

What drives inflation expectations in Guatemala, and what do they imply for monetary policy decisions?¹

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Abstract

This paper examines the process of inflation expectation formation in Guatemala since the adoption of inflation targeting in 2005. It also tries to measure the impact of inflation expectations on monetary policy decisions through impulse response functions derived from a hybrid Dynamic Stochastic General Equilibrium (DSGE) model calibrated for the Guatemalan economy. Unlike the results obtained by Cerisola and Gelos (2005), there is significant evidence of inflation persistence in determining expectations, and relatively high volatility in the process of expectation formation. As a result, monetary policy decisions tend to be biased upward, with negative consequences for consumers, firms, and for overall economic activity in the short run.

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Key Words: Inflation Expectations, Monetary Policy, Impulse Response Functions, DSGE Models

¹The opinions expressed in this document belong to the author, and they do not necessarily represent the views of the staff and the authorities of Bank of Guatemala.

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1 Introduction

The Central Bank of Guatemala adopted an explicit inflation targeting framework to conduct its monetary policy since 2005. Under this framework, it is important to assess the effectiveness of the inflation expectations channel's transmission mechanism on the economy's main macroeconomic variables. The inflation expectations channel is based on the fact that, under the premise of a high degree of credibility by the society on the actions of the monetary authorities, the announcement made by such authorities in relation to the inflation target has a direct and quick effect on the convergence to the aforementioned target.

In order to assess the consequences of inflation expectations in Guatemala and the effectiveness of such monetary policy transmission channel, in this work we formulate an inflation expectations' model, which departs from the information compiled month to month by an inflationary expectations survey to a panel of private (free-lance) economy analysts. With these data, an inflation expectations series was built and through an econometric estimation, the core fundamentals of the series were found. Based on such formulation, a dynamic stochastic general equilibrium (DSGE) model for a small and open economy was set, in which the estimated process of inflation expectations is included. Furthermore, the responses of the main macroeconomic variables to shocks on the monetary policy interest rate, inflation and the output-gap are analyzed in order to determine the validity of the model introduced, whose task is to mimic the monetary policy transmission channel. By verifying the validity of the aforementioned model, the consequences of the inflation expectations on the monetary policy are evaluated through the analysis of the main macroeconomic variables' responses to a shock on inflation expectations.

The remaining part of this document is divided as follows. Section 2 presents a brief historical description about the establishment of inflation targeting in Guatemala. Section 3 describes the methodology employed to construct a series on inflation expectations for the Guatemalan economy, and illustrates the results obtained. Section 4 shows the empirical estimates found through econometric analysis. Section 5 describes the model and presents impulse response simulations. Finally, Section 6 concludes.

2 Background and evidence about the Inflation Targeting Framework in Guatemala

Immediately after the inflation crisis that affected Guatemala in 1989-90, the Central Bank implemented some measures tending to reach a better economic efficiency through keeping inflation under control.

During the first five years of the 90's, Banco de Guatemala³ started focusing on stabilizing the overall general level of prices by way of setting an inflation target. However, at the same time, it applied different mechanisms in order to participate in the exchange market, which impaired in some degree its efficient control of the overall supply of money. Nevertheless, the Central Bank regained control of inflation, which had been lost at the end of the 80's, without the use of a definite nominal anchor⁴.

Starting in 1996, the monetary policy stance was relaxed through the decrease in the level of Open Market Operations (OMO's) and the reduction of banking reserves, as a way to stimulate economic activity. At that time, it was expected that such easing of the monetary policy would be supported by a conservative stance of the fiscal policy, which proved not to be the case. Due to this action, money supply, already abundant due to the relaxation of the monetary policy stance, increased and produced an accelerated fall of the interest rates, influencing the exchange market. Because the Central Bank was chasing two nominal objectives with only one instrument (to keep the exchange rate stable as well as the control of inflation), there was an important loss of foreign exchange reserves. It is because of these reasons that, at the end of 1999, the Central Bank began to work in order to set only one nominal anchor, the control of inflation, as the main goal of monetary policy.

In 2000 Guatemala began to work on the implementation of an explicit inflation targeting framework. It is important to mention that in 2004 Mark Stone performed an analysis in relation to the trend followed by the monetary regimes of Latin America during the 1990 – 2003 period, and found that Guatemala had been in an Inflation Targeting Lite regime between 1996 and 2003. According to Stone (2002), in a regime of this sort the adopting countries announce an inflation target while simultaneously allowing the floating of the exchange rate, but the monetary policy is not based on a clear and credible commitment with the inflation target. It was not until the end of 2004 when Banco de Guatemala announced an inflation target and an explicit nominal anchor, supporting the express commitment of reaching such target. As a result, the authorities of Banco de Guatemala requested an evaluation by the International Monetary Fund (IMF) and other experts on the field, of the progress in the implementation of the explicit inflation targeting framework. From those evaluations emerged important recommendations directed to strengthen and support the requirements needed to implement an explicit inflation targeting framework. Among those recommendations was the one directed to implement a solid forecasting system, which became reality with the adoption of a semi-structural macroeconomic model for medium term forecasting.

³Banco de Guatemala is the Central Bank of Guatemala.

⁴According to Stone and BUNDIA (2004) a nominal anchor is a nominal variable publicly announced, which is used as a target for monetary policy.

Within the context of an explicit inflation targeting framework as the one adopted by Guatemala, it is important to understand the functions of the expectations channel, which is contained within the monetary policy transmission mechanism⁵. According to Muñoz y Torres (2006), this channel is based on the fact that, when credibility is present, monetary policy authorities' announcements have a quick and direct effect upon the final goals of the monetary policy, while the traditional channels work with the presence of a lag, and with some degree of uncertainty.

Being able to rely on an expectations formation model built on the determinants of inflation expectations, could be an important factor for the success of Guatemala's inflation targeting framework, since it could provide an endogenous path for inflation expectations within the model projections.

3 Constructing a Time Series for Inflation Expectations

This section briefly describes the procedure to build a continuous time series for inflation expectations. The main data source comes from the Inflation Expectations Survey, which is monthly assessed by the Central Bank of Guatemala to a panel of domestic and international experts on Guatemalan monetary policy. Nevertheless, the survey requests from each person to reveal his/her expected inflation for the following two months, for December of the present year, and for December of the following year. Therefore, available data on inflation expectations is not a continuous series. Table 1 illustrates the data obtained from the Inflation Expectations Survey in any given year.

⁵See, King. The Transmission Mechanism of Monetary Policy. Quarterly Bulletin, Bank of England. May 1994; Mies, Morandé y Tapia. Política Monetaria y mecanismos de transmisión: nuevos elementos para una vieja discusión. Documento de trabajo No. 181, Banco Central de Chile. Septiembre 2002.

Survey	Year t												Year t+1					
Assessment	Jan	Feb	Mar	Apr	May	Jun	Jul	Ago	Sep	Oct	Nov	Dec	Jan	Feb	...	Dec		
Jan	x	x	x														x	
Feb		x	x	x														x
Mar			x	x	x													x
Apr				x	x	x												x
May					x	x	x											x
Jun						x	x	x										x
Jul							x	x	x									x
Ago								x	x	x								x
Sep									x	x	x	x						x
Oct										x	x	x						x
Nov											x	x						x
Dec												x		x	x			x

To build a continuous series on inflation expectations based on the available information, it was followed an interpolation procedure, based on seasonal factors computed from observed inflation. In fact, based on a five year data span on observed historical inflation, seasonal factors represent normalized average monthly deviations from a long term mean. Twelve values are obtained, one for each month, and their values fluctuate around one (the normalized mean value). A seasonal value greater (lower) than one indicates that average inflation in such a month is above (below) the long term mean. Given that expected inflation was available for December of the current and the following year, constant variations were computed to the closer December value. Such a constant variation was adjusted by the seasonal factor of each month, filling up the data gap for the current year. The same procedure was followed to compute inflation expectations from current year December to the same month of the following year. As a result, there were obtained complete series of inflation expectations for time horizons between one and twelve months. Figure 1 illustrates observed inflation and the computed series for twelve-month inflation expectations from 2005 to 2009, which comprehends the period since the establishment of Inflation Targeting as a monetary policy framework in Guatemala.

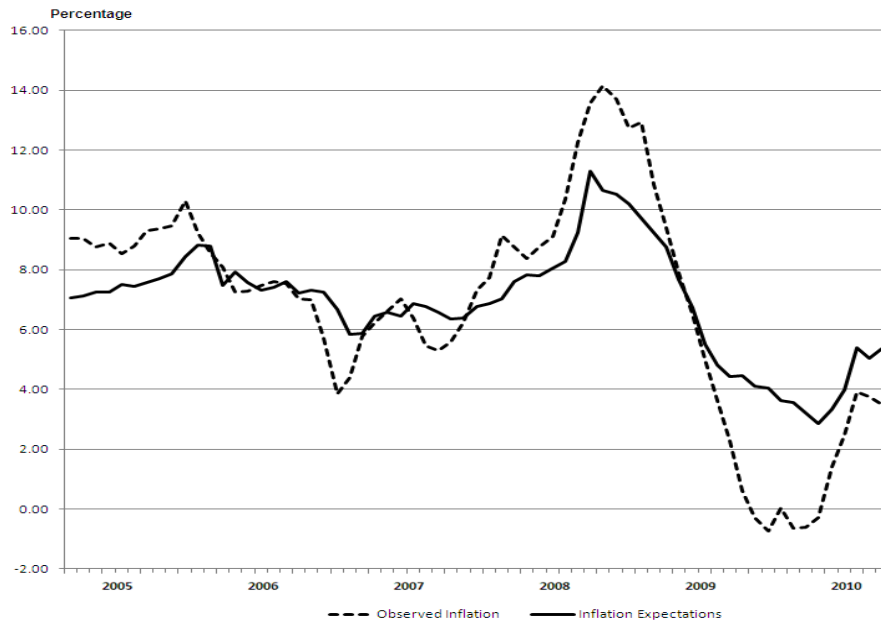


Figure 1. Inflation Expectations and Observed Inflation.

According to Figure 1 there is a close relationship between observed and expected inflation. In fact, the contemporaneous correlation between both series is 0.969. Such a result could be a clear indication that economic agents base their future inflation expectations in current inflation, despite there is an annual inflation target established each year by the monetary authority.

4 Empirical Model of Inflation Expectations Formation process in Guatemala

Departing from its fundamental determinants and with the use of four explanatory variables, the inflation expectations series developed in the former section is modeled. These explanatory variables are: the inflation deviation from its target; the inflation of the previous period; the oil prices variation; and, the inflationary expectations of the economic agents in the former time period.

Under an explicit inflation targeting framework, inflationary expectations should be directly related with inflation deviations from its target, where the latter is established by the Central Bank. Such a deviation is computed as $\pi_t - \pi_t^M$, where π_t represents inflation in period t and π_t^M represents the inflation

target for period t . This variable represents an indicator of society's credibility on Central Bank actions. Therefore, the higher the deviation, the highest would be expected future inflation by economic agents. Figure 2 shows the inflationary expectations series and also inflation deviations from its target.



Figure 2. Inflation Expectations and inflation deviations from its target.

Past observed and expected inflation are also important factors within the inflation expectations formation process. In fact, economic agent's backward looking behavior is expected to affect people's previsions of future prices. Thus, both variables are included within the inflation expectations model.

In addition, in a small open economy, like the Guatemalan economy, domestic prices are mainly determined by the foreign price of imported commodities. Therefore, it is possible to consider that inflation expectations are also affected by price variations of imported commodities. In fact, international oil price fluctuations were considered within the inflation expectations formation model. Such a price fluctuation was computed as $oil_price_t - oil_price_{t-1}$. Figure 3 depicts both inflation expectations and international oil prices variations during the period 2006-2010.

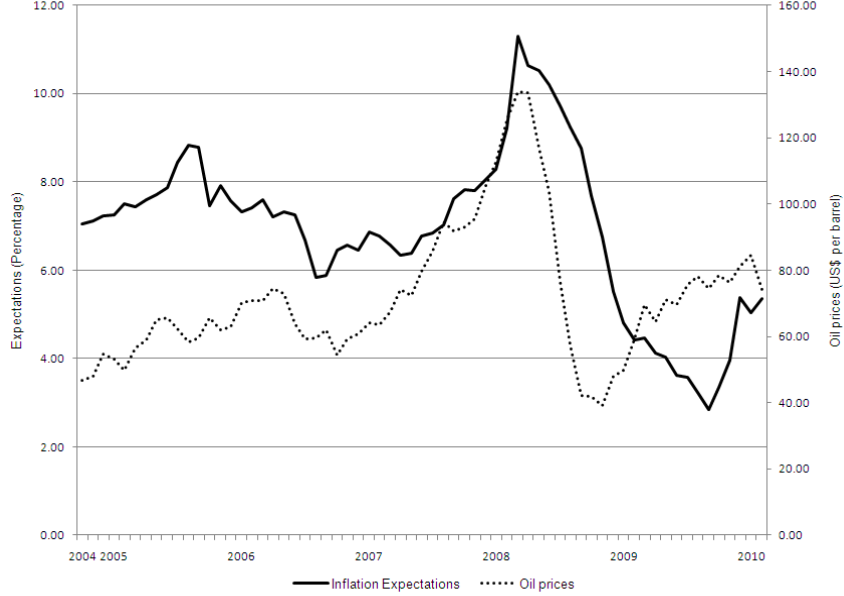


Figure 3. Inflation Expectations and oil prices.

Given the variables mentioned above, the inflation expectations formation process is given by Equation (1).

$$E_t(\pi_{t+12}) = \beta_1 \cdot E_{t-1}(\pi_{t+12}) + (1 - \beta_1) \cdot \{\pi_{t-1} + (\pi_t - \pi_t^M) + (oil_price_t - oil_price_{t-1})\} \quad (1)$$

Where:

$E_t(\pi_{t+12})$	Current expected inflation 12 periods ahead.
$E_{t-1}(\pi_{t+12})$	Previous term expected inflation 12 periods ahead.
π_{t-1}	Observed inflation.
$(\pi_t - \pi_t^M)$	Inflation deviation from its target.
$oil_price_t - oil_price_{t-1}$	Oil price variation.

Econometric estimations of Equation (1) are presented in Table 2. Estimations were performed under the Generalized Method of Moments (GMM), based on monthly data for the period 2006M01- 2010M05. Estimates were also obtained through Ordinary Least Squares (OLS) in order to have a range of values from were to choose from in the model calibration process performed in the following section.

Table 2 Inflation Expectations Estimates for the Guatemalan Economy		
Dependent Variable: Inflación Expectations 12 periods ahead		
Parameter	Equation 1	
	GMM	OLS
β_1	0.9606 ***	0.9794 ***
R^2	0.91	0.92
N	53	53
J-Stat	0.09 ***	

* Significant at 10%
** Significant at 5%
*** Significant at 1%

According to the results presented in Table 2, past expected inflation is the main factor driving the process of inflation expectations formation in Guatemala. The other factors, such as oil price changes, and inflation deviations from its mean, are also important, but in a lower degree.

5 Implication of Inflation Expectations in Monetary Policy Decisions

To measure the implications of inflation expectations (as measured in the previous section) for monetary policy decisions, it was constructed a DSGE model based on reduced form equations that simulate a small open economy, and was calibrated for the Guatemalan economy. In fact, the model consists of a series of stationary variables interrelated through 39 linear equations, where 11 of them represent behavioral equations, 9 equations belong to exogenous variables, and the remaining 19 equations represent identities. The behavioral equations of the model are listed below.

Aggregate Demand:

$$\hat{y}_t = \alpha_1 \cdot (\alpha_2 \cdot \hat{y}_{t-1} + (1 - \alpha_2) \cdot \hat{y}_{t+1}) + \alpha_3 \cdot \hat{R}_{t-1} + \alpha_4 \cdot \hat{z}_{t-1} + \alpha_5 \cdot \hat{y}_{t-1}^* + \varepsilon_t^{\hat{y}} \quad (2)$$

Where:

\widehat{y}_t	Output gap
\widehat{R}_t	Real interest rate gap
\widehat{z}_t	Real exchange rate gap
\widehat{y}_t^*	Foreign (U.S.) output gap

Phillips Curve:

$$\pi_t = \beta_1 \cdot (\beta_2 \cdot \pi_{t-1} + (1 - \beta_2) \cdot \pi_{t+1}^e) + (1 - \beta_1) \cdot (\pi_t^M - z_{tnd,t}) + \beta_3 \cdot \widehat{y}_t + \varepsilon_t^\pi \quad (3)$$

Where:

π_t	Quarterly inflation
π_t^e	Expected inflation
π_t^M	Imported Commodity Prices
z_{tnd}	Equilibrium Real Exchange Rate
\widehat{y}_t	Output gap

Imported Commodity Prices:

$$\pi_t^M = \beta_4 \cdot \pi_{t-1}^M + (1 - \beta_4) \cdot (\pi_t^* + s_t) + \varepsilon_t^{\pi^M} \quad (4)$$

Where:

π_t^M	Imported Commodity Prices
π_t^*	Quarterly foreign (U.S.) inflation
s_t	Nominal exchange rate

Expected Inflation:

$$\pi_t^e = \beta_5 \cdot \pi_{t-1}^e + (1 - \beta_5) \cdot \{\pi_{int,t-1} + (\pi_t - \bar{\pi}_t) + (\pi_t^M - \pi_{t-1}^M)\} + \varepsilon_t^{\pi^e} \quad (5)$$

Where:

π_t^e	Expected Inflation
$\pi_{int,t}$	Interannual inflation rate
$\bar{\pi}_t$	Inflation target
π_t^M	Imported Commodity Prices

Reaction Function (1):

$$i_t = \delta_1 \cdot i_{t-1} + (1 - \delta_1) \cdot \{i_{tnd,t} + \delta_2 \cdot (\pi_{int,t+6} - \bar{\pi}_{t+6}) + \delta_3 \cdot \widehat{y}_t\} + \varepsilon_t^i \quad (6)$$

Where:

i_t	Monetary Policy Rate
$i_{tnd,t}$	Interest Rate Trend
$\pi_{int,t}$	Interannual inflation rate
$\bar{\pi}_t$	Inflation target
\widehat{y}_t	Output gap

Yield Curve:

$$I_t = \gamma_1 \cdot I_{t-1} + (1 - \gamma_1) \cdot \left\{ \frac{(i_t + i_{t+1} + i_{t+2} + i_{t+3})}{4} + term_t \right\} + \varepsilon_t^I \quad (7)$$

Where:

I_t	Long Run Domestic Interest Rate
i_t	Monetary Policy Rate
$term_t$	Maturity Premium

Modified Interest Rate Parity Condition:

$$(I_t - I_t^*) = 4 \cdot (s_t^e - s_{tend,t}) + prem_t + \varepsilon_t^s \quad (8)$$

Where:

I_t	Long Run Domestic Interest Rate
I_t^*	Long Run Foreign (U.S.) Interest Rate
s_t^e	Nominal Exchange Rate Expectations
$s_{tend,t}$	Nominal Exchange Rate Trend
$prem_t$	Country Risk Premium

Nominal Exchange Rate Expectations:

$$s_t^e = \rho_1 \cdot s_{t+1} + (1 - \rho_1) \cdot \left(s_{t-1} + \frac{2}{4} \cdot (z_{tend,t} + \bar{\pi}_t - \pi_{ss}^*) \right) + \varepsilon_t^{s^e} \quad (9)$$

Where:

s_t^e	Nominal Exchange Rate Expectations
s_t	Nominal Exchange Rate
$z_{tend,t}$	Equilibrium Real Exchange Rate
$\bar{\pi}_t$	Inflation target
π_{ss}^*	Foreign (U.S.) Inflation in steady state

Reaction Function (2):

$$s_{int,t} = \tau_1 \cdot (4 \cdot (s_t - (s_{tnd,t} + \hat{s}_t))) + \varepsilon_t^{s_{int}} \quad (10)$$

Where:

$s_{int,t}$	Nominal Exchange Rate of Intervention
s_t	Nominal Exchange Rate
$s_{tnd,t}$	Nominal Exchange Rate Trend
\hat{s}_t	Nominal Exchange Rate Gap

Fisher Equation:

$$R_t = I_t - \pi_t^e \quad (11)$$

Where:

R_t	Real Long Run Domestic Interest Rate
I_t	Nominal Long Run Domestic Interest Rate
π_t^e	Inflations Expectations

The total number of parameters within the model is 37, where 7 of them are steady state values, and the remaining 30 are behavioral coefficients. To obtain the values for each parameter, every equation was estimated through the Generalized Method of Moments (GMM) approach. Nevertheless, estimations through Ordinary Least Squares (OLS) were also performed in order to have a range of values for each coefficient that allow the selection of a combination of parameter values that generate a convergent model specification. Nevertheless, there were some cases where parameter values had to be taken outside that range, in order to obtain a unique solution for the model. Table 3 shows the parameter values for each of the behavioral equations.

Table 3 Parameters values of Behavioral Equations		
Parameter	Description	Value
Agregate demand		
α_1	Relevance of past and expected output gap in current values	0.91
α_2	Output Gap Persistence	0.10
α_3	Interest Rate Elasticity of Output Gap	-0.25
α_4	Real Exchange Rate Elasticity of Output Gap	0.57
α_5	Foreign Output Elasticity of Output Gap	0.29
Phillips Curve		
β_1	Relevance of Past and Expected Inflation in Current Prices	0.92
β_2	Inflation Persistence	0.55
β_3	Aggregate Demand Elasticity of Prices	0.60
Imported Commodity Prices		
β_4	Imported Commodity Price Persistence	0.75
Inflation Expectations		
β_5	Relevance of Backward Looking Inflation Expectations	0.76
Reaction Function 1		
δ_1	Interest rate smoothing	0.45
δ_2	Central Bank Reaction to Inflation Deviations from Target	0.99
δ_3	Central Bank Reaction to Output Gap	0.15
Yield curve		
γ_1	Nominal Interest Rate Persistence	0.465
Nominal Exchange Rate Expectations		
ρ_1	Nominal Exchange Rate Flexibility	0.48
Reaction Function 2		
τ_1	Central Bank Reaction to Nominal Exchange Rate Misalignments	0.75

After identifying and calibrating the model, impulse response functions were estimated to analyze the dynamic relationship among macroeconomic variables. Nevertheless, it is important to mention that the calibration and the estimation of impulse responses followed an iterative process, since such functions also allow establishing some specific characteristics of the Guatemalan economy within the model dynamics (i.e. the sacrifice ratio, or the nominal exchange rate volatility). Four specific impulse responses are described in this document: i) a monetary policy shock, ii) an inflation shock, iii) an aggregate demand shock; and, iv) an

inflation expectations shock.

Figure 4 shows a monetary policy shock, which consist of an increment of 100 basis points to the monetary policy rate. Such an increment, is followed by an increase in the long run nominal and real interest rate, and in the real interest rate gap, which in turn generates a contraction in aggregate demand (through its effect on domestic consumption and investment), and a fall in inflation. In addition, the increase in nominal long run rates leads towards a nominal exchange rate appreciation, due to the modified interest rate parity condition, Equation (8), which induces a real currency appreciation, and reinforces the temporary fall in aggregate demand (given a reduction in exports), and the reduction in inflation. Notice that the real exchange rate converges from above its steady state value, since the fall in inflation is higher than the increase in the nominal long run interest rate in the later periods of the simulation.

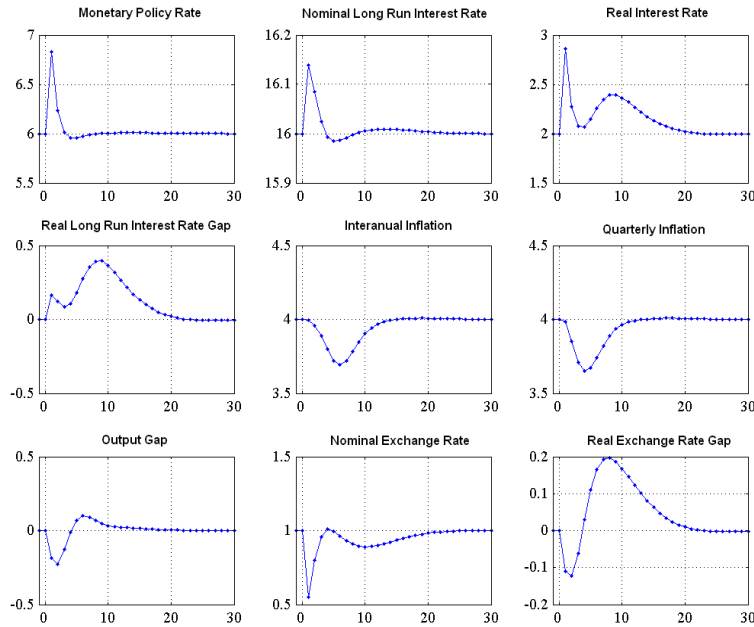


Figure 4. Responses to a Monetary Policy shock.

In the long run, when the economy returns to its long run steady state, inflation converges to its target rate, given the absence of demand pressures, since domestic output reaches its potential level (output gap equals zero). Inflation expectations also converge to the inflation target. This simulation dynamics shows that the inflation rate falls after an increase in the monetary policy rate. In the long run, the steady state for all variables within the model is achieved within 20 periods or less than five years (since each period is equivalent to one quarter).

Adding to the analysis of the effects on Guatemala's economy as a result of a monetary policy shock, we also analyze the responses to an inflation shock and an aggregate demand shock. Such effects are shown, respectively, in Figures 5 and 6.

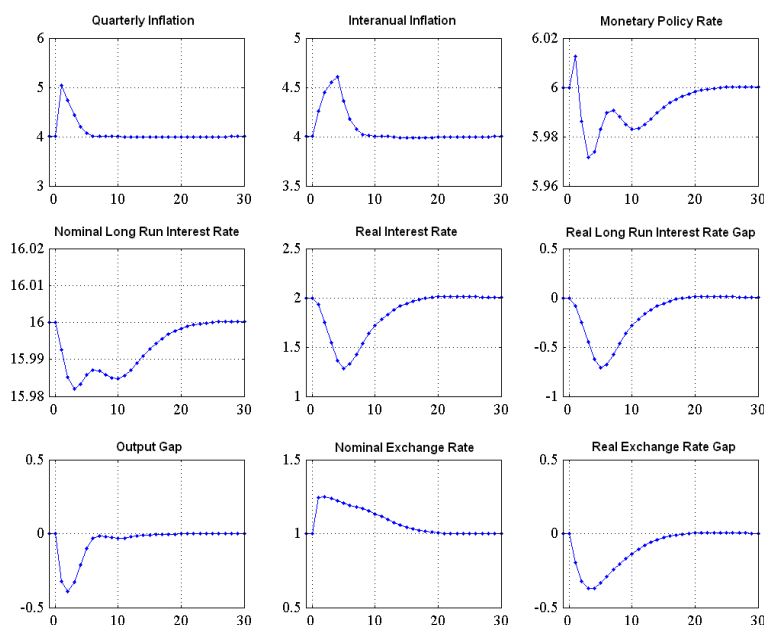


Figure 5. Responses to an inflation shock.

The reactions of the endogenous variables of the modeled economy to a one-percentage point shock on the quarterly-inflation rate can be seen on Figure 5. Such an increase determines a fall on the real exchange rate and the real exchange rate's gap; that real exchange rate depreciation induces a decrease on the output and the output-gap, diminishing the monetary policy rate. The decrease of the monetary policy rate leads to a fall on the long run nominal interest rate and on the long run nominal interest rate gap; at the same time, this fall on the long run nominal interest rate induces a depreciation of the nominal exchange rate. It can also be seen on Figure 5, the return of all the variables (during a span of time of less than five years) to the initial steady-state, as a response to a shock on quarterly inflation. This reaction is the same in response to a shock to the monetary policy interest rate.

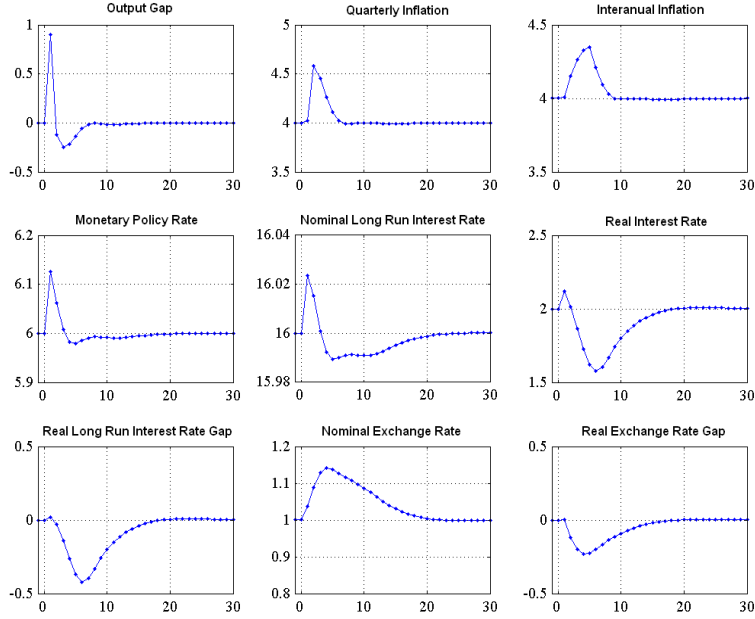


Figure 6. Responses to an Aggregate Demand shock.

The reactions of the endogenous variables of the modeled economy to a one-percentage point shock on the output-gap are illustrated in Figure 6. An increase in the output gap initially produces two effects: first, a rise on the monetary policy rate; second, an augment on quarterly inflation that reinforces the increase on the monetary policy rate, which in turn induces an increase on the long run nominal interest rate and, through it, determines an increment on the long run real interest rate. The rise on the quarterly inflation rate generates a reduction on the real exchange rate, and also on the real exchange rate gap. As a result of this depreciation on the real exchange rate, both a fall on the output and on the output-gap are induced as well as the subsequent decrease on the nominal interest rate, which then generates a reduction on the long run nominal interest rate, and a depreciation of the nominal exchange rate.

Once properly identifying the response to shocks on the main variables, we can proceed to evaluate the consequences of the inflation-expectations on the monetary policy, which are analyzed through the model's responses to a one-percentage point shock on the aforementioned inflation-expectations. Such responses are shown on Figure 7.

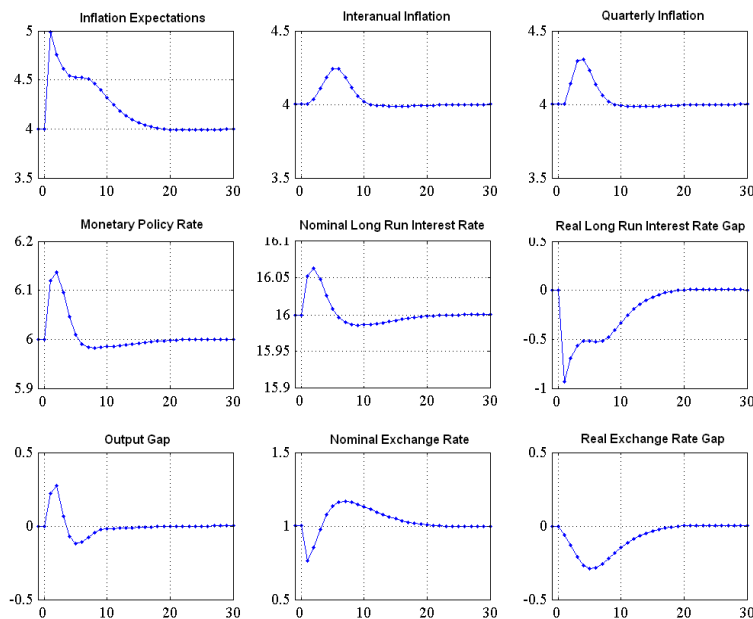


Figure 7. Responses to an Inflation Expectations shock.

Figure 7 depicts the responses of the model endogenous variables to a one-percentage point shock on the year-to-year inflation expectations. The positive shock to the year-to-year inflation expectations generates an instant response on the inflation rate, quarterly inflation as well as year-to-year's inflation rate. The rise on the inflation rate determines an increase on the monetary policy rate, and the subsequent rise on the long run nominal interest rate, which produces two effects: the first one, a decrease on both the long run real interest rate, and on the long run real interest rate gap, due to a larger increase on the inflation rate than on the long run nominal interest rate; then, this reduction on the long run real interest rate gap produces a decrease on the output gap. The second effect is an appreciation of the nominal exchange rate and the subsequent reduction on the real exchange rate gap. This reduction on the real exchange rate gap generates a decline on the output gap and determines a quicker convergence to its steady-state, with the value of such convergence evolving below the one of the steady-state's which is zero. On Figure 7 it can be seen that all variables converge to their steady-state values in a span of time of less than five years, after a shock on the year-to-year inflation expectations.

On the analysis of the responses of the endogenous variables of the modeled economy after a shock on the inflation expectations, it can be seen that such model captures in a proper way the responses of the main variables: faced by an increase on the inflation expectations, the Central Bank must make use of

its policy instruments, in this case the monetary policy rate in order to reduce the inflationary pressures.

6 Conclusions

For an Inflation Targeting central bank it is important to know the factors that determine inflation expectations, since having them anchored to the central bank inflation target is the key to monetary policy efficiency.

The empirical results presented in this document show significant and consistent evidence to conclude that economic agents in Guatemala are backward looking, that is, past inflation is the main factor driving future expected inflation, while inflation deviations from its target, and international oil prices play a secondary but significant role. Therefore, inflation deviations from target and international oil prices affect inflation expectations, not at the moment they fluctuate, but whenever they affect observed inflation.

When introducing such a backward looking characteristic within a dynamic general equilibrium model, a positive shock to inflation expectations forces an immediate increase in the monetary policy rate to make inflation converge to the central bank target in the medium term.

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