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DO INFLATION TARGETING REGIMES REDUCE INFLATION UNCERTAINTY?
EVIDENCE FROM FIVE INDUSTRIALIZED AND FIVE EMERGING COUNTRIES

THE INSTITUTE OF ECONOMICS AND SOCIAL SCIENCES
OF
BILKENT UNIVERSITY

BY

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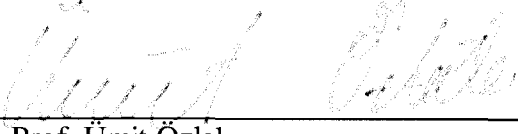
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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Economics.



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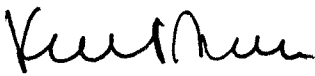
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ABSTRACT

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Master of Economics
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February, 2004

In this thesis, using a time-varying parameter model with GARCH specification, it was investigated whether there is a structural break in expected inflation and two types of inflation uncertainties –structural and impulse uncertainty- for five industrialized and five emerging countries after the implementation of inflation targeting. Many industrialized and emerging countries attempted to stabilize their price levels with the help of a monetary discipline satisfied by the features of inflation targeting. These regimes are thought to lower the uncertainties regarding inflation dynamics. This methodology allows decomposing two types of uncertainties and it was claimed that successful implementation of inflation targeting removes these uncertainties. Two types of tests were employed to detect this claim: A simple non-parametric test which examine whether the changes in the mean and the variance of expected inflation along with two types of inflation uncertainty are statistically significant; and a parametric test whether there has been a shift in mean or a shift in the trend for expected inflation and two types of uncertainties.

Both non-parametric and parametric test results indicate that the inflation targeting regimes are particularly successful in reducing expected inflation while there is less evidence that implementation of inflation targeting reduce inflation uncertainty.

Keywords: Inflation Targeting, Expected Inflation, Inflation Uncertainty, Time Varying Parameter Models

ÖZET

ENFLASYON HEDEFLEMESİ REJİMİ ENFLASYON BELİRSİZLİĞİNİ AZALTIR MI? BEŞ SANAYİLEŞMİŞ VE BEŞ GELİŞEN ÜLKEDEN KANIT

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Bu tezde, zaman içinde değişen parametre modeli ve GARCH çerçevesinde, beş sanayileşmiş ve beş gelişen ülke ekonomisinin, enflasyon hedeflemesi rejimine geçtikten sonra, enflasyon beklentilerinde ve çeşitli enflasyon belirsizliklerinde yapısal bir değişim yaşanıp yaşanmadığı incelenmiştir. Bir çok ülke, enflasyon hedeflemesi rejiminin getirdiği parasal disiplinin yardımıyla fiyat seviyesini sabitlemeye çalışmıştır. Enflasyon hedeflemesi rejiminin enflasyon dinamiklerinden doğan belirsizlikleri azalttığı düşünülmektedir. Bu sunulan yöntem iki çeşit enflasyon belirsizliğini ayırtarmakta ve enflasyon hedeflemesinin bu belirsizlikleri azalttığını iddia etmektedir. Bu iddiayı araştırmak üzere iki çeşit test uygulanmıştır. Parametrik olmayan test yardımı ile beklenen enflasyonun ve enflasyon belirsizliklerinin varyansında ve ortalamasında olan değişimler; parametrik test yardımı ile de bu serilerin ortalama değerleri ve eğilimlerinde yapısal bir kırılma olup olmadığı araştırılmıştır.

Parametrik ve parametrik olmayan testlerin sonuçlarına göre, enflasyon hedeflemesinin beklenen enflasyonu düşürdüğü kesin olarak söylenmesine rağmen, enflasyon belirsizliğini düşürdüğüne ilişkin yeterli kanıt bulunamamıştır.

Anahtar Kelimeler: Enflasyon Hedeflemesi, Enflasyon Beklentisi, Enflasyon Belirsizliği, Zaman İçinde Değişen Parametre Modeli

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1 Introduction

In the beginning of 1990's, some of the developed and developing countries pioneered inflation targeting which is a strategy for conducting monetary policy. These countries have understood the benefits of the price stability and introduced this strategy. Therefore, it is common to find that price stability as the primary goal of many central banks' monetary policy.

Inflation targeting is a framework where a specified inflation objective is tasked to achieve by the central bank. The main characteristic of this strategy is the public announcement of the inflation targets or target bands over a time range and the main goal of it is the low and stable inflation in the long run. The central bank's policy actions will then be targeting the deviations between the actual inflation and the specified inflation rate and strengthen the central bank's accountability.

Apart from low inflation, macroeconomic policy includes many goals, such as low unemployment, high real growth, and financial stability. Direct inflation targeting is considered as a statement that none of the intermediate monetary-aggregate targeting, exchange-rate targeting and the aggregate-demand management targeting policies can give a satisfactory framework for monetary policy. Inflation targeting, and therefore price stability is a signaling mechanism of free market economies to direct resources efficiently to their most productive stage. In a situation where price volatility is reduced, it will be less price alternations and it is likely to have a general economic and financial stability. Implementing price stability as the primary goal improves transparency, accountability, and

credibility to monetary policy.

The primary goal of inflation targeting which is the price stability in the long run can be seen as the ignorance of the other policy objectives, although it is not. Stabilizing the prices as the principal objective and communicating the policy goals to the public depends on three concepts.

First, the macroeconomists are not sure about the efficiency of the monetary policy in the usage of short-run fluctuations. Most of policy-makers believe in that monetary policy can only affect the inflation rate in the long run. Low inflation target is the primary goal due to that reason, not because of the unimportance of unemployment or other problems.

Second, even reasonable inflation rates are risky for the efficiency and growth of the economy so low and stable rate of inflation is crucial for other macroeconomic goals.

Third, the long run goal of monetary policy as the price stability provides a key part in the overall framework. Policy-makers use that framework and inform public about their objective. Also, they force the central bank and government to improve their accountability and discipline. In the terminology of monetary economics, an inflation target serves as a nominal anchor for monetary policy.

This regime has some benefits and costs. Inflation targeting can improve the relation between the monetary policy and other policies, depending on the way the target is defined and the target is not contradictory with other policy intentions. The inflation targets should be set jointly by government, the central bank and discussion should be done with all public, private sector, and trade

unions. The coordination between the central bank and government should guarantee the functioning of inflation targeting and the instrumental independence of central bank.

The announcement of inflation targeting make explicit the purpose of the central bank, thus makes the forecast more transparent, and reduces the uncertainty about the future path of monetary policy. Inflation targeting also improves the discipline on the monetary policy and increase the accountability of central bank.

Also, there are some disadvantages which are a complicated methodology to implement. Inflation targeting relies on forecasting. It can be the fragility because the prediction method is not reliable, so inflation forecasts become uncertain. Moreover, there is risk that inflation targeting could result in inefficient output stabilization because of a considerable supply shock like the increase of oil prices.

Before passing the inflation targeting regime, there are some preconditions that have to be provided. The freedom of the central bank is the most important precondition to achieve financial stability. The government and central bank jointly decide on the targets, however central bank should use any instrument freely to success the eventual goal of financial stability. Also Central Bank has to communicate with the public about its policy and objective.

Furthermore, there has to be a well developed financial market in the country to achieve the objectives of this strategy. The policy instruments that will be used by the monetary authorities to target inflation and keep it within that limit

will require effective money, capital and foreign exchange markets. If financial markets do not respond quickly to the instruments employed, it reduces the effectiveness of monetary policy and result in a delay in affecting the inflation.

In addition to these conditions, the inflation target will not subordinate to other objectives. Fiscal policies should not dominate monetary policies, the external position have to be strong to allow monetary policy to practice inflation targeting as its primary objective, and inflation have to be low at the beginning of inflation targeting to provide satisfactory monetary control.

Also, to achieve the credibility for inflation targeting regime, and to assure political support, initial successes in achieving inflation targets are important. It is interesting that inflation targeting is generally adopted at times when the inflation is low and falling, instead of times when inflation is rising or out of control.

The final set of condition is the need for proper resources to adopt monetary policy for the health of inflation targets. A central bank has to affect behavior of inflation by using its policy instruments and it has to understand the relation between the inflation and the effects of the policies, exchange rate goals have to be directed according to the inflation target, and public debt control and fiscal policy framework have to be in coordination with the inflation target. Moreover, central banks have necessary infrastructure such as well-educated human resources, technological equipment, and sophisticated prediction models.

There are lots of design and implementation issues for the adoption of inflation targeting regime. Two important concepts for the inflation targeting are

the flexibility and transparency. Transparency means clearly and timely communication of policy goals, targets and methods to the public. The objectives of the transparency are to improve the understanding of the public about the capabilities of the monetary policy, to reduce the financial and economic uncertainty, and to enhance the accountability of the monetary authorities. On the other hand, flexibility means the capability of the central bank to respond efficiently to short-run fluctuations under the limitations of inflation targeting regime. In the construction of the inflation targeting framework, the important concept is the balancing of the flexibility and transparency.

If we look at the key operational issues that are arose in the implementation of inflation targeting; these issues include the definition of the target, numerical targets; the time range, the condition that causes the modification of the target.

The design of the inflation targeting regime starts with decision on the price index that will be targeted. For the highest transparency, the price index has to be well-known, precise, broad-base and timely. For the highest flexibility, the prices changes in narrowly defined sectors and one-time jumps have to be excluded in the calculation of the index.

The central banks of all inflation targeting countries have measured the rate of inflation by using some version of the consumer price index. This index excludes the volatile elements due to focusing on core inflation. However, the central bank has to explain the reason of its choice to the public. The central bank has to prove that the chosen index does not guarantee the approving results among the other price indexes. Hence, the chosen index should be consistent

during the inflation targeting regime. If the data is collected by an institution that is independent of the monetary authority, the public can be ensured about the reliability of the central bank.

To choose the numerical value for the inflation target rate, central banks generally emphasize price stability as their goal. The concept of the price stability offers a rate very near to zero. Targeting the rate at zero could lead to some significant problems. These conditions suggest that inflation targets should be set above zero, around 1 to 3 percent per annum. This has been the decision of most of the inflation targeting central banks. Inflation targeting provides a border from above and below for the inflation rate. The good working inflation targeting regime should protect the economy from the deflationary forces, the risk of too little inflation and the cost of very high inflation.

Moreover, there is a discussion about the usage of price-level target and inflation target. The disadvantage of targeting the inflation rate is the unexpected shocks to the price level may be never compensated. It can lead to the large variance of the long-term estimates of the price level and hinder the plans of the private sector. Alternatively, strict price level says that overshoots and undershoots of the inflation target be fully structured. This decreases the variance of long-run estimates of the price level. In reality, central banks prefer inflation rather than price level targets.

Inflation targets can be defined for one or more horizons. Inflation is not controllable for short horizons and is not credible for long periods. Therefore the targets, shorter than 1 year and longer than 4 years are not compatible.

Inside the borders of 1 to 4 year band, the target choice of the central bank affects the tradeoff between the flexibility and the transparency.

In addition to the choices of the horizon and the numerical values, the central bank has to decide on the announcement of the targets whether it is a single point or a range around some mid point. The advantage of the range is that the targeting regime is more flexible. However, the use of range system has some costs. In this system, monetary and political authorities are generally interested in whether inflation is inside or outside the targeted band. They do not focus on the deviation from the midpoint of the range. Also, if the central bank chooses a narrower range, it is more promising for the central bank to approach its inflation goal and it decreases the ability of the central bank to react unexpected events. Due to that reason, inflation can move out of its range. Missing the target can lead to greater loss of credibility than missing the target point. One solution to these problems is to increase the target range. It reduces the instability and control problems; however, it can cause loss of credibility. Widening targets might be seen as the weakening of the determination of the monetary institutions, although they are trying to strengthen the abilities of the system. The alternative of the target range is the point target. For the success of point target strategy, the explanation of the central bank has to be convincing because holding the inflation inside a narrow band is not achievable for even the best policies. This is a tough challenge; however, as long as explanations of the central bank is reliable for the public, the bank increases its credibility and has greater flexibility to handle the target deviations.

The targets are sometimes being missed; the decisions of the monetary authorities lead to these misses. Because inflation targeting is a constrained discretion, some disturbances about macroeconomics variable other than inflation targeting can give good explanation for the missed or changes targets. According to the type of the hitting shock, the targets can be changed. For instance, an a sharp increase in the oil prices might result in a disagreement between stabilizing output and employment in the short run, and stabilizing the inflation in the long run. However, a great supply shock generally can be an excuse for the missing or changing the target. On the other hand, missing the target does not show that the inflation targeting strategy is failed. If the central bank is able to explain the reasons of this deviation to the public, the credibility of it will not decrease.

Moreover, there are some communication issues. As it is seen, one of the benefits of the inflation targeting is that it improves the transparency and accountability of monetary policy. To achieve that benefit, there are some issues that have to be clarified such as what the information does the central bank communicate to the public? To improve the credibility of the central bank for the public, the central bank should announce regular information about the economic conditions, the monetary policy of the bank, and the intentions of the policy. That has been the method of most inflation targeting central banks. Particularly, the central bank should inform the public about the underlying principals that base the chosen inflation targets and strategy; the current stance for the economy; and reports and analyses of inflation indicators that

include private sector estimates and the central bank's own estimates. Also, it should provide information about whether the targets are achieved or not by explaining why a target might have been changed or missed. The credibility of the central bank is related with the matching of the announcements and the hitting targets. In addition to them, central bank is responsible for the education of the public about the abilities of the monetary policy. It increases the policy makers' accountability and leads to a better economic result. Most of the central banks publish regular inflation reports, or any other documents which explains the economic conditions and the monetary policy. These documents improve the understanding of the public and acceptance of the bank's monetary policies.

There are some important messages to be got from the countries which have introduced inflation targeting. A number of countries like Canada, New Zealand, Sweden, and South Africa have successfully implemented the single policy goal of price stability. Evidences show that these experiences are successful. Those countries implementing a price stability goal have enhanced their inflation performance. Particularly, they have all significantly decreased their rates of inflation since implementing inflation targeting. Most of these countries improved their inflation purpose ahead of schedule. Groundwork studies show that they are more successful than the other countries in a number of other criteria as well as in lowering the inflation.

Another lesson is that setting up the credibility of inflation targeting is not easy and takes place over an extended time period. The simple announcement of

targets does not by itself provide credibility to inflation targets. After the price stability is recorded and intuitional arrangements are constructed, credibility develops as a consequence.

It is clearly seen that all central banks that have adopted inflation targeting have reported their monetary policy more open and transparent. These banks understood that, for the success of their policy, the objectives should be transparent, simple, understandable, and validated. Monthly or quarterly reports of inflation are announced by most of them.

Practices showed that when rates of inflation are low or decreasing, inflation targeting is more successful. Some of the developing markets with high inflation rates met particular problems in the application of inflation targeting. In the case of high inflation countries, the future prediction about the inflation rates becomes less accurate. Therefore, setting targets under such conditions could cause the decrease in the credibility of central banks. On the other hand, when the rate of inflation is low, the estimation accuracy becomes higher.

To sum up, the eventual success of inflation targeting needs a common agreement of the trade unions, monetary authorities and private sector to decide on the conditions of reducing inflation or maintaining the low inflation. If this approach is not helpful, then achieving this approach will be difficult. It also makes the central bank more accountable and this decreases the political pressure to follow inflationary policy.

Although inflation targeting regimes are viewed to be successful, there are also some critical studies, which state that achieving price stability is indepen-

dent of inflation targeting. For example, Cecchetti and Ehrman (1999) argue that over the last decade, aversion to inflation variability increased in all major economies irrespective of whether they are operating under inflation targeting or not. They argue that the main reason for this aversion is the significant costs induced by distorting allocation decisions of individuals and firms. Also, Bernanke et al (1999) discuss that inflation targeting is not new and add that Germany and Switzerland have employed a kind of hybrid inflation targeting for a long period of time. Also, it is often reported that the United States economy has a monetary framework that is very close to the spirit of inflation targeting. Finally, Johnson (2002) states that although there is a decrease in the level of expected inflation after the implementation of inflation targeting, there is not a change in inflation variability. He also finds that ‘inflation targeting’ countries do not significantly differ -in terms of inflation performance- from other economies which have not adopted such regimes.

In this study, we take the above discussion as our starting point and test whether there has been a structural break in expected inflation and inflation uncertainty after the implementation of inflation targeting. Our sample consists of five industrialized countries, Australia, Canada, New Zealand, Sweden and United Kingdom, which have adopted the inflation targeting regimes for sufficiently long periods of time. First, we employ a time-varying parameter framework with GARCH specification, which allows us to derive two distinct types of inflation uncertainties, -structural uncertainty and impulse uncertainty- along with expected inflation. Therefore, instead of employing the survey-based

inflation forecasts and expectations, which can be biased as Bomberger (1996) suggests, we derive both the expected inflation and the uncertainty series from a dynamic time-series model. Then, we use both non-parametric and parametric tests to detect any possible structural break in these three derived series.

Our non-parametric tests suggest that the mean and the variance of expected inflation are significantly lower after the implementation of inflation targeting (the only exception is Sweden, where variance of expected inflation is higher after the adoption of inflation targeting). They also imply that both structural uncertainty and impulse uncertainty sharply decrease for New Zealand, Sweden and the United Kingdom.

When the structural break test proposed by Banerjee et al (1992) is applied, we find a break in the mean for expected inflation for all of the countries after the adoption of inflation targeting. However, the results are less promising for the two inflation uncertainty series after the implementation of the regime.

As a result, our findings support the views put forth by Johnson (2002), which state that while inflation targeting is successful in changing inflation expectations, it is less successful in reducing uncertainty that stems from the inflation process.

The next section briefly discusses the relationship between inflation targeting regimes, expected inflation and inflation uncertainty. Then, we will introduce our baseline model in which expected inflation and inflation uncertainties are derived. In the fourth section, after the results are displayed, the structural break tests are applied along with an interpretation. The final section concludes.

2 Inflation Targeting and Uncertainty

Within the last decade, a dense amount of studies in central banking have been devoted to the search for a nominal anchor. In this context, ‘inflation targeting’ has emerged as the appropriate framework, in which ‘increased communication’ and ‘accountability’, the two main characteristics of the regime, are viewed to eliminate any type of uncertainties about price stability. However, as mentioned above, Johnson (2002)’s findings cast some doubt about the positive impact of inflation targeting framework on inflation variability¹. Also, several studies, including Bernanke et al (1999) and Groenfeld (1998) show that the implementation of inflation targeting does not exhibit any change in actual inflation process.

Another critical issue that is often discussed in the literature is the flexibility of the inflation targeting regime and its impact on macroeconomic uncertainty. While some studies such as Clarida et al (2000) argue that monetary authorities should accommodate supply shocks as long as the long-run price stability objective has not been distorted, Dittmar et al (1999) strictly prefer a ‘strict inflation targeting’ policy and state that setting multiple objectives increase uncertainty about inflation and future price levels. They conclude that if inflation-targeting regimes achieve price stability and reduce uncertainty, this success will be due to less weight attached to output stability. Gavin (2003), on the other hand, argues that the reason behind the success of inflation targeting is the extra information that central banks provide to concentrate expectations on a com-

¹See Bernanke and Woodford (2003) for a recent detailed discussion on inflation targeting.

mon trend. Such information will reduce uncertainty about long run inflation, eliminate any confusion about the stance of monetary policy and decrease the likelihood of any forms of instability.

The above discussion also implies a policy proposal for other countries that have not followed explicit inflation targeting. For example, Gurkaynak et al (2003) discuss that the United States economy could benefit more if the Federal Reserve becomes more explicit about long-run inflation objectives since United States interest rates react excessively to macro data releases and news about monetary policy.



3 Measuring Inflation Uncertainty

There are two commonly used procedures to measure inflation uncertainty in the literature. The first one is the survey-based approach as employed by Hafer (1986) and Davis and Kanogo (1996). Recently, close to these two studies, Johnson (2002) used two measures, standard deviation of expected inflation and average absolute size of inflation forecast errors in his study. However, as Bomberger (1996) noted, using the dispersion of the survey forecast does not fully provide a measure of uncertainty, rather it provides a measure of disagreement. Also, it may be the case that forecasters may try to avoid deviating from others' forecasts, which may cause a bias.

The second approach is to employ a class of Autoregressive Conditional Heteroscedastic (ARCH) models, as in Grier and Perry (1998) and Kontonikas (2002). Such a methodology adequately captures inflation uncertainty by using the conditional variance of the residuals of inflation specification. However, such models fail to account for the structural changes in the inflation process, which also provides another major source of uncertainty. A time-varying parameter framework, which relaxes the assumption that the regressors have the same impact on the inflation process during the sample period, seems to fit this purpose. In this context, the randomness in the time-varying estimates has the potential to reflect the uncertainty inherent in the structure of the inflation process. Also, if there is a change in the expectations due to the course of the monetary policy (which is to be expected at the beginning stage of an inflation targeting regime), it will again be observed in time-varying parameter estimates. As a

result, time-varying parameter models and the Kalman Filter, which emerges as the only estimation method, are capable of measuring inflation uncertainty by estimating the time-varying conditional variance of a variable's parameter estimates.

3.1 The Model

In this study, we combine two of the above-mentioned methodologies and follow a time-varying parameter model with GARCH specification. Such a methodology was first introduced by Evans (1991). By employing such a model, we do not only improve over standard ARCH models, but we also derive two distinct types of inflation uncertainties: one emerging from the conditional variance of the residuals of inflation specification and the other representing the randomness of the structure of the inflation process. Formally, the model can be written as:

$$\pi_{t+1} = X_t \beta_{t+1} + \varepsilon_{t+1}, \text{ where } \varepsilon_{t+1} \sim N(0, h_t) \quad (1)$$

$$\beta_{t+1} = \beta_t + v_{t+1}, \text{ where } v_{t+1} \sim N(0, Q) \quad (2)$$

$$h_t = h + \sum_{i=0}^m \phi_i \varepsilon_{t-i}^2 + \sum_{i=1}^n \gamma_i h_{t-i} \quad (3)$$

In the model above, π_t denotes the inflation rate and X_t is the regressor matrix, which consists of the constant term, the lagged variables of the inflation rate and a dummy variable which takes the value of one after the country has adopted inflation targeting regime.

In the first equation, ε_t is normally distributed with a time varying conditional variance of h_t , which indicates the changes in uncertainty about the

future inflation at time t . The third equation presents the conditional variance of the inflation residuals and implies that if past forecasts deviate substantially from the real rate, uncertainty will increase.

The second equation, on the other hand, represents the evolution of time varying parameters, which are assumed to follow a random walk. As explained in Evans (1991), such an assumption can be defended on theoretical grounds: If the structural variations in the economy are due to changing views about the structure of the economy, then it would be almost impossible to predict any future changes in policy and movements in time-varying betas, which would justify the choice of a random walk assumption. Again in the second equation, v_{t+1} is the vector of shocks to β_{t+1} , and it is normally distributed with a homoscedastic covariance matrix of Q .

After presenting the inflation equation, the next step is to include the Kalman Filter updating equations. In such a setting, Kalman Filter enters into process for two reasons. First, in a time-varying parameter framework, Kalman Filter emerges as the only estimation methodology. Second, and more importantly, the updating equations regarding Kalman Filter enable us to decompose different types of inflation uncertainties. The updating equations are:

$$\pi_{t+1} = X_t E_t \beta_{t+1} + \eta_{t+1} \quad (4)$$

$$H_t = X_t \Omega_{t+1|t} X_t^T + h_t \quad (5)$$

$$E_{t+1} \beta_{t+2} = E_t \beta_{t+1} + [\Omega_{t+1|t} X_t^T H_t^{-1}] \eta_{t+1} \quad (6)$$

$$\Omega_{t+2|t+1} = [I - \Omega_{t+1|t} X_t^T H_t^{-1} X_t] \Omega_{t+1|t} + Q \quad (7)$$

The conditional covariance matrix of β_{t+1} , which represents the structural uncertainty of the inflation process, is denoted by $\Omega_{t+1|t}$. Then, equation (5) shows that two types of uncertainties, -which originate from shocks to inflation process (ε_{t+1}) and from the structure of inflation (v_{t+1})– can be decomposed and estimated. On the other hand, the sixth equation shows how the estimates of time-varying betas are updated with respect to the past forecast errors. Finally, both equations (6) and (7) show how the new information about the inflation process is reflected in the conditional distribution of β_{t+1} .

The above discussion implies that it is possible to derive two different types of inflation uncertainties. First, ε can be thought as shocks that hit the economy. Then, the time-varying parameters will show how these shocks are propagated through the economy. Such a terminology is consistent with Frisch and Slutsky's distinction between impulses and propagation². Then, the uncertainty stemming from the randomness in β gives a measure of *structural uncertainty*, which is measured by $X_t \Omega_{t+1|t} X_t^T$. On the other hand, the uncertainty that originates from the randomness in ε can be named as *impulse uncertainty*, which is

²See Blanchard and Fischer (1989), page 277.

measured by h_t^3 .

It is important to further discuss the two types of inflation uncertainties. Inflation uncertainty affects both the intertemporal and intratemporal decisions of individuals and firms. In this context, structural uncertainty can be viewed as being more dominant on the intertemporal decision making process for the agents in the economy while impulse uncertainty mostly affects the temporal decisions. Such a distinction has also important policy implications from the view of monetary policy. If the impulse uncertainty stems from the shocks that are viewed as mostly temporary, then the Central Banks might not have strong incentives to change the course of monetary policy. However, if the uncertainty originates from a randomness in the structure of inflation process, which may also affect the long-run level of inflation, then Central Banks have good reasons to account for this factor in the policymaking process.

3.2 Justification of the Model

As noted above, we assume an autoregressive process for the inflation equation along with a constant term and dummy variable representing the period under inflation targeting. For each country, the length of the lags are chosen with respect to both Akaike and Schwarz Information Criteria.

On the other hand, ARCH-LM tests are employed to test the presence of an ARCH effect. It is found that an ARCH specification is appropriate for all the countries examined. After various specifications of GARCH are considered, GARCH (1,1) is selected as the process to assess the conditional variance.

³We are grateful to Peter N. Ireland for his suggestions on this issue.

3.2.1 Data

The sample consists of five industrialized countries, Australia, Canada, New Zealand, United Kingdom and Sweden, which have adopted inflation targeting early in the 1990's. These countries along with Finland are known to be the earliest inflation targeters. Table 1 shows the adoption dates of inflation targeting and the full sample period used in this study.

Table 1: Data Sample

Country	Date Adopted	Sample Period
Australia	April 1993	1980-2003, Quarterly
Canada	February 1991	1980-2003, Monthly
New Zealand	March 1990	1980-2003, Quarterly
Sweden	January 1993	1980-2003, Monthly
United Kingdom	October 1992	1980-2003, Monthly

For all of the cases, seasonally adjusted CPI inflation has been used. Augmented Dickey-Fuller test shows that inflation rate is stationary in all of the cases examined. Although most of the countries in the sample announce CPI inflation as the target variable, such a choice can also be criticized since CPI is sensitive to energy prices and seasonal factors such as food prices. However, the main goal of this study is to examine whether the expected inflation and inflation uncertainty have reduced after the implementation of inflation targeting. Since CPI is the most commonly observed price index, which is closely associated with the expectations in the economy, we believe that using CPI inflation does not cause a flaw in the analysis.

4 Results and Structural Break Tests

In this section after the regression results are presented for each country, the expected inflation series are displayed along with actual inflation. Next, a simple non-parametric test is employed to detect whether the differences in the mean and the variance for expected inflation and the two types of inflation uncertainty are statistically significant after the countries in our sample have adopted inflation targeting. Finally, by using the structural break test proposed by Banerjee et al (1992), we test whether the shift to the inflation targeting regime has caused either a shift in trend or a break in mean for inflation uncertainties and expected inflation.

4.1 Regression Results

Table 2 presents the t-statistics for the dummy variable that denotes the inflation targeting period, and the lag length of the regressor matrix where SIC and AIC take the minimum values.

Table 2: Regression Results		
Country	$t - Stat$ (Dummy for I.T.)	Lag Length
Australia	4.73	3
Canada	29.43	5
New Zealand	7.53	3
Sweden	19.64	1
United Kingdom	33.5	1

As it can be seen in Table 2, the t-statistics regarding the dummy variable that represents the inflation targeting period is very high. Such a result implies that implementing inflation targeting has been an important factor in explaining the inflation dynamics for all of the countries. Also, the graphs for time-varying

expected inflation and the two types of inflation uncertainties are displayed in Figures 1-5, at the end of the text. One common feature of the figures is that although impulse uncertainty takes on slightly lower values, the two types of uncertainties tend to comove together. Also, the figures imply that the expected inflation and the actual inflation do not diverge significantly from each other for most of the periods.

4.2 Non-Parametric Tests

In this section, a simple non-parametric test will be applied to test whether the changes in the mean and the variance of expected inflation along with two types of inflation uncertainty are statistically significant. Under the null hypothesis, there is no difference in mean or variance between two sub-periods. Table 3 through 6 present the test results regarding the three variables.

Table 3: Non-Parametric Test Results For The Mean Of Expected Inflation

Country	Pre-I.T. Mean	Post-I.T. Mean	Test Statistic
Australia	1.91	0.63	11.15 (Reject)
Canada	0.52	0.14	16.26 (Reject)
New Zealand	3.18	0.63	6.09 (Reject)
Sweden	0.65	0.21	15.33 (Reject)
United Kingdom	0.65	0.18	14.98 (Reject)

Table 4: Non-Parametric Test Results For The Variance Of Expected Inflation

Country	Pre-I.T. Variance	Post-I.T. Variance	Test Statistic
Australia	0.37	0.16	2.27 (Reject)
Canada	0.05	0.01	4.07 (Reject)
New Zealand	8.35	0.15	54.57 (Reject)
Sweden	0.02	0.09	3.70 (Reject)
United Kingdom	0.11	0.01	10.22 (Reject)

Table 5: Non-Parametric Test Results For The Mean Of Structural Uncertainty

Country	Pre-I.T. Mean	Post-I.T. Mean	Test Statistic
Australia	0.41	0.39	0.48 (Cannot Reject)
Canada	0.06	0.08	-1.75 (Cannot Reject)
New Zealand	1.99	0.33	5.44 (Reject)
Sweden	0.19	0.17	2.38 (Reject)
United Kingdom	0.18	0.15	3.96 (Reject)

Table 6: Non-Parametric Test Results For The Mean Of Impulse Uncertainty

Country	Pre-I.T. Mean	Post-I.T. Mean	Test Statistic
Australia	0.33	0.30	0.98 (Cannot Reject)
Canada	0.044	0.052	-1.96 (Cannot Reject)
New Zealand	0.13	0.12	3.17 (Reject)
Sweden	0.17	0.15	4.85 (Reject)
United Kingdom	0.16	0.12	5.67 (Reject)

Table 3 clearly shows that the average expected inflation is significantly lower after the implementation of inflation targeting for all of the countries. We find similar results in Table 4 when we consider the test results for the variance of expected inflation except Sweden, where, actually, the variance increased sharply. Also, the case for New Zealand, the pioneer of the inflation targeting regimes is interesting. While New Zealand has the smallest (though significant) t-statistics when the mean of the expected inflation is considered, it has by far the largest value when the variance of the expected inflation is taken. Therefore, it can be stated that inflation targeting regime in New Zealand is effective mostly on reducing the variability of inflation expectations, while the opposite can be claimed for the Swedish case.

Table 5 and 6 displays the results regarding the two derived inflation uncertainty series, which are very similar. While we observe that both structural

uncertainty and impulse uncertainty decrease significantly for New Zealand, Sweden and the United Kingdom, we fail to find a statistically significant difference for Australia and Canada. In fact, the uncertainty series seem to increase slightly (though not statistically significant) for Canada after the adoption of inflation targeting.

Consequently, the non-parametric results reveal that while inflation targeting regimes are promising in reducing expected inflation and its variability (if we exclude the case of Sweden), the evidence is weaker when inflation uncertainty measures are considered. The next step is to test whether the change in the expected inflation and the uncertainty measures are strong enough such that these series exhibit structural break after the implementation of inflation targeting.

4.3 Structural Break Tests

To test whether there has been a shift in mean or a shift in the trend for expected inflation and the two types of inflation uncertainties, the methodology proposed in Banerjee et al (1992) is employed. There are two major advantages of the test in our case. First, the break date is unknown a priori, and, therefore, the date for the adoption of inflation target need not be imposed. Second, the test searches for two types of breaks: “shift in trend” and “shift in mean”. *Shift in trend test* provides information about whether there has been a change in the slope of the trend. *Shift in mean*, on the other hand, provides information about a jump or a break in the trend.

Finally, the test assumes that the series are constructed from a vector of

regressors. Since the two types of inflation uncertainties and the expected inflation are derived from such a process, the above-mentioned test can be employed without any reservation.

The only disadvantage of the test is that it is designed for single break points. In order to search for multiple breaks, one obvious method is to focus on the range where you suspect that a structural break is present. This is the methodology that will be followed here: we will search for a structural break in a range of 10 years, which take the beginning of inflation targeting period as its mid-point.

The structural break test results for a *shift in trend* can be seen in Table 7. It can be seen that there is no evidence of a trend break when two types of inflation uncertainties are considered. This is not surprising for Australia and Canada since the non-parametric test results for these two countries also failed to find statistically significant differences in two sub-periods for both structural uncertainty and impulse uncertainty. However, Table 7 further indicates that inflation targeting does not lead to a change in the *slope* of the trend for two types of inflation uncertainties when other countries are also considered. On the other hand, the results are more promising in terms of expected inflation: we detect a shift in the trend for Australia and Sweden right after the implementation of inflation targeting. Especially for Sweden, the shift in trend takes place on February 1993, only one month after the official announcement of inflation targeting.

Table 8 presents the results for a *shift in mean*, which detects a jump or

a break in the trend. It is expected that the results in Table 8 should not contradict with the results gathered in the non-parametric test since both types of tests investigate whether the differences in the average expected inflation and the uncertainty measures are statistically significant. Similar to the findings of Table 7, we do not observe a shift in mean when structural uncertainty is considered. For impulse uncertainty, on the other hand, the shift in mean takes place for New Zealand, Sweden and Australia. However, only for New Zealand, the break occurs after the implementation of the inflation targeting. For Sweden and Australia, the break takes place approximately three years before the official announcement. Therefore, combining the findings of both parametric and non-parametric tests, there is only weak evidence that inflation targeting significantly reduces any uncertainty regarding the inflation process.

Finally, and more importantly, the first column of Table 8 displays the shift in mean results for expected inflation. The results strictly favor inflation targeting regimes and they are consistent with the non-parametric results of Table 3. We find that there is a structural break according to shift-in-mean test results for all of the countries. Moreover, the break occurs right after these countries officially announce inflation targeting⁴.

Consequently, it can be stated that inflation targeting regimes are particularly successful in reducing average expected inflation. However, there is less evidence about the positive impact of inflation targeting in reducing the uncertainties regarding the inflation process.

⁴Especially for United Kingdom and New Zealand, the break occurs at October 1992, which is the month of announcement of inflation targeting.

Table 7: Shift in Trend Test Results			
Country	Expected Inflation	Structural Unc.	Impulse Unc.
Australia	1994:Q1	None	None
Canada	None	None	None
New Zealand	None	None	None
Sweden	1993:M2	None	None
United Kingdom	None	None	None

Table 8: Shift in Mean Test Results			
Country	Expected Inflation	Structural Unc.	Impulse Unc.
Australia	1995:Q1	None	1990:Q3
Canada	1991:M8	None	None
New Zealand	1990:Q1	None	1992:Q2
Sweden	1993:M5	None	1990:M1
United Kingdom	1992:M10	None	None

5 Inflation Targeting For Emerging Countries

As mentioned in the previous chapters, the beginning of 1990's witnessed the implementation of inflation targeting for industrialized countries. With the exception of Chile, which adopted the regime as early as 1990, most of the emerging economies have shifted to inflation targeting in the second half of 1990's, most probably after observing the seemingly success of this new monetary regime in industrialized economies.

However, the macroeconomic dynamics that determine the monetary policymaking process in these emerging economies are significantly different than the ones regarding the industrialized ones. Most of the emerging countries have not satisfied the necessary conditions that are mentioned at Carare et al (2002). Debt sustainability, exchange rate stability, a low inflationary environment along with deep and efficient financial markets are crucial factors that lead to a healthy and successful macroeconomic environment. Moreover, price stability has been seen as the overriding goal of monetary policy. It is certain that only a limited number of emerging countries seem to satisfy the above mentioned criteria, which may cause serious distortions for price stability. As a result, the success of inflation targeting regimes should be evaluated on different grounds for industrialized economies and emerging markets.

Next, it is important to make a further analysis of the factors that are seen as pre-conditions to successful inflation targeting.

5.1 Pre-Conditions of Inflation Targeting in Emerging Markets

At Carare et al (2002), the following conditions are stressed as the pre-conditions of inflation targeting:

1) Fiscal Discipline: In the economics where fiscal discipline is not satisfied, the interest rates, which are the main policy instruments of the central banks to achieve price stability can not be used effectively. Just to give an example; an increase in interest rates to reduce inflation will also increase the debt burden of the government, which may easily lead to capital outflows, depreciation of the currency and increase in the cost of production. As a result, it is not a low probability that a tight monetary policy to achieve price stability indeed worsens price dynamics due to the lack of fiscal discipline and the debt stock.

2) Exchange Rate Stability: In the case of macroeconomic uncertainty, where any internal or external imbalances can lead to a currency crisis, the central banks should be in a position to intervene the foreign exchange and sustain exchange rate stability. For that purpose, the foreign exchange reserves and the credibility of the central banks should be well established.

3) Low Inflation: As it is made clear in the case for industrialized economics, inflation targeting is mostly seen as the appropriate framework to serve as a nominal anchor and sustain price stability. However, the application of inflation targeting in emerging countries also includes a role for reducing inflation, for which there are increasing doubts. Therefore, it is necessary that the economy, which adopted inflation targeting should conduct a price stabilization program

before shifting to this new regime.

4) Deep and Efficient Financial Markets: In case of any uncertainty that may emerge during the shift to a new regime, the structure of the financial markets gain utmost importance. If the financial markets are considered to be shallow, then any speculative development has the potential to disrupt the well-functioning of the financial markets and the overall economy. Given the fact that most of the financial markets regarding the emerging countries had several financial crisis in the past, inflation targeting should take the structure of the financial markets into account.

Consequently, these four factors lead to the notion that the performance of inflation targeting regimes may significantly be different for industrialized and emerging countries.

6 Methodology for Emerging Countries

In this section, the impact of inflation targeting on expected inflation and inflation uncertainty will be analyzed for emerging countries. There is a major difference in the methodology that is employed in this section: GARCH specification is found to be not suitable for emerging markets case. Therefore, a time-varying parameter model without any conditional heteroscedasticity will be employed for this purpose.

The sample consists of five emerging economies: Brazil, Chile, Colombia, Mexico and South Africa. The adoption dates of inflation targeting for each country can be seen in the following table.

Data Sample For Emerging Countries		
Country	Date Adopted	Sample Period
Brazil	July 1999	1980-2003, Quarterly
Chile	September 1990	1980-2003, Monthly
Colombia	September 1999	1980-2003, Quarterly
Mexico	January 1999	1980-2003, Monthly
South Africa	February 2000	1980-2003, Monthly

As Table 1 shows, except Chile, all of the countries in the sample shifted to inflation targeting regime after the second half of the 1990's. Since we fail to find any GARCH specification, the results will reveal only two series: the expected inflation and structural inflation uncertainty, which represents the randomness in the time varying parameters, which, by the way, are assumed to follow random walk.

The results of the time varying estimation can be seen in the following tables.

Table 1: Non-Parametric Test Results For The Mean Of Expected Inflation

Country	Pre-I.T. Mean	Post-I.T. Mean	Test Statistic
Brazil	0.52	0.71	-1.67 (Cannot Reject)
Chile	1.50	0.75	5.76 (Reject)
Colombia	1.09	0.71	0.31 (Cannot Reject)
Mexico	1.67	0.62	7.07 (Reject)
South Africa	0.62	0.58	0.87 (Cannot Reject)

Table 2: Non-Parametric Test Results For The Variance Of Expected Inflation

Country	Pre-I.T. Variance	Post-I.T. Variance	Test Statistic
Brazil	0.20	0.33	1.62 (Cannot Reject)
Chile	0.52	0.61	1.16 (Cannot Reject)
Colombia	55.28	0.32	171.46 (Reject)
Mexico	0.78	0.16	4.85 (Reject)
South Africa	0.01	0.06	4.19 (Reject)

Table 3: Non-Parametric Test Results For The Mean Of Structural Uncertainty

Country	Pre-I.T. Mean	Post-I.T. Mean	Test Statistic
Brazil	0.31	0.38	-1.82 (Cannot Reject)
Chile	0.80	0.39	5.02 (Reject)
Colombia	7.15	0.74	4.17 (Reject)
Mexico	0.67	0.31	4.44 (Reject)
South Africa	0.44	0.50	-6.00 (Reject)

Table 4: Shift in Trend Test Results (Emerging)

Country	Expected Inflation	Structural Unc.
Brazil	1997:M11*	None
Chile	1990:M6	None
Colombia	None	None
Mexico	None	None
South Africa	2001:M10	None

Table 5: Shift in Mean Test Results (Emerging)

Country	Expected Inflation	Structural Unc.
Brazil	1996:M8	None
Chile	1989:M8	None
Colombia	None	None
Mexico	None	None
South Africa	2002:M2	None

Consistent with several case studies, Chile seems to be the most successful country to adopt inflation targeting. This is not surprising, given the fact that Chile undertook a massive stabilization program to achieve fiscal discipline and attain debt sustainability. Also for Mexico, the mean of expected inflation exhibits a statistically significant decrease after the implementation of the regime. In case of structural uncertainty, the results for non-parametric tests are promising again for Chile, Colombia and Mexico.

When the results regarding parametric tests are analyzed, Chile again emerges as the country that exhibited a structural break both in the mean and the trend for expected inflation. However, we failed to find any structural break for inflation uncertainty.

7 Results

In the 1990's, many countries have adopted inflation targeting regimes as a means to achieve price stability and a nominal anchor. Other than viewing price stability as the overriding goal of the monetary policy, increased communication and accountability are the other important characteristics of these regimes. In that sense, one positive result of inflation targeting regime emerges as eliminating any uncertainties associated with inflation dynamics. Therefore, it is thought that both expected inflation and inflation uncertainty would decrease during the implementation of an inflation targeting regime.

In this study, we tested the above mentioned hypothesis for two types of economies: industrialized and emerging countries. To identify different types of inflation uncertainties and derive expected inflation series for these countries a time varying parameter framework has been employed. For industrialized countries, since the model was suitable for GARCH specification a TVP model with GARCH specification was used. For emerging markets, on the other hand, a conditional heteroscedasticity has not been detected and therefore GARCH has not been added to the model.

The results indicate that the inflation targeting is much more successful for industrialized countries than it is in emerging markets. While observe a structural break at the time of inflation targeting for all of the industrialized countries, we only observe such a break for Chile, which emerges as the most successful inflation targeting economy when the sample is restricted to emerging markets. Such a result is not surprising due to Chile's massive stabilization attempts and

fiscal discipline, which we do not observe for the remaining economies in the emerging markets.



8 Conclusion

In the beginning of 1990's, motivated by the search for a nominal anchor, several industrialized countries adopted inflation targeting regimes to achieve price stability. Increased communication and accountability, the two main characteristics of these regimes are thought to eliminate any uncertainty regarding the inflation process as well as to reduce expected inflation. Although the inflation performance of these countries improved, some recent studies criticized the seemingly success of inflation targeting. Recently, in a panel data framework, Johnson (2002) showed that there has been an improvement in average expected inflation. However, his results also indicate that inflation variability that is derived from surveys have not improved significantly.

In this study, instead of using the survey-based results, which may be biased according to Bomberger (1996), we derive both expected inflation and two types of inflation uncertainty -structural and impulse uncertainty- from a time-varying parameter model with GARCH specification. The sample consists of five industrialized countries, which have adopted inflation targeting at the beginning of 1990's. Our methodology, which is previously employed in Evans (1991), allows us to decompose two types of uncertainties, which provides an extra source of information about the inflation process.

The results gathered from non-parametric tests show that the average expected inflation significantly decreases after the announcement of inflation targeting. Except Canada, it is also found that there is an improvement in the variance of expected inflation. The findings about inflation uncertainty series

are less clear, however. While it is found that the two types of uncertainty series significantly decreases for New Zealand, Sweden and United Kingdom, we do not find the same evidence for Australia and Canada.

Next, the structural break test proposed by Banerjee et al (1992) is applied to these three derived series. The test searches for both a *shift in the trend* and a *break in the mean*. While we fail to find any *shift in trend* for the inflation uncertainty series, we detect a *shift* for expected inflation only in Australia and Sweden right after the announcement of inflation targeting regime. The structural break test results of inflation uncertainty series for a *break in mean* are slightly different. We do not find any break in structural uncertainty for all of the countries. On the other hand, a break for impulse uncertainty is detected when Australia, Sweden and New Zealand are considered. However, only for New Zealand, the break occurs after the implementation of inflation targeting.

Finally, the most promising results in favor of inflation targeting is obtained when the structural break test is applied to detect a *break in mean* for expected inflation. For all of the countries, we find a structural break in the expected inflation due to the implementation of inflation targeting. For New Zealand and United Kingdom, the break occurs right at the time of the adoption. For Canada and Sweden, on the other hand, we detect a shift in mean within six months after the implementation of the regime. Agents in the economy may have waited for a short period to revise their expectations about inflation. Only for Australia, the shift in mean takes place six quarters after the official announcement. These findings regarding the expected inflation are also consistent with the results of

the non-parametric tests, which also find that the differences between expected inflation for the two sub-periods are statistically significant.

Consequently, the results obtained in this study provide support for the findings of Johnson (2002). The inflation targeting regimes are particularly successful in reducing expected inflation. However, there is less evidence that inflation uncertainty is significantly decreased with the adoption of inflation targeting. As a final note, in all the cases considered, New Zealand, the pioneer of inflation targeting, seems to be the most successful country.



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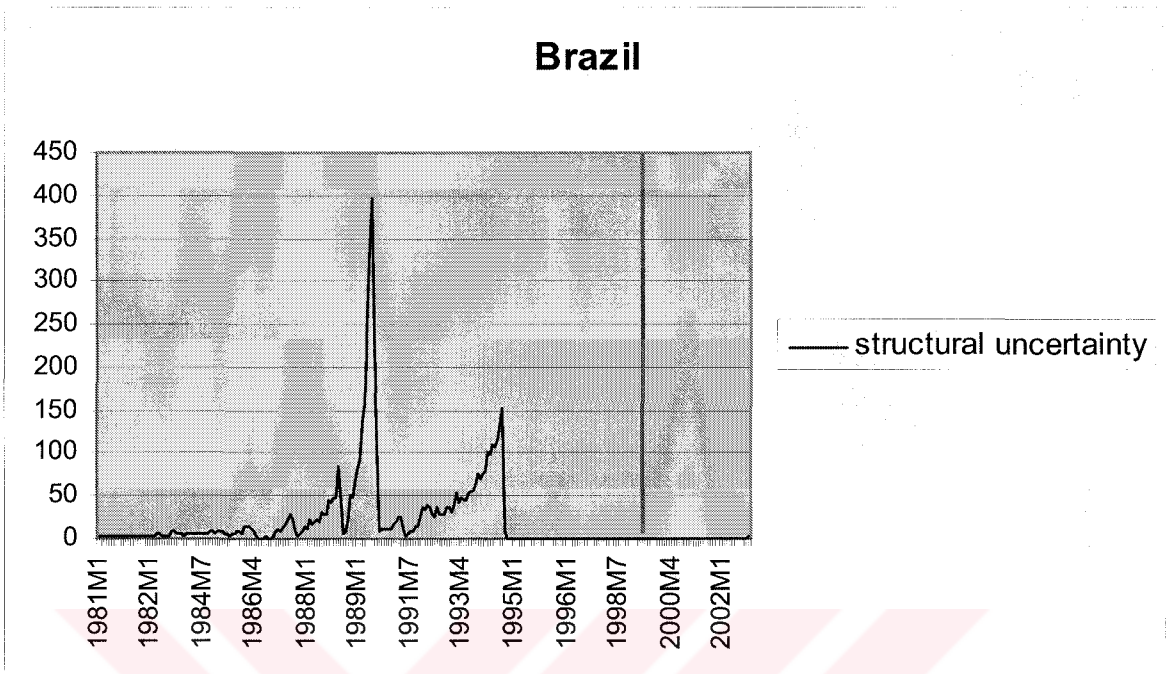


Figure 1: Structural Uncertainty of Brazil

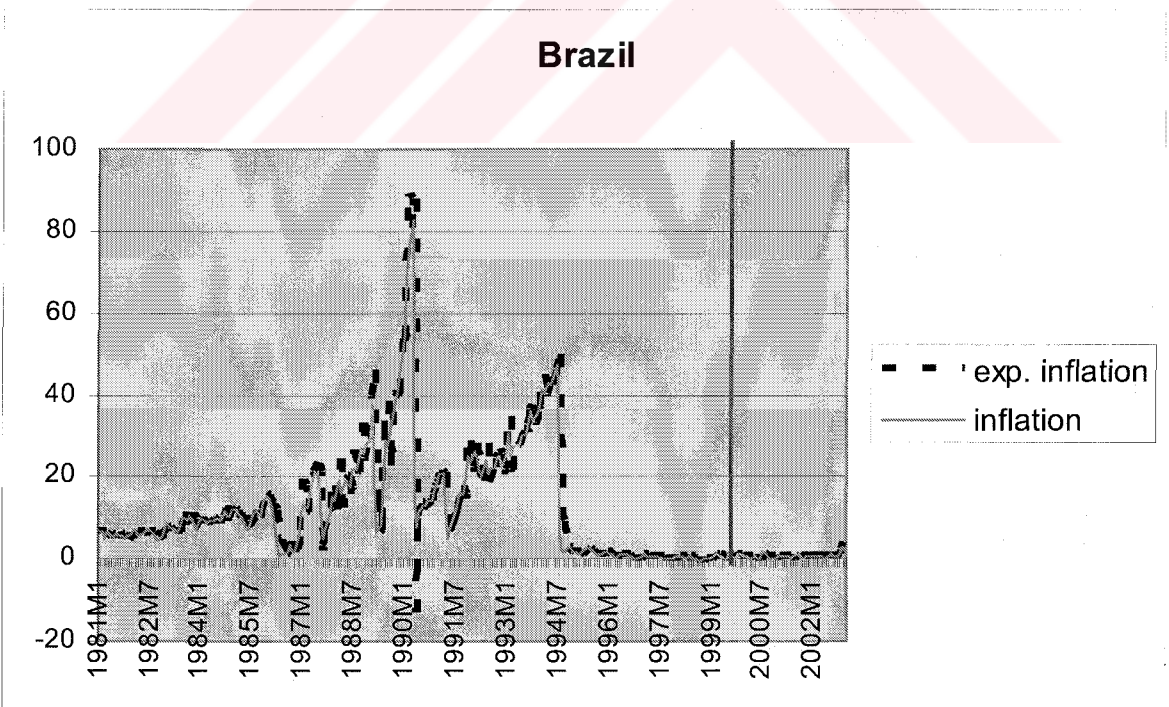


Figure 2: Expected Inflation and Real Inflation of Brazil

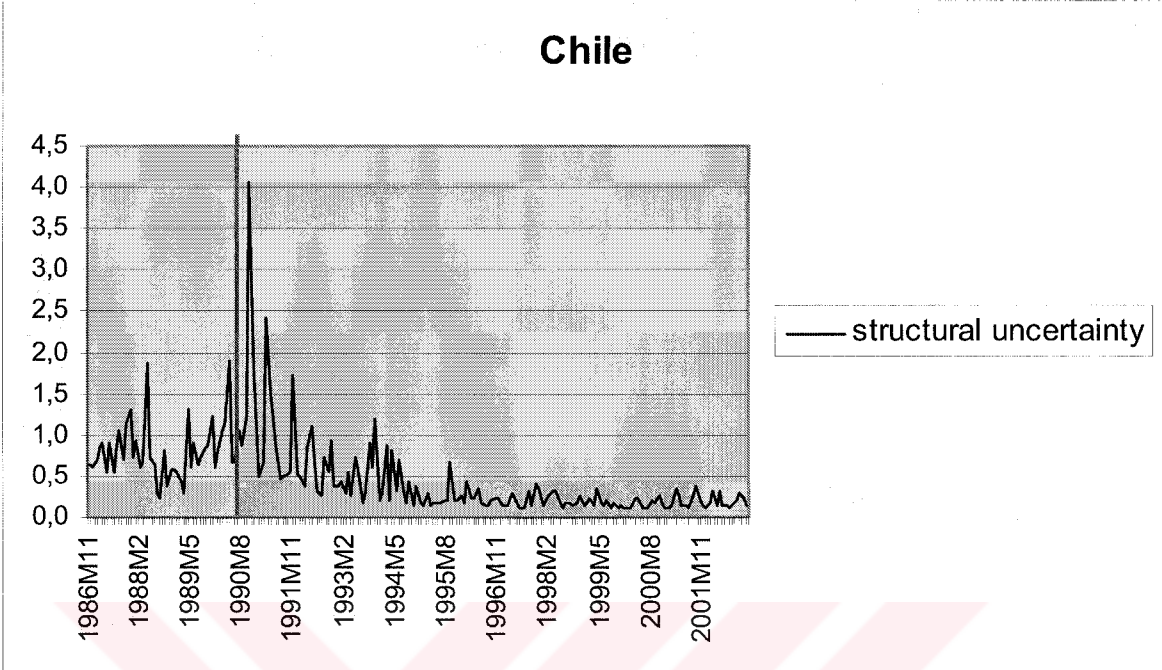


Figure 3: Structural Uncertainty of Chile

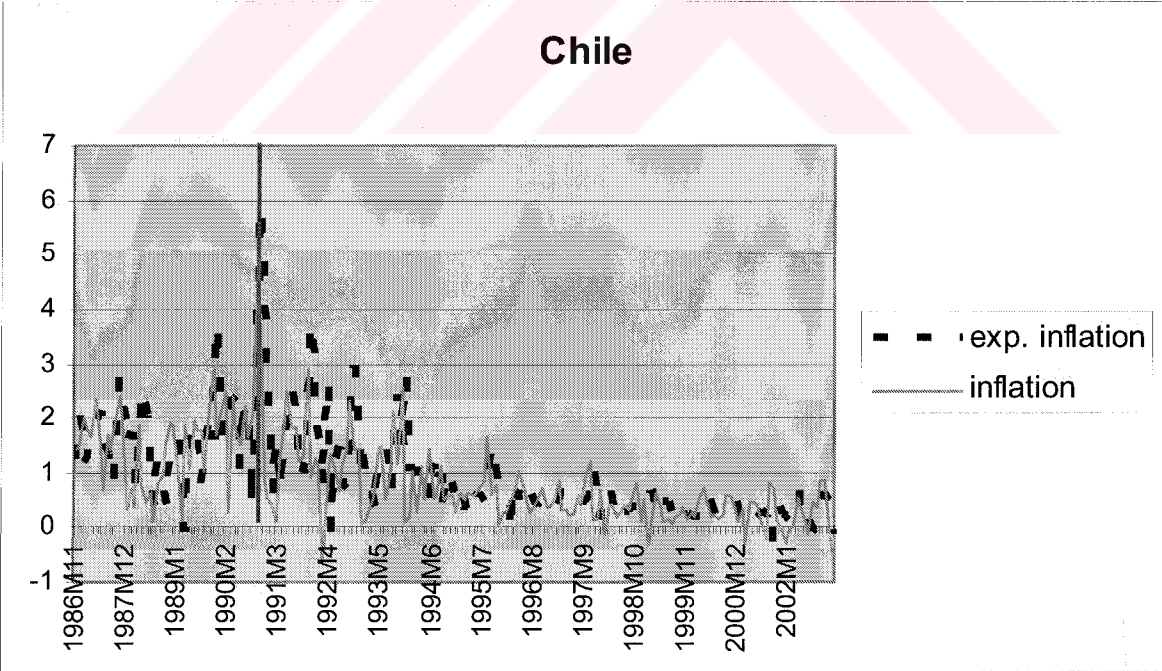


Figure 4: Expected Inflation and Real Inflation of Chile

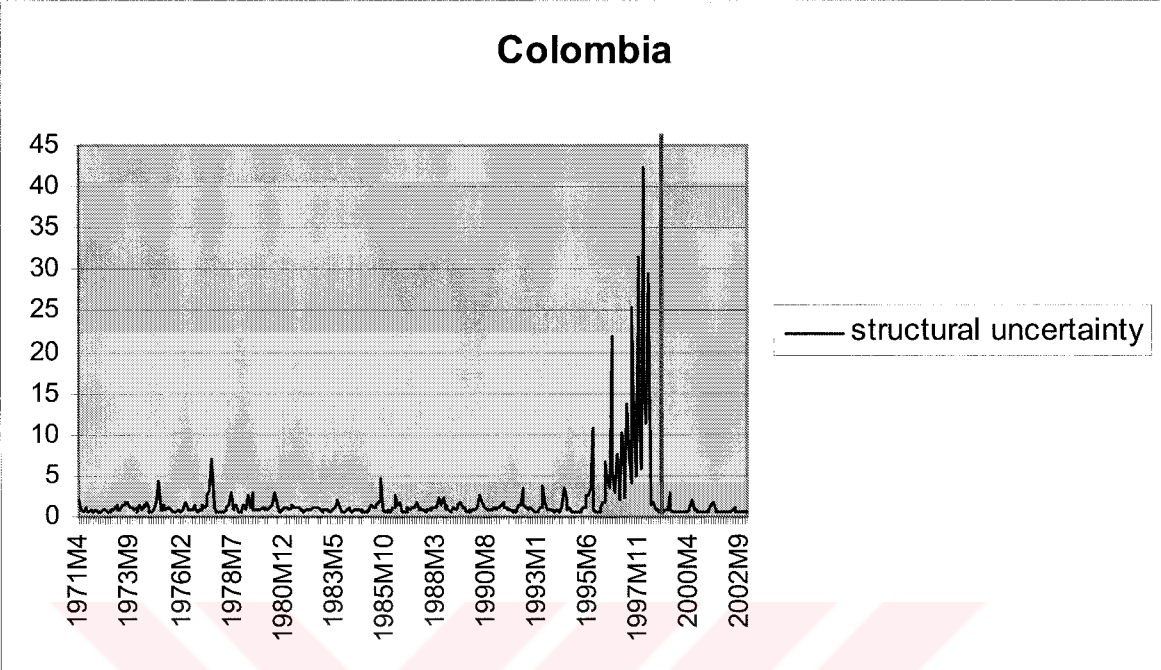


Figure 5: Structural Uncertainty of Colombia

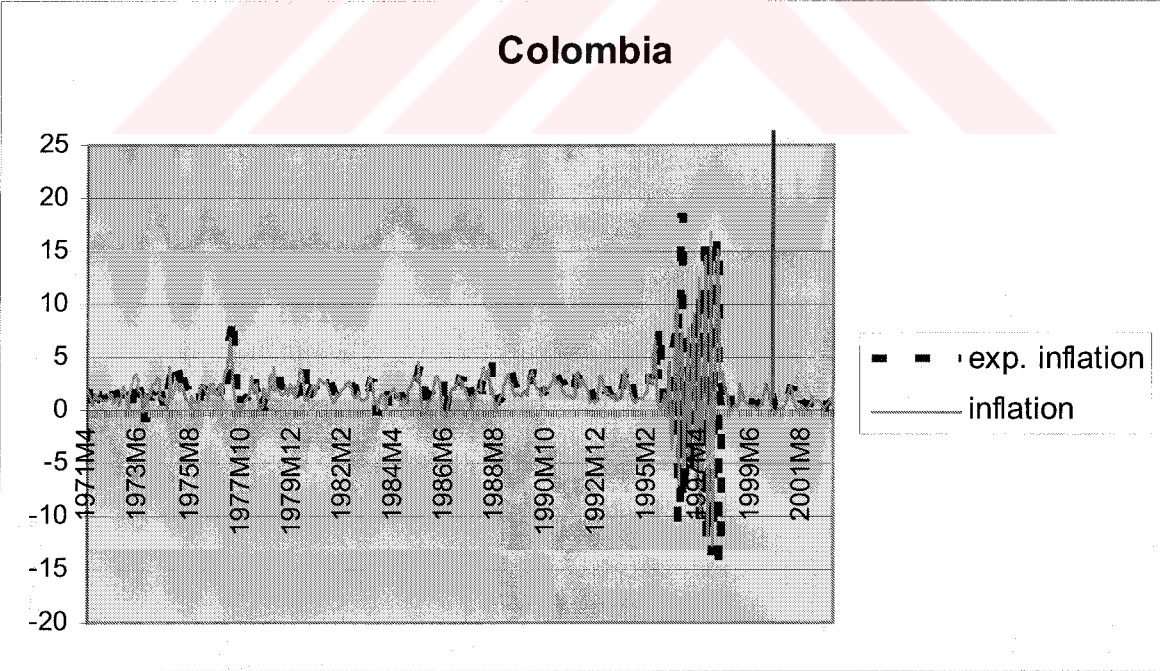


Figure 6: Expected Inflation and Real Inflation of Colombia

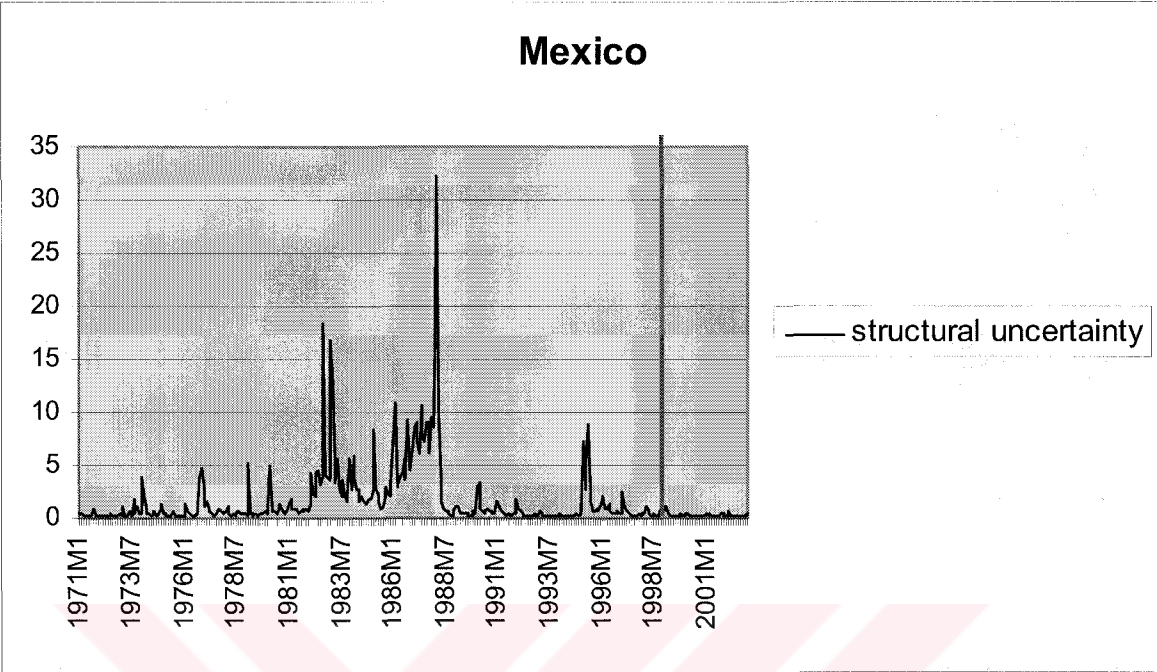


Figure 7: Structural Uncertainty of Mexico

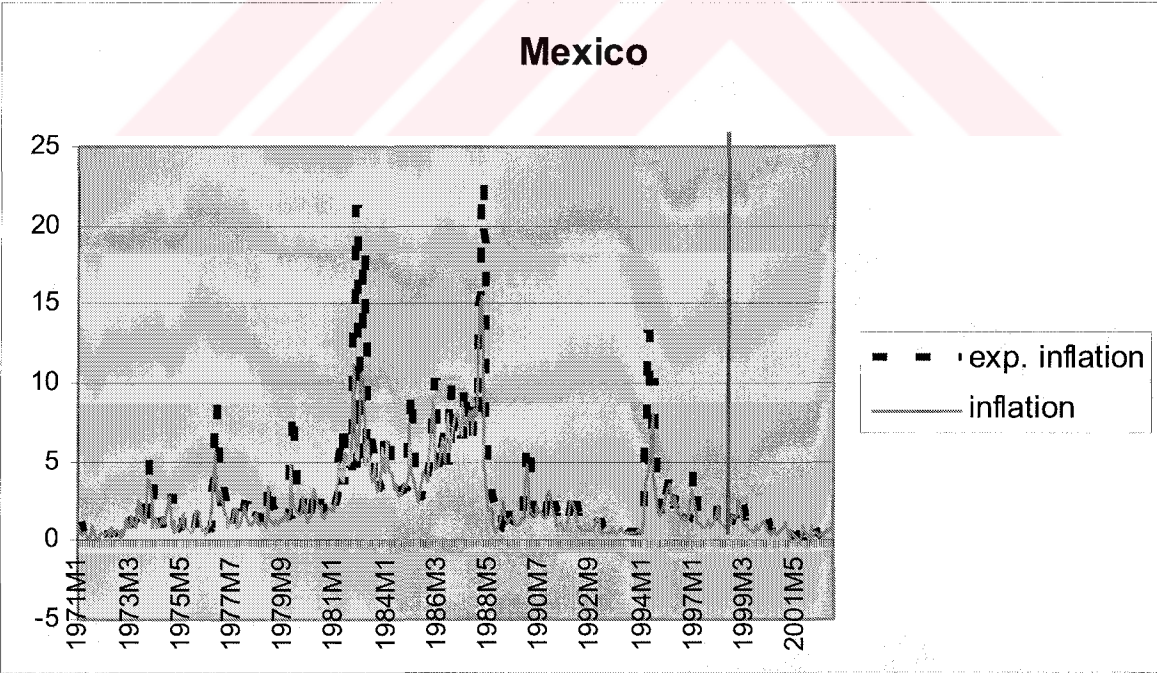


Figure 8: Expected Inflation and Real Inflation of Mexico

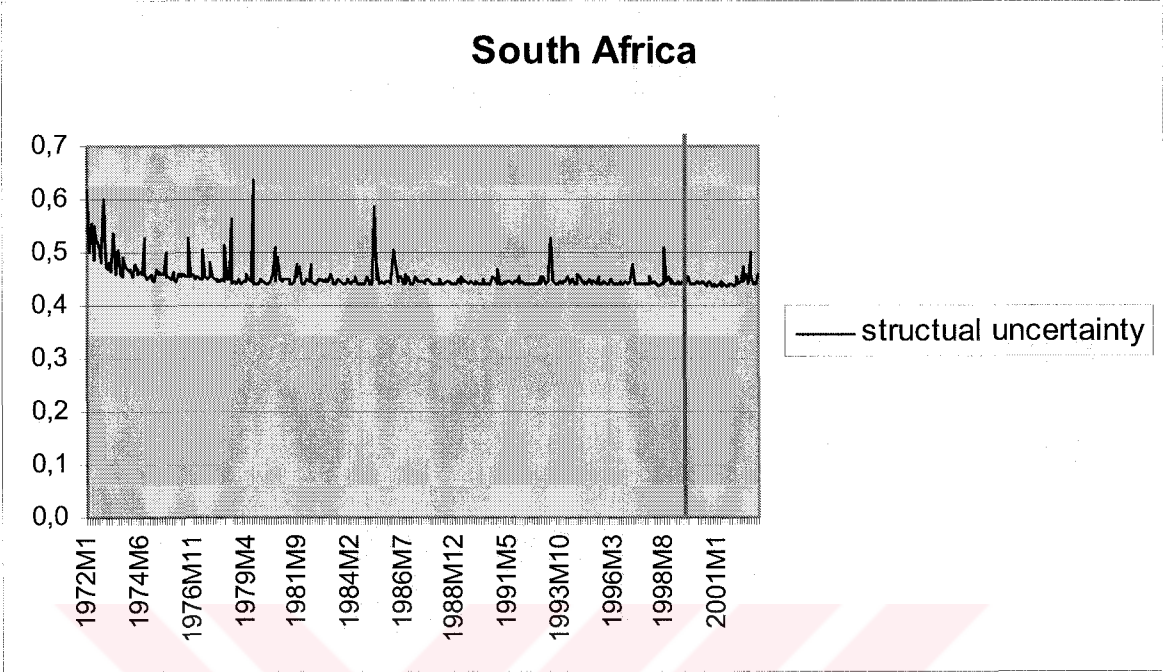


Figure 9: Structural Uncertainty of South Africa

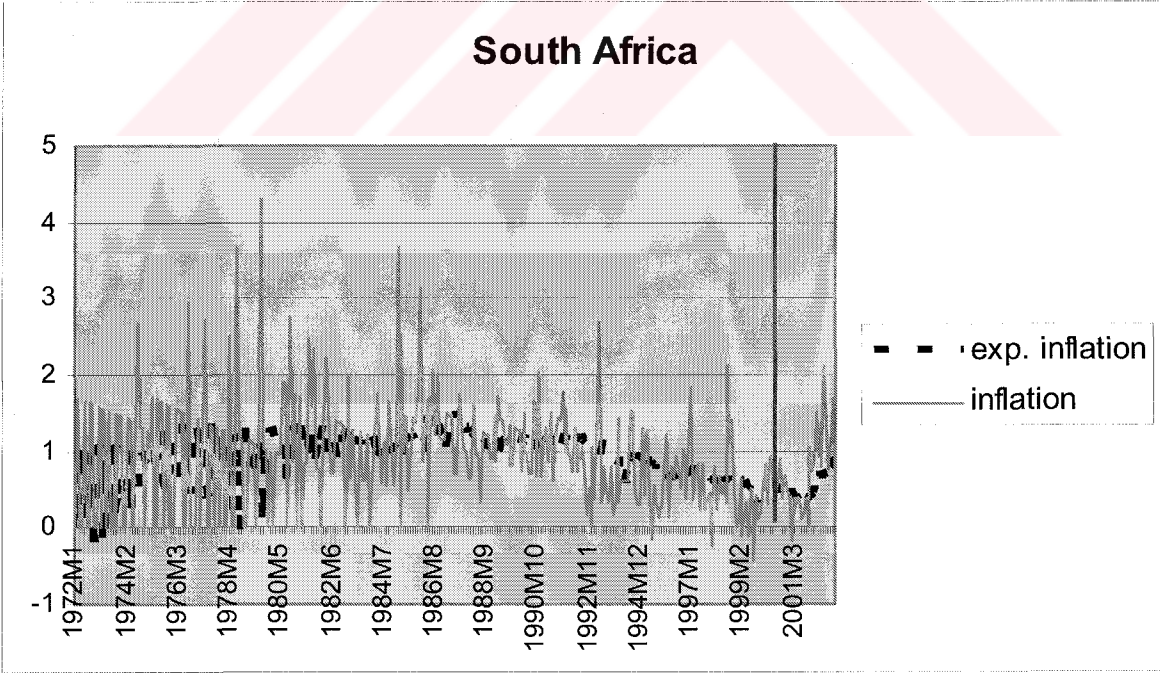


Figure 10: Expected Inflation and Real Inflation of South Africa

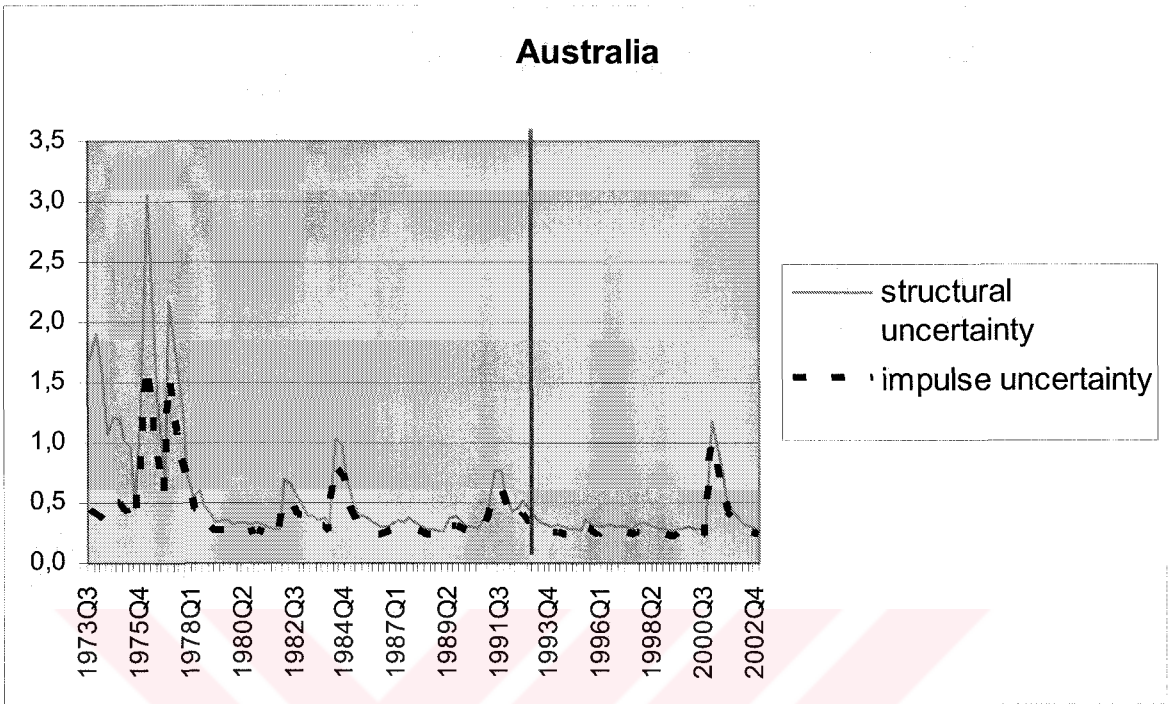


Figure 11: Structural Uncertainty and Impulse Uncertainty of Australia

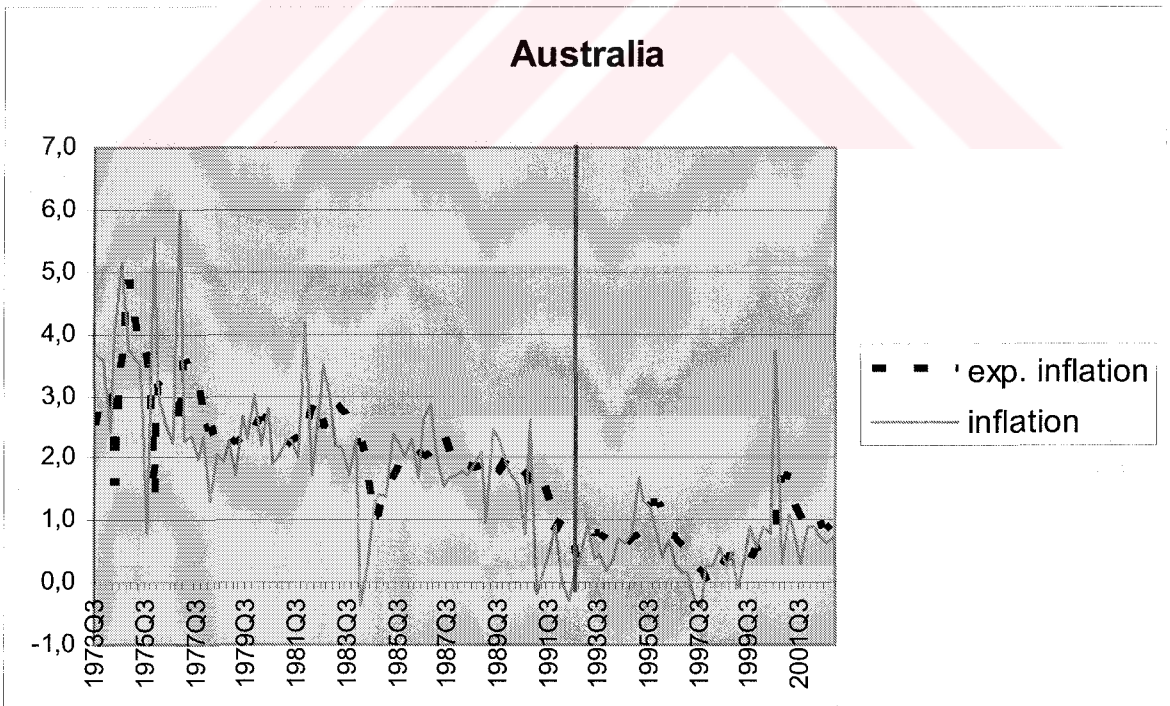


Figure 12: Expected Inflation and Real Inflation of Australia

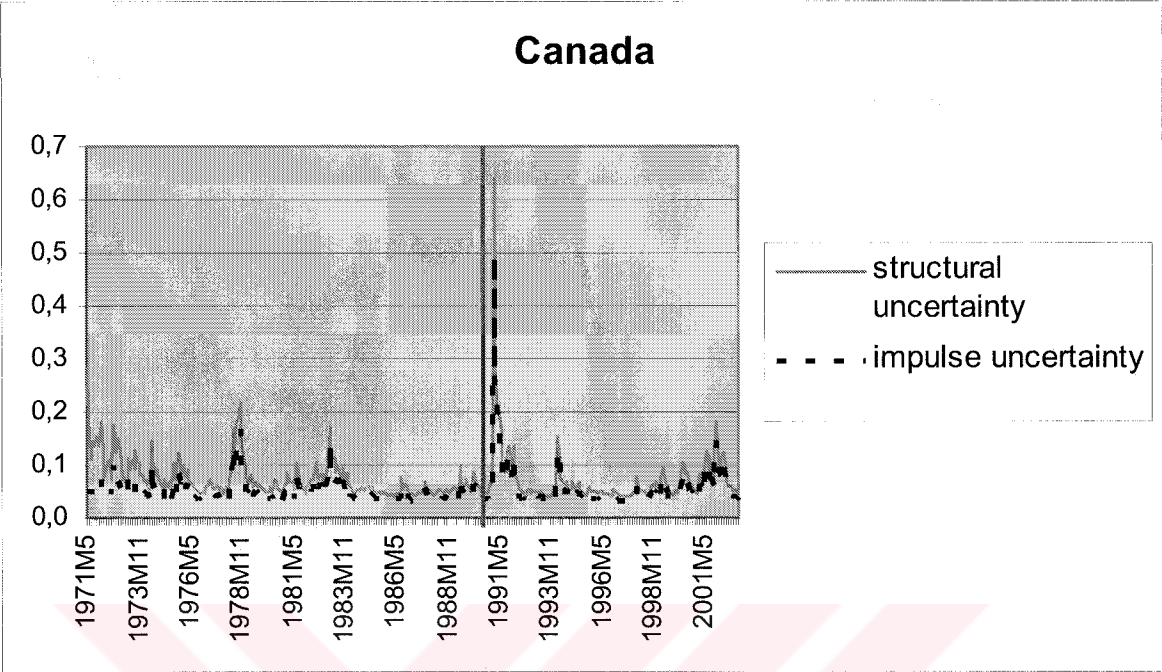


Figure 13: Structural Uncertainty and Impulse Uncertainty of Canada

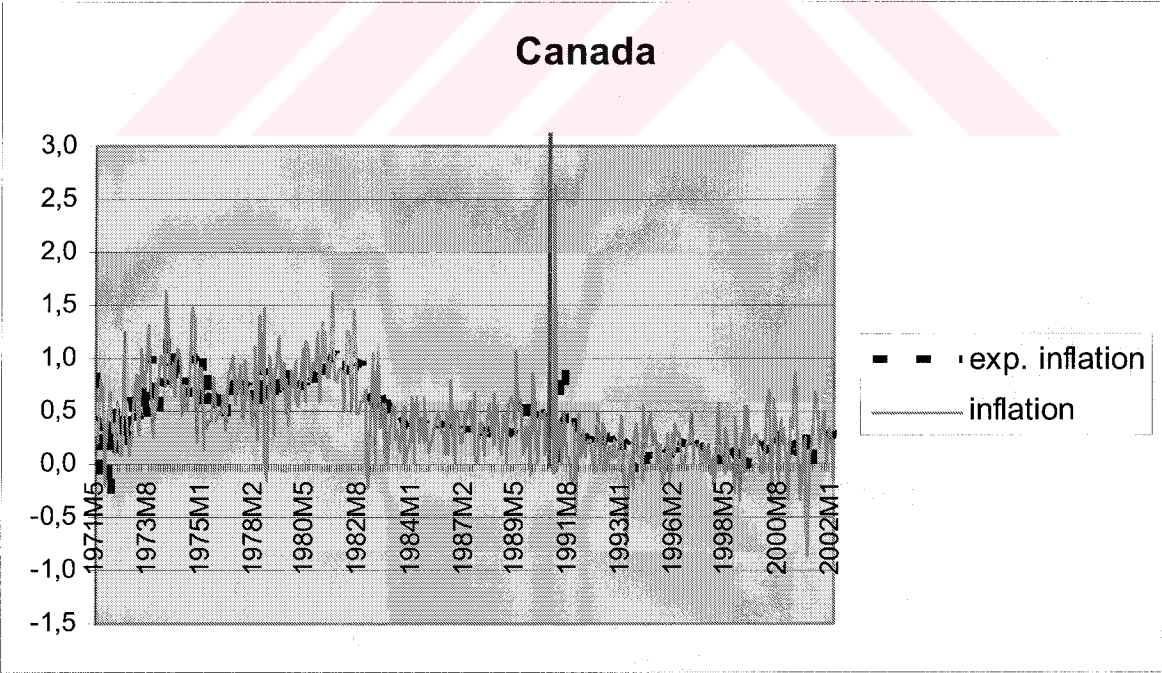


Figure 14: Expected Inflation and Real Inflation of Canada

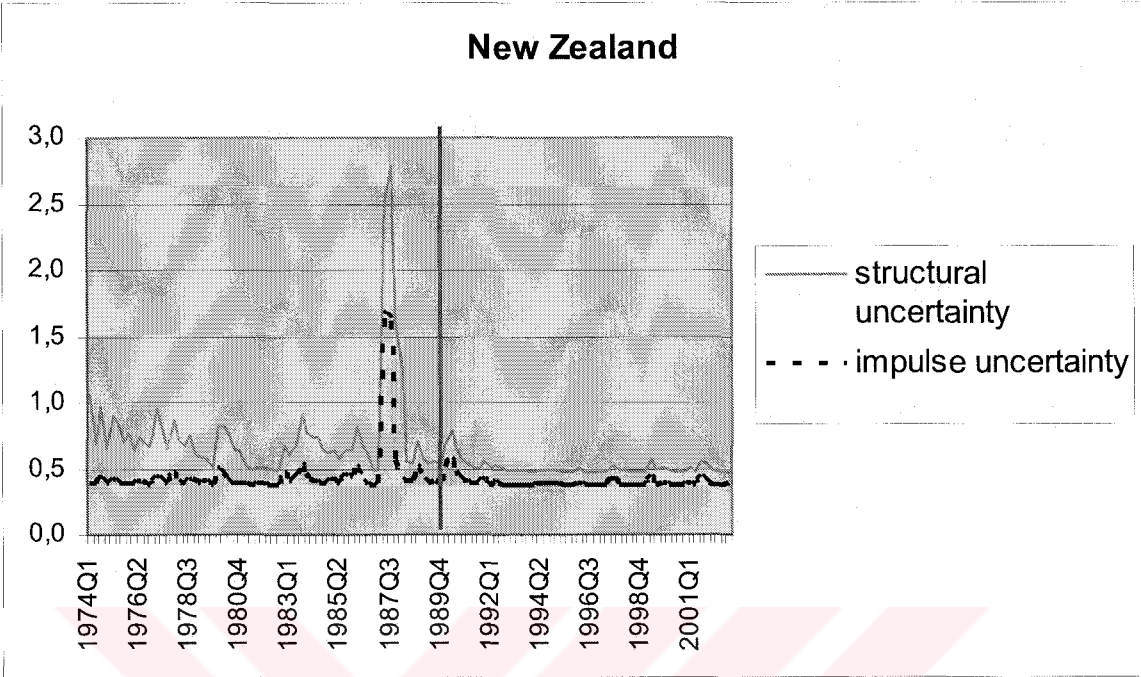


Figure 15: Structural Uncertainty and Impulse Uncertainty of New Zealand

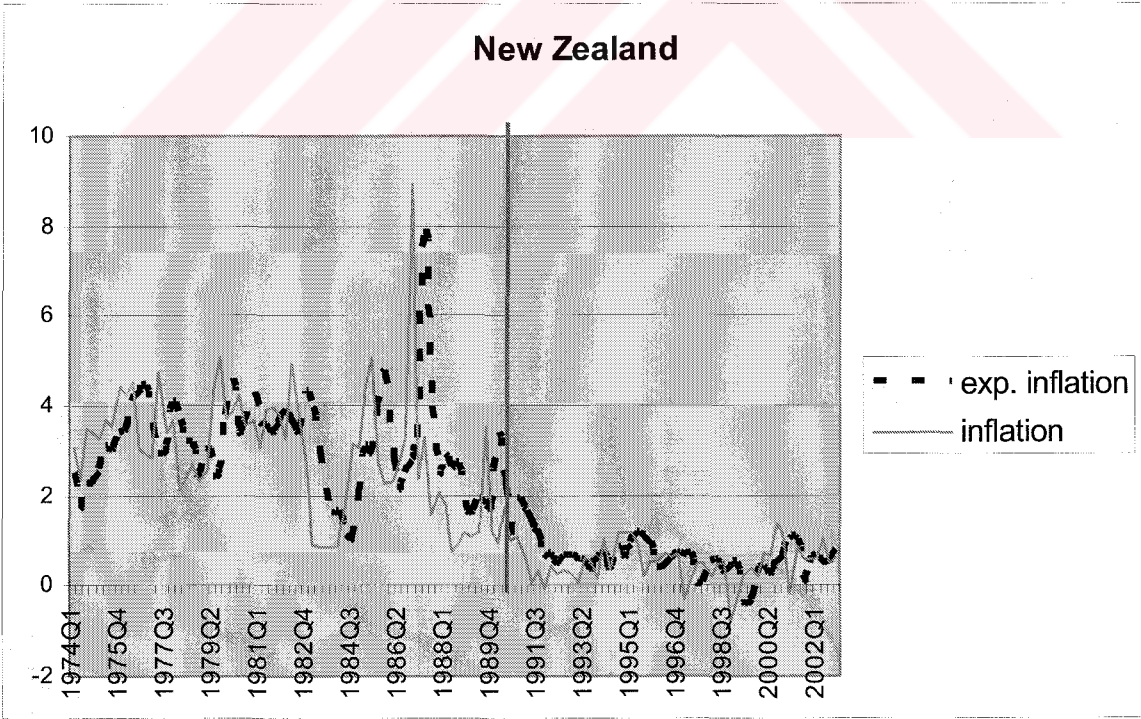


Figure 16: Expected Inflation and Real Inflation of New Zealand

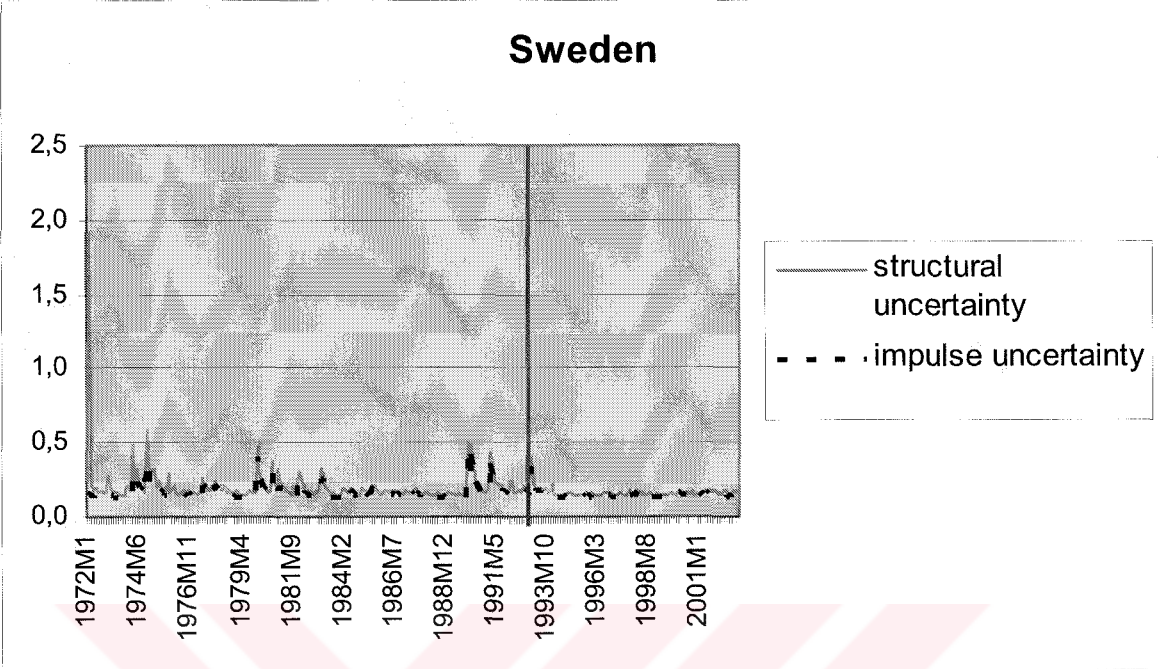


Figure 17: Structural Uncertainty and Impulse Uncertainty of Sweden

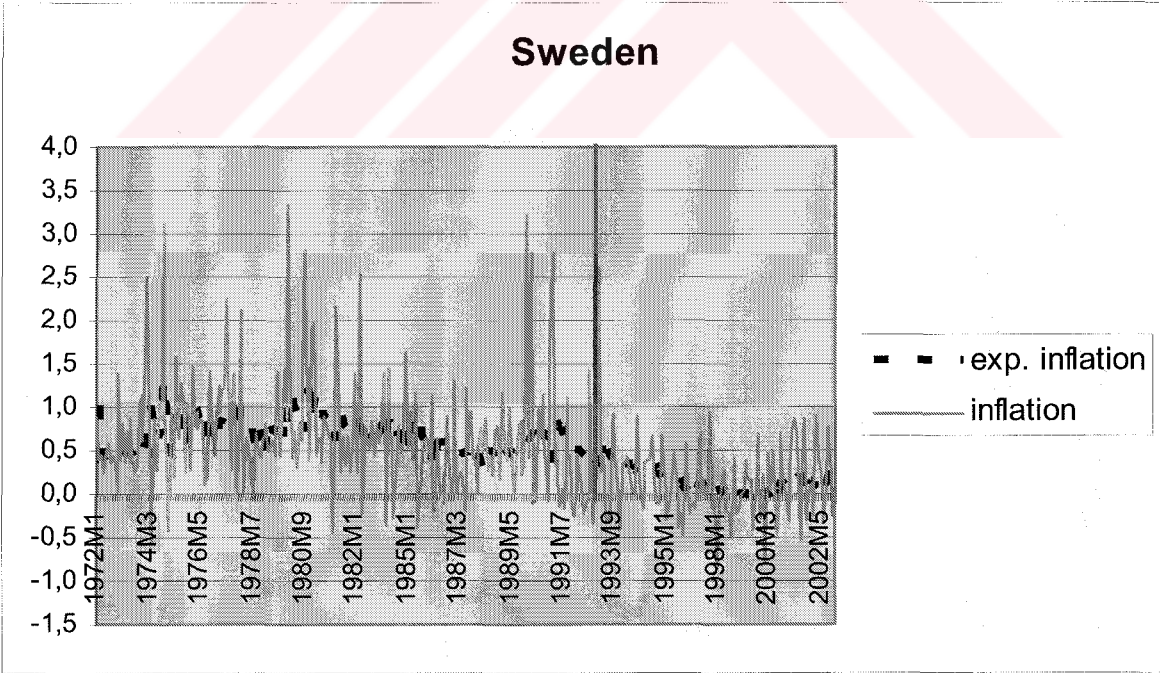


Figure 18: Expected Inflation and Real Inflation of Sweden

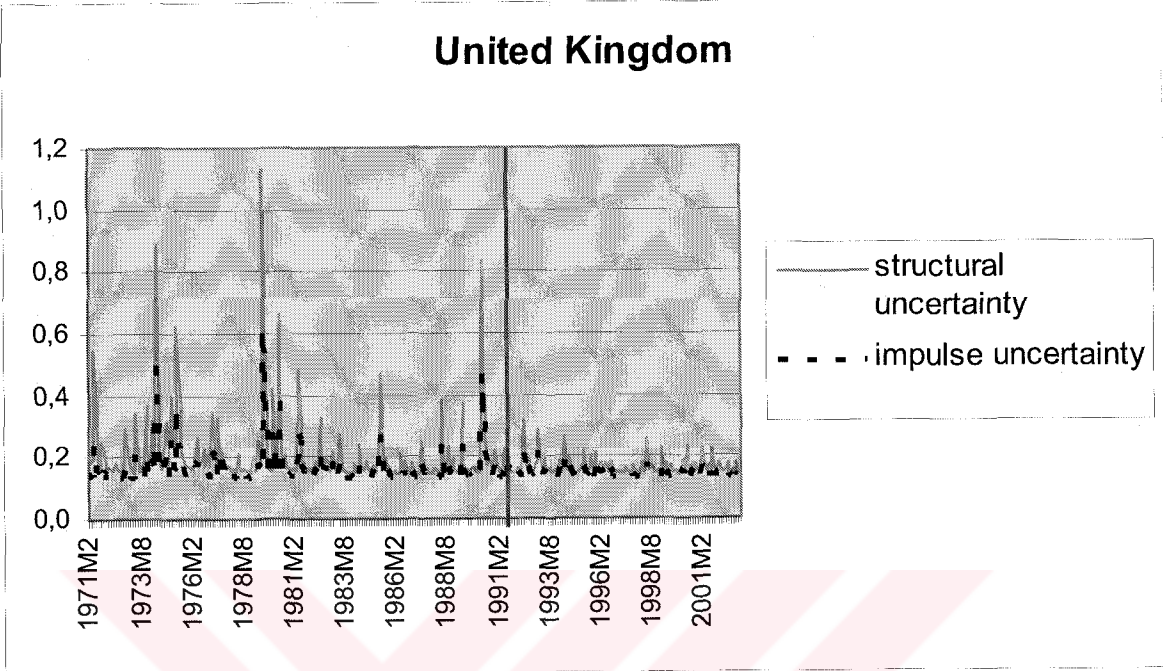


Figure 19: Structural Uncertainty and Impulse Uncertainty of the United Kingdom

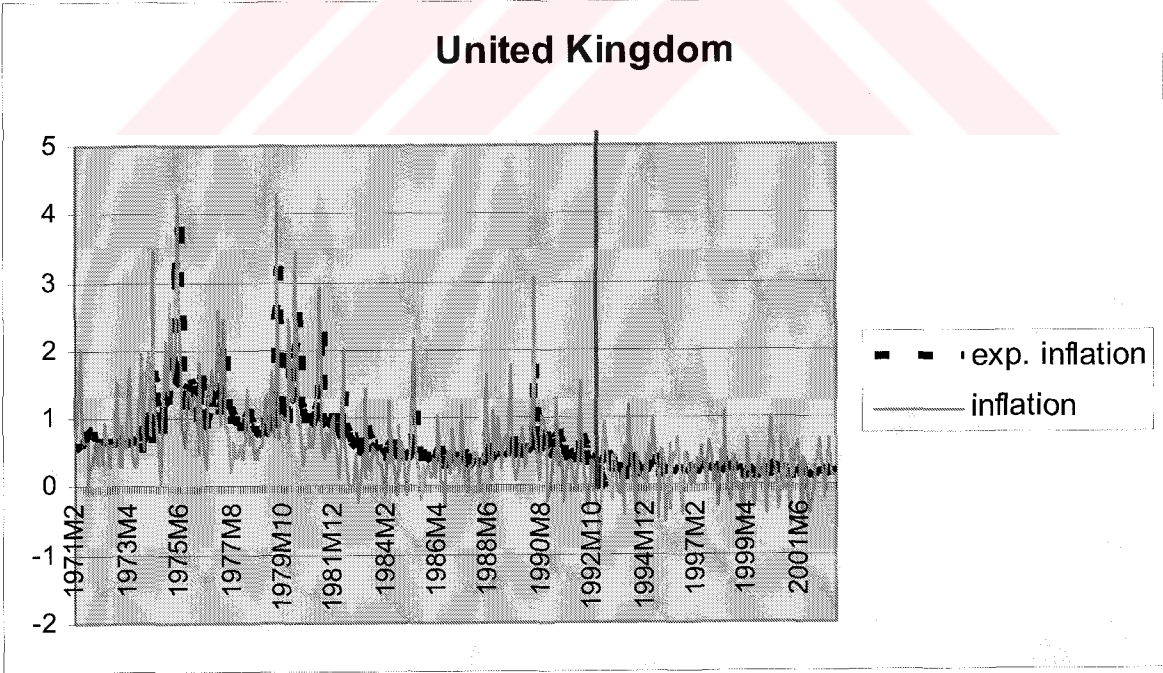


Figure 20: Expected Inflation and Real Inflation of the United Kingdom