

# Forecasting Mexico's Inflation: the Effects of an Inflation Targeting Regime

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## Abstract

This paper studies the effects the implementation of an inflation targeting (IT) regime has on the dynamics of inflation in Mexico. We contextualize the need for a regime change and study whether the implementation of this regime has made a considerable change in the dynamics of inflation in Mexico. Consumer prices are modelled using a markup model. The markup model suggests a long run relationship where the domestic price level is a markup over total unit costs, including unit labor costs, import prices, and energy prices. We then account for short-run dynamics by using an error correction model and address the issues of co-integration, dynamic specification, and parameter constancy. The results presented in this paper show the institution of an IT regime in Mexico had drastic effects on the dynamics of inflation. Namely, a Chow Test for regime change shows the existence of a different model of inflation in Mexico during the IT years. Similarly, we find the variance of the residuals of the forecasting models are significantly different after the regime change and appeal for a completely different model for these years. Results presented here advocate in favor of the notion that the regime change in Mexico had economy-wide proportions and most importantly, that the Bank of Mexico regained its credibility by successfully curbing inflation.

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# 1 Introduction

*Foreign investors have the memory of an elephant,  
the heart of a rabbit, and the legs of a hare.*

Porfirio Díaz

Porfirio Díaz was Mexico's dictator for most of the latter half of the nineteenth century. During his dictatorship economic growth relied heavily on foreign investment. He recognized stability was a key factor needed to attract foreign investment and made political peace his main concern. Modern Mexico has enjoyed a long span of peace and the definition of stability now encompasses solid economic fundamentals along with political peace.

Inflation is one of these key fundamentals; it plays a role in the growth of the economy and the development of the quality of life of its inhabitants. More precisely, high inflation influences the exchange rate by affecting purchasing power, reduces the incentive to saving, increases investor uncertainty, affects the level of unemployment through the Philips curve and, as Martínez Trigueros (1998) describes, increases socioeconomic inequality. Mexico also has one of the largest inflation-linked issuances of bonds in the world which, as Porfirio Díaz realized, requires certainty in the level of prices to attract foreign investors. Although Mexico has enjoyed comfortable levels of inflation in recent years, an accurate forecasting model and understanding of Mexican inflation is therefore desirable for different sectors of the economy. In this paper we analyze some of the causes of inflation, build a tractable model to forecast inflation, and study the effects of the institution an inflation targeting (IT henceforth) monetary regime.

In order to understand the context of the phenomena we model, we first acquaint ourselves with recent Mexican economic history. Mexico has endured several periods of economic strife in recent years. We revisit some of the major economic crises and the effects these had on the economy. We then examine the need to implement a credible regime change that would yield stability and growth as well as Mexico's approach to doing so.

Several models have been used to forecast Mexican inflation. Of these, the markup model shows particular usefulness in forecasting through the inclusion of the exchange rate in the model. This also captures the level of integration between the Mexican and United States' economy. We use this model and follow a similar modelling strategy Ericsson and de Brouwer

(1998) pursue in modelling Australian inflation. Having developed the model, we then study the effects the implementation of an IT regime has on the model. We first analyze whether the IT period deserves a separate model, and continue by analyzing the effect of the IT regime on the residuals of the model. The final model is then used to forecast Mexico's inflation.

The rest of the paper is organized as follows: Sections 2 and 3 give a brief introduction to recent Mexican economic history, the effects of inflation, and the current proliferation of IT regimes in Latin America. Section 4 presents the theoretical model used in the study and compares it to those used in previous studies. Using quarterly series from 1980–2005, Section 5 describes the data used. Section 6 explains the results of the model. Section 7 outlines the forecasting abilities of the model and Section 8 concludes.

## **2 Modern Mexico and Inflation**

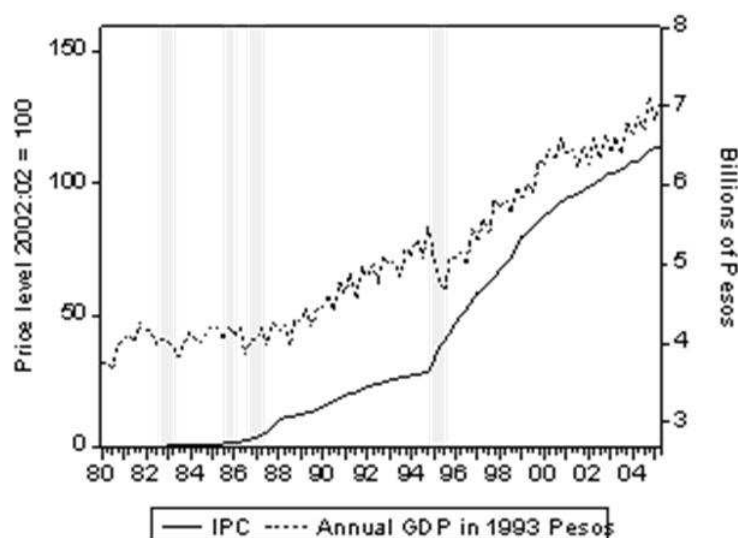
In the last thirty years Mexico has endured catastrophic economic and financial crises that have hindered the growth of its economy and affected the development of its population. By the early eighties, Third-World countries had over-borrowed exorbitant amounts of money from foreign lenders; Mexico was no exception. “In this area of syndicated bank lending the world was in distress by early 1978, although it failed to identify this condition until the Mexican debt crisis of August 1982” (Kindleberger, 2000). Mexico was able to reschedule its debt with assistance from the International Monetary Fund (IMF) and a bridging loan from the United States government. Kindleberger (2000) notes that help from abroad was necessary to prevent international contagion.

A second major economic predicament was caused by deregulation in the financial sector, the privatization of national banks, and high levels of capital inflows and outflows from Mexico. In 1994, the Mexican government faced a balance-of-payments crisis and had to devalue the peso drastically. The role of lender of last resort was again played by the IMF, the U.S. stabilization Fund and the Inter-American Development Bank. “U.S. government support for Mexico, first in 1982 and again in 1994 on two occasions, was justified on grounds [...] that countries of the North American Free Trade Agreement (NAFTA) should stick together” (Kindleberger, 2000). In an interest rate defence designed to prevent the

devaluation, Mexico depleted its international reserves and was forced to change its foreign exchange policy from a peg to a dirty float.

Although the 1982 and 1994 crises were the most notorious shocks to the Mexican economy in recent years, other periods of economic distress as well as structural changes in the Mexican economy are worth noting. In September of 1985, a catastrophic earthquake rattled the financial center of Mexico City affecting its functionality for several months and having a significant effect on the economy. Massive fiscal spending was finally curbed in 1988 with the institution of the social program Solidaridad. Similarly, the country stopped the monetization of its foreign debt in the same time period. These changes had noticeable effects on the economy. In 1993, the unit of account of Mexican currency was changed to the New Peso, simply by dividing prices by 1000, which makes changes in the price level of the 1980s less noticeable. We now look at the effects of these changes and the consequences of the economic crises on the Mexican GDP and price level.

Figure 1: Mexican Price Level and GDP



In Figure (1), we observe the price level, Índice de Precios al Consumidor, and the country's real GDP in 1993 pesos for the past twenty five years. Shaded years denote periods of economic difficulties and, in the case of the 1985 Mexico City earthquake, natural catastrophes. This Figure shows that, in periods of economic distress, the production levels of the Mexican economy diminished greatly. In the same periods, the IPC tends to grow at alarming rates.

Figure 2: Dollar-Peso Exchange Rate

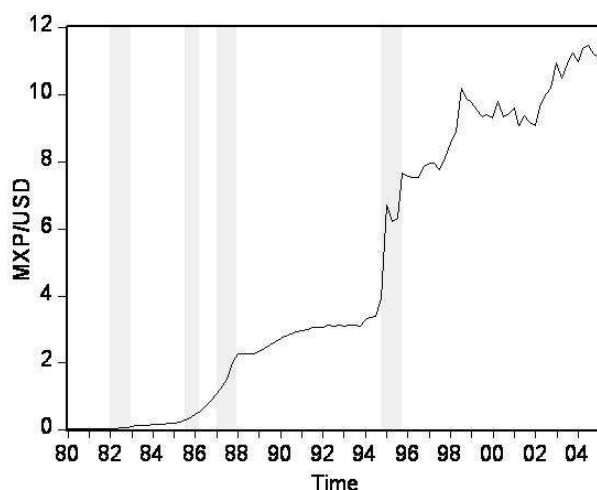


Figure (2) graphs the exchange rate between the U.S. dollar and the Mexican peso for the same time period. In Figure (2), we observe the large impact economic crises have on the exchange rate. A drastic change in the exchange rate has a double impact on the economy. First, it hinders foreign investment by lowering expected returns and increasing risk. Second, it has an indirect effect on inflation itself. “The pass-through from exchange rate depreciation to inflation is likely to be larger in emerging market economies than in industrial countries owing to low central bank credibility, a high degree of openness, and a history of high inflation” (Schmidt-Hebbel and Werner, 2002). A close analysis of the dynamics of the pass-through effect can be found in Schmidt-Hebbel and Werner (2002). Bailliu, Garcs, Kruger, and Messmacher (2003) suggest pass-through has decreased after the adoption of the IT regime in Mexico. For our purposes, we are only concerned with the existence of a significant relationship between currency devaluations and inflation.

Unpredictable inflation, and in particular high inflation, affects the growth of the economy by lowering the returns to lenders, has an effect in the real exchange rate, and affects the socioeconomic structure of the population. Martínez Trigueros (1998) conducts a thorough study of how inflation increases the level of socioeconomic inequality among Mexicans. For all these reasons, attaining a healthy and stable inflation rate was a main concern of Mexican monetary authorities in the late 1990s.

### **3 Inflation Targeting**

Mexico's financial system lost worldwide credibility after the 1994–1995 crisis. Recuperating its lost credibility was of major interest since, in Mexico, the central bank's legal objective is defined as the attainment of price stability (Corbo and Schmidt-Hebbel, 2001). IMF and U.S. Government support helped control the contagion of the crisis. Insofar as these entities were successful, the rippling effect of the crisis reached several continents earning the title: “the Tequila effect.” In addition, “the peso devaluation and subsequent inflation surge severely damaged the Bank [of Mexico]’s credibility” (Schmidt-Hebbel and Werner, 2002). In order to regain its confidence, in 1995, the Bank of Mexico started setting official targets appeasing the “public criticism focused on the lack of transparency regarding the conduct of monetary policy” (Schmidt-Hebbel and Werner, 2002). Although the official monetary growth targets were not met until 1997, this process eventually regained the central bank its lost respect.

Schmidt-Hebbel and Werner (2002) present an interesting comparison of the different approaches taken by Chile, Brazil, and Mexico when implementing an IT regime and the factors that influenced this course of action. Brazil, as did Mexico in 1994, faced a dire economic panorama after the 1998 balance-of-payments crisis. In Brazil, “the adoption of the technical and institutional infrastructure required for full implementation of inflation targeting was achieved in a very short time span of four months, which allowed the [Central] Bank [of Brazil] to announce and implement inflation targeting in July 1999” (Schmidt-Hebbel and Werner, 2002). In contrast, Chile began implementing their version of IT in 1990. The Chilean case is an example where the regime change came about as a means to achieving sustainable growth and not as a response to a crisis. As Schmidt-Hebbel and Werner (2002) note, Chile targeted both the inflation and the exchange rate for most of the 1990s, although more emphasis and commitment was put into keeping the inflation target. The Chilean case shows there are big differences in the implementation of IT regimes and there are many flavors to choose from. It is worth mentioning that, although certain characteristics of IT appeal to the resolution of crises, this type of monetary regime has been popular among industrialized countries such as the UK, Canada, Sweden, Australia and more recently the EU.

The implementation and detail of IT regimes tend to differ from country to country. Bernanke, Laubach, Mishkin, and Posen (1999) provide a detailed covering of the intricacies

of IT regimes and their differences across countries. Nonetheless, there are some intrinsic characteristics about this type of regime that helped the Bank of Mexico achieve its price stability goals, and that affect the performance of inflation forecasting models. Firstly, making the objectives of the central bank public helps in holding the bankers accountable of their actions. Secondly, a successful attempt of achieving an economic target denotes control over the economy and increases the credibility of the central bank. Through IT, Mexican monetary authorities have been successful in curbing inflation. This year, for the first time in modern history, inflation in Mexico is expected to be lower than in the U.S. This leads us to the question we address in the remains of the paper: How much have the dynamics of Mexican inflation changed, and how do these changes affect inflation forecasting models?

## 4 Model

Several frameworks have been used to forecast Mexican inflation. However, little work exists on the underlying inflation dynamics, and how these have been affected by the institution of an IT regime. In order to analyze the effects of this regime change, we first revisit several models used to forecast inflation and choose the most suitable for our question. We then analyze how the model characteristics are affected by the institution on an IT regime.

Shelley and Wallace (2004) analyze the causality between changes in the growth of the monetary base and real GDP growth. Their analysis is not suitable for our purposes since it solely focuses on long-run dynamics. Guerrero, Pena, Senra, and Alegria (2003) use a Vector Autoregressive Error Correction model to confirm the feasibility of economic forecasts. Although this model does account for short-run dynamics, the model focuses on restricted forecasts which are not the essence in this study.

Ericsson and de Brouwer (1998) implement a markup model to the forecasting of Australian inflation. “The markup model has a longstanding continuing presence in economics generally” (Ericsson and de Brouwer, 1998). Bailliu, Garcs, Kruger, and Messmacher (2003) apply this model to the case of Mexico and compare it to monetary as well as Phillips curves models. Markup models have “been applied mainly in emerging markets, whereas the other two have been typically [...] applied to industrialized countries” (Bailliu, Garcs, Kruger, and Messmacher, 2003). In addition, Bailliu, Garcs, Kruger, and Messmacher (2003) affirm that

this type of model has done a good job at forecasting inflation in Latin American countries in the past. The study concludes that the best-performing model is the mark-up model and attributes this to the role the exchange rate plays in the model. We modify the model outlined in Bailliu, Garcs, Kruger, and Messmacher (2003) by including energy prices in the markup model as suggested in Ericsson and de Brouwer (1998)<sup>1</sup>.

The markup model suggests a long run relationship where the domestic price level is a markup over total unit costs, including unit labor costs, import prices, and energy prices. That is,

$$P = \mu \cdot (W^\gamma)(IM^\delta)(PET^\kappa). \quad (1)$$

Equation (1), expressed in its log-linear form expands to

$$p = \ln(\mu) + \gamma \cdot w + \delta \cdot im + \kappa \cdot pet, \quad (2)$$

where lower case letters denote the logarithms of the corresponding variables.

The markup model describes the long-run relationship between inflation and the factors that cause it. In order to account for short-run dynamics, we examine an ADL(1) model and estimate it in its equivalent error-correction modular (ECM) form. Our analysis then focuses on the effects of the institution of an IT regime on the model. Namely, we study whether implementing this regime causes a significant structural change in the economy. Our analysis is twofold. We first consider the possibility of using separate regressions for the IT years and proceed to analyze the effect of the regime change on the residuals of the model.

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<sup>1</sup>Ericsson and de Brouwer (1998) give a thorough explanation of the the underlying theory behind the markup model and its value in testing hypotheses related to other models such as purchasing power parity and the Phillips curve. As we are only interested in the effects the institution of an IT regime has on the forecasting model, we omit this from our analysis.

## 5 Data Considerations

We use quarterly data from 1980Q1 to 2005Q2. However, after making allowance for lags and transformations, our estimation sample reduces to the period encompassing 1982Q2–2005Q2. The data are freely available through INEGI, Mexico’s central statistics agency, Banco de Mexico, Mexico’s central bank, and the Bureau of Labor Statistics.<sup>2</sup> Following caution from Ericsson and de Brouwer (1998), all the data used are not adjusted for seasonality prior to the study.

The Índice de Precios al Consumidor (IPC) is used as the main price level series for the study. Ericsson and de Brouwer (1998) note the importance of using an underlying version of the series and address the controversy behind how to select an appropriate version. We use a version of the series which excludes energy and food from the calculation.<sup>3</sup>

The wage series emanates from two sources. We splice these in a manner preserving continuity. Nonetheless, the original series exhibits exorbitant levels of volatility that suggests a smoothing procedure. Posterior to smoothing the series, we conduct tests to select the appropriate series that show the smoothed version is superior.

In choosing an import price series, we again compare two options. We use the Consumer Price Index in the U.S. and multiply it by the exchange rate to generate a version of the import price series. We conduct a similar test to that of the wage series and compare it to the series of import prices as reported by the IPC. Ericsson and de Brouwer (1998) use a domestic version of import prices while Guerrero, Pena, Senra, and Alegria (2003) and Bailliu, Garcs, Kruger, and Messmacher (2003) use a version that includes the exchange rate. Bailliu, Garcs, Kruger, and Messmacher (2003) find the inclusion of the exchange rate in the model to be of high value. Comparison of information criteria for models with each type of series concur with Bailliu, Garcs, Kruger, and Messmacher (2003). However, an assumption we make in choosing to use the series with the U.S. CPI is that import prices are reflected in its majority by the price level in the United States. This is not a far-fetched assumption given the integration of the economies and the high level of trade between the two countries.

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<sup>2</sup>For more information visit [www.INEGI.org.mx](http://www.INEGI.org.mx), [www.BANXICO.org.mx](http://www.BANXICO.org.mx), and [www.BLS.gov](http://www.BLS.gov) respectively.

<sup>3</sup>The complete price level fails to conform to this specific model. Namely, VAR co-integration analysis finds four co-integration vectors. Guerrero, Pena, Senra, and Alegria (2003) pursue a VEC Model that may be applicable to the full price level series.

One last variable of interest is the GDP gap. Ericsson and de Brouwer (1998) create a version of the GDP gap by regressing the output level on a trend and a constant. Following Bailliu, Garcs, Kruger, and Messmacher (2003), we use a Hodrick-Prescott filter to create a proxy for the GDP gap.

## Integration

Table 1<sup>4</sup> presents the statistics of fourth-order Augmented Dickey-Fuller (ADF(4)) tests for unit root in the price level, wages, import prices and petrol price series. The top number is the statistics of the test, while the number in parenthesis is the estimated deviation from a unit root. That is, a series with an estimated deviation close to 0 has a unit root.

Table 1: ADF(4) Statistics for Testing a Unit Root

| Null Order | Price Level (p)    | Petrol (pet)        | Wages (w)         | Imports (im)       |
|------------|--------------------|---------------------|-------------------|--------------------|
| I(1)       | -2.37<br>(0.00)    | -2.04<br>(-0.08)    | -1.40<br>(-0.03)  | -3.42*<br>(-0.02)  |
| I(2)       | -2.33<br>(-0.17)   | -4.18 **<br>(-1.16) | -1.31<br>(-0.13)  | -2.44<br>(-0.03)   |
| I(3)       | -5.71 **<br>(-1.6) | -7.13**<br>(-2.82)  | -3.42*<br>(-0.90) | -6.25**<br>(-2.34) |

Table 1 shows the series in question are integrated of order 2 or lower. Namely, petrol prices seem to be integrated or order 1 while the price level, import prices and wages seem to be integrated of order 2. Since the variables are all in log form, stating that a price series is integrated of order 2 is equivalent to stating that inflation of the underlying series is integrated of order 1.

## Co-Integration

“Co-integration analysis helps clarify the long-run relationship between the variables” (Ericsson and de Brouwer, 1998). We conduct a Johansen test for co-integration on a vector autoregressive (VAR) model. In order to determine the lag-length of the VAR, we estimate the model with several lag lengths and compare them using information criteria. Table 7 in Section 9 shows the results of this estimation. In this case, the two information criteria

<sup>4</sup>Henceforth, \*(\*\*) denotes rejection of the hypothesis at 5%(1%) significance level

are contradictory. We place more weight on the Schwarz criteria since it takes the parsimoniousness of the model into consideration and has a stringer theoretical backing. We thus choose to use a single lag model.

Table 2 shows the results of the Johansen test for co-integration in the VAR(1) model. The likelihood ratio test shows there is at most one co-integrating vector among the variables. Ericsson and de Brouwer (1998) give a detailed description of intricacies related to co-integration tests, the relative power of tests, and the existence of weak exogeneity. For our purposes, we use the information provided by the Johansen test to shift the analysis to a single equation dynamic model.

Table 2: Johansen Test for Co-integration in the VAR(1) model.

| Eigenvalue | Likelihood Ratio | 5 Percent Critical Value | 1 Percent Critical Value | Hypothesized No. of CE(s) |
|------------|------------------|--------------------------|--------------------------|---------------------------|
| 0.19       | 47.63            | 47.21                    | 54.46                    | None *                    |
| 0.17       | 28.69            | 29.68                    | 35.65                    | At most 1                 |
| 0.08       | 11.66            | 15.41                    | 20.04                    | At most 2                 |
| 0.04       | 3.80             | 3.76                     | 6.65                     | At most 3 *               |

## 6 Single Equation Dynamic Specification

Table 2 shows the existence of a co-integrating vector. In order to find this long run relationship, in Table 3 we estimate an econometric model based on the markup model.

Table 3: Regression (1). Dependent Variable  $p_t$  for sample 1982Q2–2005Q2.

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.  |
|--------------------|-------------|-----------------------|-------------|--------|
| $\alpha_1$         | -3.361061   | 0.403063              | -8.338789   | 0.0000 |
| $w_t$              | 0.252207    | 0.071704              | 3.517320    | 0.0007 |
| $im_t$             | 1.040178    | 0.012530              | 83.01704    | 0.0000 |
| $pet_t$            | -0.095120   | 0.041973              | -2.266215   | 0.0258 |
| R-squared          | 0.995410    | Mean dependent var    | 2.788485    |        |
| Adjusted R-squared | 0.995257    | S.D. dependent var    | 1.885391    |        |
| S.E. of regression | 0.129844    | Akaike info criterion | -1.203348   |        |
| Sum squared resid  | 1.517347    | Schwarz criterion     | -1.095123   |        |
| Log likelihood     | 60.55736    | F-statistic           | 6506.151    |        |
| Durbin-Watson stat | 0.316009    | Prob(F-statistic)     | 0.000000    |        |
| T (adjusted)       | 94          |                       |             |        |

This model has an  $R^2$  close to one, every variable is significant, and the model as a whole is significant as well. Our analysis is not confined to this model since we are interested in understanding how the IT regime affects the short run dynamics as well as the long run trends. Using this model, we now create the error-correction term ( $ecm_t$ ) to be used in the ECM model. The following formula, as derived from Table 3 above, is use to create the  $ecm_t$  term.

$$ecm_t = p_t + 3.36 - 0.25w_t - 1.04im_t + 0.095pet_t. \quad (3)$$

Henceforth, the models used are adjusted for seasonality by the inclusion of corresponding dummies in the regression. Since the data show periods of high volatility that are not fully explained by the underlying fundamentals, we include dummy variables for years of crises, economic shocks, and extreme outliers. The single equation dynamic specification we estimate is the following:

$$\Delta p_t = \alpha_1 + \alpha_2 \Delta w_t + \alpha_3 \Delta im_t + \alpha_4 \Delta pet_t + \alpha_5 ecm_{t-1} + \alpha_6 gap_t + \sum_{i=1}^3 \beta_i S_i + \sum_{i=1}^6 \gamma_i D_i + \varepsilon_t, \quad (4)$$

where  $\Delta p_t = p_t - p_{t-1}$  for every variable,  $S_i$  denotes a seasonal dummy variable,  $D_i$  denotes a dummy for the distress periods of 1982, 1985, 1987, 1988, 1995, and a fiscal policy dummy for years before 1988. The dummy for 1988 was included to control for an extreme outlier that influences the results of the estimation. This type of outlier is strange in time series since it only occurs in one quarter. There is no obvious historical explanation for this outlier and is thus controlled with the inclusion of the  $D_{88}$  dummy. The inclusion of the other dummies are motivated in the historical review. Moreover, a joint significant test confirms their relevance.<sup>5</sup>

Table 4 presents the results of the estimated ECM model specified in Equation (4). Careful interpretation of the estimated coefficients is postponed in order to conduct a series of tests to study the effects the the implementation of an IT regime on this model. In order to do so, we conduct an omitted variable test on  $D_{IT}$ , a dummy that controls for the periods of IT, and the interaction of this dummy with every other term in the model. Table 5 presents the results of this test. The omitted variable test is equivalent to the Chow Test for a regime change. The estimation results of the regression including the omitted variables is

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<sup>5</sup>Please refer to Table 8 in Section 9 for a redundant variable test.

located in Table 9 in the Appendix.<sup>6</sup> This concludes the first part of our analysis. That is, we have shown that in years of IT, Mexican inflation follows a statistically different model. The second part of the analysis tests inquiries further into the properties of the residuals of Regression (3).

Table 4: Regression (2). Dependent Variable  $\Delta p_t$  for sample 1982Q2–2005Q2.

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.  |
|--------------------|-------------|-----------------------|-------------|--------|
| $\alpha_1$         | 0.028836    | 0.004463              | 6.460363    | 0.0000 |
| $gap_t$            | 0.253438    | 0.102093              | 2.482425    | 0.0152 |
| $\Delta w_t$       | 0.286470    | 0.101580              | 2.820144    | 0.0061 |
| $\Delta im_t$      | 0.209678    | 0.042047              | 4.986699    | 0.0000 |
| $\Delta pet_t$     | -0.035789   | 0.013110              | -2.729792   | 0.0078 |
| $ecm_{t-1}$        | -0.257941   | 0.029578              | -8.720600   | 0.0000 |
| $S_1$              | -0.008242   | 0.010720              | -0.768870   | 0.4443 |
| $S_2$              | -1.69E-07   | 2.37E-07              | -0.710843   | 0.4793 |
| $S_3$              | 3.01E-07    | 2.67E-07              | 1.128720    | 0.2625 |
| $D_{FISCAL}$       | 0.127490    | 0.012147              | 10.49543    | 0.0000 |
| $D_{82}$           | -0.008117   | 0.014253              | -0.569494   | 0.5707 |
| $D_{85}$           | -0.045938   | 0.017078              | -2.689893   | 0.0087 |
| $D_{87}$           | -0.019099   | 0.018060              | -1.057553   | 0.2935 |
| $D_{88}$           | 0.170413    | 0.025866              | 6.588201    | 0.0000 |
| $D_{95}$           | -0.003956   | 0.014471              | -0.273404   | 0.7853 |
| R-squared          | 0.913847    | Mean dependent var    | 0.071188    |        |
| Adjusted R-squared | 0.898383    | S.D. dependent var    | 0.075691    |        |
| S.E. of regression | 0.024128    | Akaike info criterion | -4.464186   |        |
| Sum squared resid  | 0.045409    | Schwarz criterion     | -4.055703   |        |
| Log likelihood     | 222.5847    | F-statistic           | 59.09747    |        |
| Durbin-Watson stat | 1.745085    | Prob(F-statistic)     | 0.000000    |        |
| T (adjusted)       | 93          |                       |             |        |

Table 5: Test for Omitted Variables on Regression (2)

| Omitted Variables:   | $D_{IT}, D_{IT} \cdot gap_t,$ | $D_{IT} \cdot \Delta w_t,$ | $D_{IT} \cdot \Delta im_t,$ |
|----------------------|-------------------------------|----------------------------|-----------------------------|
|                      | $D_{IT} \cdot \Delta pet_t,$  | $D_{IT} \cdot ecm_{t-1}.$  |                             |
| F-statistic          | 2.260267                      | Probability                | 0.046972                    |
| Log likelihood ratio | 16.04906                      | Probability                | 0.013493                    |

Figure 3 shows the actual-fitted-residual graph of Regression (3). The distribution of the residuals through time is of concern. The variance of the residuals does not seem constant throughout the estimation sample, and several outliers suggest the residuals do not follow

<sup>6</sup>For completeness, we include a Chow Test for a regime change on Regression (3). Test results are located in Table 10 in Section 9.

a normal distribution. The residuals appear to have significantly lower variances in the IT years, which give rise to concerns of heteroskedasticity. Table 11, located in Section 9, presents the results of White’s Heteroskedasticity test on the residuals of Regression (3). The test rejects the null hypothesis of homoskedasticity. Figure 7 in Section 9, displays the distribution of the residuals and the result of the Jarque-Bera test for normality. The test rejects the null hypothesis of normality. The lack of normally distributed homoskedastic residuals is a major concern when evaluating the validity of Regression (3). In order to deal with these complications, we compare the results of Regression (3) to an empirical estimation of the same model using only the sub-sample of years after the institution of IT.

Figure 3: Actual-Fitted-Residual Graph for Regression (3)

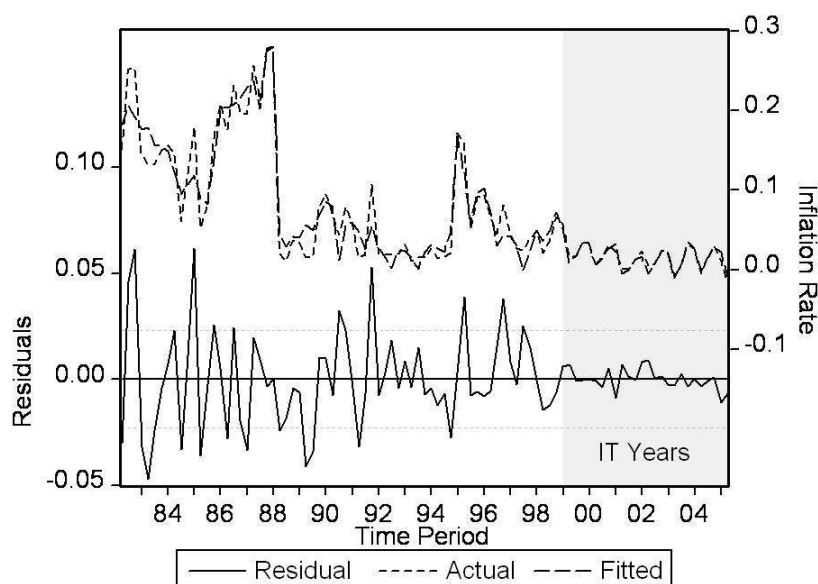


Table 6 shows the results of the regression on the sub-sample of IT years. The model is substantially the same. Dummies variables for years prior to 1999 are removed and a dummy variable for the second quarter of the year 2000 is included. A priori, there is no historical or theoretical reason for the deviation from the mean observed in this time period. The deviation is more than two standard deviation from the mean and is thus controlled for by the inclusion of a dummy variable.

Despite the small sample, Regression (4) exhibits significant results in every variable and as a model. When comparing the results of this regression to those of Regression (3) one must compare case where  $D_{IT} = 1$  and take into account this effect of the interaction terms

as well. The results of both regression are, as one would expect, very similar. However, unlike Regression (3), Regression (4) has normally distributed and homoskedastic residuals.<sup>7</sup> We have shown that during the years of IT, the variance of the residuals of the model used are of a significantly different nature. We thus advocate using a separate model for these time periods. Having found a statistically sound and meaningful model, we now turn to the interpretation of the estimated results.

Table 6: Regression (4). Dependent Variable  $\Delta p_t$  for sample 1999Q1–2005Q2.

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.  |
|--------------------|-------------|-----------------------|-------------|--------|
| $\alpha_1$         | 0.044698    | 0.002969              | 15.05642    | 0.0000 |
| $gap_t$            | 0.394845    | 0.051736              | 7.631902    | 0.0000 |
| $\Delta w_t$       | 0.479142    | 0.062316              | 7.688913    | 0.0000 |
| $\Delta im_t$      | 0.088075    | 0.024801              | 3.551312    | 0.0027 |
| $\Delta pet_t$     | 0.012789    | 0.006258              | 2.043672    | 0.0578 |
| $ecm_{t-1}$        | -0.182942   | 0.018567              | -9.852884   | 0.0000 |
| $S_1$              | -0.038351   | 0.006946              | -5.521077   | 0.0000 |
| $S_2$              | -7.49E-07   | 6.00E-08              | -12.49323   | 0.0000 |
| $S_3$              | -1.29E-07   | 7.70E-08              | -1.670117   | 0.1143 |
| $D_{00}$           | -0.013901   | 0.004615              | -3.012140   | 0.0083 |
| R-squared          | 0.962790    | Mean dependent var    | 0.015767    |        |
| Adjusted R-squared | 0.941859    | S.D. dependent var    | 0.015971    |        |
| S.E. of regression | 0.003851    | Akaike info criterion | -7.997247   |        |
| Sum squared resid  | 0.000237    | Schwarz criterion     | -7.513364   |        |
| Log likelihood     | 113.9642    | F-statistic           | 45.99851    |        |
| Durbin-Watson stat | 1.921972    | Prob(F-statistic)     | 0.000000    |        |
| T (adjusted)       | 26          |                       |             |        |

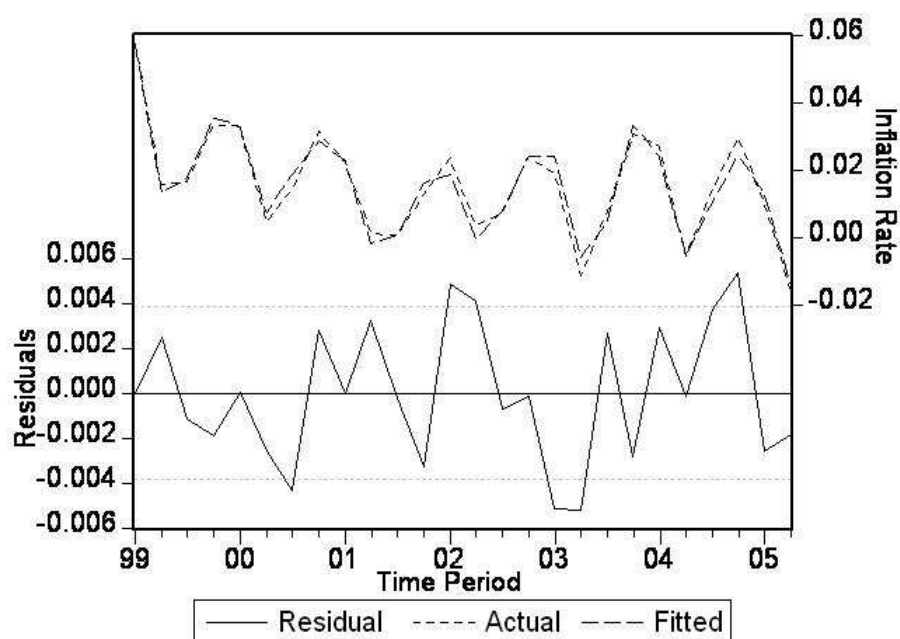
Qualitatively, it is sensible to find positive coefficients on each of the  $\Delta w_t$ ,  $\Delta im_t$ , and  $\Delta pet_t$  terms. Since each of these variables is in logarithmic form, a one period difference indicates the percentage change in price in that period, in other words quarterly inflation. Comparison of the order of magnitude of these terms requires an understanding of the Mexican economy. Firstly, it make sense for the coefficient of the percentage change in petrol prices to be smaller than the other terms given Mexico's role as an oil producer. Fiscal spending in Mexico is budgeted every year according to a conservative forecast of the world energy markets. Therefore, a sudden surge in oil prices (and income for the Mexican government) does not translate directly into massive fiscal spending that might influence

<sup>7</sup>Please refer to Table 12 for White's Heteroskedasticity test and Figure 8 for a normality test on Regression (4) located in Section 9.

inflation. Import prices and the interdependence with the U.S. economy hold an important explanatory role. Finally, we have that inflation in wages has a relatively large and positive relationship with underlying inflation. This denotes the high variability of the Mexican labor market.

The coefficient of the *ecm* term indicates the speed at which the economy adjusts to deviations from equilibrium. This coefficient has been negative and greater than  $-1$  in all of the estimations. The estimate of the *ecm* term coefficient in Regression(4) is greater than in other regressions indicating a smaller need for correction. The years of IT have seen less variation of economic performance and thus less need to adjust for deviations. The coefficient of the GDP gap is significant and positive, meaning that production past the economy's long-run capacity level has a significant effect on the economy. This is consistent with economic theory since production short of capacity reduces inflation.

Figure 4: Actual-Fitted-Residual Graph for Regression (4)

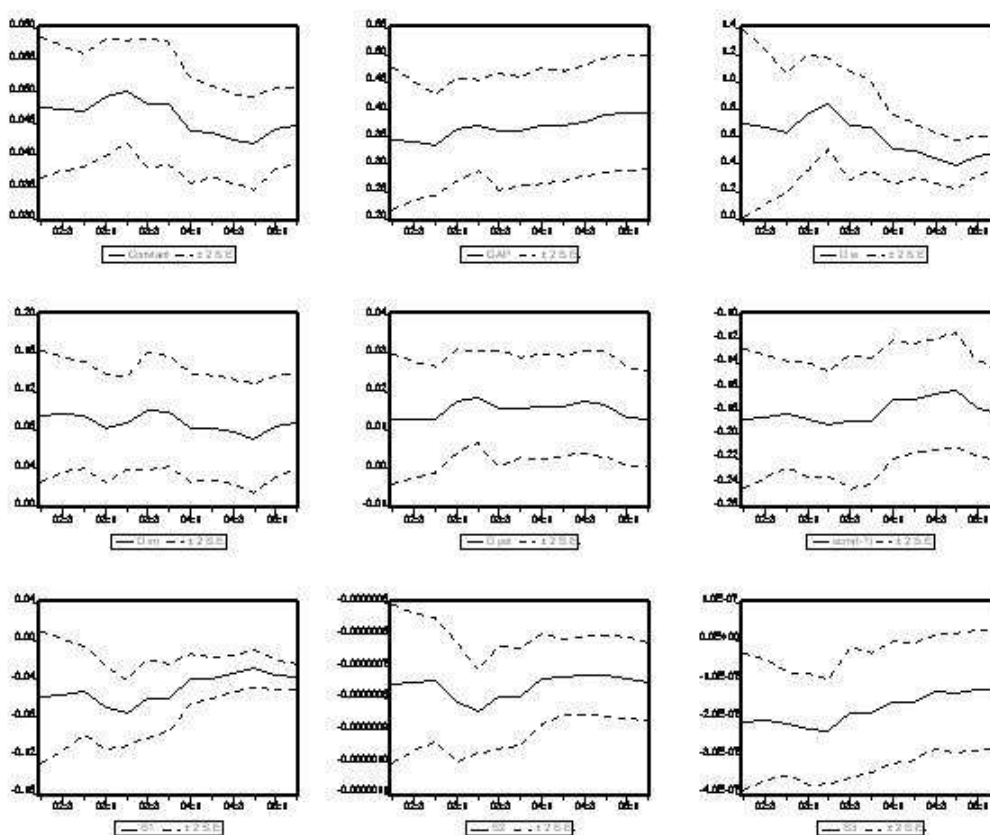


In Figure 4, we see the model estimated in Regression (4) presents a tight fit to the data. Moreover, it shows a lot of the variation is due to seasonal factors. We see the residuals follow a normal trend and show stable variation. Finally, the downwards trend the series follow is worth mentioning since it shows the success of the central bank in managing inflation.

## 7 Forecasting

The results in the previous Section show the change to an IT regime affected the dynamics of inflation in Mexico. We are now interested in crafting a forecasting model using only the data for years after this regime change. As this restricts the number of observations available, we first study how the coefficients of Regression (4) develop through time. Figure 5 graphs the results of the recursive estimation of parameters and a 2 standard deviation band from 2001–2005.

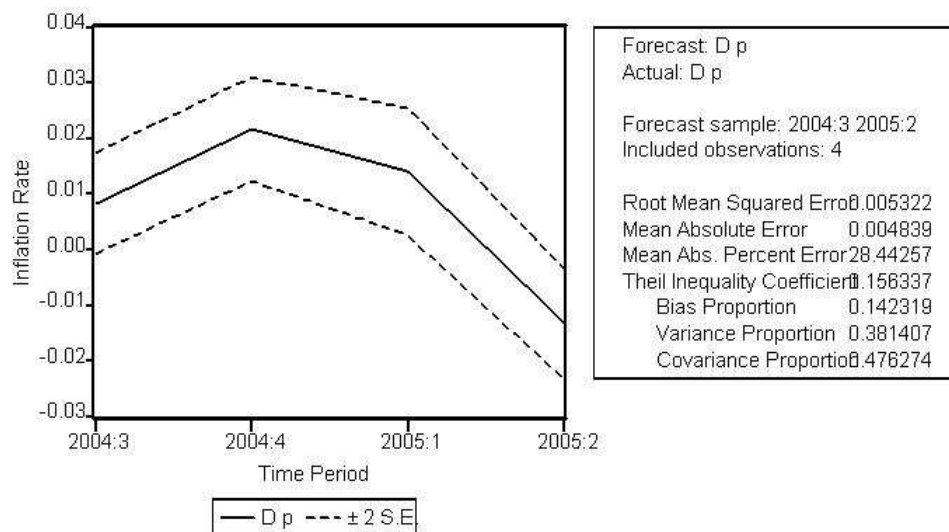
Figure 5: Recursive OLS Estimation of Parameters for Regression (4)



The first three graphs are the constant term, the coefficients of the GDP gap, and the coefficient of wage inflation. The second row includes the graphs for the coefficients of import price inflation, petrol price inflation, and the coefficient of the *ecm* term. The last row graphs the coefficients of the seasonal dummies. In all of the graphs we have that when the final coefficient is positive the value nor the bands exhibit negative values. In the case of the *ecm* term, we have that recursive estimation of the coefficient shows its value is always negative. This constancy of parameter values is reassuring of the model’s results.

Figure 5 shows that even though the sample is small, the parameters tend to converge to their final value quite fast. As data becomes available, it will surely strengthen the forecasting abilities of the model. Using the information in Figure 5, we choose to forecast only one year of inflation since the coefficients converge to their final values around the second quarter of 2004.

Figure 6: Forecast without values substituted for known values



The results of forecasting Mexican inflation in the time period 2004Q3–2005Q2 are depicted in Figure 6. The forecast fits the data quite well since the  $\pm 2$  standard error dashed lines are quite close to the forecasted value. Moreover, the root mean squared error is only 0.005. The root mean squared error is in the same units as the value forecasted. This means the model can predict the inflation rate in the next quarter with a 0.5% average error. One caveat is in order here. Since the model includes changes in wages, import, and petrol prices as well as the current GDP gap, one must accurately forecast these values before using this model.

## 8 Conclusions

The results presented in this paper show the institution of an IT regime in Mexico had drastic effects on the dynamics of inflation. Namely, a Chow Test for regime change shows the existence of a different model of inflation in Mexico during the IT years. Similarly, we find the variance of the residuals of the forecasting models are significantly different after the regime change and appeal for a completely different model for these years. This process yields a tractable and efficient forecasting model for Mexican inflation.

The intricacies of how the inflation dynamics were changed have not been treated in this paper. Nevertheless, they are interesting in their own right and they could benefit the inflation forecasting model presented here. Further inferences into the variance of inflation may bear valuable conclusions. Similarly, the forecasting model used may be adjusted to use lagged values in the forecasting. This would eliminate the causality question and make it a completely independent model. Similarly, a natural extension of this study would be to take advantage of the model used and analyze the theories it encompasses including the Philips curve and the theory of purchasing power parity.

Results presented here advocate in favor of the notion that the regime change in Mexico had economy-wide proportions. Most importantly, the Bank of Mexico gained credibility by successfully curbing inflation. However, as Corbo and Schmidt-Hebbel (2001) suggests, “ultimately, it has been the combination of progress in achieving fiscal discipline and the discretion embedded in IT that made possible the success in inflation reduction”. Similarly, one should take into consideration other factors that have been at play in these time periods, such as political stability.

Although Mexico has achieved economic stability in recent years and prospects for the future are positive, we should not be allowed forget the lessons of history. Financial crises have been a major determinant in the development of the country’s economic history and one should be wary of their development. In our days, the reaffirmation that political stability and fiscal spending discipline will continue to allow economic growth in Mexico are just as important as the understanding of the causes of inflation to the forecast of inflation. Nonetheless, Porfirio Díaz may rest peacefully knowing that, at least for now, Mexico has found in IT the means to achieve stability.

## 9 Appendix

Table 7: Lag Selection for VAR

|                             | VAR(4) | VAR(3) | VAR (2) | VAR(1) |
|-----------------------------|--------|--------|---------|--------|
| Akaike Information Criteria | -9.87  | -9.88  | -9.67   | -9.61  |
| Schwarz Criteria            | -7.98  | -8.45  | -8.68   | -9.07  |

Table 8: Test for Redundant Variables on Regression (2)

| Redundant Variables: | $D_{FISCAL}$ , | $D_{82}, D_{85}, D_{87},$ | $D_{88}, D_{95}$ . |
|----------------------|----------------|---------------------------|--------------------|
| F-statistic          | 35.36892       | Probability               | 0.000000           |
| Log likelihood ratio | 122.1935       | Probability               | 0.000000           |

Table 9: Regression (3). Dependent Variable  $\Delta p_t$  for sample 1982Q1–2005Q2.

| Variable                    | Coefficient | Std. Error            | t-Statistic | Prob.  |
|-----------------------------|-------------|-----------------------|-------------|--------|
| $\alpha_1$                  | 0.022287    | 0.004744              | 4.697590    | 0.0000 |
| $gap_t$                     | 0.245276    | 0.104230              | 2.353211    | 0.0213 |
| $\Delta w_t$                | 0.252326    | 0.103321              | 2.442148    | 0.0171 |
| $\Delta im_t$               | 0.260250    | 0.044647              | 5.829036    | 0.0000 |
| $\Delta pet_t$              | -0.045343   | 0.014436              | -3.140876   | 0.0024 |
| $ecm_{t-1}$                 | -0.307063   | 0.033474              | -9.173059   | 0.0000 |
| $S_1$                       | -0.011135   | 0.010485              | -1.062057   | 0.2918 |
| $S_2$                       | -7.14E-07   | 3.14E-07              | -2.272587   | 0.0260 |
| $S_3$                       | -7.07E-08   | 4.09E-07              | -0.173063   | 0.8631 |
| $D_{FISCAL}$                | 0.132873    | 0.012288              | 10.81332    | 0.0000 |
| $D_{82}$                    | -0.018779   | 0.013978              | -1.343434   | 0.1834 |
| $D_{85}$                    | -0.053400   | 0.016515              | -3.233509   | 0.0018 |
| $D_{87}$                    | -0.035878   | 0.018215              | -1.969647   | 0.0527 |
| $D_{88}$                    | 0.164682    | 0.024816              | 6.636065    | 0.0000 |
| $D_{95}$                    | -0.014964   | 0.014338              | -1.043655   | 0.3001 |
| $D_{IT} \cdot gap_t$        | 0.176143    | 0.304693              | 0.578099    | 0.5650 |
| $D_{IT} \cdot \Delta w_t$   | -0.041425   | 0.172724              | -0.239836   | 0.8111 |
| $D_{IT} \cdot \Delta im_t$  | -0.194307   | 0.152564              | -1.273614   | 0.2069 |
| $D_{IT} \cdot \Delta pet_t$ | 0.062187    | 0.038752              | 1.604764    | 0.1129 |
| $D_{IT} \cdot ecm_{t-1}$    | 0.159419    | 0.108457              | 1.469881    | 0.1460 |
| $D_{IT}$                    | 0.013548    | 0.010756              | 1.259486    | 0.2119 |
| R-squared                   | 0.927502    | Mean dependent var    | 0.071188    |        |
| Adjusted R-squared          | 0.907364    | S.D. dependent var    | 0.075691    |        |
| S.E. of regression          | 0.023037    | Akaike info criterion | -4.507725   |        |
| Sum squared resid           | 0.038212    | Schwarz criterion     | -3.935847   |        |
| Log likelihood              | 230.6092    | F-statistic           | 46.05670    |        |
| Durbin-Watson stat          | 1.876771    | Prob(F-statistic)     | 0.000000    |        |
| T (adjusted)                | 93          |                       |             |        |

Table 10: Chow Test for Regime Change in Regression (3)

| Variables:           | $D_{IT}, D_{IT} \cdot gap_t,$ | $D_{IT} \cdot \Delta w_t,$ | $D_{IT} \cdot \Delta im_t,$ |
|----------------------|-------------------------------|----------------------------|-----------------------------|
|                      | $D_{IT} \cdot \Delta pet_t,$  | $D_{IT} \cdot ecm_{t-1}.$  |                             |
| F-statistic          | 2.260267                      | Probability                | 0.046972                    |
| Log likelihood ratio | 16.04906                      | Probability                | 0.013493                    |

Table 11: White Heteroskedasticity Test on Regression (3)

|               |          |             |          |
|---------------|----------|-------------|----------|
| F-statistic   | 1.569170 | Probability | 0.065973 |
| Obs*R-squared | 42.37097 | Probability | 0.103940 |

Figure 7: Normality Test for Regression (3)

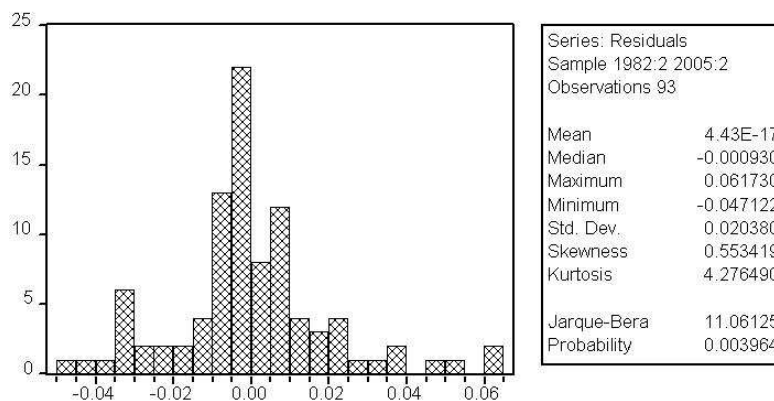
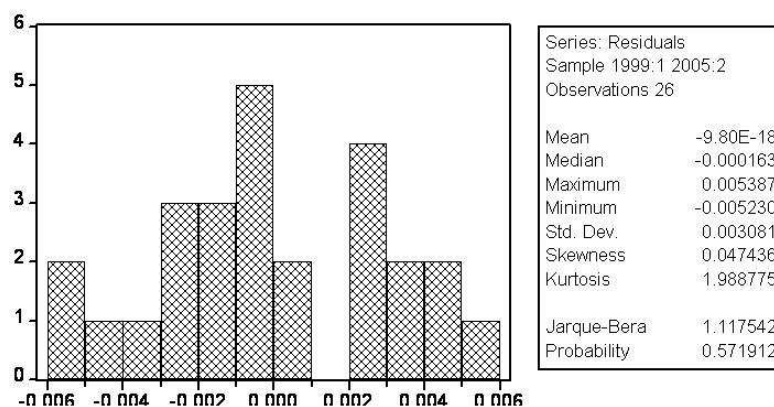


Table 12: White Heteroskedasticity Test on Regression (4)

|               |          |             |          |
|---------------|----------|-------------|----------|
| F-statistic   | 2.050790 | Probability | 0.118361 |
| Obs*R-squared | 18.79798 | Probability | 0.172813 |

Figure 8: Normality Test for Regression (4)



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