brazil the new mean inflation and nominal interest rates are 8.5 and 54.1 percent per quarter respectively, for Peru they are 10.3 and 32.3 percent per quarter respectively.

Appendix B Table 4 presents the mean posterior estimates and 95 percent confidence intervals of the Pre-IT (A)* samples. The posterior distributions (see Appendix B Figure 2) show that by excluding high inflation we have better identified the model for Brazil, though this appears to be less so for Peru. The posterior distributions for Brazil are now more widely distributed indicating that the estimates are representative of more observations. Notably for Brazil these distributions are bimodal for four of the parameters which reflects the exclusion of eleven years from the middle of the sample. The bimodal distributions reflect the two separate time periods in the Pre-IT (A)* sample.

The most notable differences between the original estimates and those for the sample where high inflation is excluded, are the estimates of each countries´ central bank aggression to inflation deviations. In Brazil, the mean β posterior estimate is reduced from 2.71 to 1.34. In Peru the estimate for β is increased from 0.89 to 1.35.

Interest rate persistence increases in both countries. When we exclude high inflation in Peru, ρ is estimated to be extremely high at 0.92. In Brazil the estimate of ρ increases from 0.23 to 0.63. These results represent the much dampened immediacy and volatility of the interest rate outside hyperinflation.

Our results indicate that the Pre-IT (A) estimates of an extremely responsive Central Bank of Brazil are more representative of the Central Bank´s behavior during high inflation than throughout the sample period. Including the high inflation periods for Peru´s Pre-IT (A) sample also appears to have overstated the Central Bank of Peru´s responsiveness to inflation.[20]

4.3 Adding a Fiscal Variable

There are two prominent views about the causes of chronic high inflation, the "fiscal" view, and the "balance of payments view" (Montiel 1988). Because we employ a closed-economy model we shall focus on the fiscal view.

Proponents of the fiscal view argue that the contentious expansion of the monetary base arises from fiscal disequilibrium (Sargent and Wallace 1981). Reinhart and Savastano (2003) identify that in Brazil and Peru, hyperinflation was triggered by an uncontrolled expansion in the money supply fuelled by endemic fiscal imbalances.

As an exercise to better identify the DSGE model for Brazil and Peru in the Pre-IT (A) sample, we add a new explanatory variable to our baseline model, fiscal balances.

4.3.1 Data

Data on fiscal balances were attained from the IMF's *IFS* database. We use quarterly fiscal balances as a percentage of quarterly GDP (g_t) to estimate the extended model. For Brazil, quarterly data for fiscal balances is incomplete. There is no quarterly data for the periods 1986q1 to 1986q3, and for 1988q3 to 1989q3. Annual fiscal balance data is available from *IFS* but is not compatible with the quarterly fiscal balance data.[21] We use the method described in Appendix A to estimate these vacant quarterly values from the annual fiscal balance data.

4.3.2 The AS Equation plus Fiscal Balances

To better explain the hyperinflation episodes in the Pre-IT (A) samples for Brazil and Peru, we incorporate fiscal balances into the AS equation. As in the previous section we want to generate more explanatory Pre-IT (A) estimates.

By including fiscal balances into the AS equation we do not suggest that government spending affects aggregate supply. Rather, we are reflecting the idea that when government debt reaches an unsustainable level, such debts may been monetized (Reinhart and Savastano 2003). We are interested in whether

[20] The product of $(1-\rho)\beta$ is greater for Peru using the Pre-IT (A) sample than it is for the Pre-IT (A)* sample.

[21] The quarterly fiscal balance data did not sum to the annual data. The measurements were vastly different and the first differences had a huge range.

adding this variable might help us better explain inflation in Brazil and Peru in the early 1990s.

The application of this model to the Post-IT sample may also generate interesting results. Blanchard (2005) observes that the level and the composition of public debt in Brazil in 2002 was particularly inflationary.[22] Cerisola and Gelos (2005) include primary fiscal balances as a percentage of GDP in a reduced form inflation expectations equation; they use this as a signal of the governments' commitment to fiscal sustainability.[23] They explain that in models with forward looking behavior, the whole path of expected future deficits typically matters for the behavior of today's inflation.

The addition of g_t to the AS equation means that the monetization of fiscal debt, rather than being incorporated into the model as unexplained random inflation shocks, is incorporated into the AS equation through fiscal balances. This acts as a type of proxy variable for hyperinflation. Its explanatory value is measured by the parameter α.

$$\pi_t = \delta E_t \pi_{t+1} + (1-\delta)\pi_{t-1} + \lambda y_t + \alpha g_t + \varepsilon_{AS,t} \tag{5}$$

We specify g_t as a function of its own lag and some random shock.

$$g_t = \nu g_{t-1} + \varepsilon_{g,t} \tag{6}$$

Where ν is the contribution of the previous periods fiscal balance to today´s balance, and $\varepsilon_{g,t}$ is a random fiscal shock. The error term $\varepsilon_{g,t}$ is assumed to be independently and identically distributed with homoskedastic variance $\sigma^2_{g,t}$.[24]

4.3.3 Estimation Results

The re-specified AS equation was tested for four of the Latin American ITers.[25] Only for Brazil and Peru did we find mentionable results.[26] Appendix B Table 4 displays the parameter estimates for Brazil and Peru using Equations (8) and (9). Appendix B Figure 3 presents the posterior distributions. We estimate the Pre-IT (A) and Post-IT sample periods for Brazil and Peru. We refer to these as Pre-IT (A)^G and Post-IT^G sample estimates.

For Brazil and Peru, fiscal balances are estimated to have strongly contributed to inflation during the Pre-IT (A)^G period. The data has updated the posterior estimates of α considerably relative to the prior for both countries, from 0.01 to 0.07. The posterior distributions of this parameter suggest that

[22] Blanchard (2005) identifies that in Brazil from 2002-3 higher interest rates under IT were inflationary because given the level and composition of public debt, higher interest rates were seen as a signal of an increased probability of default, this caused an exchange rate depreciation.

[23] The measure is intended to act as a proxy for the expected future path of fiscal balances in the short- to medium-term.

[24] For this experiment the inflation expectations operator in Equation (3) E_{t+i} is forward looking i.e. $i = 1$.

[25] We did not perform the experiment for Chile as there was insufficient fiscal balance data.

[26] The results for the other IT countries did not differ from their respective estimates using the baseline model.

these estimates are explanatory for only a few observations. This is what one would expect given the hyperinflation outliers we are trying to explain.

For both countries Pre-IT $(A)^G$, we estimate an inverse Phillips curve relation. This is understandable given the context of hyperinflation. During hyperinflation, output and inflation may be negatively correlated as the costs of chronic inflation reduce purchasing power and the efficiency of production. This estimate of λ is supported by the narrowest of confidence intervals.

For the Post-IT^G sample, fiscal balances do not have any explanatory value for either Brazil or Peru. The addition of this variable has not considerably changed the Post-IT^G estimates from those of the baseline model.

Unfortunately, our modification has not greatly improved the identification of the model. It has however served to show the robustness of particular parameter estimates and the lack of robustness of others. Lower error term estimates Pre-IT $(A)^G$, particularly of ε_{MP}, suggest that this model better fits the data in the Pre-IT (A) period for Brazil and Peru than does the baseline model.

The experiment is an interesting application of the DSGE model. Our results have tended towards those of Catáo and Terrrones (2003) who find that for a sample of one hundred and seven countries between 1960 to 2001, there is a strong positive association between deficits and inflation among high inflation developing country groups but not among low inflation economies. Cerisola and Gelos (2005) assess the fundamental determinants and changes in inflation expectation dynamics since the adoption of IT in Brazil. Their results suggest that the adoption of IT has helped anchor expectations and that consequently, the dispersion of inflation expectations have declined considerably. They find that the stance of fiscal policy has been important in shaping inflation expectations.

5 Sensitivity to Priors

We now investigate the sensitivity of the posterior estimates of the baseline model to their respective priors. We have emphasized our concern for the robustness of the MRF estimates β and ρ. This is especially so for the Pre-IT (B) and Post-IT estimates where the sample sizes are small. The prior and posterior distributions for these parameters have been very similar to each other for these sample periods.

The difficulty of identifying the parameters β and γ in a model such as ours is recognized by Canova (2007). Canova suggests that difficulties encountered with these particular parameters are not necessarily due to sample instability but are related to the near non-identifiability of these parameters from the data.

We suspect also that there is an econometric identification issue between the parameters β and ρ. Although the parameters are supposed to represent two different policy decisions, it appears that behavior which should be attributed to β (long-term responsiveness to inflation) is being estimated through $(1-\rho)$ via a reduction in estimates of ρ (interest rate smoothing). We conduct robustness tests to determine whether, given another prior, the evidence is sufficient to update the posteriors and reinforce the original posterior estimates. For this experiment we double the prior value of β from 1.5 to 3.0.

5.0.4 Estimation Results

Appendix B Tables 5 (a,b) display the mean posterior estimates and 90 percent confidence intervals with the revised prior estimate of β equal to 3.0. The prior and posterior distributions are exhibited in Appendix B Figure 4.

Estimates of the AS and IS equations are largely unaffected by the new β prior. The common exception is μ which often changes in large magnitudes. This reflects the lack of robustness of the estimates for this parameter and the difficulty of the model to describe the behavior of aggregate demand.

The new β prior has greatly affected the posterior estimates of the MRF. In every instance the posterior estimate of β is substantially different from its original estimated value (when the β prior was equal to 1.5). In many instances the new β posterior distributions closely reflect the new prior distribution and accordingly, the mean posterior estimates of β reflect the mean prior value. For Chile, Colombia, Mexico and Peru, estimates of β continue to be slightly increased throughout the sample periods, from the Pre-IT (A) through to Post-IT sample; though interesting, this does not indicate significance.

The lack of responsiveness of the β parameter and its interaction with ρ is both an econometric problem and a real world issue. Imposing a new prior specification for β requires very informative data to update the posterior estimates to their original values. Unfortunately, the original estimates themselves have proved to possess little explanatory value. In most cases the entire change in policy behavior has occurred through the interest rate smoothing parameter ρ. The responsiveness of this parameter to the change in the β prior has been very consistent. In almost every case, the higher β estimate is accompanied by a reduction in interest rate smoothing. This indicates that the responsiveness of a central bank to inflation, both in the long-run and the short-run, rather than being reflected by the parameter β, is predominantly estimated through a reduction in ρ. This has occurred because of the interaction of the two parameters in the MRF whereby β is multiplied by $(1 - \rho)$.

Mello and Moccero (2007) estimate a similar model for four of the five Latin American ITers using monthly data. They estimate that under IT, the interest rate smoothing parameter ρ is 0.61 in Brazil, 0.63 in Colombia, and 0.56 in Mexico, all are significant to the 1 percent level.[27] These are vaguely consistent with our initial estimates using the original β prior. They help explain to some extent why our estimates of ρ are unlikely to rise too far beyond these values and sufficiently offset the increase in β.

The misidentification we observe in the MRF is also a real world problem. It is difficult to identify the three decisions that a central bank makes based solely on the observation of one response variable, the nominal interest rate. This is because three decisions are made which could in fact be counteracting each-other. For example, a central bank may decide to increase its responsiveness

[27] IT adoption dates used by Mello and Moccero (2007) are the same as we use. Their Post-IT sample ends in February 2006.

to inflation but to do so in a more flexible way, i.e. more smoothly. The result could observably be the same as what they had previously been doing. When β is effectively fixed, both decisions are estimated through the parameter ρ and the central banks actual preferences are very difficult to determine. To better understand our estimates, we simulate the whole model´s response to an inflation shock in Section 6.

6 Estimation Results for NITers

We employ seven Latin American NITers to estimate the DSGE model: Bolivia, Costa Rica, Guatemala, Honduras, Nicaragua, Paraguay, and Uruguay. Appendix B Tables 6 (a,b) display the mean posterior estimates and 90 percent confidence intervals for the NITers. Appendix B Figure 5 displays the prior and posterior distributions.

Consistent with the findings of McMenamin (2008), we estimate that the NITers exhibit similar persistence and accordingly similar weights on forward looking inflation expectations as the ITers during the Post sample period. This is despite the fact that NITers generally exhibit much higher inflation persistence estimates than the ITers over the Pre (A) sample; Bolivia, Costa Rica and Guatemala in particular display very high inflation persistence for this sample. Estimates of δ in the Pre (B) sample indicate that the credibility of NIT central banks improved markedly over this time; only Guatemala and Uruguay exhibit δ estimates less than 0.71. For the Post period, five of the seven NITers exhibit an increase in the weight on forward looking inflation expectations, these δ estimates increase to approximately the same Post-IT values as those exhibited by the ITers. Honduras is the only NITer to exhibit an increase in inflation persistence in the Post sample relative to Pre sample estimates; inflation expectations in Nicaragua are estimated to have been unchanged.

The NITers´ estimates of λ and ϕ closely mirror their respective priors, we are uncertain of their explanatory value. As we found for the ITers, the parameter ϕ is increased for all NIT countries throughout the sample, except for Bolivia. The NIT estimates of μ again range widely.

We are most interested in estimates of central bank behavior. The NITers posterior estimates of β and γ closely mirror their priors. Despite this, estimates of central bank responsiveness to inflation gradually increase throughout the sample. Estimates of ρ again seem to explain the responsiveness of the NIT central banks to inflation and output. We estimate that the NITer central banks engage in greater interest rate smoothing than the IT central banks in each sample. As such, given the similarities of the ITers and NITers β estimates, it appears that IT central banks have been consistently more aggressive in their responsiveness to inflation fluctuations even before IT was adopted. Under IT this trend continues.

It is difficult to determine if the ITers are more aggressive in responding to inflation than the NITers by observing only the mean point estimates. This is because of the interaction between the parameters of the model. Consequently, we conduct a simulation to determine how the model as a whole estimates the central banks' responses to an inflationary shock.

7 Impulse Response Functions

7.1 Methodology

We use the mean posterior estimates of the previous sections to simulate impulse response functions (IRFs) to a unit inflationary shock through an exogenous shock variable (s) in the AS equation. Because we have estimated very low inflation persistence, particularly in the Post-IT period, we simulate an exogenous inflationary shock that exhibits persistence. We do this by specifying s as an AR(1) function where θ is equal to 0.4. The benefit of doing this is that we may better simulate a central bank´s response to a persistent shock and better replicate the stylized facts of persistence. The baseline model is adjusted for the simulation as shown below:

$$\pi_t = \delta E_t \pi_{t+1} + (1-\delta)\pi_{t-1} + \lambda y_t + s_t \quad (7)$$
$$y_t = \mu E_t y_{t+1} + (1-\mu) y_{t-1} - \phi(r_t - E_t \pi_{t+1}) + \varepsilon_{IS,t} \quad (8)$$
$$r_t = \rho r_{t-1} + (1-\rho)[\beta(\pi_{t+i} - \overline{\pi}) + \gamma y_{t+i}] + \varepsilon_{MP,t} \quad (9)$$
$$s_t = \theta s_{t-1} + \varepsilon_{AS,t} \quad (10)$$

We conduct simulations for each country in each sample period.[28] This experiment allows one to see how the model as a whole describes the movement of the three dependent variables in reaction to an inflationary shock in a dynamic setting. This is advantageous as it illustrates how the variables themselves change as the parameter estimates interact with each other.

In addition to simulating the IRFs, we also perform a test for the Taylor principle. The Taylor principle explains that in order to successfully reduce inflation, the nominal interest rate must be increased by more than a given inflation shock, i.e. the real interest rate must move. Our test is a simple subtraction of the nominal interest rate (r_t) from the inflation rate (i_t) over eight quarters from when inflation first responds to the shock. If χ is greater than zero then the Taylor principle is achieved, if χ is less than zero it is not.

$$\text{Taylor Principle:} \quad \chi > 0$$

$$\text{Where}: \chi = \sum_{t=1}^{8} (r_t - \pi_t) \quad (11)$$

[28] We present only those estimates generated with the original β prior of 1.5, where i=-1 in Equation (3). We do not display IRF results for the estimates of Brazil and Peru generated with the extended AS equation.

7.2 Simulation Results

7.2.1 Taylor Principle Test

The results of the Taylor principle test for the ITers are displayed in Table 1. We shall discuss these as we describe the IRFs of each ITer.

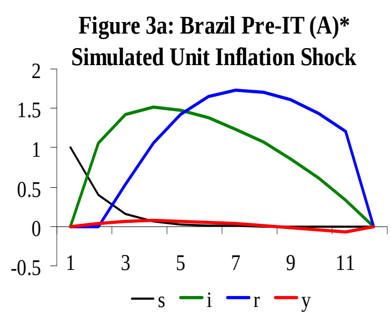
Table 1: Taylor Principle Test for ITers

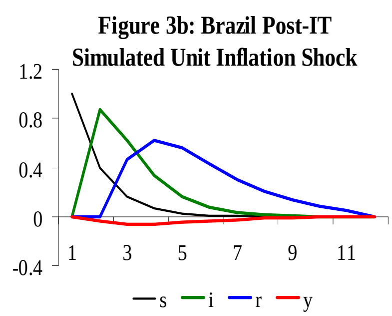
	Pre-IT (A)	Pre-IT (A)*	Pre-IT (B)	Transition	Post-IT
Brazil	13.18	-0.31	5.47	-	0.62
Chile	0.23	-	0.62	0.78	0.93
Colombia	0.08	-	0.77	-	1.02
Mexico	-5.03	-	-2.89	0.73	1.02
Peru	-2.30	-1.89	0.70	-	1.05
Average	1.23	-1.10	0.93	0.76	0.93

Source: Authors´ estimates

7.2.2 IT Impulse Response Functions

Brazil





* Excludes high inflation period >100% p.a. (1983q1, 1994q3)
Source: Authors´ estimates

Figures 3 (a,b) depict the IRFs of a unit inflationary shock (s) using the posterior estimates for Brazil.[29]

In the Pre-IT (A)* period the model is clearly unstable. Brazil's inflation response to the shock is large and persistent. Had we not imposed a terminal condition that all variables must converge to zero in the twelfth period, inflation would explode indefinitely. High inflation persistence illustrates predominantly backward looking inflation expectations in Brazil during this period. Although chronic high inflation has been excluded from the sample estimates, price and

[29] We use the Pre-IT (A)* sample estimates that exclude observations where annual inflation is over 100 percent per annum.

wage indexation is still observed. In contrast, Post-IT the model is stable, 90 percent of the inflationary effects of the shock disappear after seven quarters.

The policy responses of the Pre-IT (A)* and Post-IT samples are very different.[30] For the Pre-IT (A)* sample, because of high inflation persistence, the policy response is far more prolonged. It lasts the whole simulation and peaks in the seventh period. Under IT, the policy response peaks after only five periods.

For the Pre-IT (A)* simulation one observes a temporary increase in output because of the reduction in the real interest rate. This movement is reversed from the eighth quarter. Post-IT, the real interest rate is increased and the output gap becomes negative in the first half of the simulation.

The results of the Taylor principle test in Table 1 describe the Central Bank of Brazil´s responsiveness to inflation. For both Pre-IT (A) and (B) periods, the Central Bank was extremely responsive to inflation. However, for those years outside high inflation, the Central Bank was much less aggressive and was not following the Taylor principle; χ is calculated as -0.31. Post-IT, χ is calculated as 0.62 and as such the Central Bank is estimated to adhere to the Taylor principle.

The Central Bank of Brazil is estimated to be the least hawkish of the ITers Post-IT. Accordingly, Brazil did not achieve its inflation target between 2002-3.

Chile

Figure 4a: Chile Pre-IT (A)
Simulated Unit Inflation Shock

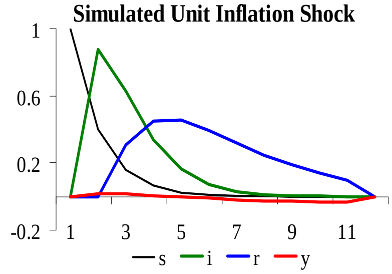
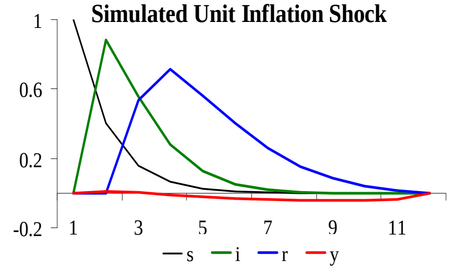


Figure 4b: Chile Post-IT
Simulated Unit Inflation Shock



Source: Authors´ estimates

Figures 4 (a,b) show that the IRFs of Chile are stable in each period. A feature of both response functions is that the inflationary effects of the unit shock are reduced quickly. In both periods the effect of the shock on inflation subsides by the seventh quarter. The lack of inflation persistence reflects the predominantly forward looking nature of inflation expectations.

The most notable difference between the two simulations is the Central Bank of Chile's policy response. Under IT, the Central Bank's initial reaction to the inflation shock is more hawkish than it is for the Pre-IT (A) sample. Under IT

[30] Because we specify lagged inflation in the MRF we do not simulate a policy response until one period after the inflation response.

the nominal interest rate peaks in the fourth quarter at 0.77 percent, whereas in the Pre-IT (A) sample it peaks in the fifth quarter at 0.45. The policy response is more prolonged Pre-IT (A).

Another difference exists between the Pre-IT (A) and Post-IT output responses. In the Pre-IT (A) sample, output temporarily rises as inflation expectations exceed the policy change and the real interest rate falls. In the Post-IT sample, output becomes negative soon after the policy response occurs.

Table 1 shows that in Chile the Taylor principle has been followed in all sample periods. This may well have contributed to the low level of inflation persistence exhibited before IT was adopted. The responsiveness of the Central Bank has become consistently more aggressive in each sample period, and is most hawkish under IT.

Colombia

Figure 5a: Colombia Post-IT Simulated Unit Inflation Shock

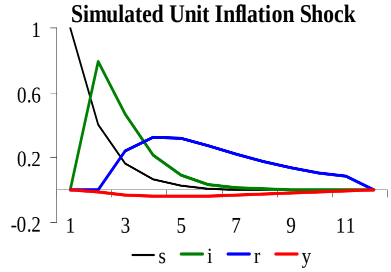
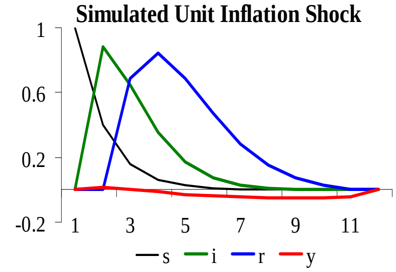


Figure 5b: Colombia Post-IT Simulated Unit Inflation Shock

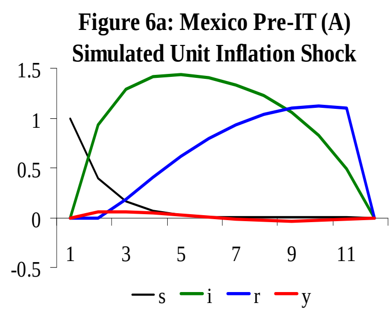


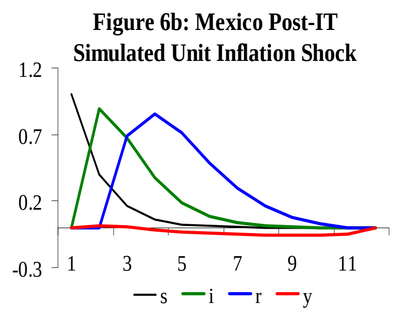
Source: Authors´ estimates

Figures 5 (a,b) show the IRFs of a unit shock to inflation using Colombia's Pre-IT (A) and Post-IT posterior estimates. In each sample period the model is stable. The IRFs describe low inflation persistence in both samples. Post-IT, the inflationary effect of the shock persists for slightly longer than in the Pre-IT (A) sample. The Central Bank of Colombia appears to possess substantial credibility in both periods but has not benefited from the adoption of IT in this respect.

The policy response for each period is very different. Under IT, Colombia is much more aggressive in its initial response to the inflation shock than it is in the Pre-IT (A) sample. Post-IT, the interest rate is increased to 0.84 percent in the fourth quarter, whereas Pre-IT (A) it is raised to only 0.33. Table 1 shows that, like Chile, much of the increase in the Central Bank of Colombia's responsiveness had already occurred prior to IT adoption. We calculate the Taylor principle test for the Pre-IT (A) sample at 0.08, this barely satisfies the Taylor principle. Pre-IT (B), χ is much higher at 0.77. Under IT the Central Bank is more hawkish and χ is calculated at 1.02. Despite the Central Bank of Colombia being most responsive to inflation Post-IT, it does not appear to have achieved any credibility gain in terms of reduced inflation persistence. This may however reflect the converging inflation target and disinflation exhibited by Colombia over the Post-IT sample (see Marquez 2004, and McMenamin 2008).

Mexico





Source: Authors´ estimates

Figures 6 (a,b) show the IRFs for Mexico. The difference between the Pre-IT (A) and Post-IT simulations is dramatic. Primarily the model is not stable in the Pre-IT (A) sample but it is so under IT. Pre-IT, inflation is very responsive to the unit shock and is very persistent. The inflationary effects last the length of the simulation in comparison to only eight quarters under IT.

The Central Bank of Mexico's response to the inflation shock is much more decisive under IT than it is Pre-IT (A). Pre-IT (A), the nominal interest rate increases until the eleventh quarter; it converges to zero in the twelfth quarter to satisfy the terminal condition. In contrast, under IT the Central Bank of Mexico´s response peaks in the fourth quarter at 0.86 percent and is complete by the tenth.

In the first half of the Pre-IT (A) simulation the output gap is positive, it becomes negative from the sixth quarter onward. Under IT, the output response is negative and marginally more severe than it is Pre-IT (A). This is due to the larger policy response and lower inflation exhibited under IT. We do not attach a great amount of weight to such differences in output responses because of the poor identification of the parameters ϕ and γ.

Table 1 shows that Mexico was not following the Taylor principle in either of the Pre-IT sample periods. However, in the Transition period the Taylor principle test value χ is increased to 0.73. As a fully-fledged ITer the Central Bank becomes even more hawkish; χ is calculated at 1.02.

Peru

Figure 7a: Peru Pre-IT (A)*
Simulated Unit Inflation Shock

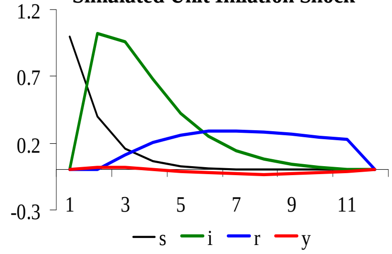
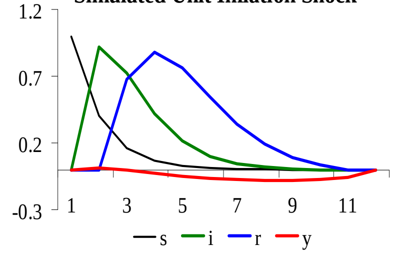


Figure 7b: Peru Post-IT
Simulated Unit Inflation Shock



* Excludes high inflation period >100% p.a.(1988q1, 1991q2)
Source: Authors´ estimates

Figure 7a shows that in Peru, the inflation response to the supply shock lasts a similar length of time in both periods but is much more severe Pre-IT (A)*.

Using the Pre-IT (A)* sample estimates, the Central Bank of Peru´s policy response to the shock lasts the full simulation. However, the nominal interest rate only exceeds the inflation rate after the inflation response effectively subsides. In contrast, Post-IT the response is large and prompt, the nominal interest rate reaches 0.88 percent in the fourth quarter, over twice that exhibited Pre-IT (A)*.

Table 1 shows that early in the sample the Central Bank of Peru was not following the Taylor principle (Pre-IT (A) nor Pre-IT (A)*). During the eight years prior to IT adoption the Central Bank becomes much more aggressive; χ is estimated as 0.70 in the Pre-IT (B) period. Post-IT, the Central Bank is more responsive and the Taylor principle is easily satisfied; χ is calculated at 1.05.

Once again we see a dramatic improvement in the responsiveness of the Central Bank to inflation under IT. However, a substantial part of this improvement had already occurred before IT was adopted.

7.2.3 NITers Impulse Response Functions

Table 2 displays the results of the Taylor principle test for the seven NITers. We have estimated that on average, the ITers are more responsive to inflation than the NITers Post-IT. Three out of five of the ITers exhibit an estimated value of χ equal to or greater than the most responsive NIT central bank (Honduras). The Central Bank of Brazil is the least responsive to inflation of any central bank in our sample over the Post-IT period. Overall however, the difference in central bank responsiveness to inflation between the ITers and NITers is not large.

The NITers were, on average, much less responsive to inflation than the ITers in the Pre (A) sample. Pre (B) the NITers exhibit a large increase in central bank responsiveness and most became increasingly hawkish in the Post sample.

Notably, two NIT central banks (Guatemala and Paraguay) exhibit a reduction in their responsiveness to inflation in the Post-IT sample. No IT central bank exhibits this trend.[31]

Table 2: Taylor Principle Test for NITers

	Pre (A)	Pre (B)	Post
Bolivia	-4.60	0.55	0.76
Costa Rica	-5.10	0.71	0.87
Guatemala	-3.30	0.94	0.86
Honduras	-0.86	-0.67	1.02
Nicaragua	-	0.08	0.82
Paraguay	-	0.80	0.79
Uruguay	-	-2.07	0.50
Average	-3.47	0.05	0.80

Source: Authors´ estimates

8 Summary

The IRFs show that the DSGE model is stable for all countries under IT. Pre-IT, the model was unstable for Brazil, Mexico and Peru. The fundamental question is, what role has IT played?

In Brazil, the adoption of IT coincides with a steep reduction in inflation persistence. Estimates for Chile, Colombia, Mexico and Peru indicate that inflation persistence had been predominantly reduced before IT was adopted. For Chile, Colombia and Peru we actually find marginally higher inflation persistence estimates for the Post-IT samples than we do for their respective Pre-IT sample estimates.[32]

Latin American NITers have also exhibited reductions in inflation persistence throughout the sample. Our estimates have tended toward the results of McMenamin (2008) who shows that there is no significant difference between the inflation persistence of IT and NIT Latin America countries.

We have estimated that IT central banks are more aggressive toward inflation fluctuations under IT than they have been prior to IT adoption.[33] Countries that undertook a gradual adoption of IT, Chile and Mexico, are also estimated to be more hawkish after they became fully-fledged ITers. However, NITers exhibit similar increases in central bank responsiveness. Although no NIT country is estimated to follow the Taylor principle in the Pre (A) sample, in the Pre (B) sample the majority do, and in the Post sample all NITers satisfy the Taylor principle.

[31] The exception is Brazil compared to the Pre-IT periods that include hyperinflation. When we excluded high inflation periods from the Pre-IT sample, we estimated that the Central Bank of Brazil is most hawkish under IT.

[32] Chile compared to its Transition, Colombia compared to its Pre-IT (A) and (B) samples, and Peru compared to its Pre-IT (B) sample estimates.

[33] The exception is Brazil during hyperinflation.

We do not support findings which show that IT central banks respond less aggressively to offset inflation as a result of credibility gains (Corbo et al. 2002, Neumann and von Hagen 2002, Pétursson 2004). We find that although IT central banks appear to be, if anything, slightly more aggressive than NIT central banks in combatting inflation, there exists no obvious difference between the inflation persistence exhibited by either group. As yet, we detect little evidence that inflation expectations are more anchored in Latin American IT countries than in NIT countries.

The fact that both IT and NIT countries have become increasingly hawkish suggests that a fortuitous international inflationary environment (see McMenamin 2008) is not alone responsible for improved inflation performances. We have not determined whether increased central bank aggression improved inflation performances or whether central banks merely took advantage of the low inflation environment to adopt better monetary rules, "locking in" inflationary gains. What we have found is that price stability in Latin America coincides with more inflation averse monetary policy in both IT and NIT countries.

Our results better align with those of Cecchetti and Ehrmann (2000) who find evidence that IT and NIT countries alike increased their aversion to inflation variability during the 1990s. Cecchetti, Flores-Lagunes and Krause (2006) employ a structural macro-model with AD and AS equations. They find that more efficient monetary policy has been the driving force behind improved stability in industrial and developing countries. In twenty of the twenty-one countries that experienced more stable macroeconomic outcomes, better policy accounted for over 80 percent of the measured gain.

Mello and Moccero (2007) suggest that the conduct of monetary policy has been effective in anchoring inflation expectations in four Latin American IT countries. By employing a control group of NITers we have shown that this phenomenon has not been unique to Latin American countries that adopted IT as their monetary policy framework.

9 Appendix

9.1 Appendix A

Using annual and quarterly data between 1978 and 1994 we use a standard AR(1) model to estimate the explanatory power of annual fiscal balances as a percentage of annual GDP (g_t^A) to the annual sum of quarterly fiscal balances as a percentage of annual GDP (g_t^Q). This process is described by Equations (14) (15) and (16).

$$g_t^Q = c + \varphi g_t^A + \varepsilon_t \quad (12)$$

$$\text{where } g_t^Q = \left(\frac{\sum_{i=1}^{4} G_{i(t)}^Q}{GDP_t} \right) \times 100 \quad (13)$$

$$\text{and } g_t^A = \left(\frac{G_t^A}{GDP_t} \right) \times 100 \quad (14)$$

Where $G_{i(t)}^Q$ is quarterly fiscal balances at quarter i in year t, GDP_t is annual GDP at year t, G_t^A is annual fiscal balances at year t, and ε_t is a stochastic error term. The estimated coefficients for Equation (14) are shown below:

Estimates for Equation (14)

Variable	Coefficient	t-statistic
c	0.367	
	(0.391)	0.985
φ	0.099	
	(0.063)	1.571

Source: Authors´ estimates
Standard errors in parentheses

Using the AR(1) model estimates we forecast the period from 1978 to 1994. We may then attain values of g_t^Q for missing years 1986, 1988 and 1989. From these we calculate respective estimates for $\sum_{i=1}^{4} G_i^Q$. Thereafter, we use a quadratic-match sum frequency converter to calculate the missing estimates of $G_{i(t)}^Q$.[34]

The data we use to estimate the extended model are quarterly fiscal balances as a percentage of quarterly GDP (g_t).

$$g_t = \frac{G_t^Q}{GDP_t^Q} \times 100 \quad (15)$$

[34] Using Eviews.

9.2 Appendix B: Model Application

The likelihood function can be computed by constructing a Kalman filter system of the following form:

$$\begin{aligned} \text{State equation} \quad &: \quad X_{t+1} = \Gamma_1 X_t + \Gamma_2 \varepsilon_{t+1} && (16) \\ \text{Measurement equation} \quad &: \quad Y_t = G X_t + H\nu && (17) \end{aligned}$$

For our New Keynesian model there exists a solution of the form:

$$X_{t+1} = \Gamma_1 X_t + \Gamma_2 \epsilon_{t+1} \tag{18}$$

To derive the solution we must first rewrite our model in matrix form:

$$AX_t = BE_t X_{t+1} + CX_{t-1} + \epsilon_t \tag{19}$$

This gives:

$$\begin{bmatrix} 1 & -\lambda & 0 \\ 0 & 1 & \varphi \\ 0 & -(1-\rho)\gamma & 1 \end{bmatrix} \begin{bmatrix} \pi_t \\ y_t \\ r_t \end{bmatrix} = \begin{bmatrix} \delta & 0 & 0 \\ \phi & \mu & 0 \\ (1-\rho)\beta & 0 & 0 \end{bmatrix} E_t \begin{bmatrix} \pi_{t+1} \\ y_{t+1} \\ r_{t+1} \end{bmatrix} + \begin{bmatrix} 1-\rho & 0 & 0 \\ 0 & 1-\mu & 0 \\ 0 & 0 & \rho \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ y_{t-1} \\ r_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{AS,t} \\ \epsilon_{IS,t} \\ \epsilon_{MP,t} \end{bmatrix}$$

We use the method of undetermined coefficients, and substitute Equation (1) into Equation (2) to get:

$$AX_t = BE_t[\Gamma_1 X_t + \Gamma_2 \epsilon_{t+1}] + CX_{t-1} + \epsilon_t \tag{20}$$

Rearranging and given that under rational expectations $E_t \epsilon_{t+1} = 0$:

$$[A - B\Gamma_1]X_t = CX_{t-1} + \epsilon_t \tag{21}$$

We pre-multiply by $[A - B\Gamma_1]^{-1}$ to obtain:

$$\begin{aligned} \Gamma_1 &= [A - B\Gamma_1]^{-1} C \\ &= \left[\begin{bmatrix} 1 & -\lambda & 0 \\ 0 & 1 & \varphi \\ 0 & -(1-\rho)\gamma & 1 \end{bmatrix} - \begin{bmatrix} \delta & 0 & 0 \\ \phi & \mu & 0 \\ (1-\rho)\beta & 0 & 0 \end{bmatrix} \Gamma_1 \right]^{-1} \begin{bmatrix} 1-\rho & 0 & 0 \\ 0 & 1-\mu & 0 \\ 0 & 0 & \rho \end{bmatrix} \end{aligned}$$

$$\begin{aligned} \Gamma_2 &= [A - B\Gamma_1]^{-1} \\ &= \left[\begin{bmatrix} 1 & -\lambda & 0 \\ 0 & 1 & \varphi \\ 0 & -(1-\rho)\gamma & 1 \end{bmatrix} - \begin{bmatrix} \delta & 0 & 0 \\ \phi & \mu & 0 \\ (1-\rho)\beta & 0 & 0 \end{bmatrix} \Gamma_1 \right]^{-1} \end{aligned}$$

Therefore our model in the form of Equation (1) is:

$$\begin{bmatrix} \pi_{t+1} \\ y_{t+1} \\ r_{t+1} \end{bmatrix} = \left[\begin{bmatrix} 1 & -\lambda & 0 \\ 0 & 1 & \varphi \\ 0 & -(1-\rho)\gamma & 1 \end{bmatrix} - \begin{bmatrix} \delta & 0 & 0 \\ \phi & \mu & 0 \\ (1-\rho)\beta & 0 & 0 \end{bmatrix} \Gamma_1 \right]^{-1} \begin{bmatrix} 1-\rho & 0 & 0 \\ 0 & 1-\mu & 0 \\ 0 & 0 & \rho \end{bmatrix} \begin{bmatrix} \pi_t \\ y_t \\ r_t \end{bmatrix}$$
$$+ \left[\begin{bmatrix} 1 & -\lambda & 0 \\ 0 & 1 & \varphi \\ 0 & -(1-\rho)\gamma & 1 \end{bmatrix} - \begin{bmatrix} \delta & 0 & 0 \\ \phi & \mu & 0 \\ (1-\rho)\beta & 0 & 0 \end{bmatrix} \Gamma_1 \right]^{-1} \begin{bmatrix} \epsilon_{AS,t} \\ \epsilon_{IS,t} \\ \epsilon_{MP,t} \end{bmatrix}$$

9.3 Appendix B: Tables

Appendix B Table 1: Additional Data

Country	y	r	i	From	Until	IT Adoption
Brazil	GDP (quarterly)	Money Market Rate	CPI (National)	1980Q2	2006Q3	1999Q3
Chile	GDP (quarterly)	Deposit Rate	CPI (Santiago all inclusive)	1980Q1	2006Q3	1999Q4
Colombia	GDP**	Discount Rate	CPI (Low and middle income urban)	1980Q1	2006Q1	1999Q4
Mexico	GDP (quarterly)	Bankers' Acceptances	CPI (All country communications and services)	1980Q1	2006Q3	2001Q1
Peru	GDP (quarterly)	Discount Rate	CPI (Lima all inclusive)	1980Q1	2006Q3	2002Q1
Bolivia	GDP (annual)	Deposit Rates	CPI (National)	1999Q4	2006Q4	1999Q4
Costa Rica	GDP (annual)	Discount Rate Commercial	CPI (San Jose-Low & Medium Income)	1980Q1	2006Q4	1999Q4
Guatemala	GDP (annual)	Lending Rate	CPI (Low and Middle Income)	1981Q2	2005Q4	1999Q4
Honduras	GDP (annual)	Lending Rate	CPI (National)	1982Q1	2005Q4	1999Q4
Nicaragua	GDP (annual)	Lending Rate	CPI (National)	1991Q3	2005Q4	1999Q4
Paraguay	GDP (annual)	Money Market Rate	CPI (GT Asunctional-Workers Households)	1991Q3	2006Q4	1999Q4
Uruguay	GDP (annual)	Discount Rate	CPI (Montevideo employee's)	1981Q2	2006Q4	1999Q4

** Annual GDP data from 1980Q1 to 1993Q4, quarterly thereafter

Sources: IMF *IFS* and Truman (2003)

Appendix B Table 2: Priors

	Domain	Density	Mean	Variance
δ	[0,1]	Beta	0.50	0.10
λ	$\Re$	Normal	0.01	0.01
μ	[0,1]	Beta	0.50	0.20
ϕ	$\Re$	Normal	0.01	0.01
ρ	[0,1]	Beta	0.50	0.20
β	$\Re$	Normal	1.50	0.20
γ	$\Re$	Normal	0.50	0.20
ϵ_{AS}	$\Re^+$	Inv. Gamma	5.00	1.00
ε_{IS}	$\Re^+$	Inv. Gamma	5.00	4.00
ε_{MP}	$\Re^+$	Inv. Gamma	7.00	2.00

Appendix B Table 3a: IT Baseline Model Estimates

	Brazil			Colombia			Peru		
	Pre-IT (A)	Pre-IT (B)	Post-IT	Pre-IT (A)	Pre-IT (B)	Post-IT	Pre-IT (A)	Pre-IT (B)	Post-IT
δ	0.50	0.47	0.76	0.84	0.77	0.75	0.57	0.76	0.72
	(0.48, 0.52)	(0.44, 0.49)	(0.66, 0.85)	(0.78, 0.90)	(0.67, 0.85)	(0.65, 0.85)	(0.53, 0.61)	(0.67, 0.86)	(0.61, 0.83)
λ	0.07	0.06	0.01	0.01	0.01	0.01	0.00	0.01	0.01
	(0.07, 0.07)	(0.06, 0.06)	(0.00, 0.02)	(0.00, 0.03)	(0.00, 0.01)	(0.00, 0.02)	(0.00, 0.01)	(0.00, 0.01)	(0.00, 0.02)
μ	0.13	0.05	0.85	0.63	0.12	0.10	0.16	0.12	0.24
	(0.04, 0.24)	(0.02, 0.09)	(0.75, 0.97)	(0.57, 0.69)	(0.03, 0.20)	(0.02, 0.18)	(0.02, 0.29)	(0.02, 0.23)	(0.01, 0.73)
ϕ	0.00	0.01	0.02	0.01	0.02	0.02	0.00	0.02	0.02
	(0.00, 0.00)	(0.00, 0.01)	(0.00, 0.03)	(0.00, 0.02)	(0.01, 0.03)	(0.01, 0.03)	(0.00, 0.00)	(0.01, 0.03)	(0.00, 0.03)
ρ	0.23	0.46	0.63	0.79	0.61	0.50	0.74	0.66	0.52
	(0.22, 0.24)	(0.39, 0.55)	(0.38, 0.94)	(0.74, 0.85)	(0.41, 0.87)	(0.20, 0.81)	(0.74, 0.74)	(0.46, 0.88)	(0.22, 0.82)
β	2.71	1.90	1.47	1.46	1.50	1.54	0.89	1.50	1.53
	(2.63, 2.77)	(1.62, 2.18)	(1.15, 1.78)	(1.26, 1.63)	(1.16, 1.78)	(1.21, 1.85)	(0.87, 0.90)	(1.19, 1.81)	(1.23, 1.85)
γ	0.66	0.47	0.51	0.66	0.55	0.55	0.58	0.54	0.51
	(-0.13,1.61)	(0.16, 0.74)	(0.19, 0.84)	(0.36, 0.94)	(0.31, 0.87)	(0.23, 0.86)	(0.54, 0.63)	(0.23, 0.86)	(0.22, 0.83)
ε_{AS}	11.15	14.45	2.88	2.22	2.79	2.98	32.21	2.82	3.24
	(9.97, 11.99)	(12.09, 17.07)	(2.35, 3.37)	(2.05, 2.39)	(2.34, 3.25)	(2.42, 3.50)	(31.78, 32.53)	(2.35, 3.30)	(2.59, 3.85)
ε_{IS}	2.04	3.47	1.34	0.88	1.24	1.18	1.66	1.30	1.41
	(1.48, 2.58)	(2.75, 4.17)	(1.04, 1.63)	(0.87, 0.90)	(0.99, 1.48)	(0.93, 1.42)	(1.38, 1.98)	(1.03, 1.55)	(1.04, 1.78)
ε_{MP}	91.08	124.26	3.15	2.43	3.04	3.26	134.22	3.25	3.68
	(81.9, 100.8)	(114.8, 134.8)	(2.55, 3.74)	(2.31, 2.56)	(2.49, 3.58)	(2.60, 3.87)	(132.8, 135.4)	(2.63, 3.84)	(2.83, 4.47)

Appendix B Table 3b: IT Baseline Model Estimates

	Chile				Mexico			
	Pre-IT (A)	Pre-IT(B)	Transition	Post-IT	Pre-IT (A)	Pre-IT (B)	Transition	Post-IT
δ	0.76	0.75	0.79	0.77	0.41	0.50	0.71	0.74
	(0.68, 0.84)	(0.66, 0.85)	(0.70, 0.88)	(0.68, 0.87)	(0.24, 0.59)	(0.31, 0.61)	(0.60, 0.83)	(0.65, 0.85)
λ	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01
	(0.00, 0.01)	(0.00, 0.01)	(0.00, 0.01)	(0.00, 0.02)	(0.00, 0.03)	(0.00, 0.03)	(0.00, 0.02)	(0.00, 0.02)
μ	0.09	0.09	0.10	0.11	0.69	0.84	0.20	0.15
	(0.01, 0.17)	(0.01, 0.16)	(0.01, 0.18)	(0.01, 0.18)	(0.60, 0.77)	(0.73, 0.95)	(0.01, 0.49)	(0.02, 0.25)
ϕ	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02
	(0.01, 0.03)	(0.01, 0.03)	(0.01, 0.03)	(0.00, 0.03)	(0.00, 0.02)	(0.00, 0.02)	(0.01, 0.03)	(0.01, 0.03)
ρ	0.75	0.66	0.58	0.53	0.84	0.79	0.71	0.50
	(0.58, 0.93)	(0.43, 0.90)	(0.29, 0.86)	(0.24, 0.83)	(0.74, 0.95)	(0.63, 0.95)	(0.54, 0.90)	(0.21, 0.82)
β	1.28	1.44	1.51	1.54	1.19	1.24	1.54	1.53
	(0.91, 1.70)	(1.13, 1.79)	(1.19, 1.83)	(1.24, 1.86)	(1.00, 1.46)	(1.00, 1.52)	(1.22, 1.84)	(1.19, 1.84)
γ	0.61	0.57	0.52	0.52	0.58	0.55	0.56	0.52
	(0.30, 0.88)	(0.27, 0.91)	(0.23, 0.84)	(0.20, 0.83)	(0.26, 0.92)	(0.25, 0.88)	(0.24, 0.88)	(0.22, 0.85)
ε_{AS}	2.93	3.09	2.72	2.82	3.15	3.45	3.36	3.08
	(2.46, 3.35)	(2.54, 3.59)	(2.24, 3.16)	(2.34, 3.31)	(2.62, 3.69)	(2.83, 4.05)	(2.71, 4.00)	(2.50, 3.65)
ε_{IS}	1.14	1.12	1.19	1.23	1.03	1.25	1.42	1.32
	(0.94, 1.34)	(0.89, 1.32)	(0.97, 1.42)	(0.96, 1.47)	(0.87, 1.28)	(0.98, 1.50)	(1.08, 1.73)	(1.02, 1.63)
ε_{MP}	3.59	3.83	3.18	3.17	3.76	4.65	3.85	3.38
	(3.02, 4.20)	(3.11, 4.52)	(2.64, 3.77)	(2.53, 3.73)	(3.29, 4.31)	(3.74, 5.51)	(3.05, 4.67)	(2.69, 4.09)

Appendix B Table 4: Extensions Brazil and Peru Model Estimates

	Brazil			Peru		
	Pre-IT (A)*	Pre-IT (A)^G	Post-IT^G	Pre-IT (A)*	Pre-IT (A)^G	Post-IT^G
δ	0.46	0.53	0.76	0.65	0.59	0.65
	(0.28, 0.69)	(0.52, 0.54)	(0.67, 0.84)	(0.65, 0.65)	(0.57, 0.61)	(0.28, 0.82)
λ	0.00	-0.01	0.01	0.00	-0.01	0.01
	(-0.01, 0.02)	(-0.01, -0.01)	(0.00, 0.02)	(0.00, 0.00)	(-0.02, 0.00)	(0.00, 0.02)
α	-	0.07	0.01	-	0.07	0.01
	-	(0.07, 0.07)	(0.00, 0.02)	-	(-0.07, 0.07)	(0.00, 0.02)
μ	0.15	0.97	0.84	0.54	0.36	0.11
	(0.03, 0.25)	(0.97, 0.97)	(0.73, 0.96)	(0.51, 0.60)	(0.29, 0.41)	(0.02, 0.20)
ϕ	0.02	0.00	0.02	0.01	0.00	0.02
	(0.00, 0.03)	(0.00, 0.00)	(0.00, 0.03)	(0.00, 0.01)	(0.00, 0.00)	(0.01, 0.03)
ρ	0.63	0.21	0.57	0.92	0.10	0.50
	(0.40, 0.96)	(0.21, 0.22)	(0.26, 0.89)	(0.88, 0.96)	(0.06, 0.14)	(0.25, 0.81)
β	1.34	2.75	1.50	1.35	0.94	1.53
	(0.87, 1.73)	(2.75, 2.75)	(1.19, 1.83)	(1.35, 1.35)	(0.87, 1.00)	(1.24, 1.83)
ν	-	0.97	0.55	-	0.99	0.40
	-	(0.97, 0.98)	(0.28, 0.82)	-	(0.99, 0.99)	(0.13, 0.66)
γ	0.52	0.31	0.50	0.53	0.79	0.50
	(0.18, 0.82)	(0.03, 0.63)	(0.16, 0.82)	(0.53, 0.53)	(0.72, 0.90)	(0.21, 0.84)
ε_{AS}	3.99	19.69	2.88	3.65	19.05	3.21
	(3.12, 4.76)	(19.35, 20.46)	(2.36, 3.35)	(3.19, 4.03)	(17.78, 20.07)	(2.64, 3.82)
ε_{IS}	1.68	21.55	1.34	1.23	1.39	1.37
	(1.33, 1.98)	(20.97, 22.25)	(1.05, 1.62)	(1.11, 1.42)	(1.13, 1.63)	(1.05, 1.71)
ε_{MP}	12.67	134.48	3.13	3.01	30.37	3.68
	(10.75, 14.75)	(134.28, 135.38)	(2.50, 3.70)	(2.69, 3.34)	(28.49, 32.08)	(2.84, 4.41)
ε_G	-	6.74	4.69	-	3.53	4.18
	-	(5.94, 7.81)	(3.95, 5.51)	-	(3.15, 4.10)	(3.28, 5.04)

Appendix B Table 5a: Sensitivity to Priors ($\beta = 3$)

	Brazil			Colombia			Peru		
	Pre-IT (A)	Pre-IT (B)	Post-IT	Pre-IT (A)	Pre-IT (B)	Post-IT	Pre-IT (A)	Pre-IT (B)	Post-IT
δ	0.57	0.55	0.72	0.83	0.76	0.75	0.57	0.76	0.71
	(0.52, 0.62)	(0.53, 0.57)	(0.62, 0.87)	(0.77, 0.90)	(0.67, 0.86)	(0.65, 0.84)	(0.55, 0.59)	(0.67, 0.86)	(0.59, 0.83)
λ	0.01	-0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
	(0.01, 0.01)	(-0.02, 0.00)	(0.00, 0.03)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.01)	(0.00, 0.02)	(0.00, 0.03)
μ	0.03	0.66	0.85	0.05	0.11	0.09	0.36	0.12	0.21
	(0.00, 0.05)	(0.56, 0.75)	(0.73, 0.96)	(0.01, 0.08)	(0.01, 0.20)	(0.01, 0.17)	(0.30, 0.40)	(0.02, 0.22)	(0.01, 0.69)
ϕ	0.00	0.00	0.02	0.02	0.02	0.02	0.00	0.02	0.02
	(0.00, 0.00)	(0.00, 0.00)	(0.00, 0.03)	(0.01, 0.03)	(0.01, 0.03)	(0.00, 0.03)	(0.00, 0.01)	(0.01, 0.03)	(0.00, 0.03)
ρ	0.19	0.39	0.80	0.87	0.75	0.56	0.46	0.79	0.58
	(0.17, 0.20)	(0.32, 0.46)	(0.65, 0.97)	(0.8, 0.95)	(0.60, 0.91)	(0.24, 0.84)	(0.42, 0.51)	(0.65, 0.93)	(0.30, 0.87)
β	4.14	3.24	2.97	2.98	2.98	2.99	1.73	2.98	2.99
	(4.14, 4.14)	(2.95, 3.57)	(2.7, 3.31)	(2.67, 3.31)	(2.66, 3.32)	(2.66, 3.31)	(1.73, 1.79)	(2.65, 3.31)	(2.65, 3.32)
γ	0.63	0.57	0.51	0.53	0.53	0.54	0.62	0.50	0.50
	(0.30,0.94)	(0.53, 0.60)	(0.18, 0.84)	(0.17, 0.86)	(0.21, 0.86)	(0.21, 0.84)	(0.31, 0.99)	(0.18, 0.80)	(0.18, 0.82)
ε_{AS}	23.73	13.81	2.85	2.24	2.80	2.95	32.37	2.84	3.21
	(19.54, 28.29)	(12.09, 17.07)	(2.35, 3.31)	(2.05, 2.43)	(2.34, 3.26)	(2.40, 3.47)	(32.17, 32.53)	(2.36, 3.34)	(2.57, 3.84)
ε_{IS}	33.44	1.60	1.30	0.91	1.23	1.19	1.62	1.31	1.39
	(32.17, 34.34)	(1.26, 1.96)	(1.02, 1.58)	(0.87, 0.97)	(1.00, 1.48)	(0.93, 1.44)	(1.40, 1.83)	(1.02, 1.56)	(1.03, 1.75)
ε_{MP}	135.37	135.03	3.12	2.34	3.12	3.28	53.74	3.30	3.73
	(134.4, 135.4)	(134.6, 135.4)	(2.53, 3.71)	(2.31, 3.39)	(2.53, 3.73)	(2.60, 3.89)	(49.34, 59.32)	(2.69, 3.92)	(2.85, 4.56)

Appendix B Table 5b: Sensitivity to Priors ($\beta = 3$)

	Chile				Mexico			
	Pre-IT (A)	Pre-IT(B)	Transition	Post-IT	Pre-IT (A)	Pre-IT (B)	Transition	Post-IT
δ	0.76	0.75	0.78	0.77	0.52	0.56	0.71	0.75
	(0.67, 0.84)	(0.65, 0.84)	(0.69, 0.86)	(0.67, 0.86)	(0.43, 0.61)	(0.50, 0.61)	(0.59, 0.82)	(0.64, 0.84)
λ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.00, 0.01)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.03)	(0.00, 0.03)	(0.00, 0.02)	(0.00, 0.01)	(0.00, 0.03)
μ	0.09	0.09	0.10	0.11	0.70	0.85	0.12	0.40
	(0.01, 0.17)	(0.01, 0.16)	(0.02, 0.20)	(0.02, 0.19)	(0.60, 0.79)	(0.75, 0.96)	(0.02, 0.22)	(0.02, 0.89)
ϕ	0.02	0.02	0.02	0.02	0.00	0.00	0.02	0.02
	(0.01, 0.03)	(0.00, 0.03)	(0.01, 0.03)	(0.00, 0.03)	(0.00, 0.00)	(0.00, 0.01)	(0.01, 0.03)	(0.00, 0.03)
ρ	0.88	0.83	0.71	0.62	0.96	0.95	0.77	0.58
	(0.80, 0.96)	(0.71, 0.95)	(0.51, 0.92)	(0.36, 0.90)	(0.93, 0.99)	(0.91, 0.98)	(0.64, 0.92)	(0.31, 0.87)
β	2.94	2.95	2.97	2.99	2.93	2.93	2.97	2.98
	(2.59, 3.26)	(2.60, 3.27)	(2.65, 3.29)	(2.67, 3.32)	(2.60, 3.24)	(2.60, 3.27)	(2.67, 3.25)	(2.67, 3.30)
γ	0.55	0.53	0.51	0.48	0.51	0.53	0.54	0.50
	(0.23, 0.85)	(0.18, 0.84)	(0.20, 0.84)	(0.15, 0.79)	(0.20, 0.85)	(0.20, 0.86)	(0.24, 0.85)	(0.17, 0.82)
ε_{AS}	2.96	3.12	2.70	2.84	3.02	3.47	3.40	3.05
	(2.47, 3.47)	(2.54, 3.63)	(2.25, 3.12)	(2.35, 3.32)	(2.56, 3.49)	(2.83, 4.08)	(2.94, 3.92)	(2.48, 3.62)
ε_{IS}	1.13	1.12	1.18	1.23	1.04	1.28	1.43	1.36
	(0.93, 1.33)	(0.90, 1.32)	(0.96, 1.40)	(0.96, 1.48)	(0.87, 1.19)	(0.99, 1.54)	(1.15, 1.78)	(1.04, 1.71)
ε_{MP}	3.67	3.99	3.26	3.25	3.80	4.69	3.89	3.48
	(3.03, 4.31)	(3.20, 4.77)	(2.63, 3.85)	(2.53, 3.73)	(3.20, 4.39)	(3.79, 5.57)	(3.22, 4.77)	(2.73, 4.19)

Appendix B Table 6a: NIT Baseline Model Estimates

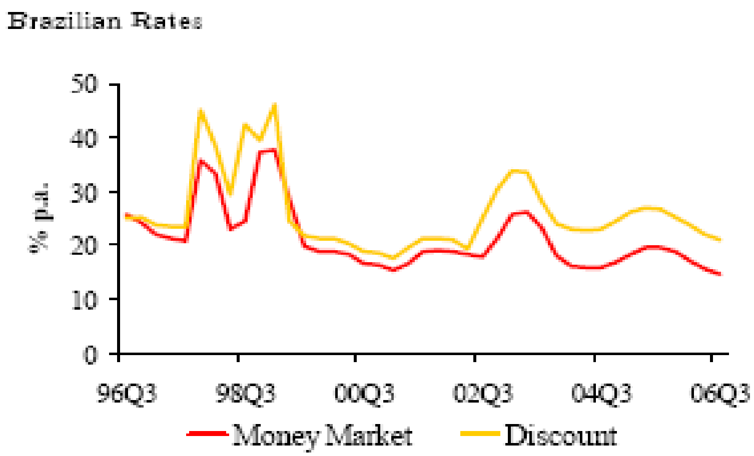
	Bolivia			Costa Rica			Guatemala		
	Pre (A)	Pre (B)	Post	Pre (A)	Pre (B)	Post	Pre (A)	Pre (B)	Post
δ	0.60	0.74	0.77	0.33	0.76	0.77	0.19	0.62	0.76
	(0.56, 0.64)	(0.65, 0.90)	(0.69, 0.87)	(0.15, 0.66)	(0.67, 0.86)	(0.69, 0.87)	(0.12, 0.26)	(0.19, 0.87)	(0.66, 0.85)
λ	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.02)	(0.01, 0.03)	(0.00, 0.01)	(0.00, 0.01)	(0.00, 0.02)	(0.01, 0.03)	(0.00, 0.02)
μ	0.79	0.86	0.88	0.66	0.09	0.10	0.83	0.92	0.89
	(0.72, 0.87)	(0.76, 0.97)	(0.79, 0.98)	(0.63, 0.70)	(0.01, 0.16)	(0.01, 0.17)	(0.76, 0.92)	(0.85, 0.99)	(0.81, 0.98)
ϕ	0.00	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.01
	(0.00, 0.00)	(0.00, 0.03)	(0.00, 0.03)	(0.00, 0.02)	(0.01, 0.03)	(0.01, 0.03)	(0.00, 0.02)	(0.00, 0.03)	(0.00, 0.03)
ρ	0.99	0.68	0.58	0.88	0.64	0.58	0.82	0.64	0.53
	(0.99, 1.00)	(0.44, 0.94)	(0.31, 0.88)	(0.83, 0.93)	(0.41, 0.89)	(0.30, 0.86)	(0.73, 0.92)	(0.39, 0.88)	(0.22, 0.83)
β	1.41	1.48	1.48	1.30	1.48	1.53	1.10	1.46	1.49
	(1.06, 1.69)	(1.12, 1.77)	(1.17, 1.81)	(1.10, 1.51)	(1.16, 1.78)	(1.22, 1.84)	(1.06, 1.16)	(1.12, 1.75)	(1.18, 1.83)
γ	0.50	0.51	0.51	0.58	0.56	0.52	0.54	0.52	0.51
	(0.17, 0.80)	(0.17, 0.81)	(0.21, 0.85)	(0.29, 0.88)	(0.25, 0.86)	(0.22, 0.83)	(0.43, 0.63)	(0.22, 0.85)	(0.19, 0.85)
ε_{AS}	31.12	2.80	2.81	2.63	2.87	2.88	2.55	2.73	2.94
	(29.66, 32.53)	(2.30, 3.27)	(2.34, 3.29)	(2.24, 2.97)	(2.37, 3.31)	(2.37, 3.40)	(2.21, 2.87)	(2.28, 3.20)	(2.39, 3.48)
ε_{IS}	0.90	1.20	1.22	0.94	1.13	1.19	0.93	1.10	1.23
	(0.87, 0.94)	(0.95, 1.44)	(0.96, 1.47)	(0.87, 1.05)	(0.91, 1.32)	(0.95, 1.42)	(0.87, 1.01)	(0.88, 1.27)	(0.97, 1.51)
ε_{MP}	4.61	2.99	3.14	2.39	3.03	3.18	2.35	3.02	3.31
	(4.07, 5.21)	(2.42, 3.49)	(2.53, 3.73)	(2.29, 2.53)	(2.46, 3.53)	(2.58, 3.76)	(2.29, 2.44)	(2.46, 3.54)	(2.64, 4.00)

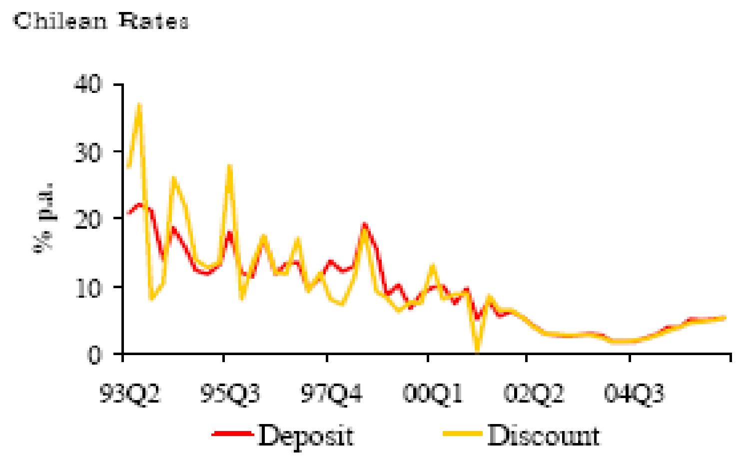
Appendix B Table 6b: NIT Baseline Model Estimates

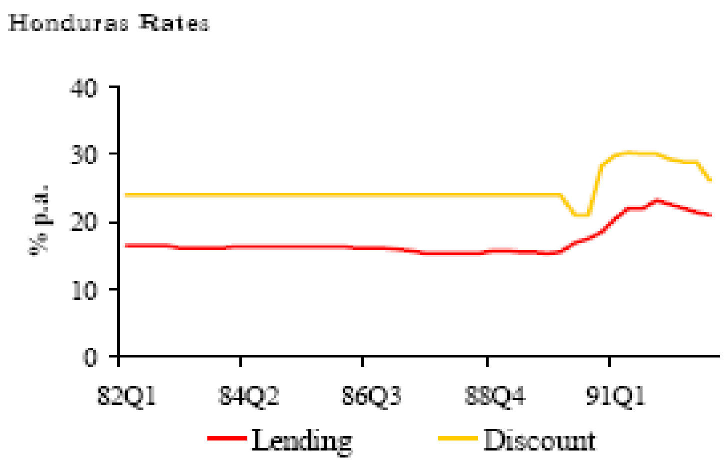
	Honduras			Nicaragua		Paraguay		Uruguay	
	Pre (A)	Pre (B)	Post	Pre (B)	Post	Pre (B)	Post	Pre (B)	Post
δ	0.73	0.71	0.67	0.75	0.75	0.75	0.76	0.24	0.73
	(0.66, 0.81)	(0.62, 0.80)	(0.25, 0.86)	(0.67, 0.85)	(0.65, 0.85)	(0.66, 0.85)	(0.67, 0.85)	(0.13, 0.33)	(0.63, 0.83)
λ	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00
	(0.01, 0.02)	(0.00, 0.01)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.02)	(0.00, 0.01)
μ	0.72	0.09	0.43	0.08	0.12	0.08	0.09	0.10	0.17
	(0.64, 0.81)	(0.01, 0.17)	(0.02, 0.90)	(0.01, 0.14)	(0.01, 0.20)	(0.01, 0.15)	(0.01, 0.17)	(0.01, 0.18)	(0.01, 0.30)
ϕ	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
	(0.00, 0.01)	(0.00, 0.03)	(0.00, 0.03)	(0.01, 0.03)	(0.01, 0.03)	(0.01, 0.03)	(0.01, 0.03)	(-0.01, 0.03)	(0.01, 0.04)
ρ	0.87	0.88	0.52	0.81	0.61	0.60	0.63	0.76	0.75
	(0.81, 0.91)	(0.80, 0.96)	(0.22, 0.84)	(0.68, 0.95)	(0.33, 0.87)	(0.37, 0.87)	(0.43, 0.87)	(0.59, 0.92)	(0.63, 0.89)
β	1.2	1.45	1.53	1.48	1.50	1.48	1.51	1.38	1.53
	(1.04, 1.37)	(1.12, 1.77)	(1.20, 1.86)	(1.17, 1.79)	(1.20, 1.84)	(1.16, 1.81)	(1.20, 1.83)	(0.92, 1.69)	(1.20, 1.86)
γ	0.59	0.54	0.51	0.55	0.53	0.57	0.54	0.53	0.62
	(0.35, 0.80)	(0.22, 0.85)	(0.22, 0.85)	(0.23, 0.86)	(0.21, 0.86)	(0.25, 0.89)	(0.24, 0.85)	(0.22, 0.90)	(0.31, 0.93)
ε_{AS}	3.49	4.49	2.96	3.40	3.05	2.86	3.05	2.84	3.10
	(2.99, 3.97)	(3.70, 5.27)	(2.40, 3.50)	(2.82, 3.96)	(2.49, 3.65)	(2.37, 3.31)	(2.51, 3.58)	(2.38, 3.31)	(2.50, 3.63)
ε_{IS}	0.97	1.17	1.29	1.08	1.21	1.08	1.17	1.24	1.38
	(0.87, 1.07)	(0.95, 1.39)	(0.98, 1.58)	(0.87, 1.24)	(0.94, 1.45)	(0.88, 1.25)	(0.92, 1.39)	(0.99, 1.49)	(1.03, 1.70)
ε_{MP}	2.39	3.04	3.31	3.05	3.41	3.13	3.36	3.26	4.82
	(2.29, 2.48)	(2.46, 3.57)	(2.64, 4.00)	(2.48, 3.65)	(2.65, 4.10)	(2.53, 3.69)	(2.74, 4.00)	(2.66, 3.87)	(3.85, 5.74)

9.4 Appendix B: Figures

Appendix B Figure 1: Alternative Interest Rates

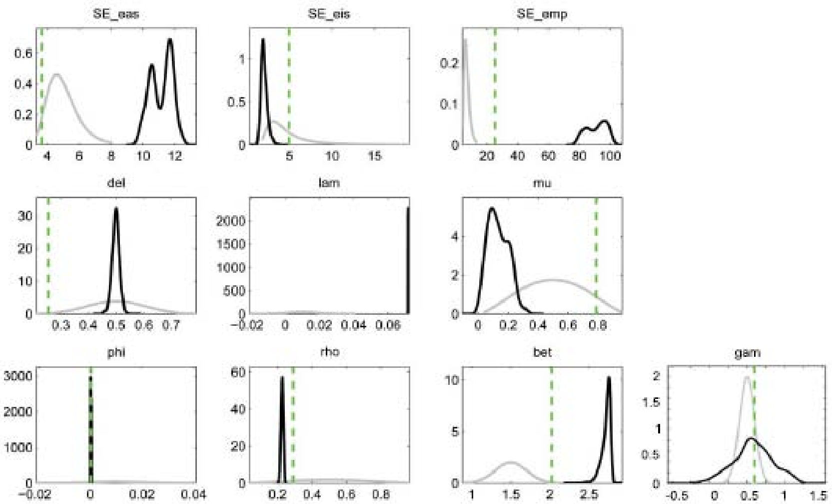




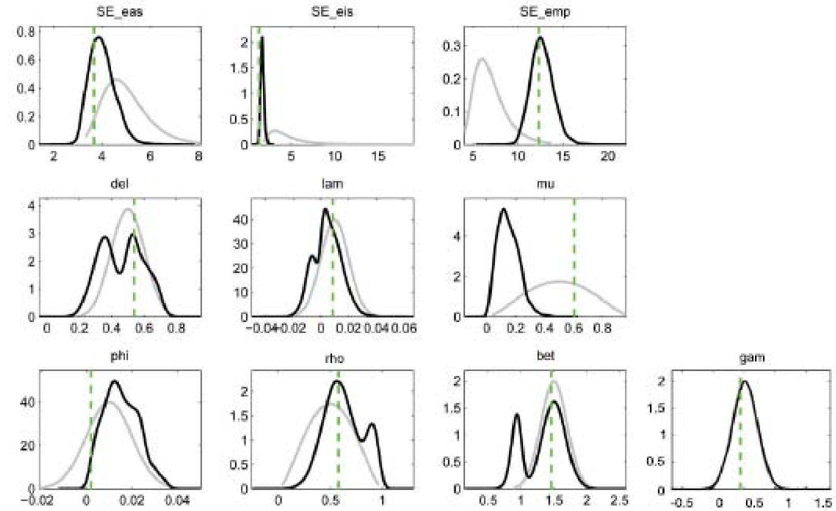


Appendix B Figure 2: IT Baseline Model Priors and Posterior Distributions

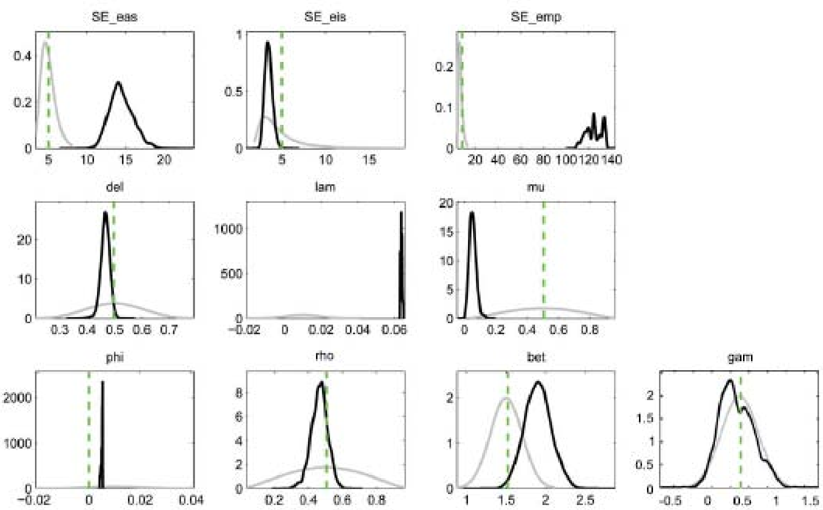
Brazil Pre-IT (A)



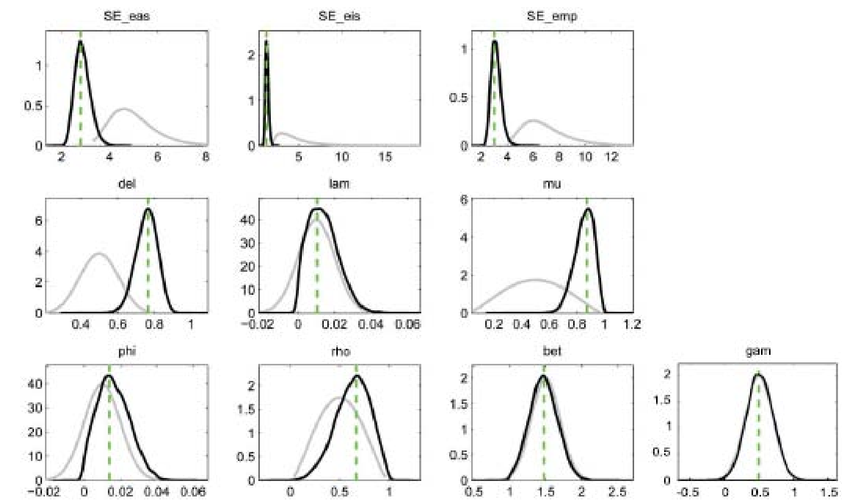
Brazil Pre-IT (A)*



Brazil Pre-IT (B)

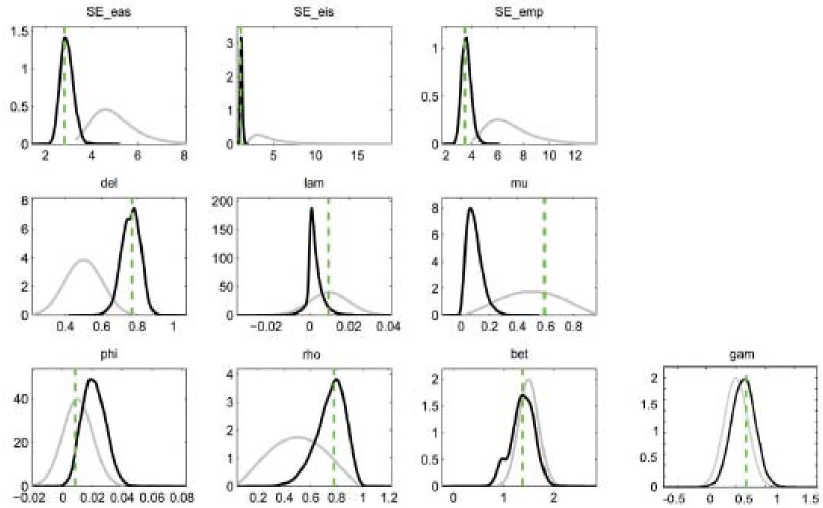


Brazil Post-IT

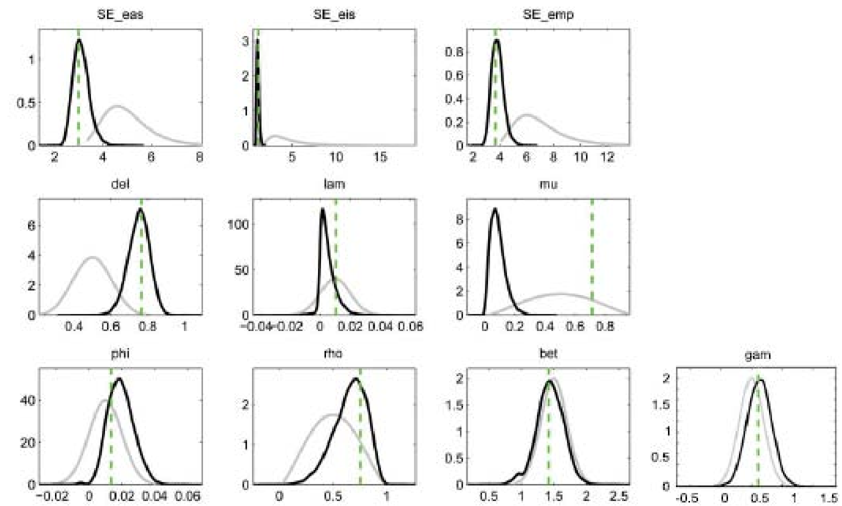


Appendix B Figure 2: IT Baseline Model Priors and Posterior Distributions

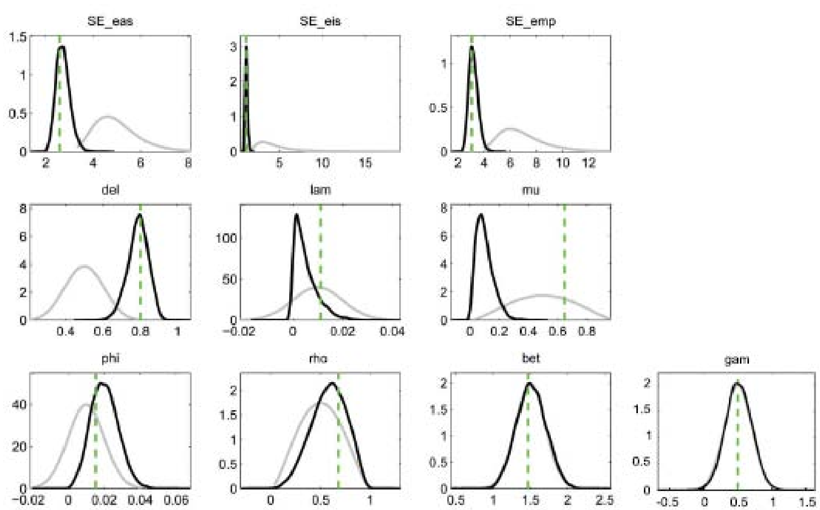
Chile Pre-IT (A)



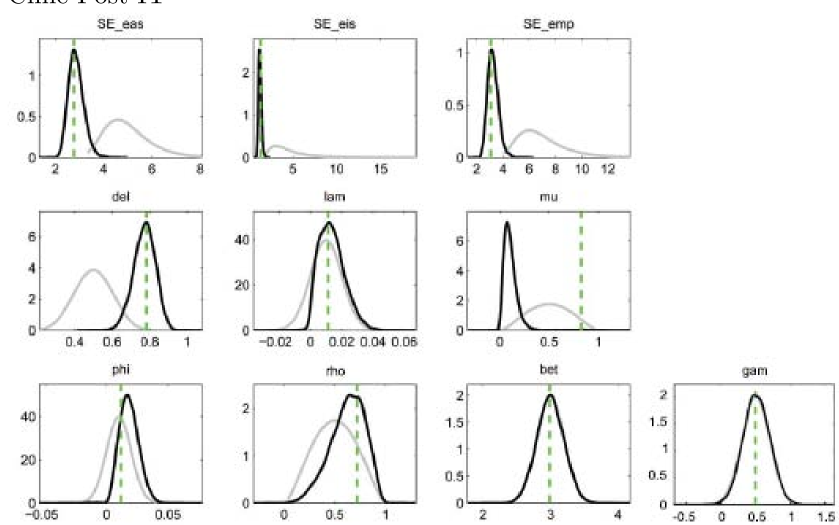
Chile Pre-IT (B)



Chile Transition

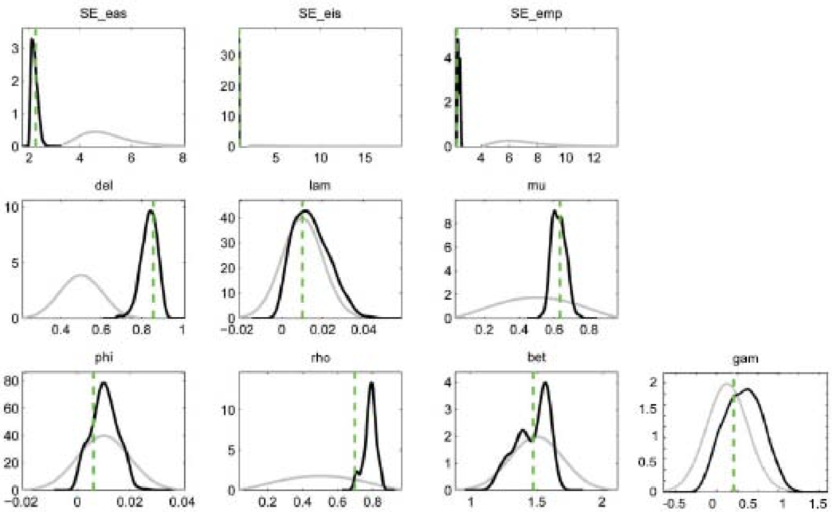


Chile Post-IT

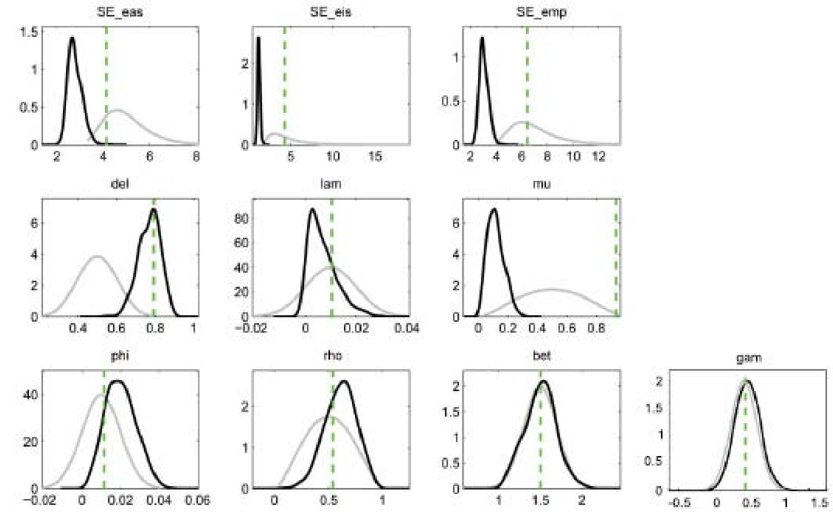


Appendix B Figure 2: IT Baseline Model Priors and Posterior Distributions

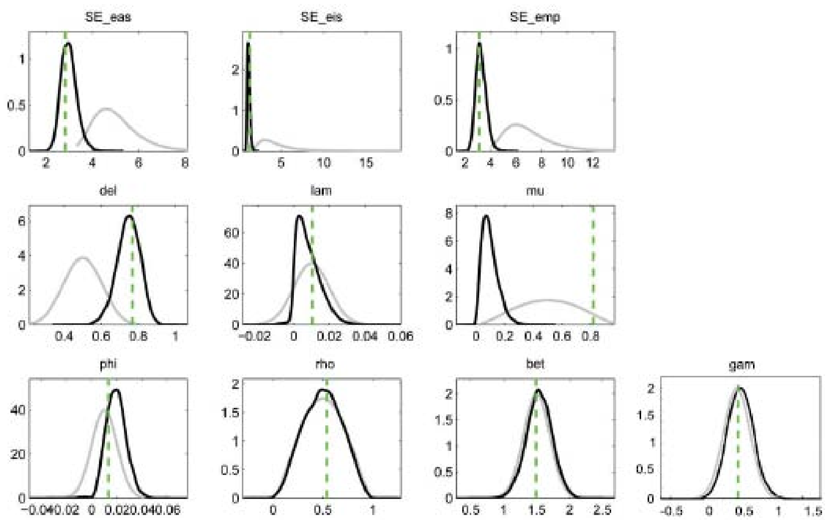
Colombia Pre-IT (A)



Colombia Pre-IT (B)

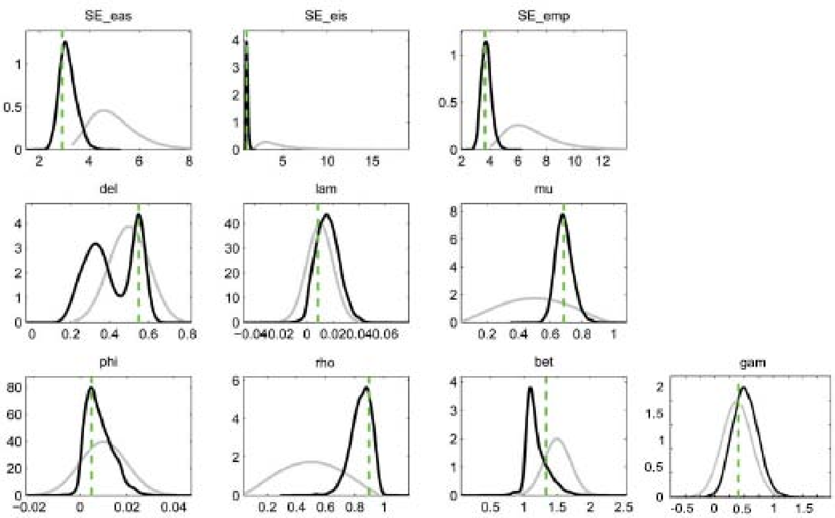


Colombia Post-IT

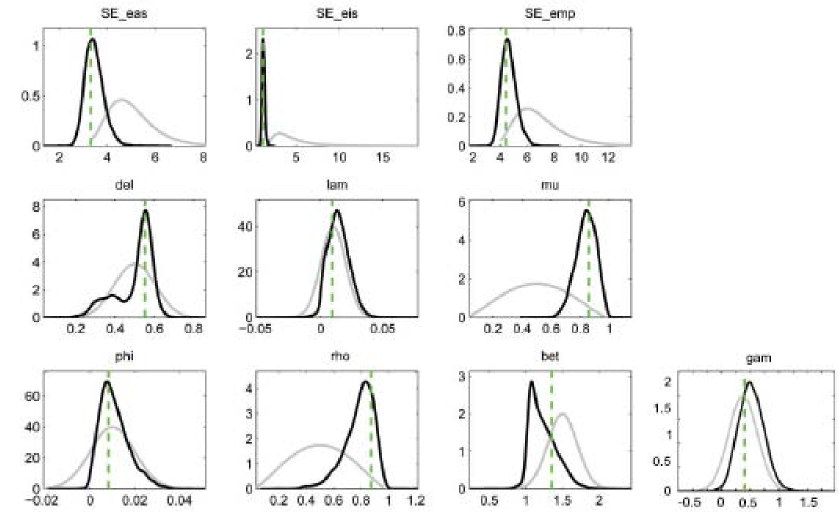


Appendix B Figure 2: IT Baseline Model Priors and Posterior Distributions

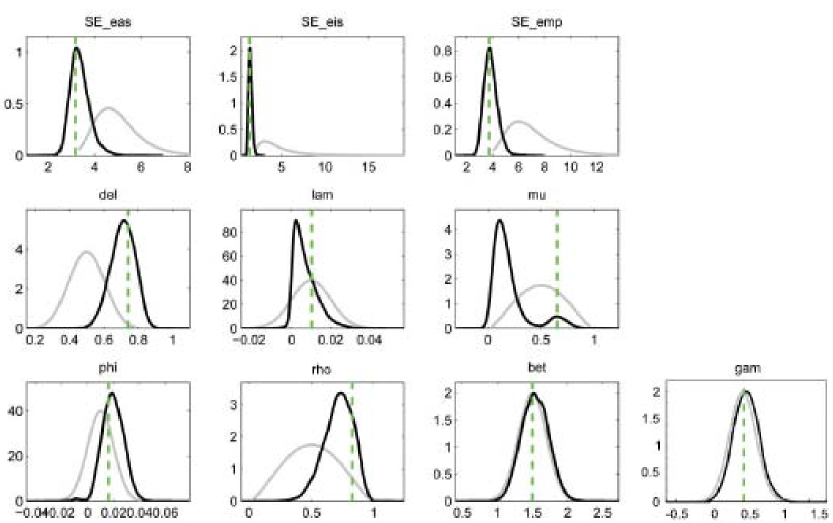
Mexico Pre-IT (A)



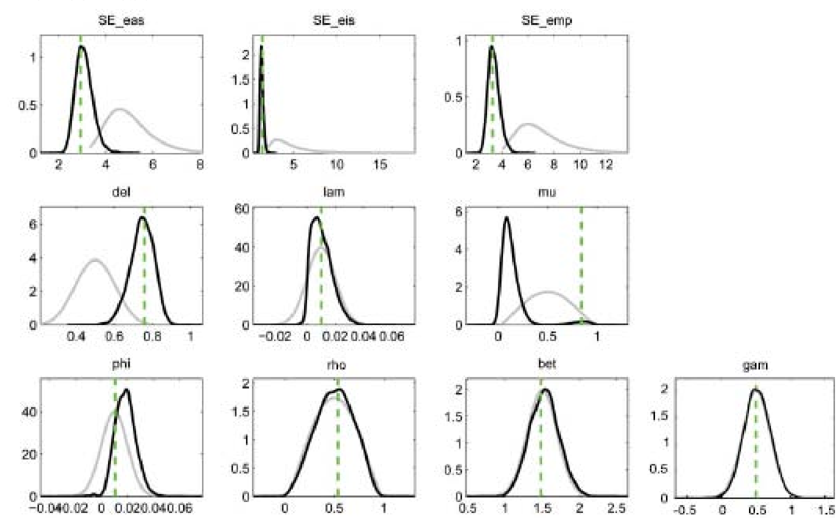
Mexico Pre-IT (B)



Mexico Transition

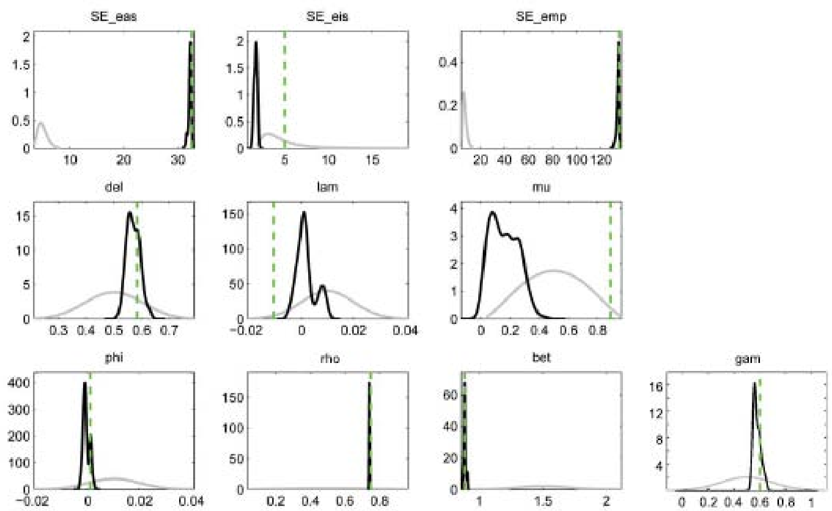


Mexico Post-IT

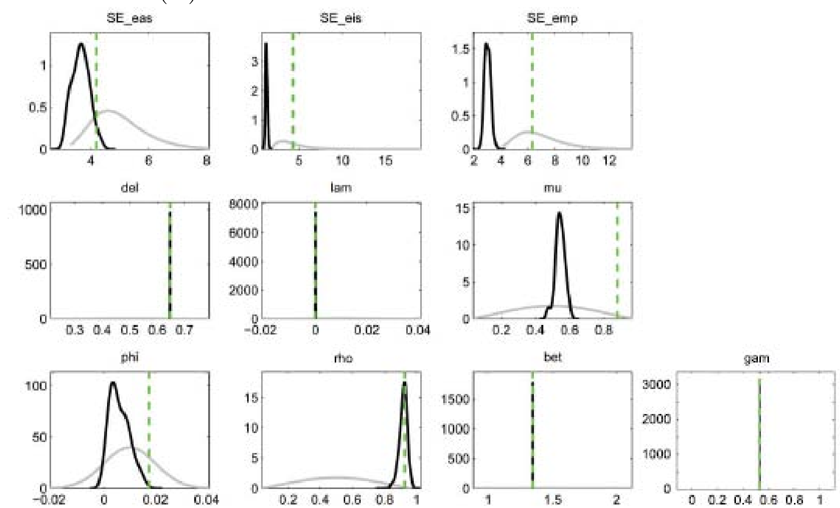


Appendix B Figure 2: IT Baseline Model Priors and Posterior Distributions

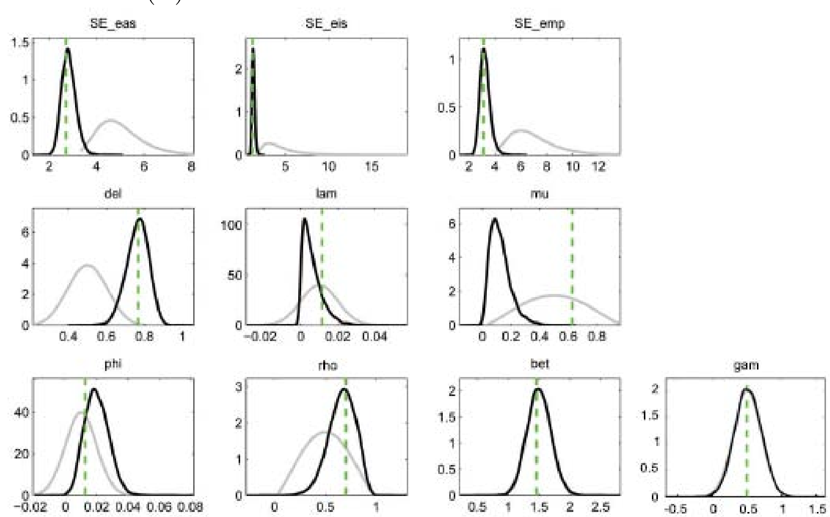
Peru Pre-IT (A)



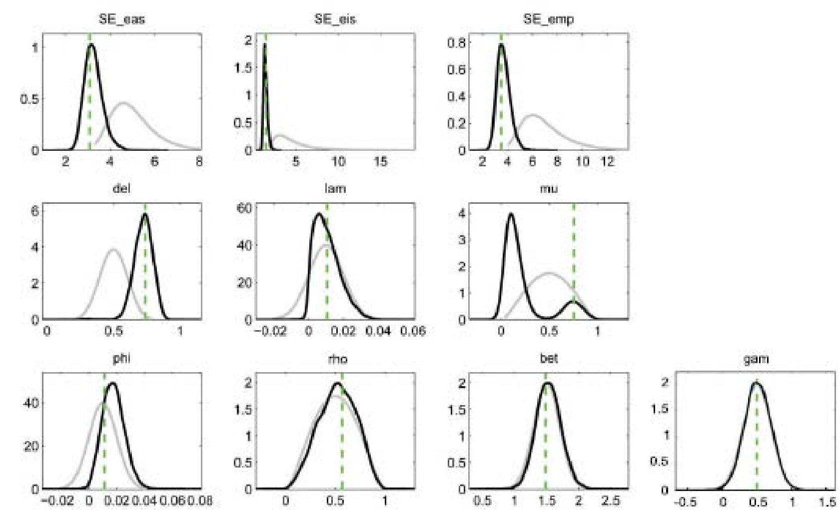
Peru Pre-IT (A)*



Peru Pre-IT (B)

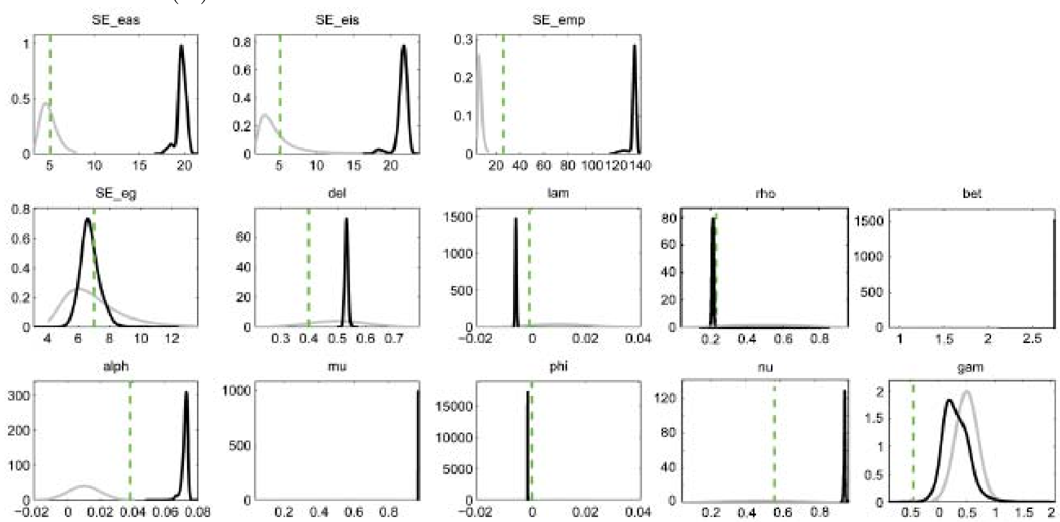


Peru Post-IT

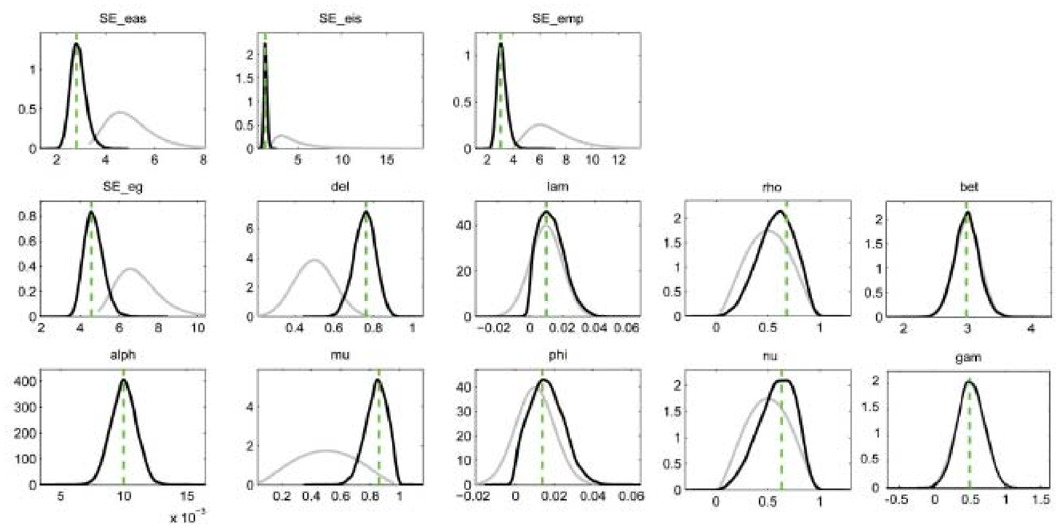


Appendix B Figure 3: Adding Government Balances (Brazil)

Brazil Pre-IT $(A)^G$

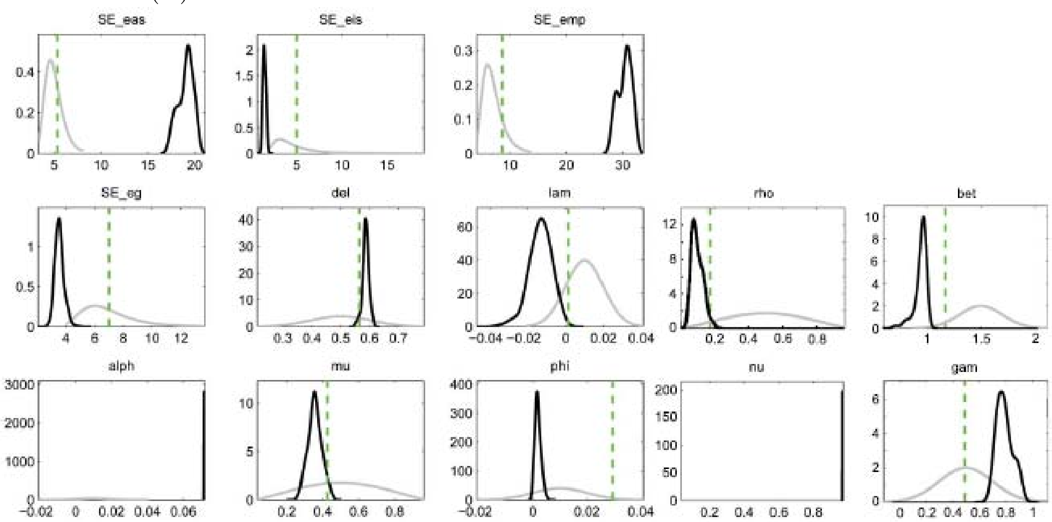


Brazil Post-IT^G

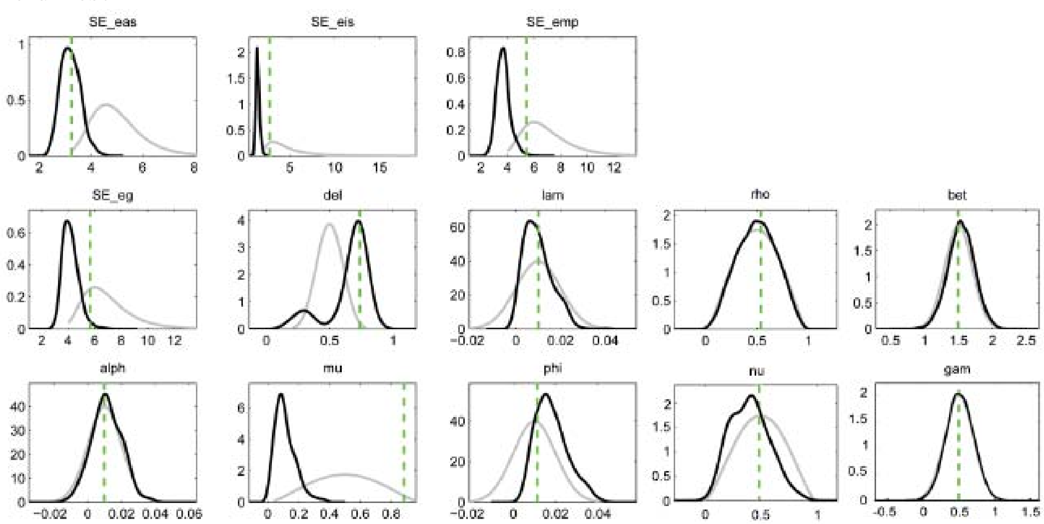


Appendix B Figure 3: Adding Government Balances (Peru)

Peru Pre-IT (A)^G

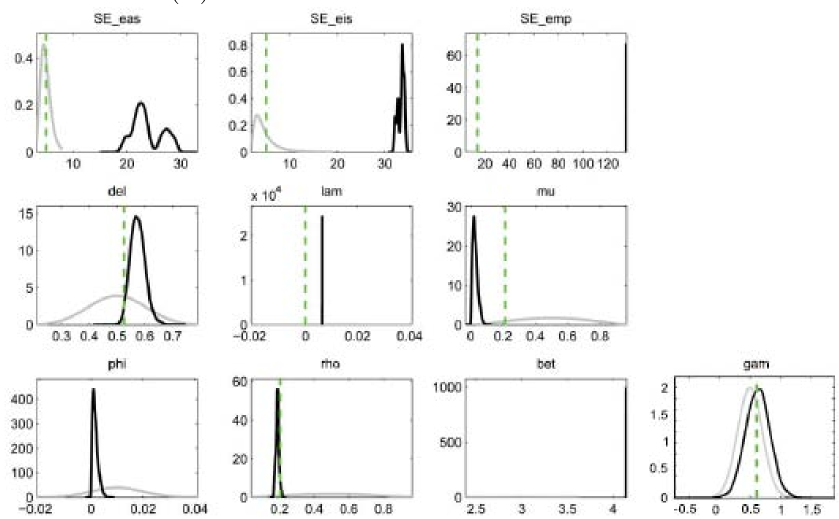


Peru Post-IT^G

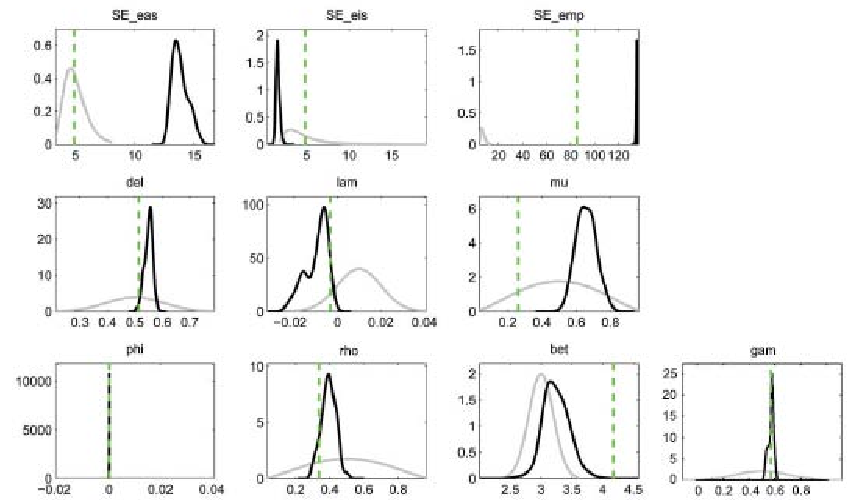


Appendix B Figure 4: IT Sensitivities to Priors

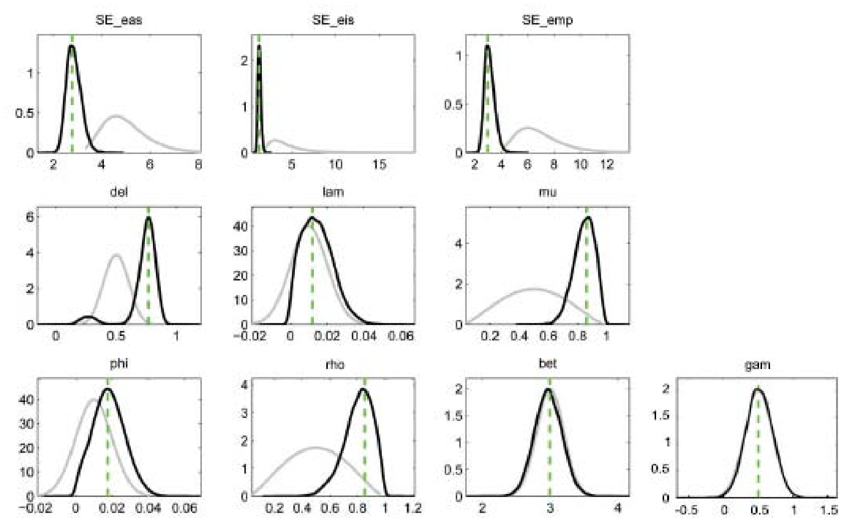
Brazil Pre-IT (A)



Brazil Pre-IT (B)

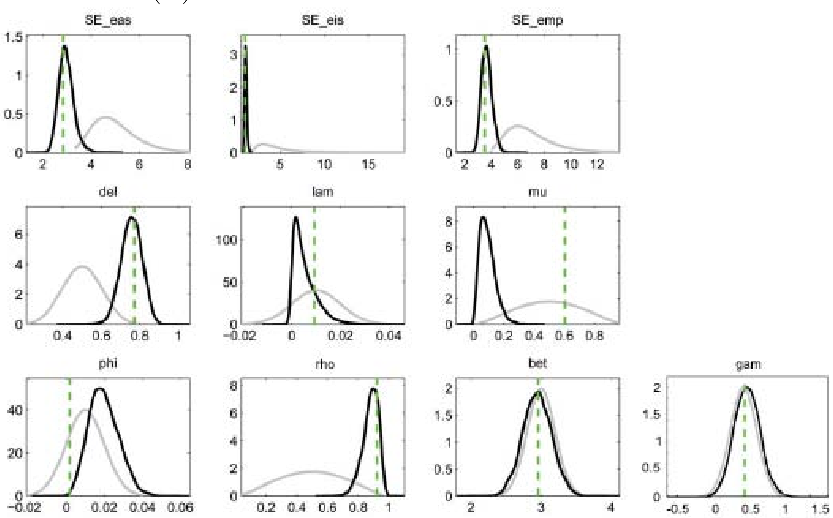


Brazil Post-IT

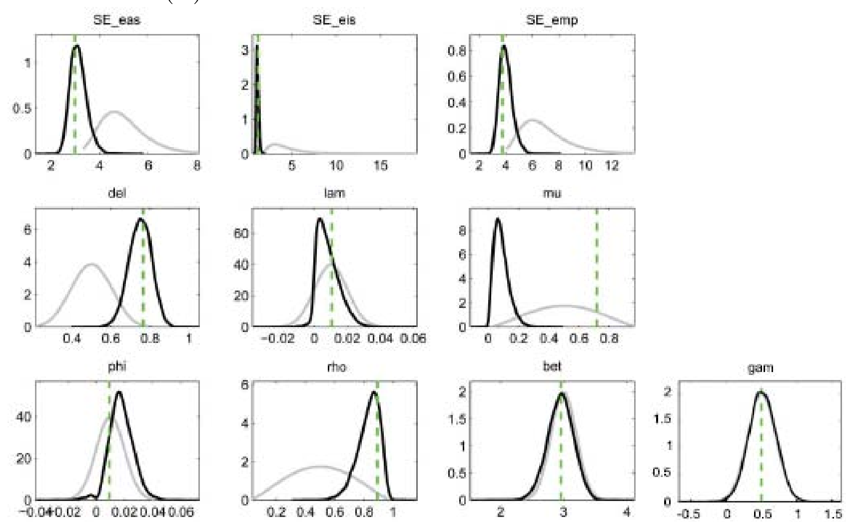


Appendix B Figure 4: IT Sensitivities to Priors

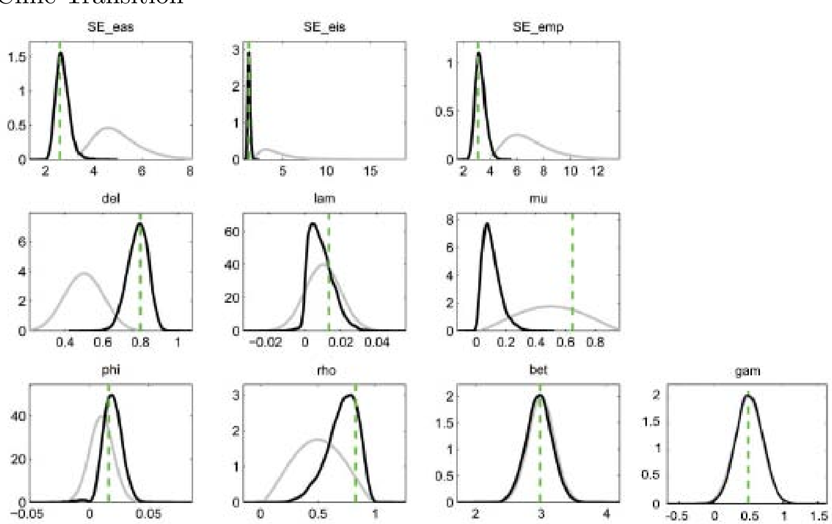
Chile Pre-IT (A)



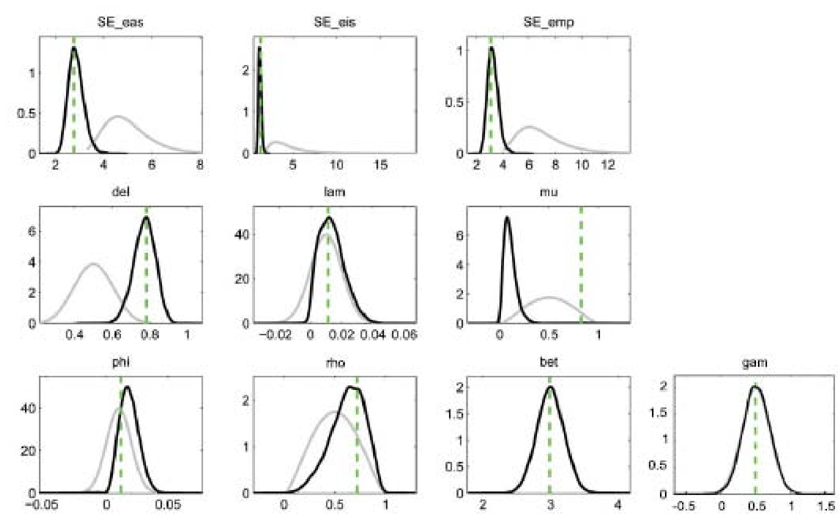
Chile Pre-IT (B)



Chile Transition

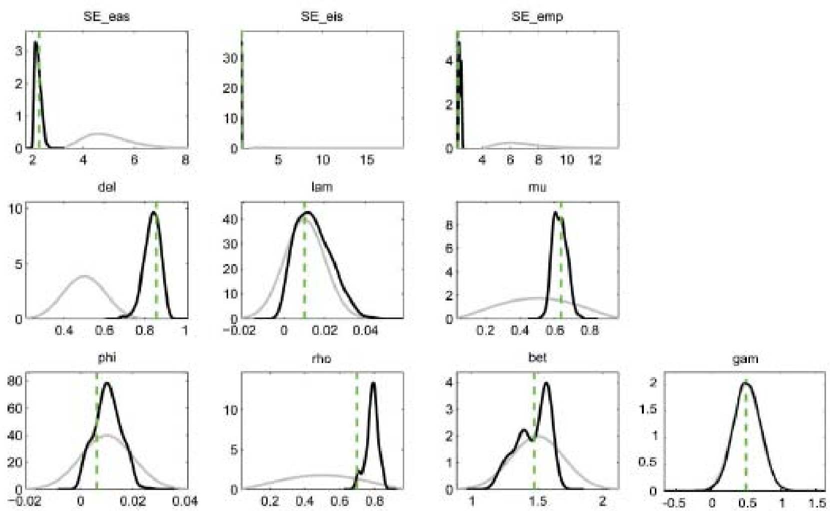


Chile Post-IT

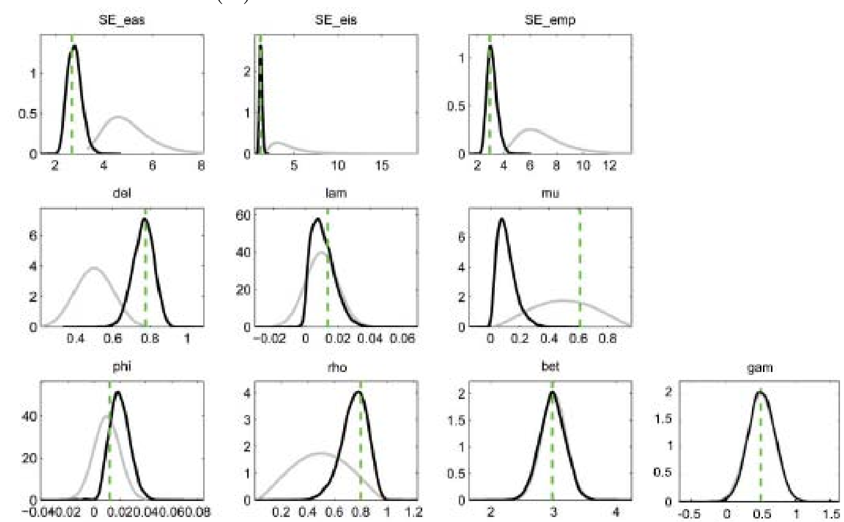


Appendix B Figure 4: IT Sensitivities to Priors

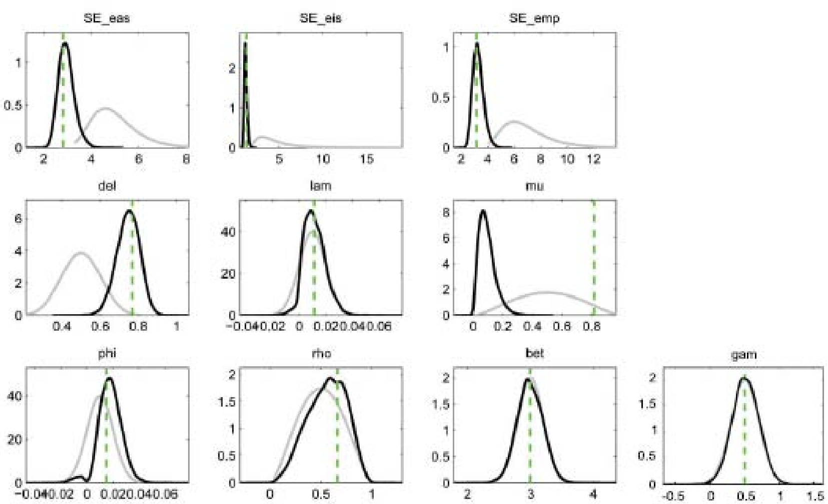
Colombia Pre-IT (A)



Colombia Pre-IT (B)

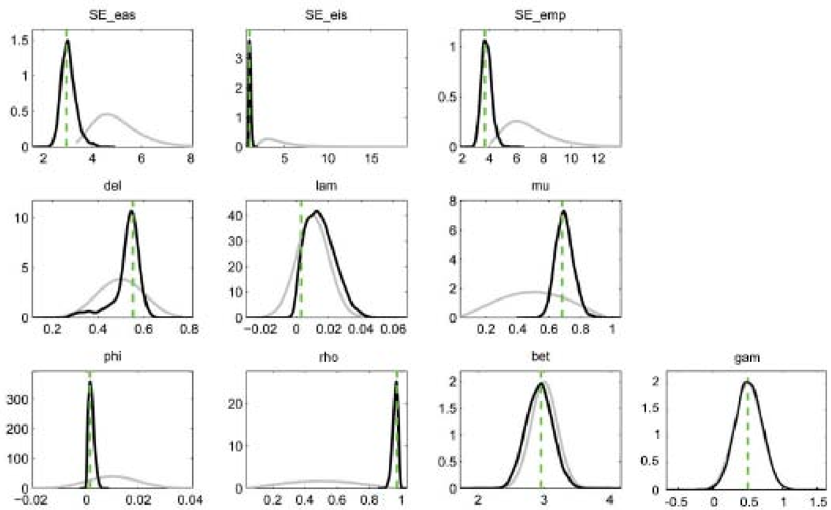


Colombia Post-IT

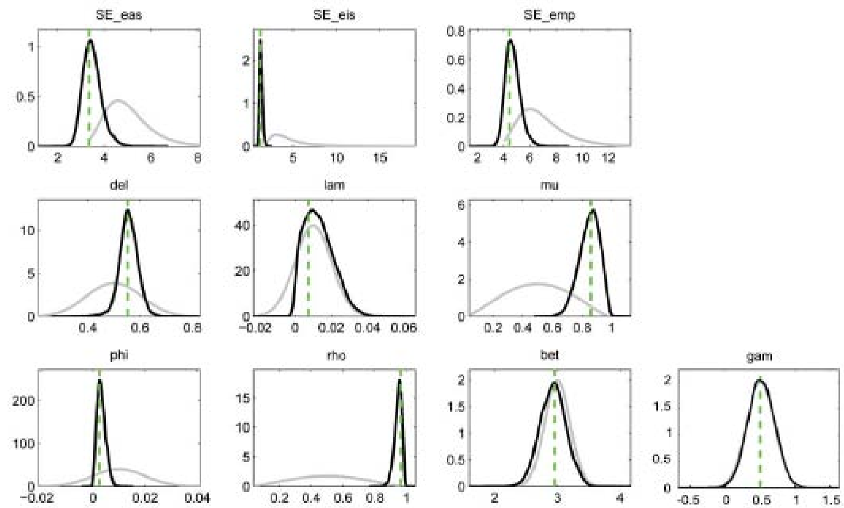


Appendix B Figure 4: IT Sensitivities to Priors

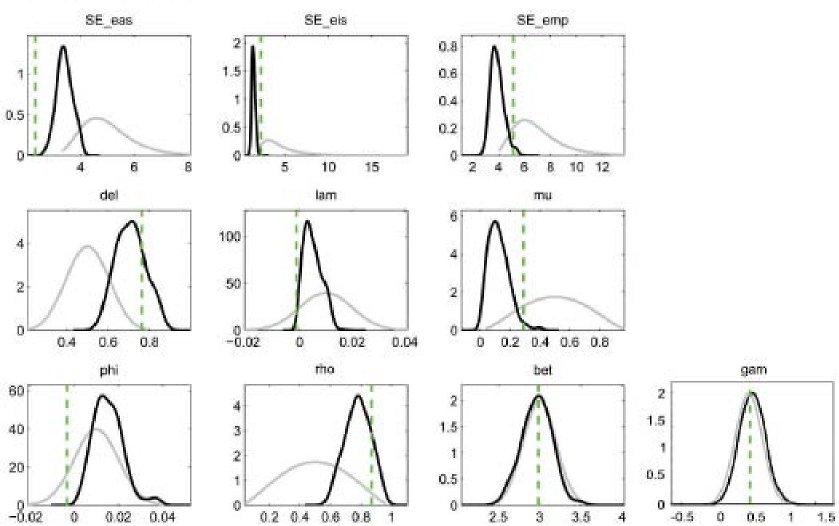
Mexico Pre-IT (A)



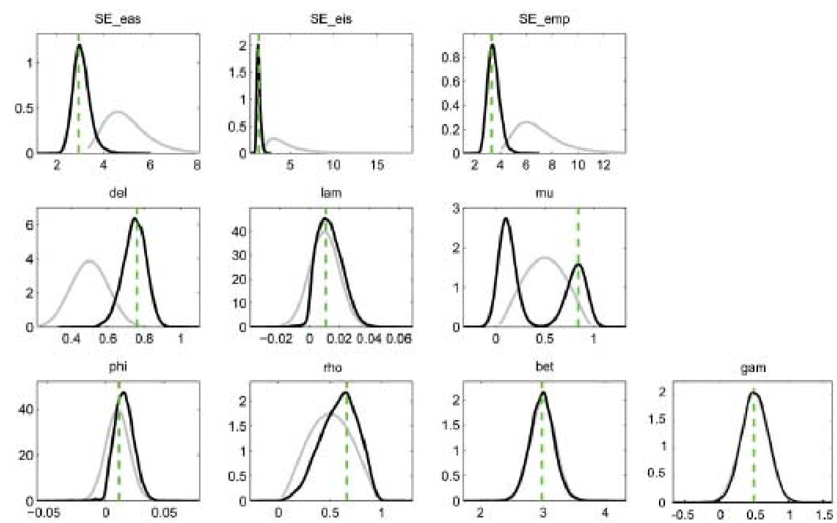
Mexico Pre-IT (B)



Mexico Transition

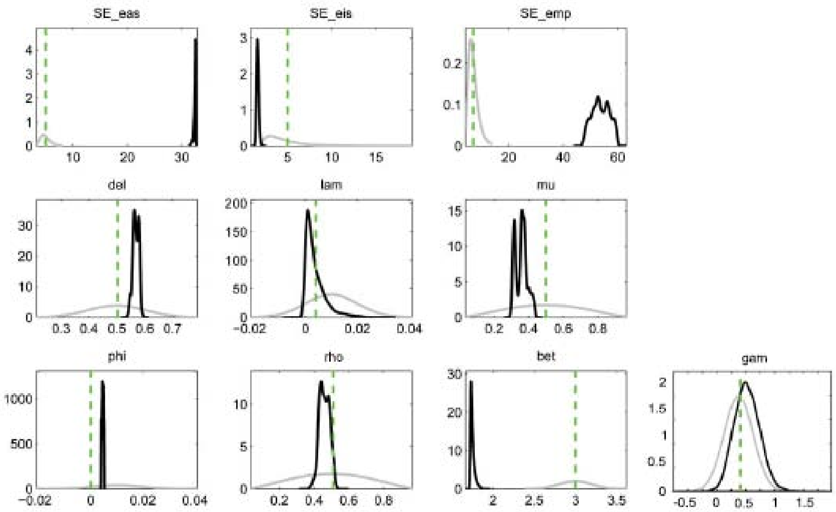


Mexico Post-IT

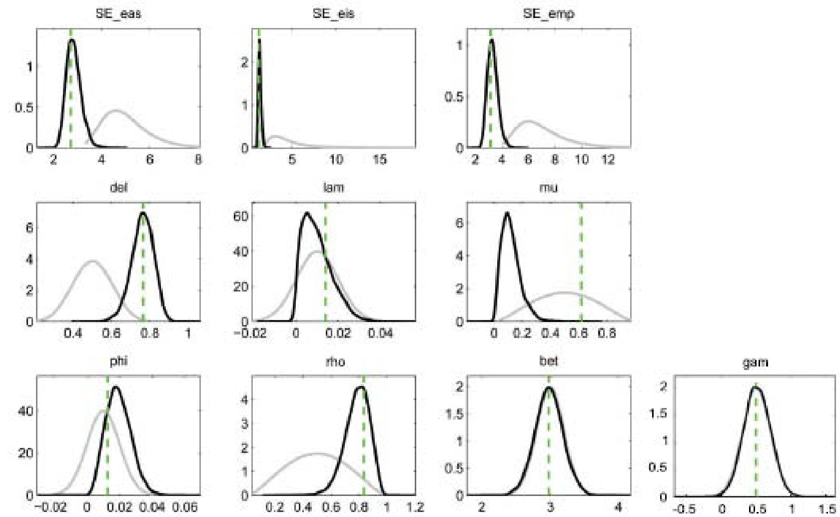


Appendix B Figure 4: IT Sensitivities to Priors

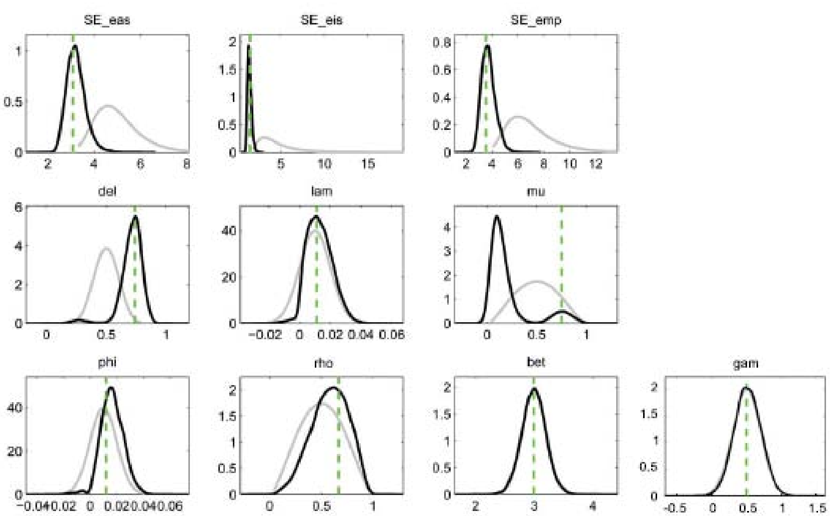
Peru Pre-IT (A)



Peru Pre-IT (B)

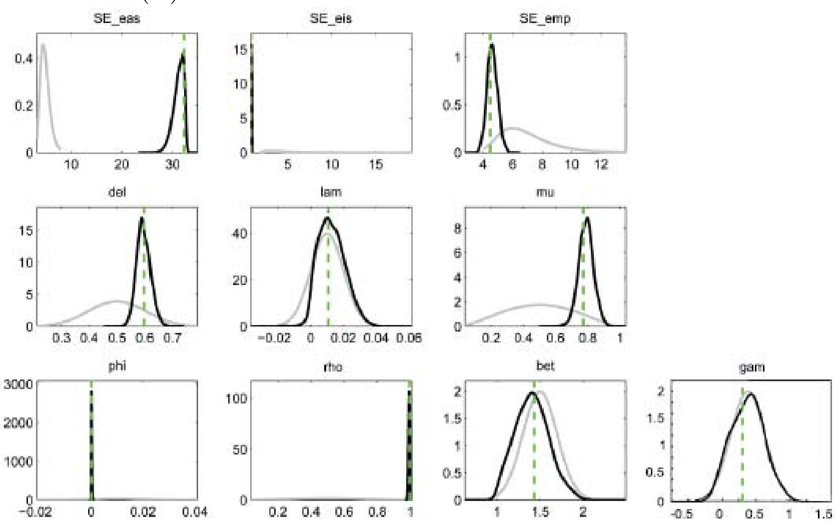


Peru Post-IT

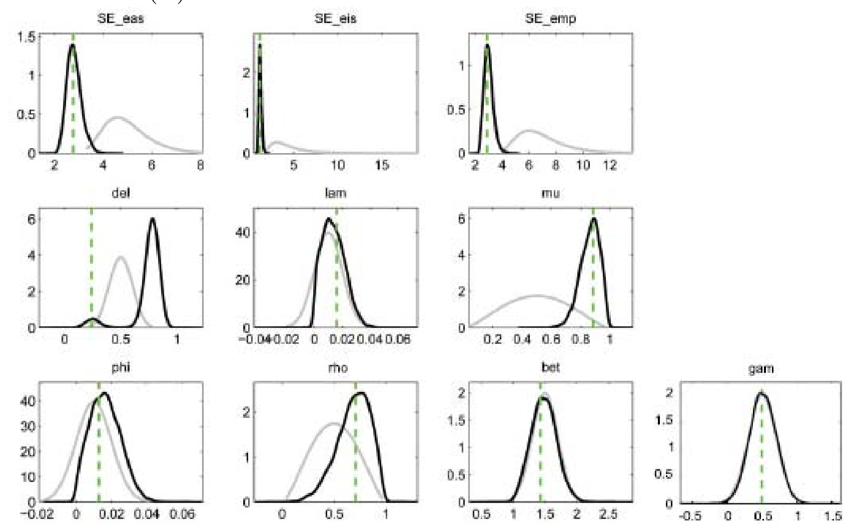


Appendix B Figure 5: NIT Baseline Model Priors and Posterior Distributions

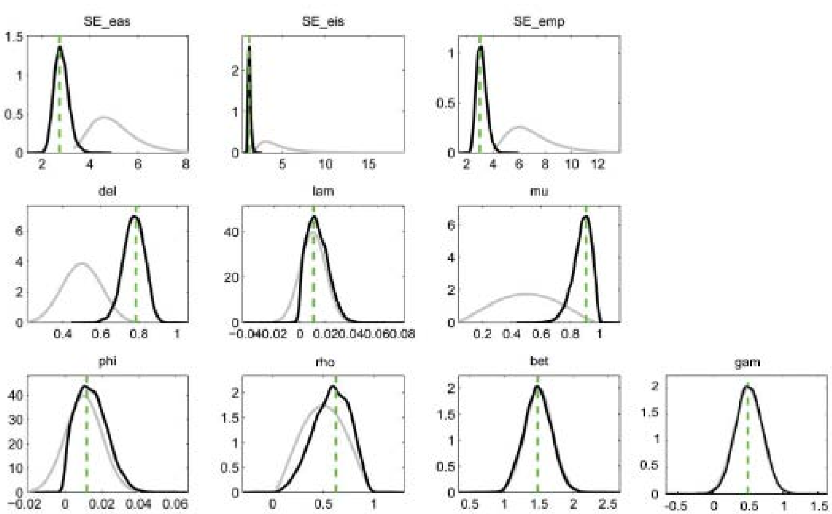
Bolivia Pre (A)



Bolivia Pre (B)

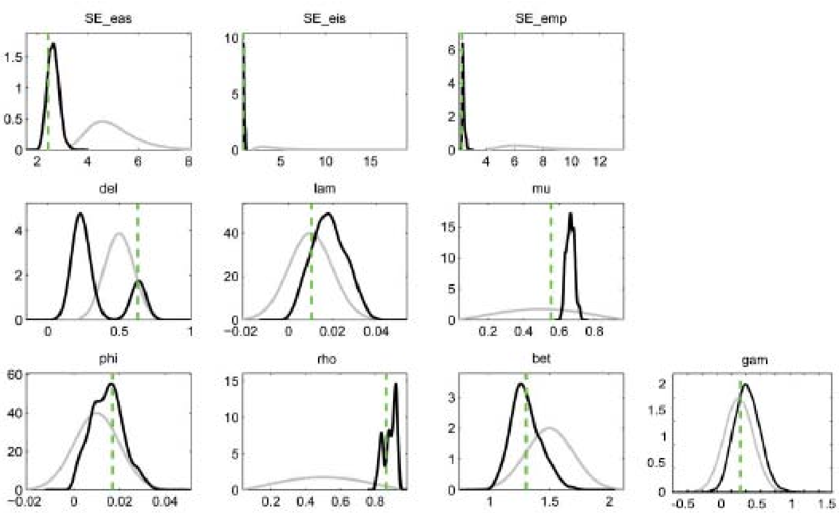


Bolivia Post

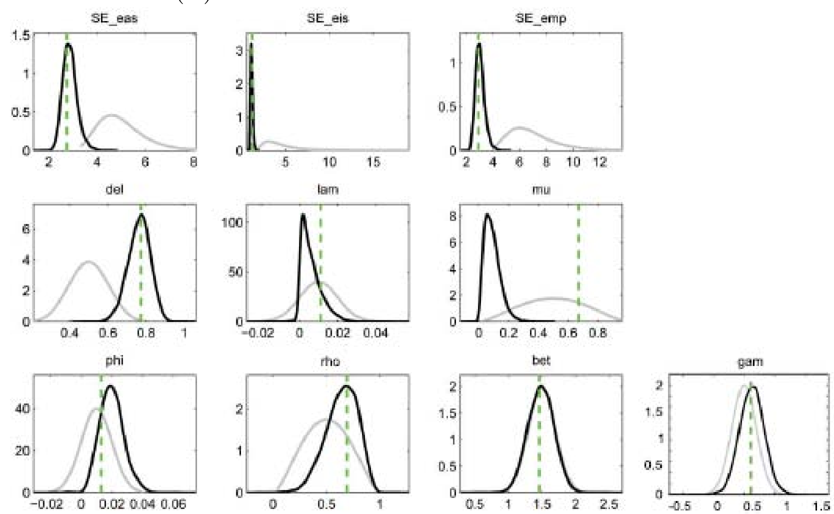


Appendix B Figure 5: NIT Baseline Model Priors and Posterior Distributions

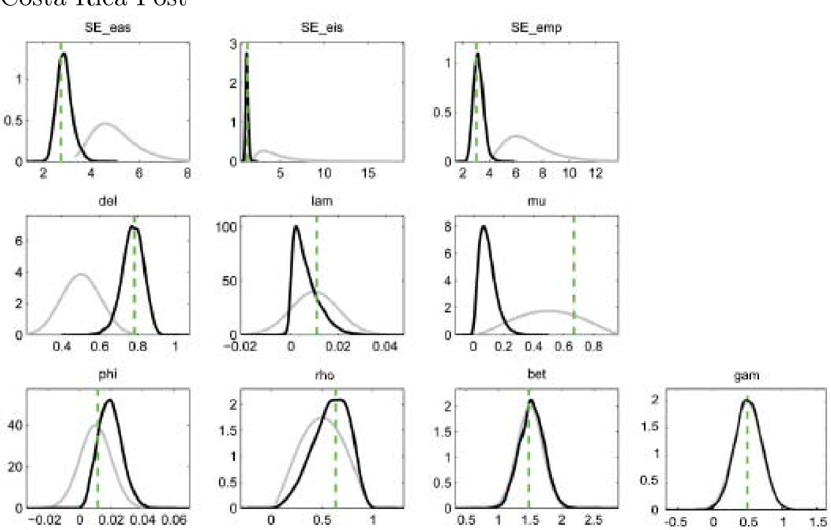
Costa Rica Pre (A)



Costa Rica Pre (B)

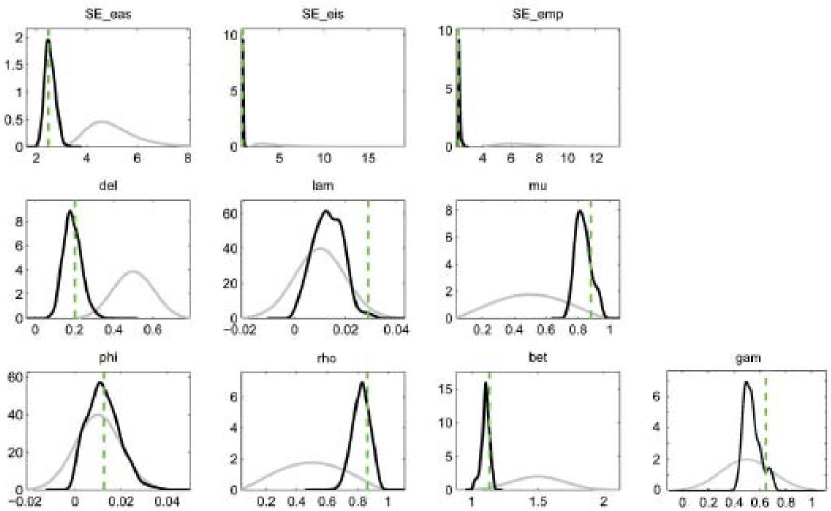


Costa Rica Post

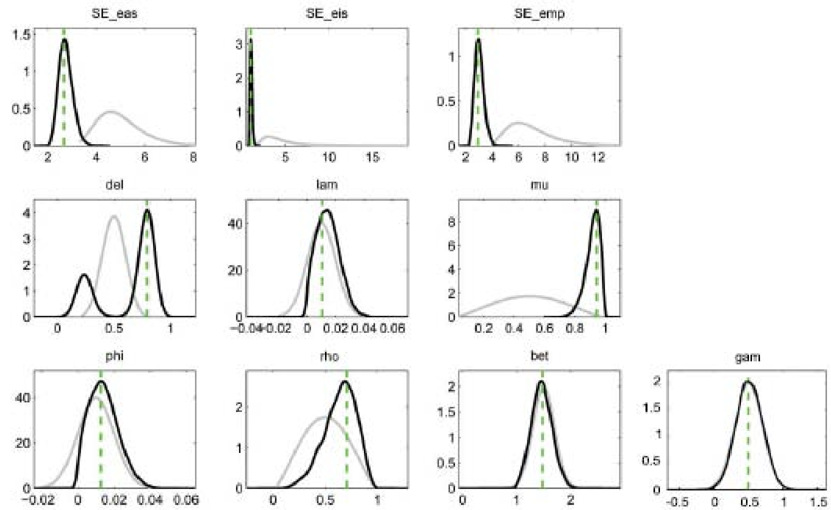


Appendix B Figure 5: NIT Baseline Model Priors and Posterior Distributions

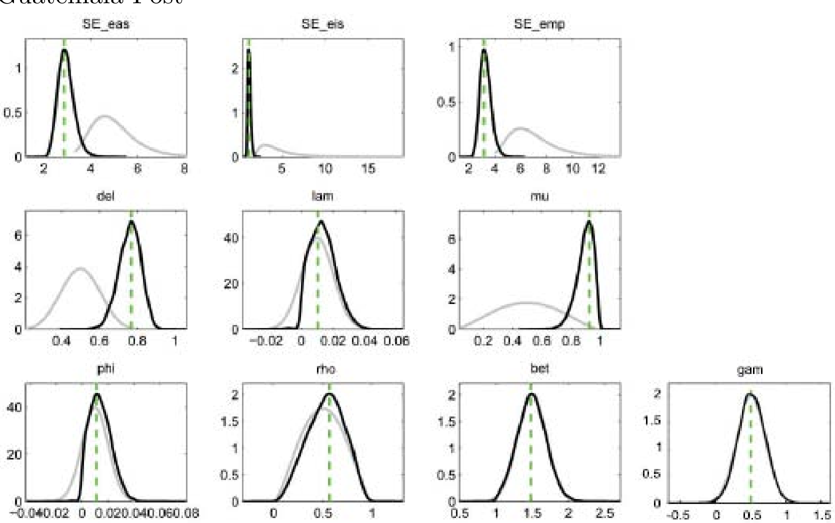
Guatemala Pre (A)



Guatemala Pre (B)

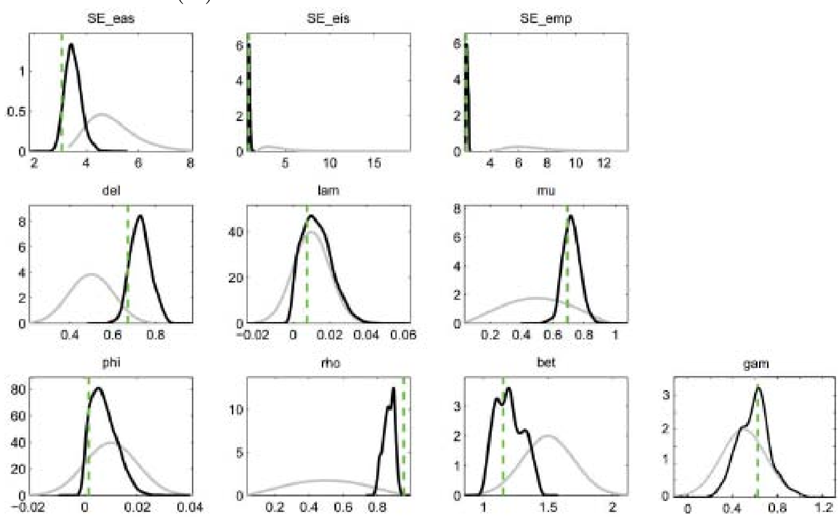


Guatemala Post

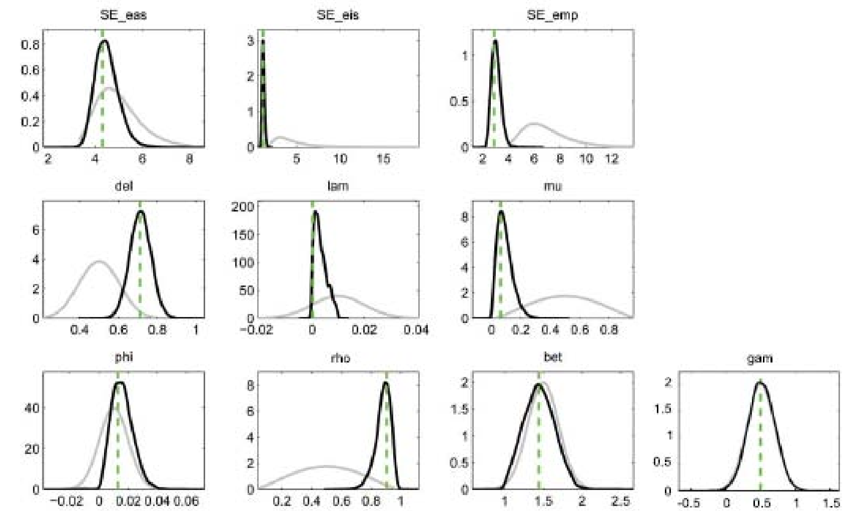


Appendix B Figure 5: NIT Baseline Model Priors and Posterior Distributions

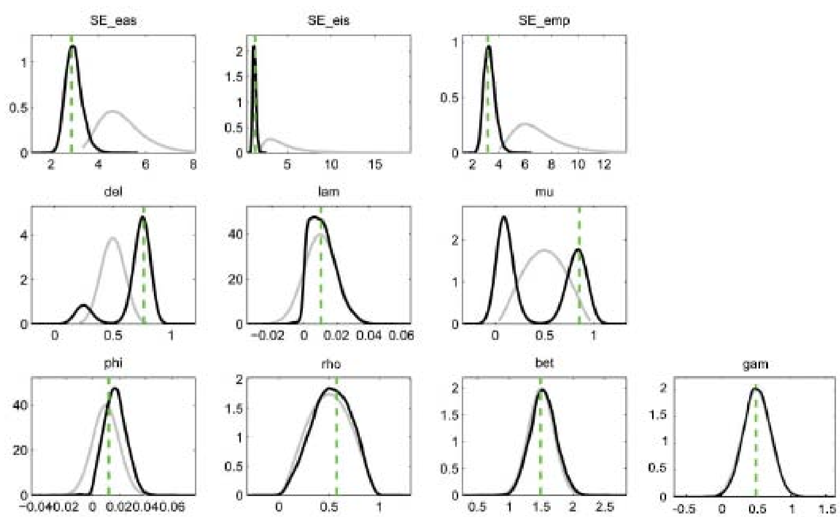
Honduras Pre (A)



Honduras Pre (B)

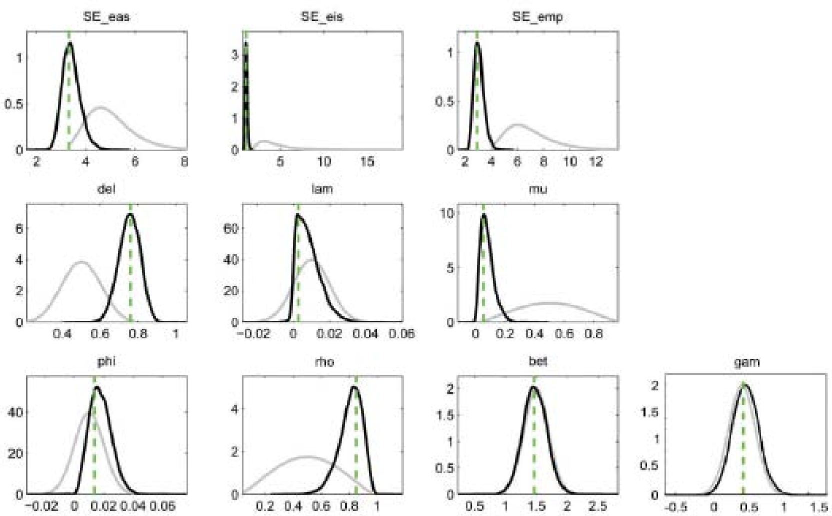


Honduras Post

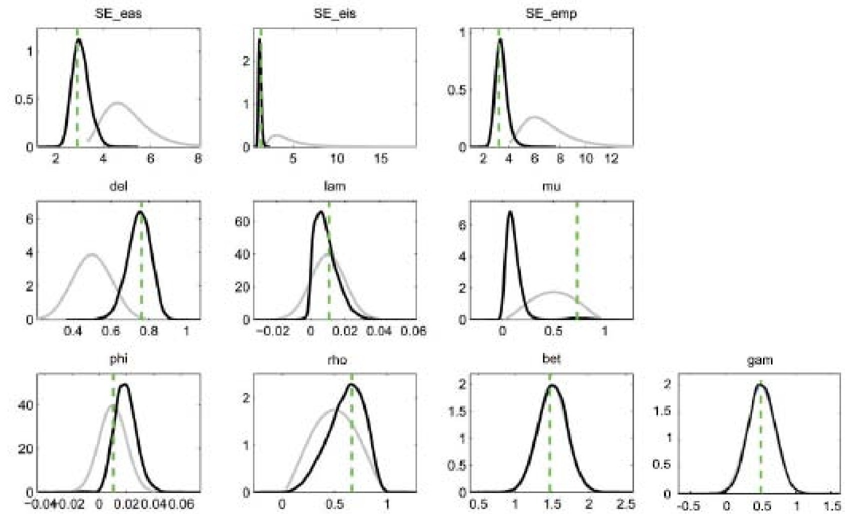


Appendix B Figure 5: NIT Baseline Model Priors and Posterior Distributions

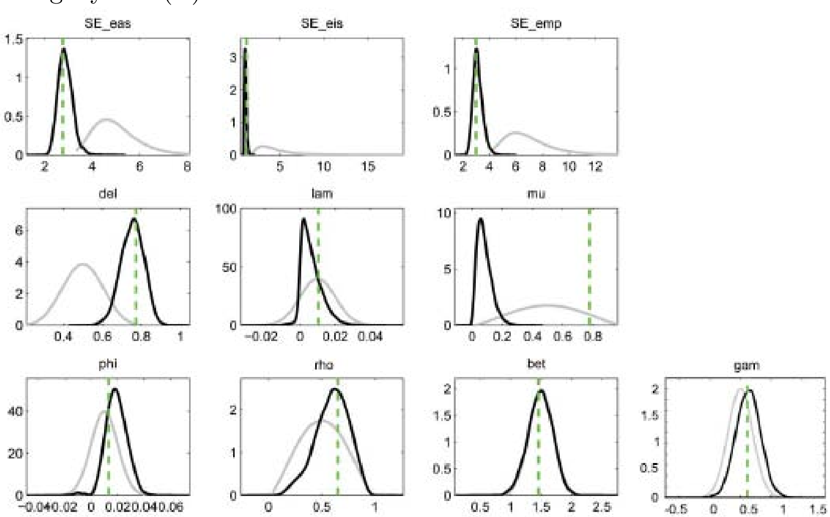
Nicaragua Pre (B)



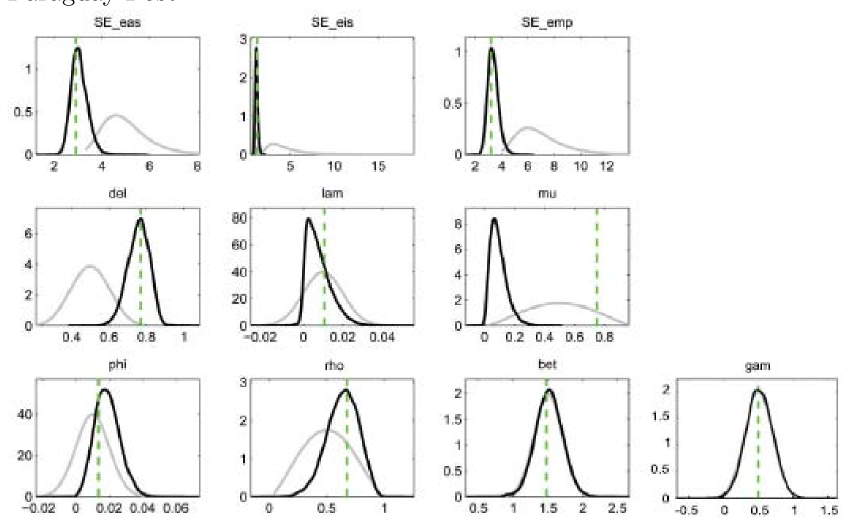
Nicaragua Post



Paraguay Pre (B)

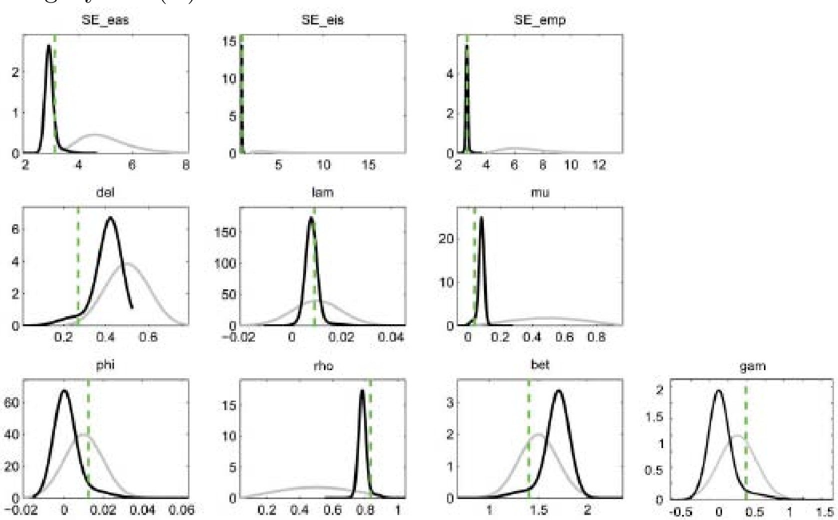


Paraguay Post

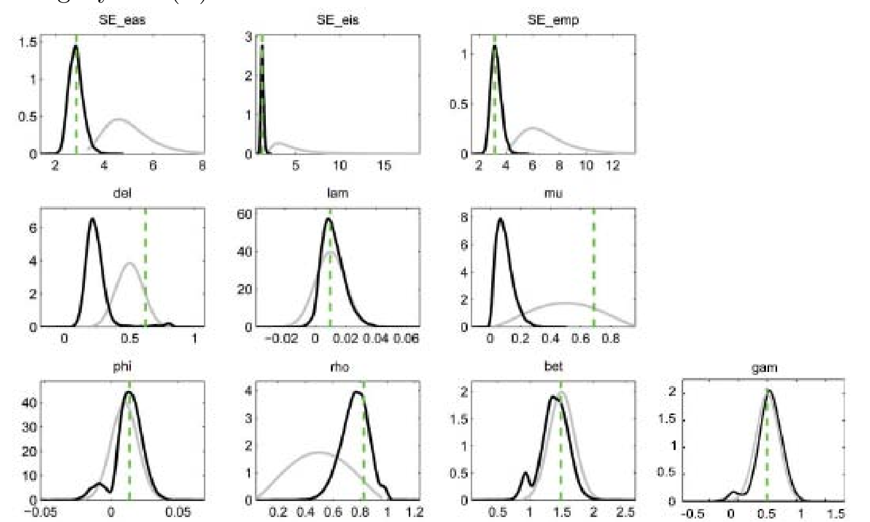


Appendix B Figure 5: NIT Baseline Model Priors and Posterior Distributions

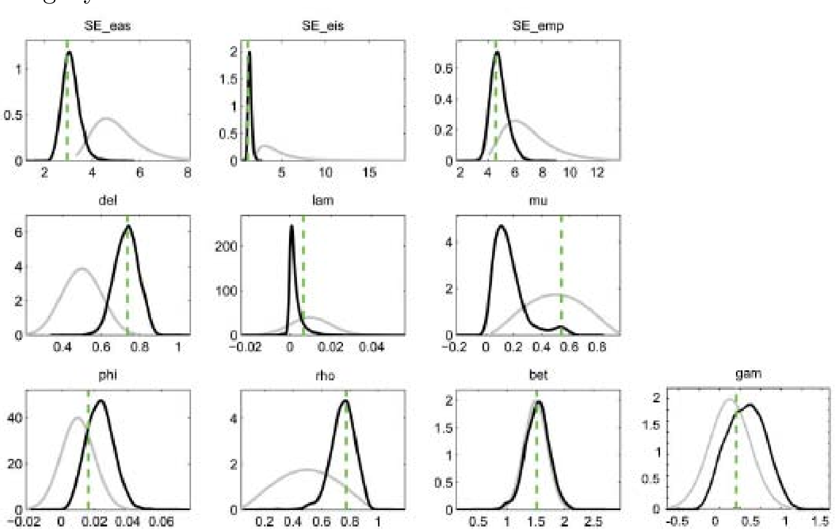
Uruguay Pre (A)



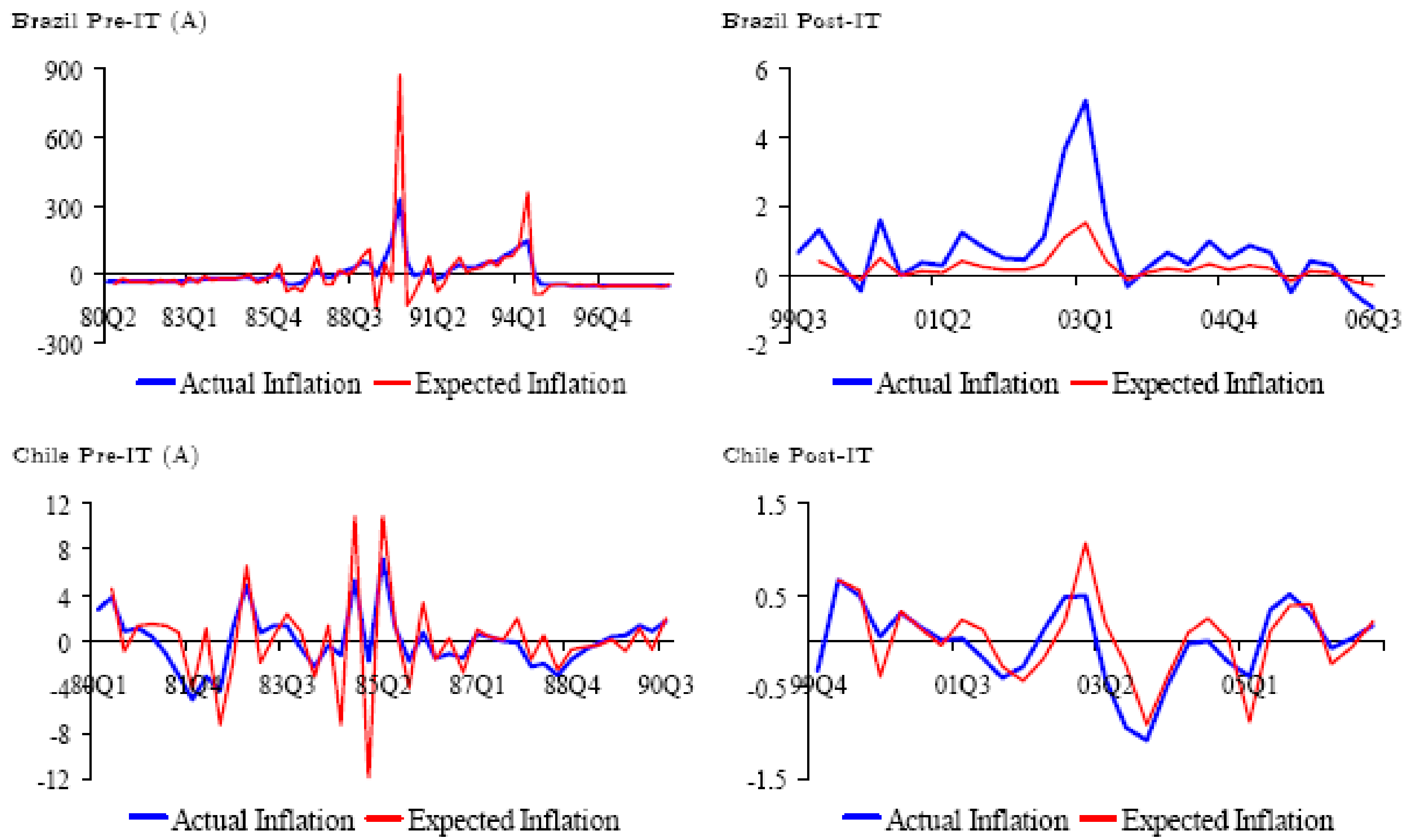
Uruguay Pre (B)



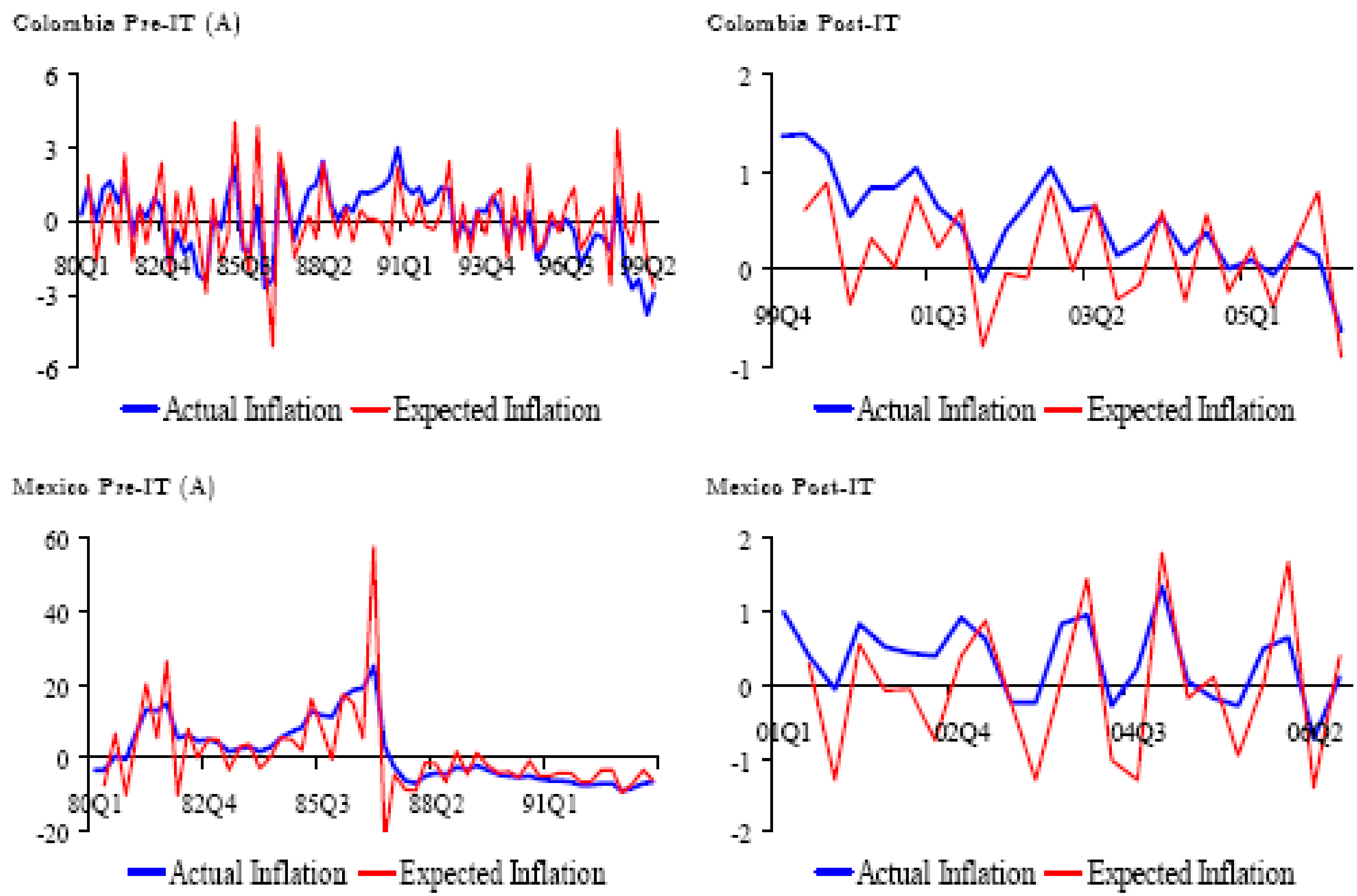
Uruguay Post



Appendix B Figure 6: Generated Inflation Expectations vs. Actual Inflation

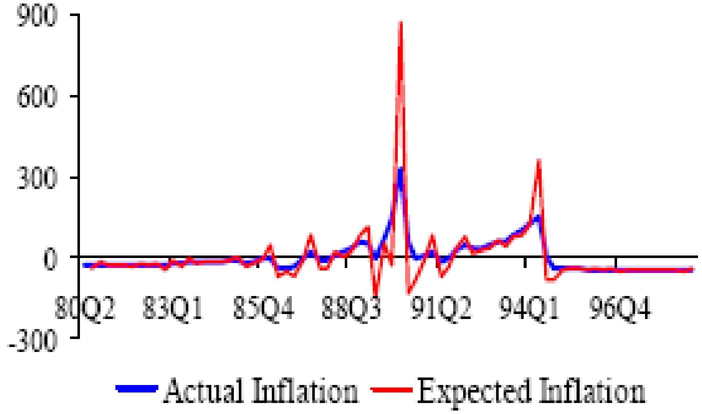


Appendix B Figure 6: Generated Inflation Expectations vs. Actual Inflation

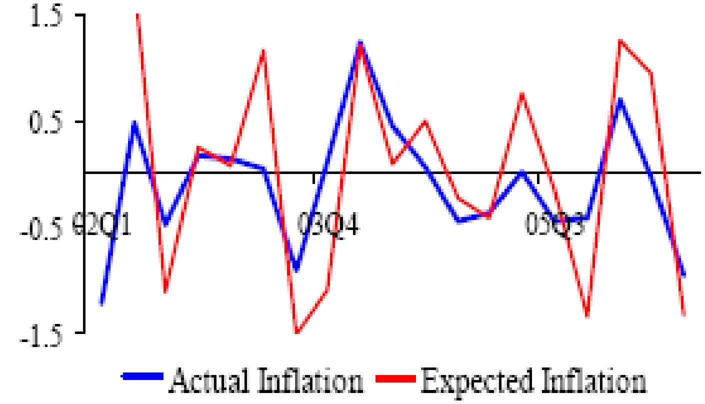


Appendix B Figure 6: Generated Inflation Expectations vs. Actual Inflation

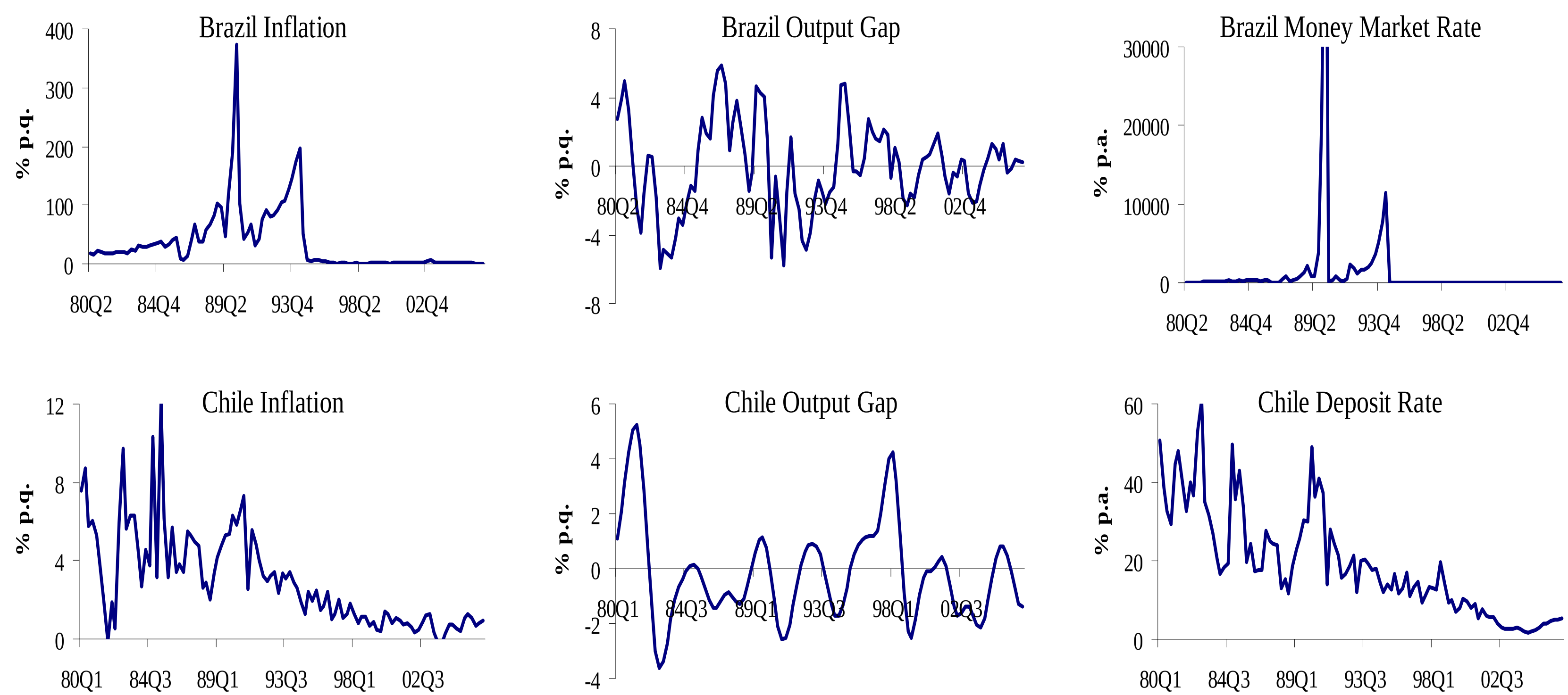
Peru Pre-IT (A)



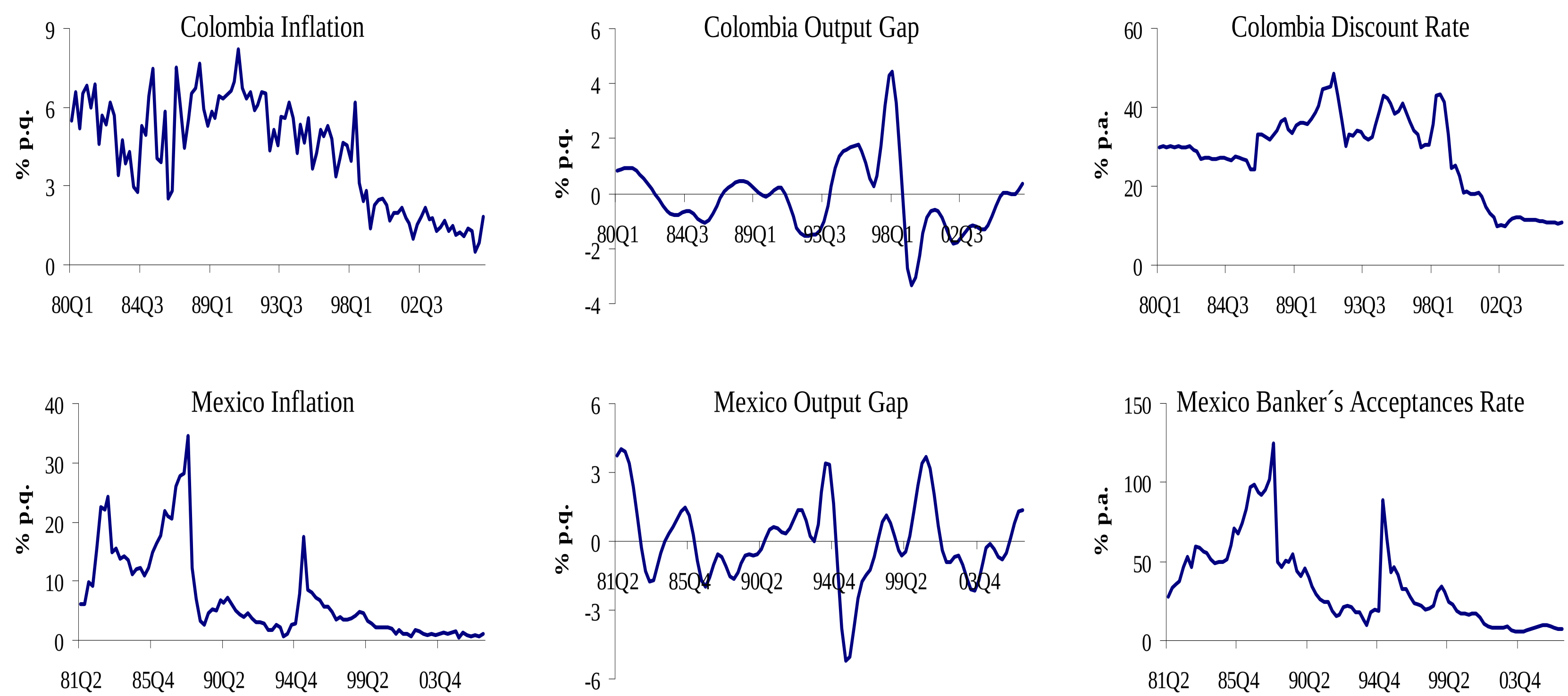
Peru Post-IT



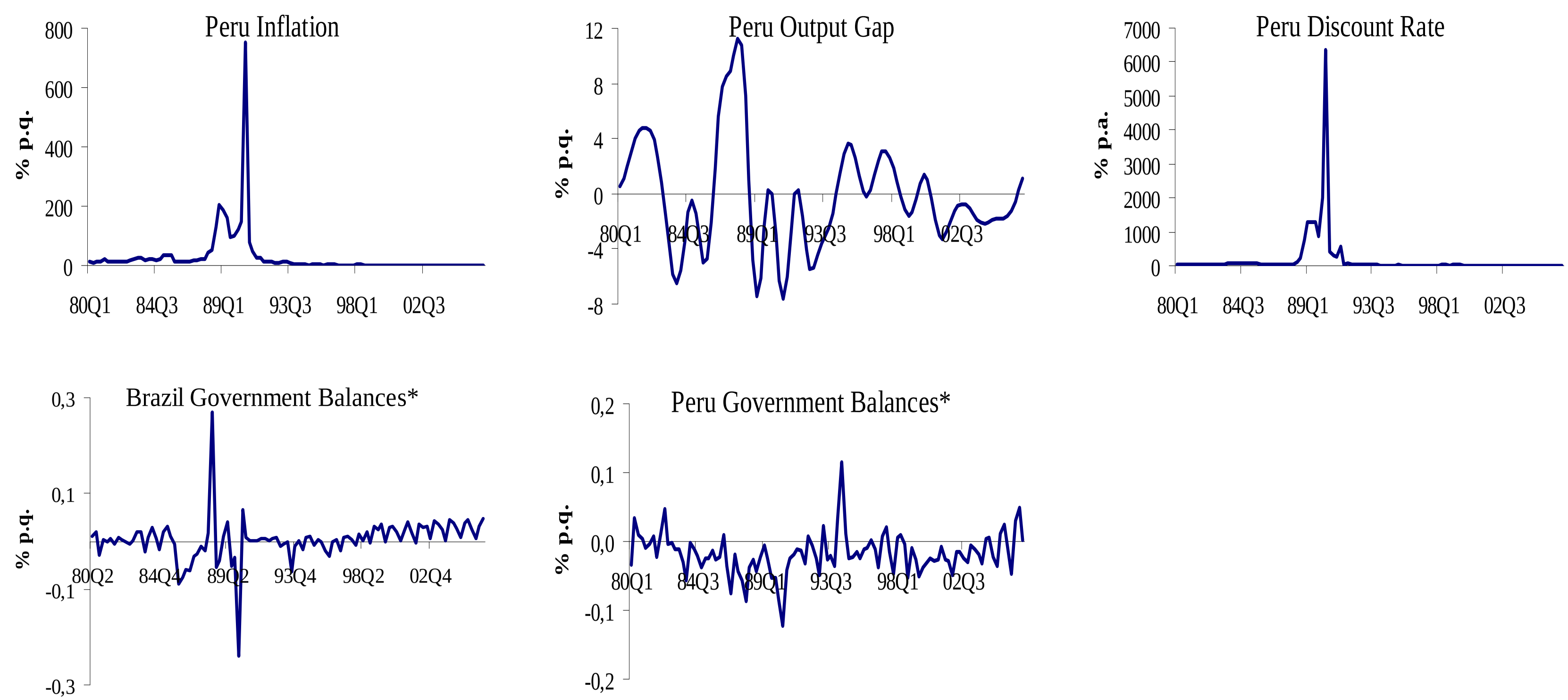
Appendix B Figure 7



Appendix B Figure 7

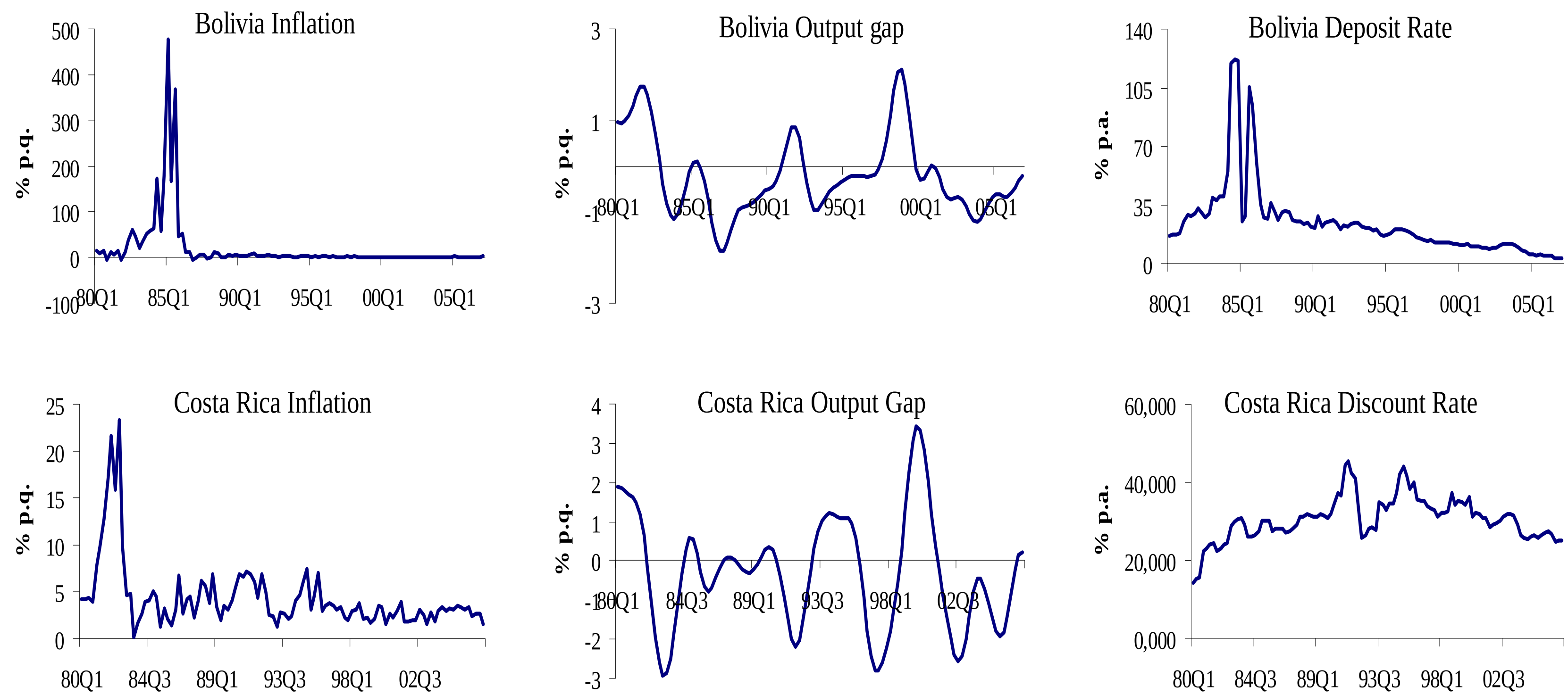


Appendix B Figure 7

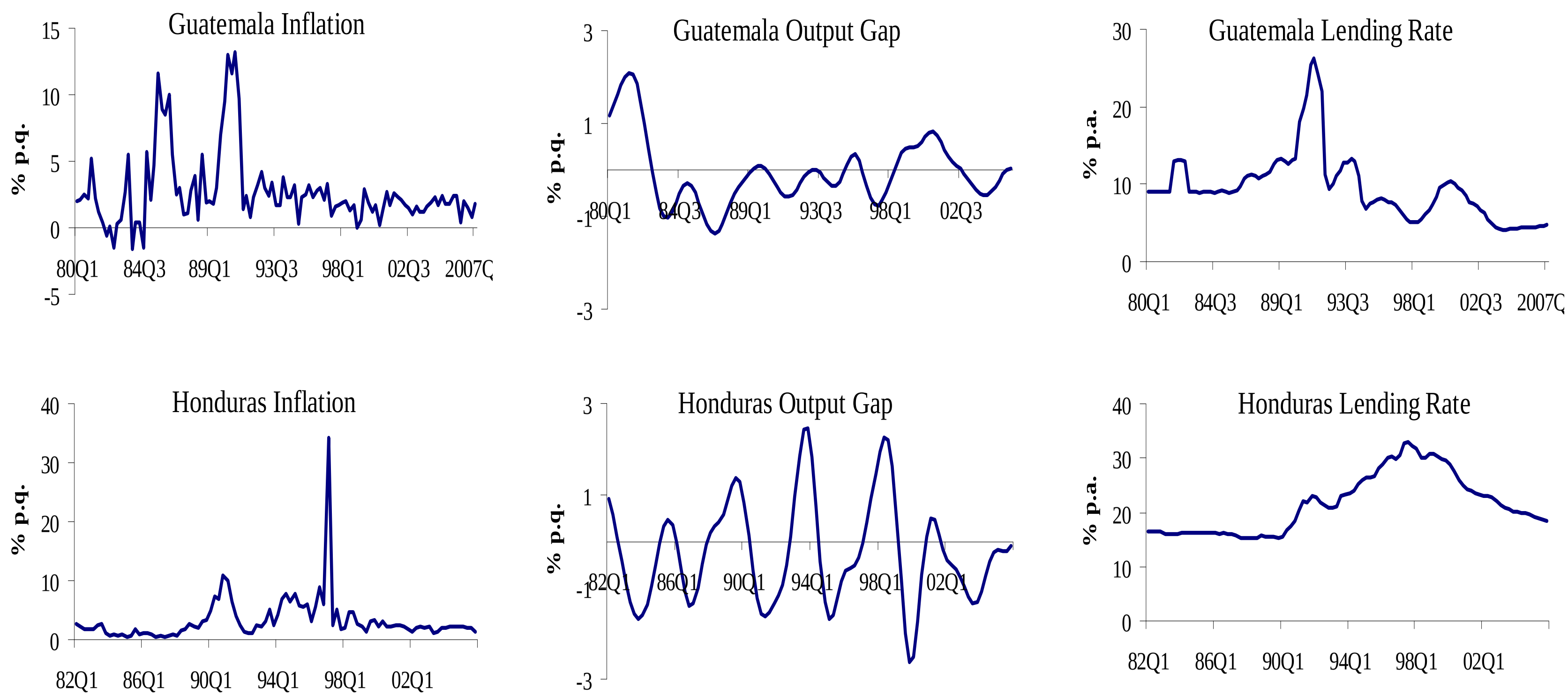


* Quarterly government balances as a percentage of quarterly GDP

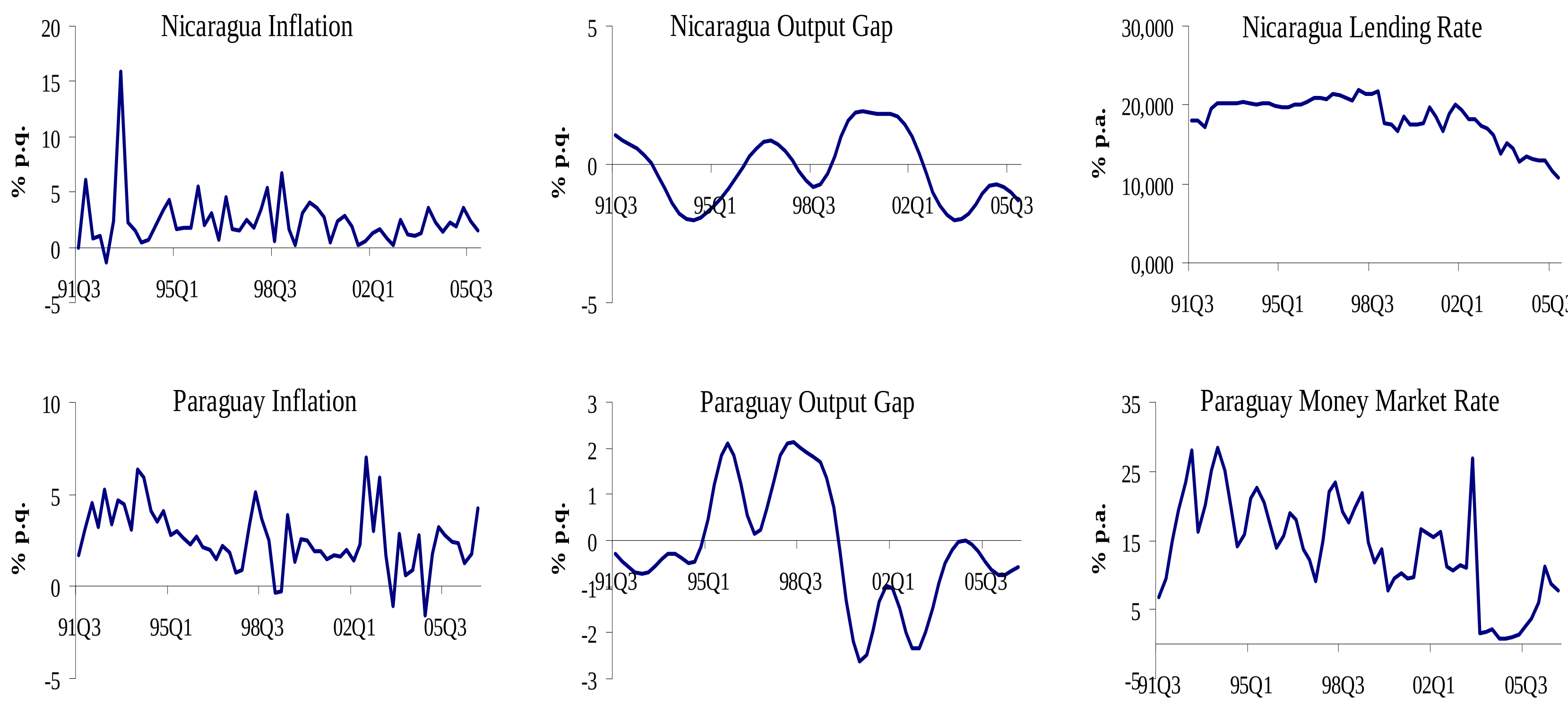
Appendix B Figure 7



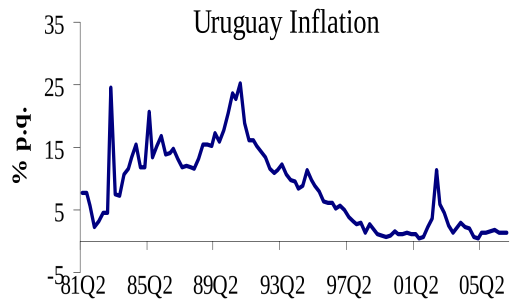
Appendix B Figure 7

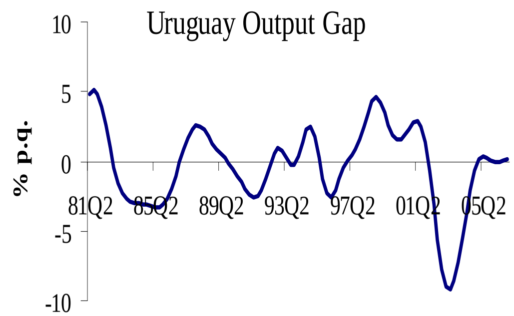


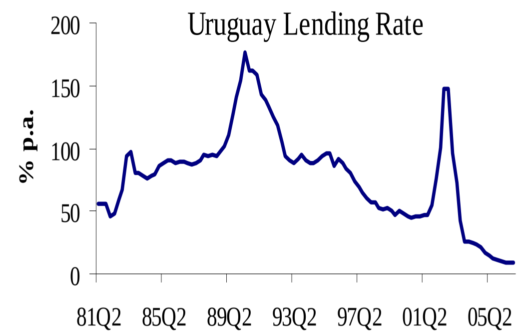
Appendix B Figure 7



Appendix B Figure 7







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