Inflationary Dynamicsin Guatemala

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Abstract. Short-run price dynamics for Guatemala are analyzedusing a linear transfer function methodology. This approach has previously been employed for other national economies such as the United States, Mexico, Colombia, Ecuador, and Nigeria. The data for this study range from 1960 to 2010. Inflation is measured using the consumer price index. Explanatory variables include the monetary base, real output, interest rates, and the exchange rate. Allof the estimated coefficients exhibit the arithmetic signs hypothesized by the theoretical model. Almostall of the parameter estimates satisfy the 5-percent significance criterion and all exhibit economically plausible magnitudes. Estimation results indicate that although monetary policy effects begin to materialize within twelve months of implementation, the bulk of the impacts associated with the money supply do not occur until the second year after any monetary policy action is taken.

Keywords. Inflation, Guatemala, Monetary Economics, Applied Econometrics.

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1. Introduction

Inflation continues to be problematic in many developing economies due to its influence on economic growth, social welfare, and income distribution (Kemal, 2006; Yavari & Serletis, 2011). In the case of Guatemala, a double digit rate of inflation was registered as recently as 2008. Price stability remains an elusive goal in this important Central American economy. To date, however, there have been relatively few formal econometric studies of aggregate price movements in the land of the quetzal.

To examine aggregate price trends in Guatemala, a monetary model is developed and then estimated using a nonlinearautoregressive moving average exogenous (ARMAX) approach (Pagan, 1974). That framework is employed because variants of it have previously been successfully applied to the analysis of inflationary dynamics in a number of other economies around the world, including several in Latin America (Fullerton & Tinajero, 2001). A dynamic specification isdeveloped that incorporate lags of key explanatory variables, but does not have excessive data or degree of freedom requirements associated with it.

Subsequent sections of the study are as follows. A brief overview of related literature is provided in the next section. A theoretical model for aggregate prices

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is discussed in the third section of the paper. Data and empirical results are summarized next. Policy implications are also discussed. A summary and conclusion finalize the analysis.

2. Previous Research

Latin American economies have long struggled with chronic inflation (Pazos, 1949). Accordingly, there has been a fair amount of research devoted to this topic (Glezakos & Nugent, 1984). Results in these studies underscore the importance of both monetary conditions and currency market effects on domestic inflation in these economies (Fullerton, 1993; Arize & Malindretos, 1997). A number of other problems often contribute to, and are worsened by, aggregate price instability (Beetsma & van der Ploeg, 1996).

Several other variables have also been found to affect inflation rates in Latin America. Among those playing prominent microeconomic roles areunit labor costs, sometimes approximated by real wage measures (Fullerton & Tinajero, 2001). Macroeconomic factors associated with the velocity of circulation include interest rates, sometimes approximated by other variables in countries where financial data are incomplete. The theoretical frameworks employed for these studies generally draw upon monetary models augmented by microeconomic cost of production constructs (Harberger, 1963; Hanson, 1985; Fullerton & Araki, 1996; Fullerton, 1999).

Although the long-run relationship between money and inflation is largely agreed upon, many questions remain regarding short-term price dynamics throughout Latin America and the rest of the world (Bernanke & Mihov, 1997). The money supply is not the sole driver behind inflation. The Cambridge equation links inflation to the ratio of money stock and output times velocity and provides a good starting point for analyzing short-run price dynamics, albeit without any prior insight to the dynamic lags involved in the process (Dwyer & Hafer, 1999).

In that context, money and output levels obviously influence aggregate price movements. Interest rates also play important roles in the inflationary process via impacts on the velocity of circulation (Tosoni, 2013). More specifically, deposit rates represent the opportunity cost of holding idle cash balances and affect velocity. Nominal interest rates were fixed until 1974. However, nominalyield variations did not begin in earnest in Guatemala until approximately 1986.

For much of its economic history, a nominal fixed exchange rate was also maintained between the quetzal and the United States dollar. Perhaps not surprisingly, the first large scale devaluation of the quetzal also occurred in 1986. Currency overvaluation was problematic throughout much of the 1980s and the quetzal was devalued nine times in 1990 alone (Ghosh et al., 1996). To avoid the imbalances associated with trading partner inflationary mismatches and fixed exchange rates, the central bank currently employs a floating exchange rate policy.

Price instability remains problematic in many emerging economies throughout the world (Goncalves & Salles, 2008; Lee, 2011). Although Guatemala is the largest economy in Central America, it has been the subject of relatively little macroeconometric analysis. This study attempts to partially fill that gap within the international economics literature by developing a model of short-term price dynamics for this economy. A discussion of the theoretical framework for the study follows.

3. Theoretical Model

Quantity theory of money constructs are still utilized as the starting points for many inflationary studies (Fullerton & Tinajero, 2001; Moroney, 2002). Those

approaches employ the so-called Cambridge equation involving money, the velocity of circulation, aggregate price levels, and national output. The most common expression for this framework is shown in Equation (1).

$$MV = PQ \tag{1}$$

where M is a measure of the money supply, V is velocity, P is the nominal price level, and Q is real gross domestic product (GDP).

Equation (1) can be transformed using natural logarithms and first differences to obtain an expression using the percentage changes traditionally associated with inflation. Introduction of a time subscript and rearrangement yields the well-known Harberger (1963) equation:

$$DLP_t = DLM_t - DLQ_t + DLI_{t-1} \tag{2}$$

where the last term results from substituting for velocity with a foregone interest earnings measure and D represents a difference operator.

To ensure cointegration, it will be helpful to multiply an interest rate measure such as the deposit rate with national savings or the money supply to construct a foregone interest earnings estimate (Fullerton & Tinajero, 2001). Such a step is recommended because consumer prices are unbounded from above (for an alternative strategy, see Elder & Kennedy, 2001). In contrast, nominal interest rates generally oscillate between 0 and 100 percent in most economies. During the sample period utilized, the deposit rate in Guatemala ranges between a low of 4.2 percent in 2004 and a high of 24.4 percent in 1991.

Equation 2 indicates that inflation will vary positively with respect to the money supply and foregone interest earnings, but inversely with respect to real output. A statistically significant intercept term will enter the estimated equation if there is a deterministic trend in the price index. If only contemporaneous lags of LM and LQ enter in the equation, the parameters for both variables are hypothesized to be equal to one. These possibilities can be empirically examined using the specification shown in Equation 3.

$$DLP_t = a_0 + a_1 DLM_t - a_2 DLQ_t + a_3 DLI_{t-1} + u_t \tag{3}$$

Where a_1 and a_3 are hypothesized to be positive, and the absolute values of a_1 and a_2 should both be statistically indistinguishable from unity. The last argument in the expression represents a stochastic disturbance term.

Equation 3 represents a fairly parsimonious framework for analyzing inflationary dynamics. That does not necessarily pose any problems, but extensions of this model have sometimes proven useful. Hanson (1985) and Fullerton (1999) employ an implicit cost function dual of an aggregate production function that is homogeneous of degree one to expand the framework above to include costs of production. In some cases, expanding the microeconomic features of this model can be helpful (Fullerton & Tinajero, 2001).

Equation 3 does not provide very much insight with respect to potential lag structures. For example, the inflationary impact of a change in the money supply may occur over a period of many months. Given that, the implied lag structure for a model estimated with annual data could easily go beyond the contemporaneous lags shown above and cannot really be known in advance. Equation 4 reflects this empirical possibility.

$$DLP_t = a_0 + \Sigma_i(a_{1i}DLM_{t-i}) + \Sigma_j (a_{2j}DLQ_{t-j}) + \Sigma_k(a_{3k}DLI_{t-k}) + u_t \qquad (4)$$

The above model provides a starting point for examining aggregate price trends. It is not, however, without potential problems for analyzing price movements in a relatively high inflation country such as Guatemala. One concern arises from utilizing first differenced, log-transformed time series data in the equation to be estimated. If the resulting series are stationary, the equation can be estimated with reduced risk of obtaining spurious correlation affecting the results. As shown in studies of hyperinflationary economies, however, higher order differencing may be necessary during periods in which prices increase very rapidly (Engsted, 1993). Because Guatemala has never undergone a hyperinflationary episode, the specification shown in Equation 4 should work reliably.

Asecond concern arises from possible omitted variables. While this problem is not expected to be severe, it could potentially lead to serial correlation. Fortunately, the transfer function version of Equation 4 allows for that eventuality. Equation 5 includes univariate autoregressive and moving average components for the stochastic error term (Fullerton & Tinajero, 2001). In the event that the error term is random and serial correlation is not present, the various estimated coefficients for a_4p and a_{5q} will be statistically indistinguishable from zero.

$$DLP_t = a_0 + \Sigma_i(a_{1i}DLM_{t-i}) + \Sigma_j(a_{2j}DLQ_{t-j}) + \Sigma_k(a_{3k}DLI_{t-k}) + \Sigma_p(a_{4p}u_{t-p}) + \Sigma_q(a_{5q}v_{t-q})$$
$$+ v_t \qquad (5)$$

A third concern arises from the manner in which the theoretical model is specified. Equation 5 assumes unidirectional causality from the explanatory variables to the dependent variable. Granger causality F-tests are utilized to assess whether this assumption is reasonable. Should the results of the causality tests indicate that simultaneity is present in the sample, additional steps would be required prior to estimation or a system of equations approach could be employed (Fullerton & Araki, 1996; Enders, 2010).

4. Empirical Analysis

Table 1 liststhe variables included in the sample and units of measure. The period analyzed ranges from 1960 to 2012. As noted above, Guatemala had fixed nominal interest rates prior to 1974. Effective nominal interest rates, however, varied during this period as a consequence of bank administrative fees and other charges. Historical data for thenational deposit rate are available from 1978 to 2012. For the period from 1960 to 1977, fitted values from an equation for the deposit rate as a function of the discount rate are utilized (Friedman, 1962). The regression equation used to estimate the deposit rate is shown in Equation 6 and the regression output for it is shown in Table 2.

$$I_t = c_0 + c_1R_t + w_t \qquad (6)$$

Table 1. *Variable Names and Data Descriptions*

Mnemonic	Description
DLP	First Difference of the Natural Logarithm of the Consumer Price Index, 2005=100
DLM	First Difference of the Natural Logarithm of Broad Money Supply, Quetzals
DLQ	First Difference of the Natural Logarithm of Real Gross Domestic Product, 2005 Quetzals
DLI	First Difference of the Natural Logarithm of Foregone Interest Earnings Approximated by the Product of the Money Supply with the Average

	Commercial Bank System Deposit Rate
I	Commercial Bank System Deposit Rate
R	Central Bank Discount Rate

Notes: (1). Sample Period: 1960-2012. (2). Source: IMF, 2013, *International Financial Statistics*, Washington, DC: International Monetary Fund.

Table 2. *Deposit Rate Regression Output*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.547	1.610	1.581	0.139
DISCOUNTRATE	0.662	0.128	5.158	0.000
R-squared	0.689178	Mean dependent variable		10.35714
Adjusted R-squared	0.663277	Std. dev. dependent var.		3.537864
S.E. of regression	2.052947	Akaike inf. criterion		4.407994
Sum squared resid.	50.57511	Schwarz inf. criterion		4.499287
Log likelihood	-28.85596	Hannan-Quinn criterion		4.399543
F-statistic	26.60736	Durbin-Watson statistic		2.090244
Prob.(F-statistic)	0.000238			

Note: Sample Period: 1960-2012.

A unit-root test is used to examine stationarity. The Augmented Dickey-Fuller t-statistics are calculated with intercept, only, and with trend and intercept. The intercept captures a mean not equal to zero and the trend captures a deterministic time trend or drift term (Elder & Kennedy, 2001). Results of those tests are summarized in Tables 3 and 4. The first differencesof the logarithmically transformed variables are found not to have unit roots using a 5-percent critical value. Those outcomes indicate that the differenced data series are stationary and higher differencing is not necessary (Engsted, 1993).

Table 3. *Augmented Dickey-Fuller Unit Root Stationarity Tests (with intercept)*

Series	Non-differenced ADF Test Statistic	Differenced ADF Test Statistic	5% MacKinnon Critical Value -2.919952
Log(P)	-0.053396	-3.627624	
Log(M)	1.333750	-5.397195	
Log(Q)	-2.521245	-5.682151	
Log(LI)	-0.285055	-6.598288	

Note: Sample period: 1960-2012.

Granger causality F-tests are next used to check for causality. With respect to the money supply, the test examines monetarist affirmations that nominal increases in the monetary base generally lead to higher price levels (Friedman, 1983). The two-period lag length for Guatemala, selected using Akaike, Schwarz, and Hannan-Quinn information criteria, corresponds well with empirical evidence for relatively quick monetary policy transmission time spans in lower income economies (Osinubi, 2005; Havranek & Rusnak, 2013). Empirical results are reported in Table 5. Fairly strong evidence indicates that changes in consumer prices are preceded by movements in the money supply. For the other regressors, the results are indeterminate. Those outcomes differ from the results reported for Mexico by Fullerton & Tinajero (2001) and raise the risk that the parameter estimates for Equation 5 will not satisfy the 5-percent significance criterion.

Table 4. *Augmented Dickey-Fuller Unit Root Stationarity Tests (with trend and intercept)*

Series	Non-differenced ADF Test Statistic	ADF Test Statistic	5% MacKinnon Critical Value -3.500495
Log(P)	-2.294625	-3.575005	
Log(M)	-2.829295	-4.148465	
Log(Q)	-1.825417	-6.105849	
Log(LI)	-2.291162	-6.528921	

Note: Sample period: 1960-2012.

Table 5. *Pairwise Granger Causality Tests*

Null Hypothesis	Observations	F-Statistic	Probability
DLM does not precede DLP	50	6.38415	0.0036
DLP does not precede DLM	50	0.45414	0.6379
DLQ does not precede DLP	50	0.15646	0.8556
DLP does not precede DLQ	50	0.34325	0.7113
DLI does not precede DLP	50	0.50231	0.6085
DLP does not precede DLI	50	0.52271	0.5965

Notes: (1). Sample Period: 1960-2012. (2). Two-period lags are employed for the F-tests.

Table 6 summarizesparameter estimation output for Equation 5. Lag length selection was determined using the same approach as for the pairwise causality tests. All of the estimated coefficients exhibit the expected signs. All but three of the parameters satisfy the 5-percent significance criterion. Although the constant term is positive, it is not statistically significant, implying that the generally upward trend in consumer prices in Guatemala is not strongly deterministic in nature (Svensson, 1999).

Table 6. *Estimation Output*

Variable	Coefficient	Standard Error	t-Statistic	Probability
Constant	0.017118	0.020410	0.838687	0.4064
DLM	0.171277	0.079457	2.155599	0.0369
DLM(-1)	0.393669	0.081701	4.818439	0.0000
DLQ	-0.442611	0.216248	-2.046780	0.0470
DLQ(-1)	-0.304298	0.207339	-1.467633	0.1497
DLI	0.102910	0.032195	3.196432	0.0026
DLI(-1)	0.023565	0.033029	0.713477	0.4795
AR(1)	0.428854	0.140097	3.061114	0.0038
R-squared	0.692091	Mean dependent variable		0.082504
Adjusted R-squared	0.640773	Std. dev. dependent var.		0.074233
S.E. of regression	0.044492	Akaike inf. criterion		-3.241383
Sum squared resid.	0.083139	Schwarz inf. criterion		-2.935460
Log likelihood	89.03459	Hannan-Quinn criterion		-3.124886
F-statistic	13.48630	Durbin-Watson statistic		2.055474
Prob.(F-statistic)	0.000000			

Notes: (1). Sample Period: 1960-2012. (2). Dependent Variable: DLP. (3). Inverted AR Root: 0.43. (4). Included Observations: 50 after adjustments. (5). Convergence achieved after 8 iterations.

The parameters estimated for the contemporaneous and one-year lags of the money supply are both significantly different from zero. Although aggregate prices begin reacting to changes in the money supply in a contemporaneous manner, the elasticity with respect to the one-year lag is greater. The impacts of greater output on consumer prices are negative for both lags, with the stronger, and statistically more reliable, reaction occurring during the contemporaneous period. Those outcomes are similar to those reported for other Latin American economies and

underscore for Guatemala the monetary roots of inflationary processes observed throughout the region (Hanson, 1985; Fullerton & Tinajero, 2001).

Although only the parameter for the contemporaneous lag of real output satisfies the 5-percent significance criterion, both of the coefficients for the lags of real output are negative as hypothesized. This potentially implies that aggregate supply shocks dominate aggregate demand shocks in Guatemala during the sample period in question (Karras, 1993). Although there are circumstances under which a positive relationship may exist between output and prices (Hanson, 1985; Fullerton & Araki, 1999; Walsh, 2002), those conditions appear not to be present in Guatemala and modification of the model is not necessary for analyzing inflationary trends in this economy.

Aggregate price responses to changes in foregone interest earnings, included to account for fluctuations in the velocity of circulation, occur primarily within the first year and essentially die down after that. That implies that Guatemalan consumers and investors react fairly quickly to interest rate changes and presumably manage idle cash balances in manners that safeguard purchasing power. As documented in prior studies for Latin American economies using this general framework (Fullerton, 1993; Fullerton & Tinajero, 2001), serial correlation is present in the residuals. Based on Chi-squared statisticsfor autocorrelation function and correlogram estimation results, a one-period autoregressive parameter is also included in Table 6 to address that issue.

The estimation results in Table 6 have several policy implications associated with them. The inflationary process in Guatemala exhibits classical monetary characteristics. Consumer prices respond to changes in the money supply, overall economic conditions, and interest rates. As in many economies around the world, the results in Table 6 indicate that the bulk of the response to changes in monetary policy occur more than a year after the initial action is taken. That implies that central bank policy actions, while effective, do take time to influence aggregate price trends and officials should be aware of this fact when attempting to put a halt on inflation (Havranek & Rusnak, 2013).

5. Conclusion

Monetary policy remains an important area of debate for many developing economies. This is especially the case in Latin America where prevailing inflation rates tend to outpace the rates observed elsewhere. In order to design effective monetary policy, a useful first step is to understand how aggregate prices empirically behave. Although Guatemala is the largest economy in Central America, its macroeconomic performance has been the focus of relatively little econometric research. This study attempts to at least partially fill that gap in the applied economics literature.

The theoretical model is based on the Cambridge equation variant of the quantity theory of money. Estimation results confirm most of the hypotheses associated with the functional form of the model as specified. Although the effects of shocks to any of the variables in the model are noticeable within twelve months, the impacts of money supply changes are most prominent during the second year following the policy change. The delayed aspects of the monetary policy effects may represent a source of political difficulties for central bank policy initiatives.

Although the results for Guatemala indicate that this approach to inflationary modeling appear to hold promise, it is not known whether similar outcomes would be obtained for other countries in Central America. Additional modeling for the neighboring economies in this region would be useful. The conduct of monetary policy varies substantially across Central America, with two countries, Panama and

El Salvador, even using the United States dollar as their local currencies. The modeling approach employed for this study may offer a good starting point for analyzing aggregate price trends in the other economies in this region.

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