# The Relationship between Inflation and Inflation Uncertainty in Turkey.

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## Abstract

This study investigates the nexus between inflation and inflation uncertainty for Turkey employing a vector autoregressive model based on a monthly time series covering 1975:1-2005:12. I used AR – GARCH models to estimate the conditional variance of inflation to proxy inflation uncertainty. The significance and direction of causality between inflation and inflation uncertainty have been investigated using F-tests on the sum of lagged coefficients of inflation and inflation uncertainty. The findings of the study indicate that the rise in inflation increases inflation uncertainty supporting Friedman-Ball hypothesis. Further, the result confirms that higher inflation uncertainty is associated with lower inflation in favor of Holland hypothesis. Both causalities are statistically significant.

# 1. INTRODUCTION

Inflation is defined as a vast amount of money purchasing fewer goods, growth in general prices, or a rise in purchasing power that is not accompanied by a rise in goods' supply. Inflation is mainly computed as the growth rate of the Consumer Price Index (CPI). Inflation is an essential factor for the economy of the countries and attracts significant attention in macroeconomics because of its consequences and costs on all economic activities. It is the major source of welfare costs as it causes relative distorted prices and resource allocation. The relationship between inflation uncertainty and inflation is vital since it provides insight concerning the cost of inflation. Economists usually debate that inflation bears a minimal cost effect if it is correctly forecasted. However, it is exceptionally high if costs increase due to the uncertainty. Inflation uncertainty could be expressed as economic discomfort resulting from economic agents making different expectations about the inflation rate than the actual rate. Unpredictability regarding the futuristic life cycle of inflation makes things difficult to predict for all concerns. Hence, inflation uncertainty influences growth, consumption, and investment adversely. Moreover, it has a positive effect on debtors' status, whereby degrading the status of creditors regarding the contracts that are given in nominal terms. People taking debts opt for short-term borrowing as there is fear for the debt value to rise because of the unforeseen deflation (Erdem and Yamak, 2014, pp 246-248). Inflation uncertainty causes long-term investment debt to be riskier. Inflation uncertainty drives investors to look elsewhere to safeguard their budgeted resources from higher options towards more stable and safe ventures. With inflation uncertainty rising, the business world spends more of its resources to predict inflation cost. Some of them may take additional security measures to safeguard unpredictable inflation employing special instruments like "derivatives." Resorting to such risk safeguarding measures through financial tools could imply deviating resources from more productive goals. These actions may reduce unexpected inflation risk but cannot eradicate it.

Golob (1994, p 33) observed that "whenever anticipated inflation is a factor in an economic conclusion, uncertainty pertaining inflation is also likely to be a factor." The author further implies that "this unpredictability has a negative economic impact that increases with inflation," meaning that high interest rates for an extended period hinder the contributing activities of the economy. The findings of Elder (2004, pp. 911-928) also support this notion. Inflation impacts the economy, whether positively or negatively, is still a controversial topic amongst economists. However, it is agreed that uncertainty in inflation negatively impacts the economy, mainly production and economic growth. The notion which the inflation uncertainty is seen as the core cost of inflation is backed by Fischer (1981), Golob (1993), and Holland (1993b).

Erdem and Yamak (2014, pp 246-248) indicated that a significant factor in determining long-term interest rates is a return rate from investments. The nominal return of long-term borrowing is risky if the future rate of inflation is not certain. Investors tend to opt for a higher rate of return in this case. This thereby brings about an increase in the interest rate in the long term. The capital and finance markets are affected negatively by the rise in long-term interest rates. That is further impacted by high inflation uncertainty and thereby evolving in less equipment and business investments. That decrease leads to an increase in unemployment, the deterioration of income distribution, and even the rise of inflation. The most significant impact of inflation uncertainty on the economy is that it results in the unpredictability of interest rates and other aspects of the economy. These factors tend to make economic campaigns postpone production and reduce employment. The high cost of return makes the investment very sensitive.

Badir Alwan et al. (2014, p 5) demonstrated that limited predictability, delayed investment decisions, diminishing purchasing power, and demand are the main costs of unstable inflation, forcing policymakers to make "Price Stability" the prime objective. Ensuring price stability reduces the uncertainty of the general prices, decreases the inflation risk premium of interest rates, alleviates the distorting impacts of tax systems and supports the increase of living standards, and contributes to financial stability. Therefore, price stability has been the main target in monetary policy for many countries.

Evans (1991, p 171) asserted that uncertainty is not equivalent to variability. If representatives are vague and have inadequate knowledge about inflation, they may see the future as extremely unpredictable. Conversely, there may be minor instability regarding significant alterations in actual inflation rates since representatives are well aware of these changes in advance.

The most significant macroeconomic variable is inflation in Turkey. This study emphasizes Turkish inflation over the period 1975M1 – 2005M12 to test the correlation between inflation uncertainty and inflation. The generalized autoregressive conditional heteroskedasticity (GARCH) model is employed to create a conditional variance of inflation as a proxy for inflation uncertainty. Section 2 discusses theoretical and empirical literature. Section 3 demonstrates a history of the Turkish inflation rate. The data is given in section 4. The econometric methodology is denoted in Section 5, and the outcomes of the analysis are considered in Section 6. R language is utilized for the complete methodology part. Section 7 summarizes the findings and includes the conclusion.

## 2. LITERATURE REVIEW

### 2.1. Four Main Hypotheses

There are four basic approaches in the literature regarding the link between inflation uncertainty and inflation. Among these approaches, Friedman-Ball's (1977, 1992) hypothesis argued that inflation increases the inflation uncertainty, while the Pourgerami-Maskus (1987) hypothesis indicated that inflation reduces inflation uncertainty. In contrast, the notion which inflation uncertainty affecting inflation was supported by Cukierman - Meltzer hypothesis (1986), defending a positive relationship and by the Holland (1995) hypothesis arguing the negative correlation.

Okun (1971, pp 493-497) initially debated that inflation positively correlates with its standard deviation. He applied annual data on 17 Organization for Economic Co-operation and Development (OECD) countries from 1951 to 1968. Okun believes that a positive linkage between inflation and inflation variability exists because monetary policy becomes harder to estimate during high inflation. Later, Friedman (1977, pp 464-468) defined an argument regarding a monetary policy that accompanies inflationary times where a rise in inflation increases inflation variability. As Friedman stated, high inflation tends to raise the political pressure to mitigate it. Nevertheless, the recessionary impacts of conflicting monetary policy make policymakers reluctant to deflation. High inflationary periods make futuristic monetary policy more difficult to predict, bringing about greater uncertainty of future inflation. Consequently, it causes a detrimental effect on real economic activity and efficiency. Ball (1992, p 371-388) asserts that inflation uncertainty originates from the unpredictability of the monetary policy regime, called "regime uncertainty." Policymakers face a dilemma in high inflation, as they have insufficient information about monetary authority policy. The monetary authority wants to reduce inflation; however, they might fear recessionary effects in the economy. Ball (1992, pp 375-376) structured an economic model more formally to advocate Friedman's argument. He employed an asymmetric game perspective between the public and monetary authority. Two policymakers are considered in Ball's model; one is willing to accept a recession to mitigate the inflation, while the other is not. When the observed inflation is low in the economy, both policymakers try to keep a low inflation level. On the contrary, the economic consequences of disinflation will be merely tolerated by the anti-inflation policymaker for high inflation levels. Hence, the people are generally insecure and uncertain of futuristic monetary policy as they are unaware of the type of policymakers during times of high inflation. Estimation of future monetary policy is much more complicated in periods of high inflation. It is difficult for the public to estimate the response of prices to monetary policy. Concentrating on Friedman's initial channel and applying an asymmetric information game showed that the root cause of inflation uncertainty is high inflation which advocates Friedman's work. Including the model of Ball's contribution to Friedman's argument, the positive impact of inflation on inflation uncertainty is known as Friedman - Ball hypothesis.

Cukierman and Meltzer (1986, pp 1102-11) conducted the reverse linkage by denoting the causality from inflation uncertainty to inflation. Central Banks make monetary surprises that either expand output or keep the low level of inflation. An imprecise monetary control mechanism makes the money supply process random. Central banks are convinced to surprise the public by following more discretionary policy to have economic gains and stimulate output growth instead of commitment mechanism in the period of high inflation uncertainty. Hence, they might not always opt for the most appropriate policy instrument when they are free to select. Consequently, inflation uncertainty induces higher inflation than the predictions of economic agents because of opportunistic central bank behavior. Hence, the analysis implies that the rise in inflation uncertainty increases inflation, known as Cukierman and Meltzer hypothesis.

Another significant contribution concerning the relationship between inflation and inflation uncertainty was demonstrated by Pourgerami and Maskus. In contrast to Friedman-Ball Hypothesis, Pourgerami and Maskus (1987, pp 287-290) are convinced that agents might invest more resources in creating correct estimations, mitigating their prediction error. Therefore, a rise in inflation results in lower future inflation uncertainty on average. They indicated that the association between inflation and inflation uncertainty is negative, rejecting the harmful effect of high inflation on prices' predictability. This hypothesis demonstrates a negative impact of inflation on inflation uncertainty named the Pourgerami-Maskus hypothesis. The formal side of the analysis of this effect was provided by Ungar and Zilberfarb (1993, pp 709-720). They developed the same approach by including the theoretical modeling of the assumption that agents invest more resources in estimating inflation when inflation rises. As a result, they support the notion where inflation itself forms a dynamic resulting in better anticipation of the level of prices and decreasing inflation uncertainty in the future.

Holland (1995, pp 828-829) demonstrated a different notion originating from the stabilization motive of the monetary authority. He implied that the welfare cost of inflation uncertainty determines the stabilization tendency of the central bank. The welfare cost increases owing to inflation uncertainty, where inflation uncertainty is induced by higher inflation. By rejecting the assumption of Cukierman-Meltzer, Holland implies that the short-term opportunistic behavior could not be accepted as a solely feasible policy response by the central bank in periods of inflation uncertainty. The inflation uncertainty and the related adverse effects are handled by means of the contraction of the money supply growth (Conrad and Karanasos, 2005a). Policymakers might either be governed by some commitment mechanism that demands the stability of the price or has long-term stabilization incentives themselves to achieve this goal. A rise in inflation uncertainty is comprehended as costly by policymakers, hence making them decrease future inflation. As a result, the hypothesis which inflation uncertainty decreases the average inflation rate is known as Holland Hypothesis.

## 2.2. Literature for the countries except Turkey

A variety of measures was used to quantify inflation uncertainty. The majority of studies utilized the GARCH model developed by Engle (1982) and Bollerslev (1986). GARCH model is employed to form the conditional variance of inflation as a proper measure of inflation uncertainty. The variance of the unpredictable part of an inflation forecast constitutes inflation uncertainty, which is known as the conditional variance of inflation according to the theories of Ball (1992) and Cukierman and Meltzer (1986). Most of the studies assert a positive bidirectional causality relationship between inflation and inflation uncertainty. Hence, they mainly advocate Friedman-Ball and Cukierman-Meltzer hypotheses. Moreover, several pieces of evidence supporting the nonlinear linkage between inflation and inflation uncertainty are also noted. Chang (2012, p 532) asserts that inflation uncertainty is negatively influenced by inflation in times of high inflation volatility, while low inflation volatility periods make its effect insignificant.

The association between inflation and inflation uncertainty was researched by many empirical studies, including Evans (1991), Baillie et al. (1996), Caporale and McKiernan (1997), Grier and Perry (1998, 2000), Kontonikas (2004), Daal et al. (2005), Conrad and Karanasos (2005a), Berument and Dincer (2005), Wilson (2006), Fountas and Karanasos (2007), Thornton (2007), Ozdemir and Fisunoğlu ( 2008), Payne (2008), Fountas (2010), Bhar and Mallik (2010), Balcilar et al. (2010), Jiranyakul and Opiela (2010), Rizvi and Naqvi (2010), Hegerty (2012), Hartmann and Herwartz (2012), Barimah and Amuakwa-Mensah (2012), Karahan (2012), Abayie and Doe (2013), Daniela et al. (2014), Alwan et al. (2014), Barimah (2014), Nasr et al. (2015), and Buth et al. (2015), etc.

As per a comprehensive survey given by Davis and Kanago (2000), studies that focused on industrialized countries mainly support the Friedman-Ball hypothesis much more than Cukierman–Meltzer Hypothesis; however, there is also very little evidence advocating the Pourgerami and Maskus and Holland Hypothesis.

Hwang (2001) inspected the connection of inflation with its uncertainty in the USA regarding the long series of month-wise data from 1926 to 1992 with autoregressive fractionally integrated moving average (ARFIMA) mean and GARCH variance type models. He observed that inflation negatively influences its uncertainty in a small amount, whereas the way uncertainty influences inflation is not significant. Hence, in contrast to Friedman-Ball's hypothesis, he debated that a higher inflation rate does not infer a high uncertainty of inflation.

Chen et al. (2008) scrutinized the Friedman-Ball and Cukierman–Meltzer hypotheses involving South Korea, Taiwan, Singapore, and Hong Kong, performing both linear and nonlinear regression models. They employed moving average standard deviation to measure inflation uncertainty. The Friedman hypothesis does not hold for involved economies in the linear model. However, the nonlinear model advocates the Friedman hypothesis for all economies, excluding Hong Kong. Besides, the Cukierman– Meltzer hypothesis holds for all economies in the nonlinear model.

Chowdhury (2014) examined the correlation between inflation and inflation uncertainty for India utilizing Granger causality tests. He used the monthly wholesale price index (WPI) data for the analysis covering 1954:04 -2010:04. The outcome of the GARCH model with maximum likelihood estimation demonstrates a positive correlation between inflation and its uncertainty. However, the causality test implies bidirectional causality among the two series.

Grier and Perry's (1998) examination encompass G-7 countries from 1948 to 1993 in a two-step procedure and implies a strong relationship between inflation and inflation uncertainty, hence advocating the Holland and the Cukierman–Meltzer hypotheses. In their studies in 2000, they utilized the GARCH-M model to examine the impacts of nominal and real uncertainty on average inflation in the US between 1948:07 and 1996:12. The result affirmed the Cukierman–Meltzer hypothesis.

Joyce (1995) asserts that inflation uncertainty is more sensitive to positive inflation shocks than negative ones in his examination of the United Kingdom.

Badir Alwan et al. (2014) concentrated on the linkage between inflation and uncertainty for Jordan. The conditional variance was applied from a GARCH model to calculate the inflation uncertainty. In addition, Granger methodologies are used to conduct causality amongst inflation uncertainty and inflation. The findings supported the hypotheses of Cukierman-Meltzer and Friedman-Ball.

Balcilar and Ozdemir (2013a) researched the time-varying and asymmetric causalities amongst inflation and inflation uncertainty with the data for G-7 nations from December 1959 to October 2008. Inflation uncertainty was measured by a fractionally integrated smooth transition autoregressive moving average asymmetric power (FISTARMA-APARCH) model that takes into account long memory and nonlinear features. The causal connection between inflation and inflation unpredictability was scrutinized applying the direct VAR and MS-VAR models with time-varying parameters. The MS-VAR model can capture the nonlinearities of the relationship that might occur due to regime changes or structural breaks. It also reveals information about the signs and the causality direction. The Cukierman-Meltzer hypothesis was supported by weak evidence. Furthermore, the authors discovered powerful proof verifying Holland's hypothesis for France, Canada, Japan, Germany, the USA, and United Kingdom. Further, the results for Canada and the United States also advocated the Friedman hypothesis.

Pretorius (2012) investigated the correlation between inflation and inflation uncertainty in South Africa applying quarterly data from 19960:01 to 2012:01. GARCH-M model was employed for measuring inflation uncertainty. Inflation uncertainty negatively affects inflation, backing Holland's hypothesis for stabilizing the central bank's behavior in this research. On the contrary, he also implied that higher inflation gives rise to inflation uncertainty supporting Friedman-Ball's hypothesis.

Nasr et al. (2015) researched the time-varying and asymmetric causalities amongst inflation uncertainty and inflation for South Africa employing the conditional MS-VAR model framework. They used the Smooth Transition Autoregressive Asymmetric Power GARCH (SEA-FISTAR-APGARCH) model, which is calculated recursively to produce the conditional variance of inflation to measure inflation uncertainty. The results advocated Friedman's hypothesis.

Fountas and Karanasos (2007) investigated the impact of inflation uncertainty on inflation for G-7 nations. Inflation uncertainty was calculated applying a variance of past inflation series to analyze the linkage between inflation and inflation uncertainty. The outcome indicated that inflation primarily determines inflation uncertainty, as provided by

Friedman's hypothesis. Moreover, mixed evidence was obtained in favor of the Cukierman-Meltzer hypothesis.

Daal et al. (2005) analyzed the relationship in several developed and emerging countries performing the asymmetric PGARCH (Power GARCH) model, which was developed by Ding, Granger, and Engle (1993). They found powerful evidence for the Friedman-Ball hypothesis for both developed and developing countries.

Balcilar et al. (2010) applied the GARCH model to produce inflation uncertainty from CPI on a monthly basis between 1957:01 and 2006:10. Linear and nonlinear Granger causality tests are employed to analyze the causal correlation between inflation and its uncertainty. Outcomes of parametric and nonparametric tests are in line with Cukierman-Meltzer and Friedman-Ball hypothesis for all nations.

The researches of Valdovinos (2001), Ricketts and Rose (1995), Conrad and Karanasos (2005a), Kontonikas (2004), Caporale and McKiernan (1997), Bouoiyour and Selmi (2014), Wilson (2006) are in tune with Friedman-Ball hypothesis.

The investigations of Bhar and Mallik (2010), Fountas (2010), Neanidis and Sava (2011), Grier and Grier (2006) advocated the Cukierman-Meltzer hypothesis.

## 2.3. Literature for Turkey

Yamak (1996) tested the correlation of inflation uncertainty and inflation for Turkey between 1949 and 1992, performing a regression analysis. The outcome of the test indicated a positive effect of inflation on inflation uncertainty. He verified that Friedman-Ball's hypothesis holds for Turkey.

Nas and Perry (2000) created a monthly time series for Turkey, including a full sample period and three subsamples covering 1960-1998. A performed Granger causality test indicated that an increase in inflation gives rise to inflation uncertainty advocating the Friedman-Ball hypothesis. The evidence of the causality from inflation uncertainty on inflation was found to be varied depending on the sample.

Berument et al. (2001) determined Turkey's inflation uncertainty through the EGARCH method between 1986 and 2000. They used month-wise CPI inflation. Their empirical findings indicated that the effect of positive shocks to the inflation on the inflation uncertainty was comparatively more than the impact of adverse shocks to the inflation.

Another study on the relationship between inflation and inflation uncertainty for Turkey was performed by Telatar and Telatar (2003). They used monthly inflation data with time-varying parameters, including heteroskedastic disturbances. The existing causative relationship from inflation to inflation uncertainty was found to be originated from time-varying parameters of the inflation model. However, the heteroskedasticity in the disturbance term was not found to influence this correlation.

Ozer and Türkyilmaz (2005) analyzed the correlation covering 1990:04 - 2004:04 for Turkey. They used the Granger causality tests, EGARCH model, variance decomposition, and impulse response analysis. They concluded that uncertainty in inflation is associated and determined by inflation.

Ozdemir and Fisunoğlu (2008) examined the Turkey, Philippine, and Jordan CPI-based inflation series for 1987-2003. They employed the ARFIMA-GARCH type of model to produce a time-varying conditional variance of inflation uncertainty. The outcomes supported the hypothesis of Friedman-Ball. Weak evidence was also found to advocate the positive impact of inflation uncertainty on inflation, as reported by Cukierman-Meltzer.

Erdem and Yamak (2014) investigated the correlation between inflation and inflation uncertainty using monthly data and comparing 1988-2004 and 2004-2010. They used the Kalman Filter technique for both periods to obtain inflation uncertainty. Friedman-Ball hypothesis was supported for high inflation periods, while lower inflation periods affirmed the Cukierman-Meltzer hypothesis.

The findings of Neyapti and Kaya (2001), Cetin (2004), Erdoğan and Bozkurt (2004), Akyazı and Artan (2004), Daal et al. (2005), Karahan (2012); Oltulular ve Terzi (2006), Yılmaz et al. (2006) supported Friedman-Ball hypothesis. The researches by Thornton (2007), Erkam (2008), Saatçioğlu ve Korap (2009), Keskek and Orhan (2010), Korap (2010) are in favor of both Friedman-Ball and Holland hypotheses. The investigations of Artan (2008), Omay (2008), Sever and Demir (2008) advocated both Friedman-Ball and Cukiermann-Meltzer hypotheses.

To conclude, most studies used the estimated conditional variance from GARCH models to proxy inflation uncertainty. The outcomes remain sensitive to how the inflation uncertainty is evaluated. Hence, concise and precise identification of inflation dynamics must be made.

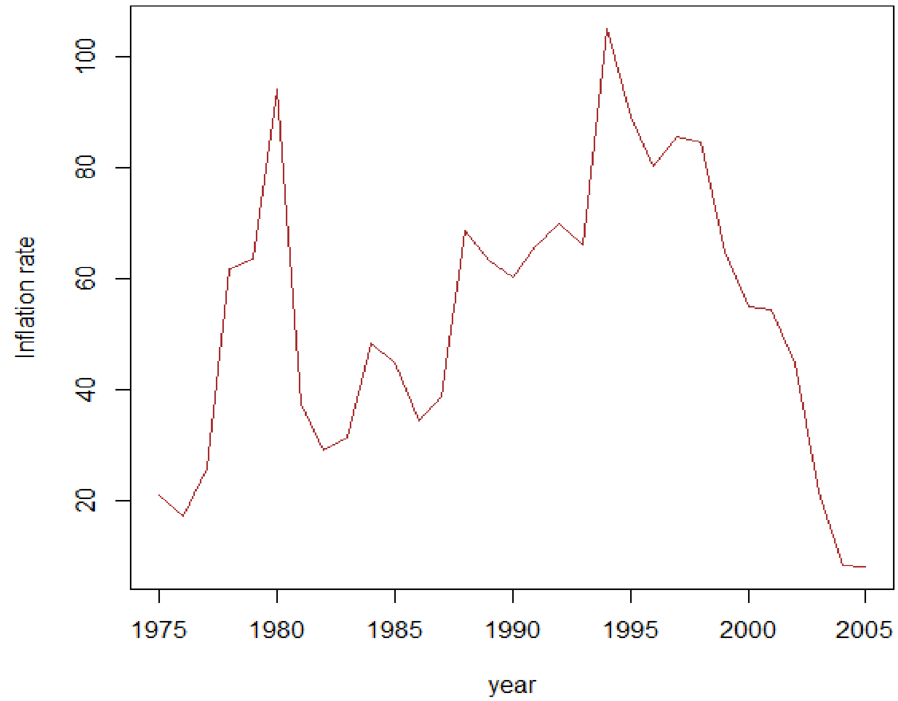
## 3. THE HISTORY OF TURKISH INFLATION: 1975 - 2005

One feature of Turkey's high inflation process is that there had been periods of smooth fluctuations around a mean rate. However, high volatility of the series had also been observed at other times. Therefore, persistently high and volatile behavior of the inflation rate over a stretched time period attracted policymakers' attention to maintain price stability for sustained economic growth. The chronic high rate of inflation is a crucial factor that reinforces the economic instability by hampering monetary policy management and rational fiscal since the second half of 1970 until the early years of the 2000s (Tuna and Payaslioglu, 2011, p 89). This led the Turkish economy to suffer from financial disintermediation and instability in growth. High and persistent inflation rates were a major factor in the Turkish economy during the past three decades in spite of many efforts for disinflation. Earlier attempts of ad hoc economic stabilization programs have been unsuccessful in lowering the rate of inflation. The economy, which heavily relied on short-term debts, continued to suffer from high inflation rates accompanied by a balance of payments deficits and unemployment rates. Turkey has witnessed several economic crises due to the failure of disinflation strategies (Akyuz and Boratav, 2003).

Dibooglu and Kibritcioglu (2004) implied that the major factors that caused inflation from the late 1970s are attributed to monetization of public sector deficits, rises in the price of imported inputs that are major to production, high public sector deficits, political instability, massive investments from various governments, considerable military spending, increasing exchange rates and persistent inflationary predictions of economic agents. Inflation is not easy to control since the factors causing inflation are numerous.

Turkey's economy experiences a volatile and painful history of inflation between 1975 and 2005. Figure 1 plots the percentage change in CPI on an annual basis covering 1975-2005.

**Figure 1:** Annual inflation rate




In the 1970s, the Turkish economy faced inflation mainly due to the shocks in oil prices. The average annual inflation rate was 47% between 1975-1980 (see Figure 1). The country faced a balance of payment crisis during 1979, followed by a liberalization and stabilization program which relied on stand-by agreements with the International Monetary Fund (IMF) (Ekinci and Genc, 2018, p 476). The long-term program jointly designed by the World Bank (WB) and the IMF launched in 1980 to maintain price stability and sustained economic growth with reasonable budget deficits. The stabilization program involved adopting an outward-oriented policy by opening up the economy to foreign capital and shifting to an independent floating exchange rate system (Tuna and Payaslioglu, 2011, p 89). The economy had experienced a series of regulatory restructuring processes for the successful implementation of the program. The annual inflation rate was 95% (see Figure 1) by the end of 1980. However, the average inflation rate was about 38% between 1981 and 1987 with the help of the stabilization program. The crisis was managed through extensive liberalization in finance and trade. Measures resulted in a capital account liberalization during August 1989 (Uygur, 2010). As a result, the economic growth rate was around 5.5% during 1984-1993. This growth was financed by high domestic and foreign borrowing, which resulted in about 60-70% of inflation rates throughout 1988-1993. The authorities were not successful in mitigating inflation to adequate levels, despite substantial measures which were taken towards financial liberalization in the 1980s. Inflation rates ascended significantly over 100% owing to the exchange rate crisis in early 1994 (Ozatay, 2000) (see Figure 1). The new economic stabilization program led the economy to enter into a budget deficit circle, with high inflation rates and external debt. A new disinflation program was initiated to stabilize the economy following the crisis, but a low level of inflation was not achieved owing to the Russian crisis that happened in 1998 (Keskek and Orhan, 2010, p 1283)

Turkey experienced an economic crisis during 1999 and 2001 that resulted in rising inflation rates. An exchange-rate-based stabilization program was launched in December 1999 to alleviate inflation to low levels. The stabilization program was adopted in 2000 and was based on a crawling exchange rate peg (Ekinci and Genc, 2018, p 476). The IMF-backed program attained substantial results in its initial phases but was abandoned because of the exchange rate and liquidity crises during 2000 and 2001 (Selcuk, 2004). Consequently, the exchange rate-based stabilization program collapsed, and the economy had to disorderly exit from the fixed exchange rate regime. February 2001 was marked as the start of a new era of massive structural reforms to strengthen the banking system and the financial markets. The currency peg was abandoned, and the CBT became independent and cleared the floating rate of the exchange regime. This regime required complete independence of monetary authority to ascertain inflation targets in tune with the fiscal policy and applications of all the necessary mechanisms to attain the goals. The objective of the new stand-by program was to achieve sustainable growth and mitigate the crises' adverse effects. The program was successfully implemented in minimizing inflation for the last three years. Granting the independence of CBT was one of the significant developments for the success of the inflation targeting policy. The inflation rate based on the consumer price index decreased to 8% in 2005 from 65% in 1999 (see Figure 1). As reported in Hasanov et al. (2010), the average annual growth rate of GDP in the post-crisis period was 6.2%. Achieved economic stability in the financial markets, the monetary authorities' success in maintaining the inflation target, and the Turkish Lira's appreciation have been essential factors in reverting the negative expectations to positive in the second half of 2003.

Akyazı and Ekinci (2010, p 350) specified 2004 for Turkey as inflation persistency breaking year (see also Kara (2008, p 9); Ozatay (2005, p 7)).

# 4. DATA AND DESCRIPTIVE STATISTICS

## 4.1. Descriptive statistics and properties of inflation

Turkish Consumer Price Index is used covering the period 1975M01 - 2005M12. The data [1]is seasonally adjusted and obtained from the Turkish Statistical Institute. Monthly frequency observations were put into consideration. The inflation is computed as $[(CPI_t - CPI_{t-1})/\ CPI_{t-1}]$ in its linear form.

Figure 2 illustrates the highly volatile characteristic of inflation under the investigation period. Particularly, periods of 1980 (21%), 1987:12 (11.2%), 1994:4 (23.9%) and 2001:04 (10.3%) experienced the highest inflation rate.

**Figure 2:** Monthly inflation rate

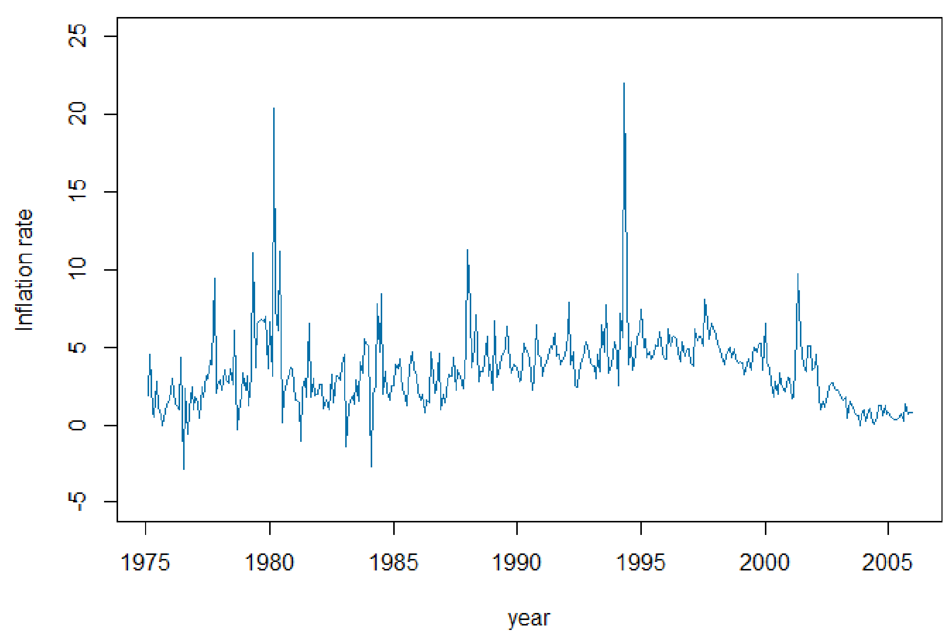



Table 1 confirms the high volatility behavior of the inflation for Turkey. The monthly inflation rate rises by 3.5 percent on average per month within the study period denoted by the mean value. The inflation volatility is high at around 2.47%, which is measured through

[1] https://www.economy.com/turkey/consumer-price-index-cpi/seasonally-adjusted

the standard deviation. The standard deviation value denotes the high degree of volatility in time series.

**Table 1:** Descriptive statistics of inflation series

| Inflation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| nobs | Min | Max | Mean | Median | Sum | Variance | Stdev. | Skewness | Kurtosis |
| 371 | -2.9 | 21.99 | 3.51 | 3.37 | 1302 | 6.08 | 2.47 | 2.22 | 13.50 |

The minimum inflation rate is (−2.90) while the maximum is recorded at 22. The discrepancy among the maximum and the minimum values advocates the notion that price changes have high volatility. Skewness measures the asymmetry of the distribution of the series around its mean, and the skewness of the normal distribution would be zero. The skewness value is 2.22, confirming non-normality. On the other hand, kurtosis measures whether the tails of a given distribution indicate extreme values compared to the tails of a normal distribution. The series of the normal distribution is 3. The distribution peaked relative to the normal if the kurtosis is larger than 3. The kurtosis value is 13.50 in the inflation series, which is considerably higher than 3, denoting excess kurtosis and implying that the inflation series is leptokurtic and the tails are thick. Descriptive statistics demonstrate that monthly inflation data have a right tail. The leptokurtic appearance of the inflation series denotes extreme values. As the distribution skewed towards the right, the mean value of the inflation series is higher than its median. The pointedness of the inflation series indicates that its distribution is far from normality.

**Table 2:** Normality tests for inflation

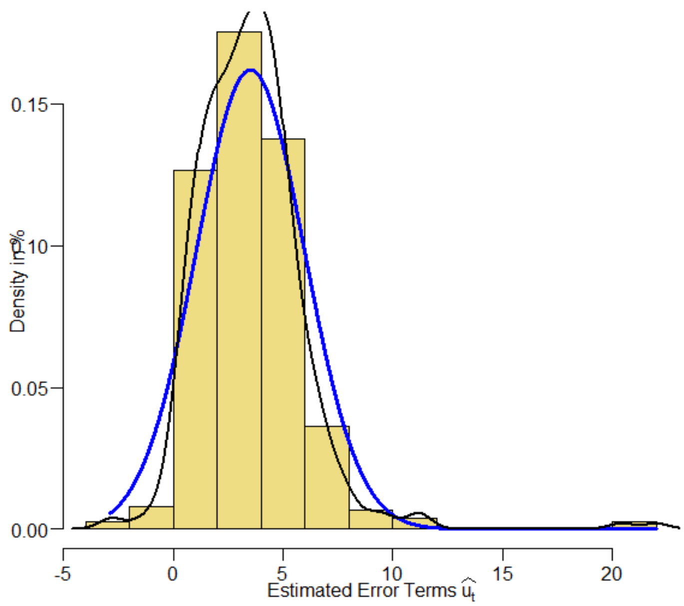
| **Jarque Bera Test**<br>H0: normality | |
|---|---|
| X-squared | 3206.8 |
| p-value | < 2.2e-16 |

*Note:* The null hypothesis implies that the residuals are normally distributed.

The non-normality of the distribution is also denoted by the significance of the Jarque-Bera normality test below, where the null hypothesis of normality is rejected (see Table 2).

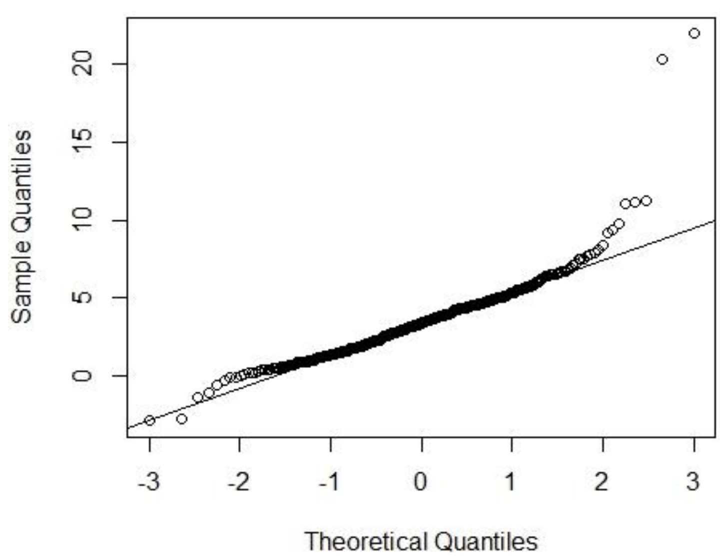
A further graph to check the normality of the series is a histogram of the distribution of the series. As illustrated in the histogram given in Figure 3, the distribution is right-skewed, and it has fat tails.

**Figure 3:** Histogram of inflation




Another way to investigate the distribution of the residuals is to draw a plot of quantiles.

**Figure 4:** Normal Q-Q Plot of Inflation



The points in the Quantile-Quantile plots should lie alongside a straight line when the residuals are normally distributed (Saatcioglu and Korap, 2009, p 243). The points depart upward from the straight line as following the quantiles from left to right. A normal Q-Q plot denoted by Figure 4 also indicates the fat tails and nonnormality of the inflation.

Before estimating the ARMA and GARCH models, stationary properties of the inflation series have to be established. In the econometric literature, the stationarity of included endogenous variables is important, especially in the VAR models. Granger and Newbold (1974) investigated the spurious regression problem and demonstrated that using non-stationary time series results in biased standard errors and unreliable correlations. This implies that the variables must be differenced d times until it gets a covariance-stationary process. Augmented Dickey-Fuller (1979) (ADF) and Phillips-Perron (1988) (PP) tests are employed to test whether the variables are stationary. The null hypothesis test is whether a unit root in the series exists or not. If the null hypothesis is rejected, it denotes that the series is stationary. I test the stationarity of the series in levels. I use both conventional ADF and PP tests to check the stationarity of the inflation series. I checked the rest regression with a trend in which the trend is not significant (Table A1). However, the ADF unit root test with drift is rejected at 1%, (Table A2), where the intercept is significant. This means that the series is stationary with a constant mean

**Table 3:** Phillips-Perron Unit Root Test of Inflation

| **Phillips-Perron Unit Root test** |
|---|
| Dickey-Fuller Z(alpha) = -230.14, Truncation lag parameter = 5, p-value = 0.01 |
| alternative hypothesis: stationary |

*Note:* The null hypothesis implies that there is a unit root in the series.

Phillips-Perron unit root test also confirms the stationarity of inflation series in level as depicted in Table 3. The unit root tests for the inflation data indicate that the series is stationary in level so that d = 0.

## 4.2. Descriptive statistics and properties of inflation uncertainty

Table 4 illustrates the descriptive statistics of inflation uncertainty. The difference between the minimum and the maximum values advocates the notion that significant volatility exists in the inflation uncertainty series. The monthly inflation uncertainty rate rises by 6.21 percent per month within the study period. The standard deviation is high at around 16, showing the distribution and indicating high volatility. Skewness and kurtosis values indicate excess kurtosis and right skewness of the series.

**Table 4:** Descriptive statistics of inflation uncertainty

| **Inflation uncertainty** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| nobs | Min | Max | Mean | Median | Sum | Variance | Stdev. | Skewness | Kurtosis |
| 371 | 1.42 | 176.51 | 6.25 | 2.41 | 2318 | 253.6 | 15.92 | 7.76 | 75.59 |

The histogram confirms the non-normality of the series illustrated by Figure 5. Further, the null hypothesis of normality in the Jarque-Bera test is rejected, affirming the series's nonnormality (see Table 5).

**Figure 5:** Histogram of inflation uncertainty

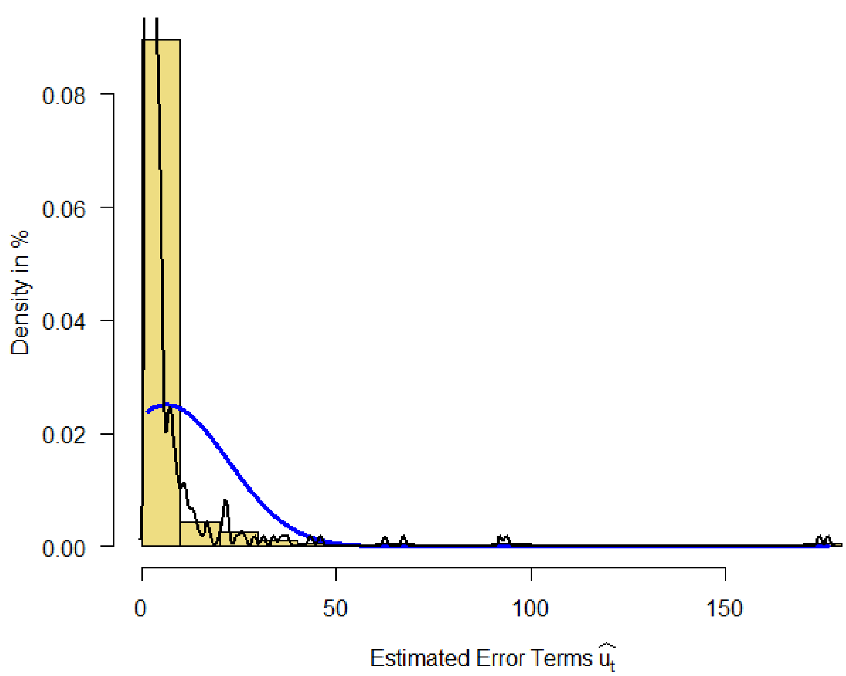


**Table 5:** Normality tests for inflation uncertainty

| Jarque Bera Test<br>H0: normality | |
|---|---|
| X-squared | 83874 |
| p-value | < 2.2e-16 |

*Note:* The null hypothesis implies that the residuals are normally distributed.

I also analyzed the existence of a unit root for inflation uncertainty variable with ADF test. The test regression denotes that the series is stationary with a constant mean (see Table A3).

# 5. ECONOMETRIC METHODOLOGY

## 5.1. AR-GARCH model

I employ the AR-GARCH model for generating inflation uncertainty. The variance and mean models from the series of inflation are estimated following Nas and Perry (2000) and Grier and Perry (1998). First of all, the mean equation in the form of ARMA is specified. $\pi$ is a process of inflation series and function of weighted aggregation of its lagged value in an AR model. The AR model in the general form concerns the inflation series and is provided below:

$$\pi_t = \alpha_0 + \sum_{n=1}^{\infty} \alpha_1 \pi_{t-1} + \varepsilon_t \quad (1)$$

Equation 1 represents the standard time-series model of inflation ($\pi$) at time t, where the error term ($\varepsilon_t$) is assumed to be $\varepsilon_t \mid \Psi \sim N(0, h_t^2)$ and the conditional mean of inflation follows an autoregressive AR process. $\varepsilon_t$ is the innovation in the AR model for a stationary series $y_t$. The functional form of a GARCH process is formally given by

$$h_t^2 = \alpha_0 + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{p} \delta_j h_{t-j}^2 \quad (2)$$

where p ≥ 0; q > 0; and $\delta_j \geq 0$, for j = 1,2, …, p. The error term $\varepsilon_{t-j}^2$ is a white noise process and $h_t^2$ denotes the conditional variance where $h_t^2$ is strictly positive for all realizations. The conditional variance is used as a proxy for inflation uncertainty.

## 5.2. VAR model

Mentioned by Christopher A. Sims (1980), the Vector Autoregressive (VAR) model determine and interpret economic shocks and is employed to estimate their influences on other variables considered. In the VAR model, each of the variables in the VAR model is considered as endogenous, and the present value of an endogenous variable is linearly dependent on the past values of it and all the other endogenous variables. To put it differently, vector autoregression (VAR) is the multivariate generalization of univariate ARMA processes where a vector of time series variables is regressed on lagged vectors of these variables in a VAR model (Schmelzer et al., 2020, p. 472). Lag selection criteria is used for choosing the optimal lag length. VAR system with only two variables is considered as below.

$$y_{1,t} = \alpha_{11} y_{1,t-1} + \alpha_{12} y_{2,t-1} + u_{1,t}$$

$$y_{2,t} = \alpha_{21} y_{1,t-1} + \alpha_{22} y_{2,t-1} + u_{2,t}$$

The error terms (u) are denoted as "innovations." They are the forecast errors of a variable being conditional on its past values and other variables' past values. They should not be predictable, meaning that they should be uncorrelated with the right-hand side variables. This system can be estimated consistently and efficiently by OLS.

It is difficult and complicated to interpret the coefficients of the VAR. Therefore, I employ an F-test, Impulse Responses Functions (IRF), and Forecast Error Variance Decompositions (FEVD) to analyze the linkage between the variables of the model.

IRF was formed for the VAR system to have complete information on system variables. The IRF defines how many consecutive periods the considered variables are influenced by one exogenous shock on the residuals of a variable, and until which period the variables are impacted by that shock (Lütkepohl, 2005, p 51). I examine the impact of one-standard deviation inflation and inflation uncertainty shocks on each other and their own values considering orthogonalized IRFs and accumulated responses covering 1975m01 - 2005m12. Confidence intervals (CI) are based on 95% for the significance of IRFs and accumulated responses. I set the period to 24 months.

FEVD is a further tool that is used for the interpretation of a VAR model. It helps to identify the proportion of variation of the dependent variable explained by the shock in itself against exogenous shocks in the other variables (Brooks, 2008, p 300).

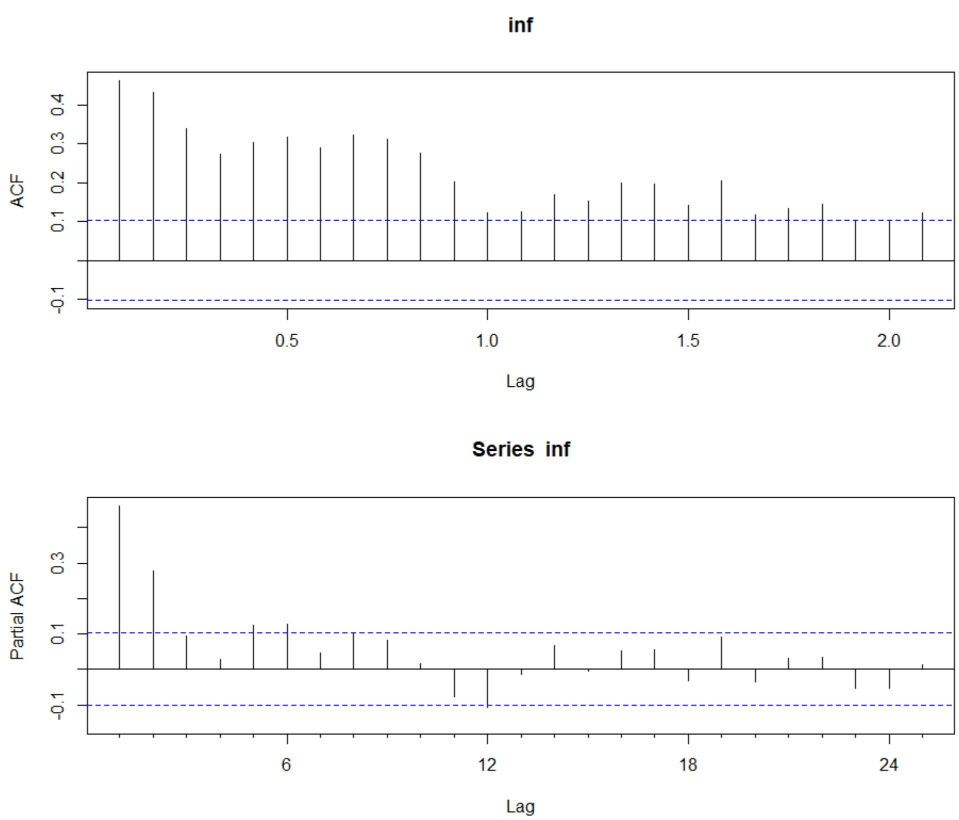
I execute R language for the entire analysis.

# 6. EMPIRICAL EVIDENCE

## 6.1. AR (2) mean model

The numbers of AR and MA terms can be identified by looking at ACF and PACF plots. The PACF. The best-fitting ARMA model of inflation is identified and estimated for monthly data over the 1975:01 – 2005:12 according to Autocorrelation (ACF), and Partial Autocorrelation (PACF) plots given in Figure 6. As depicted below, ACF does not break up, and PACF is positive, which breaks up after two lags meaning that the best fitting mean model is AR (2).

**Figure 6:** ACF and PACF plots



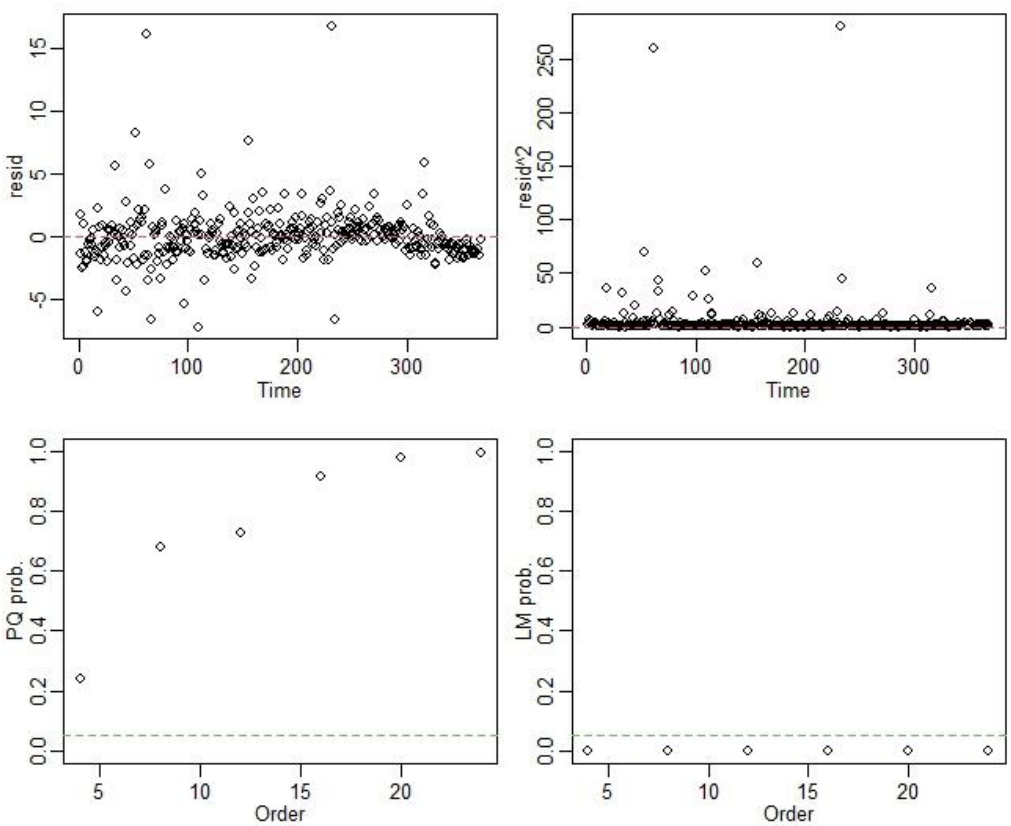
As shown in table 6, The sum of AR coefficients is less than one satisfying the stability condition and indicating the stationarity of the AR process.

**Table 6:** Mean Model

| | | | |
|---|---|---|---|
| Call: | | | |
| Coefficients: | | | |
| | ar1 | ar2 | intercept |
| | 0.3376 | 0.2807 | 3.4915 |
| s.e. | 0.0498 | 0.0499 | 0.2820 |

After determining the mean model, I check whether the model has autocorrelation in the residuals. There should be no presence of serial correlation in the residuals for the adequacy of the chosen model.

**Figure 7:** Portmanteau(Q) and ARCH-LM tests



The residuals are free of serial correlation according to the Portmanteau-Q (1970) test denoted in Figure 7. The p-values are larger than the 0.05 significant level, confirming the null hypothesis of no serial correlation.

ARCH-LM test by Engle (1982) is utilized to identify ARCH effects in the inflation series. The availability of the ARCH effects in the whole sample is confirmed by the ARCH-LM test depicted in Figure 7. The availability of the ARCH effects implies that we could use the variance model to capture the existing volatility in the series.

## 6.2. GARCH (1,1) variance model

Here, the objective is to define the relevant order of p and q in the GARCH (p, q) process and estimate the resulting GARCH models. The GARCH (1, 1) model is mostly employed.

**Table 7:** Variance Model – GARCH (1,1)

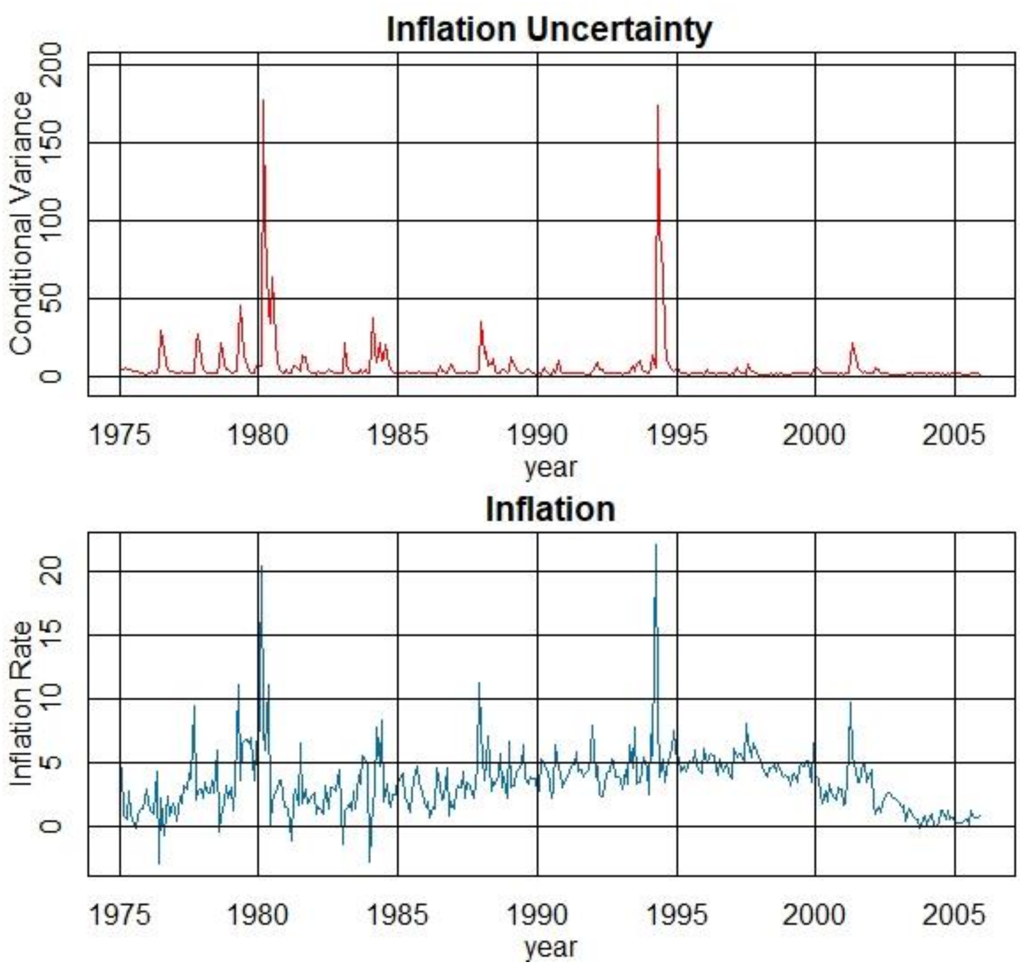
| | | | | |
|---|---|---|---|---|
| * GARCH Model Fit * | | | | |
| Conditional Variance Dynamics | | | | |
| ----------------------------------- | | | | |
| GARCH Model: sGARCH(1,1) | | | | |
| Mean Model: ARFIMA(2,0,0) | | | | |
| Distribution: norm | | | | |
| | | | | |
| Optimal Parameters | | | | |
| ------------------------------------ | | | | |
| | Estimate | Std. Error | t value | Pr(>\|t\|) |
| mu | 3.13796 | 0.473084 | 6.6330 | 0.000000*** |
| ar1 | 0.64726 | 0.072929 | 8.8753 | 0.000000*** |
| ar2 | 0.20968 | 0.069738 | 3.0067 | 0.002641*** |
| omega | 0.91357 | 0.218438 | 4.1823 | 0.000029*** |
| alpha1 | 0.63945 | 0.106573 | 6.0002 | 0.000000*** |
| beta1 | 0.35955 | 0.065750 | 5.4684 | 0.000000*** |

*Note:* *** implies that coefficients are significant at 1% significance levels.

As depicted in table 7, the alpha1 is 0.63945, and beta1 is 0.35955, reflecting respective ARCH and GARCH coefficients. The coefficients in the variance equation are statistically significant. Further, the sum of the ARCH and GARCH coefficients ($\alpha + \beta$) is 0.99, indicating that the volatility exhibits a high degree of persistence, but it has a mean-reverting behavior as $\alpha + \beta < 1$. The conditional variance from the GARCH model is used as a measure for inflation uncertainty.

Figure 8 plots the inflation and inflation uncertainty. A sudden rise and falls in both inflation and inflation uncertainty accompany the same period as depicted in Figure 8. This pattern is a signal of the existing correlation between inflation and inflation uncertainty. I use an F-test for econometric analysis of this relationship to define the direction of causality.

**Figure 8:** Inflation and Inflation Uncertainty



## 6.3. VAR model and F- test

I bind inflation and inflation uncertainty variables together to create the VAR system (see Table A4). I select the optimal lag order according to the Akaike information, which is lag 9 in my series. As it is very difficult to interpret estimated VAR model coefficients, I use F-tests to check the significance of the impacts of inflation and inflation uncertainty variables on each other. Initially, I generate two test regressions by regressing uncertainty on the lags of inflation and lags of uncertainty variables (see Table A5) and regressing inflation on the lags of uncertainty and lags of inflation variables (see Table A7). The lag length is determined at 9 to make it analogous to the VAR model. Then, I run F-tests on the sum of lagged coefficients of inflation taken as a group in a regression model denoted in Table A5 and on the sum of lagged coefficients of inflation uncertainty in a regression model illustrated by Table A7. The respective results are shown in Table A6 and Table A8. The sum of lagged coefficients of the inflation variable is positive in sign and statistically significant at 5% significance (see Table A6). This implies the positive effect of inflation on inflation uncertainty. Further, the sum of lagged coefficients of inflation uncertainty (see Table A8) is negative in sign and significant at a 5% significance level, implying that the rise in inflation uncertainty decreases inflation. Based on F-tests, both inflation and inflation uncertainty cause each other as bidirectional causality between variables exists. The rise in inflation increases inflation uncertainty supporting the Friedman-Ball hypothesis, while inflation is affected by inflation uncertainty in an opposite way advocating the Holland hypothesis.

## 6.4. VAR Model Diagnostics

I run several diagnostics tests to check the existence of heteroscedasticity, autocorrelation, stability, and the normality of the VAR model.

One of the assumptions is that the residuals should not be correlated. The null hypothesis should be accepted for the adequacy of the model, which means that the residuals are white noise and uncorrelated with its values of previous periods. The null hypothesis of no autocorrelation is accepted according to the Portmanteau test (see Table 8), affirming that the model is appropriate.

**Table 8:** Portmanteau Test

| Portmanteau Test (asymptotic) |
|---|
| Chi-squared = 19.377, df = 12, p-value = 0.07982 |
| alternative hypothesis: there is autocorrelation |

*Note:* The null hypothesis indicates that there is no serial correlation (autocorrelation).

A further test to consider is the existence of heteroscedasticity. ARCH effects in time series are essentially clustered in volatility areas of time series.

**Table 9:** ARCH-LM Test

| ARCH (multivariate) |
|---|
| Chi-squared = 512.84, df = 108, p-value < 2.2e-16 |
| alternative hypothesis: there is an ARCH effect |

*Note:* The null hypothesis implies that no ARCH effect is available.

The result of the ARCH test (see Table 9) indicates the existence of heteroscedasticity as we reject the null hypothesis. Hence, the ARCH effects in the model are present.

A soft pre-requisite but a desirable requirement is the normality of the distribution of the residuals. The model's residuals are not normally distributed based on the results of Table 10.

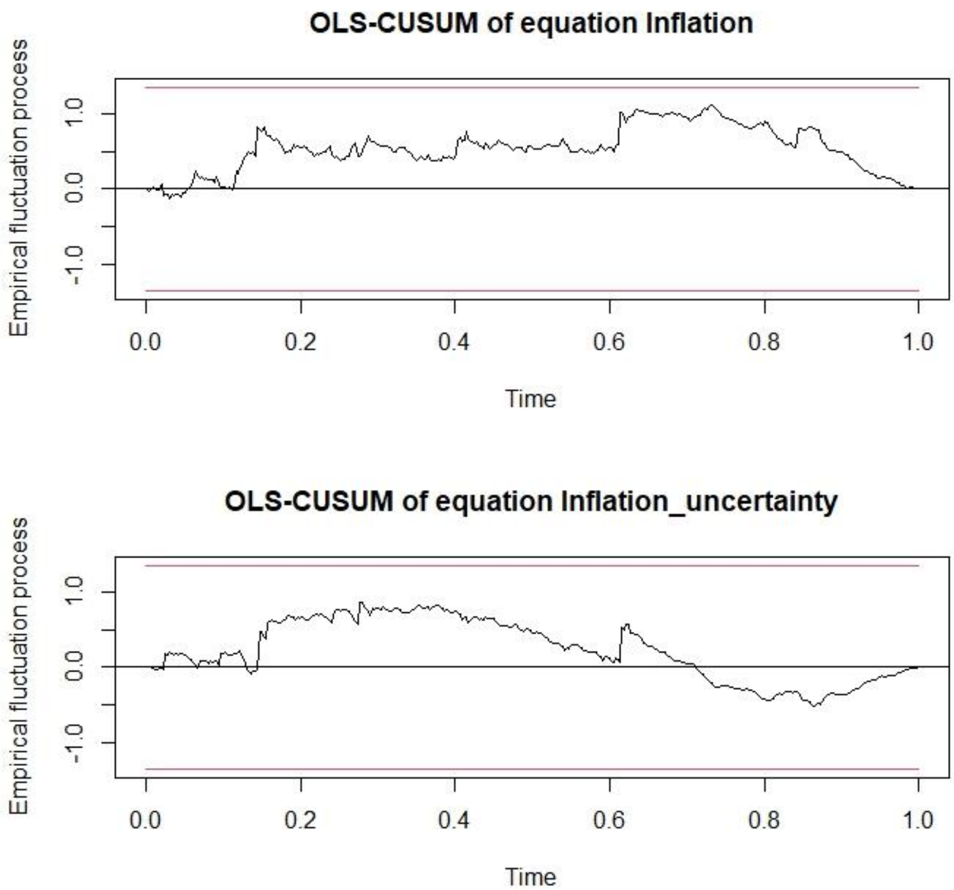
**Table 10:** Jarque-Bera Test

| JB-Test (multivariate) |
|---|
| Chi-squared = 40497, df = 4, p-value < 2.2e-16 |
| alternative hypothesis: residuals are not normally distributed |

*Note:* The null hypothesis is normality. If the p-value is smaller than 0.05, the null hypothesis is rejected.

Further, a stability test should be executed to check for the presence of structural breaks. If structural breaks in the series are present, the whole estimation results might be affected. A test is employed to plot the sum of recursive residuals (see Figure 9). If the plot crosses the red lines at any point in the graph, then a structural break happened to be present in that area. The model passes this particular test as there are no structural breaks based on Figure 9.

**Figure 9:** OLS-CUSUM of equation inflation and inflation uncertainty

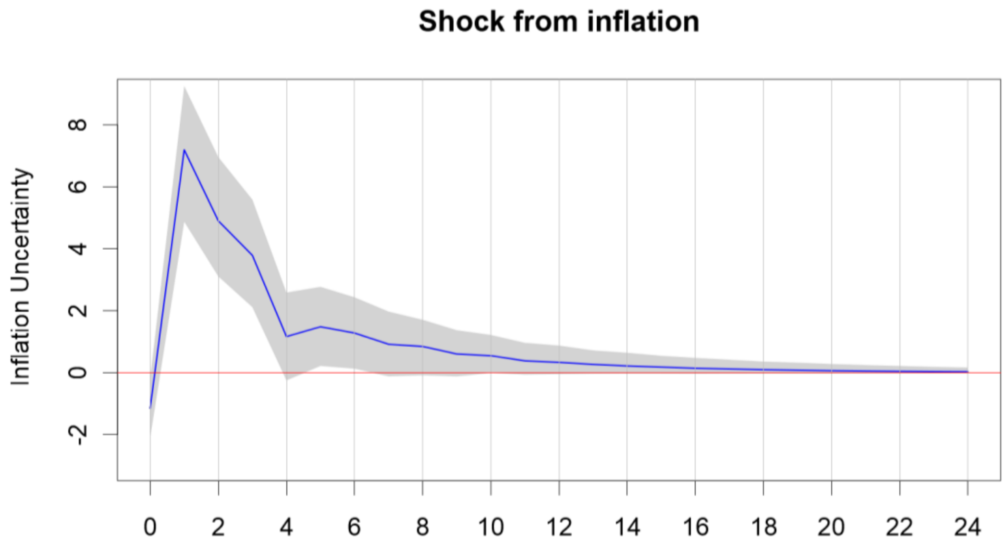



## 6.5. Impulse Response Functions

Figures 10 and 11 show responses of inflation uncertainty and inflation respectively to one unit of standard deviation shock in the inflation variable of the baseline two-variable VAR.

The inflation uncertainty increased approximately seven percentage points (pp) in response to one unit of positive standard-deviation shock in inflation during the first month. This response coefficient is significant from first to fourth period under a two-standard error criterion (roughly 95% CI) (e.g., see Lütkepohl, 2005, p 119. The response from inflation uncertainty experiences a sharp decrease of 7 pp from one to four months where the response is significant before the effects become insignificant from the fourth period onward. The effects shrink down and die out after about fourteen months, as depicted in Figure 10.

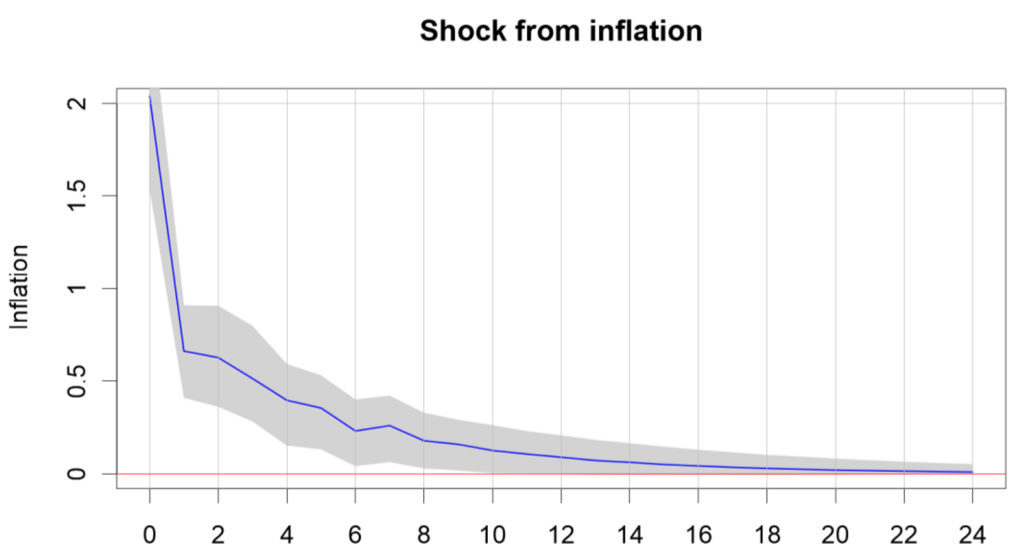
**Figure 10:** Response of inflation uncertainty to shock in inflation




***Notes:*** Grey-shaded areas indicate 95% confidence bands, the middle line represents the impulse response function. 500 runs are used for the bootstrap.

One-unit standard deviation shock in inflation influences itself nearly -1.5 pp during the first month, where the response is significant (see Figure 11). The responses are significant until the tenth month. The effect reduces gradually to its steady level and becomes insignificant after about ten months, and dies out after sixteen months.

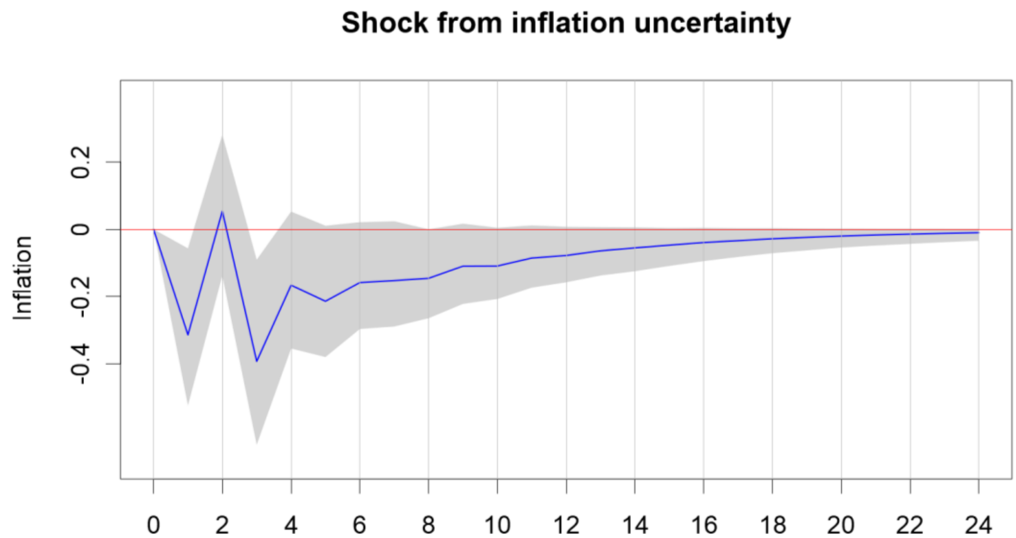
**Figure 11:** Response of inflation to shock in inflation




***Notes:*** Grey-shaded areas indicate 95% confidence bands, the middle line represents the impulse response function. 500 runs are used for the bootstrap.

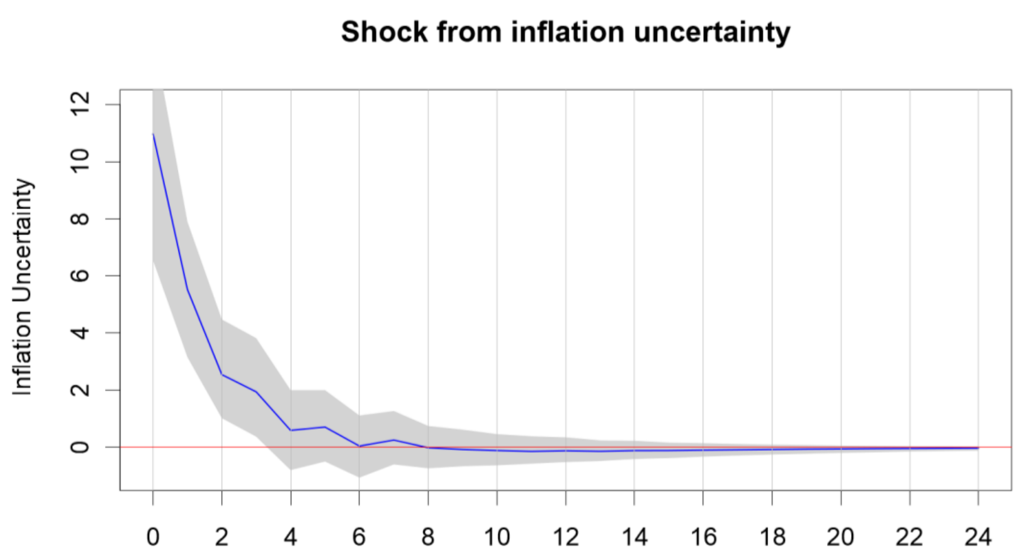
Figures 12 and 13 show IRFs of inflation and inflation uncertainty after one unit of standard deviation innovation in the inflation uncertainty variable of the baseline two-variable VAR.

**Figure 12:** Response of inflation to shock in inflation uncertainty




***Notes:*** Grey-shaded areas indicate 95% confidence bands, the middle line represents the impulse response function.

**Figure 13:** Response of inflation uncertainty to shock in inflation uncertainty




***Notes:*** Grey-shaded areas indicate 95% confidence bands, the middle line represents the impulse response function.

Shock in inflation uncertainty decreases inflation nearly 0.3 pp during the first month, where the response is significant. The uncertainty reverts to the previous value in the second month, where the effect is insignificant (see Figure 12). The response during the third month is significant. The effects become insignificant after the fourth period.

The response of inflation uncertainty to the shock on itself is significant that falls substantially by 9 pp until the second month. Subsequently, the shock decreases inflation uncertainty by almost 1 pp from two to three months, where the response is significant. The effect becomes insignificant after three months and dies out after six months, as depicted in Figure 13.

## 6.6. Forecast Error Variance Decomposition

Variance decomposition demonstrates the proportion of independent variables in explaining the variability in the dependent variables over time. I plot the forecast error variance decomposition for inflation and inflation uncertainty below in Figure 14 and Figure 15, respectively. As depicted below, inflation is mainly influenced by the shock on itself. In the first period, the entire change both in inflation and inflation uncertainty is explained by their own shocks. Almost the whole shift in inflation is due to the shock on itself till the fourth period. The shock in inflation uncertainty influences inflation for the periods ahead, but the proportion is tiny. The effect of the shock to the uncertainty on inflation increases as the period extends until the eleventh months. The shock in uncertainty explains about 10 percent of the change in inflation after eleven months.

**Figure 14:** FEVD for inflation

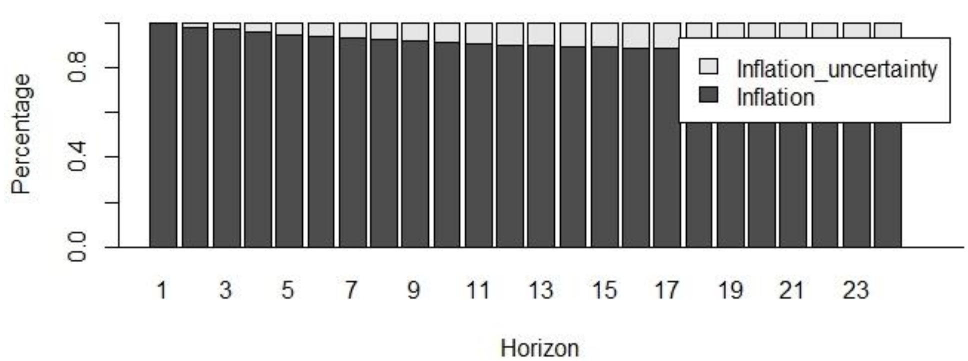
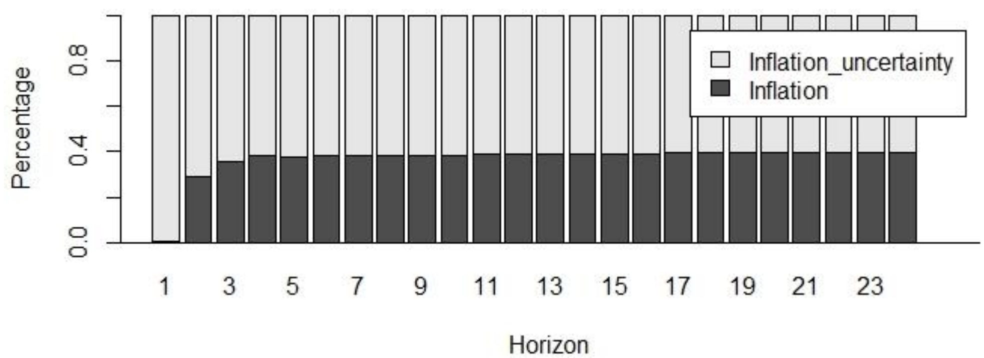


Figure 15 demonstrates FEVD for inflation uncertainty. In contrast to the shock in inflation uncertainty, the impact of the shock in inflation is high in explaining uncertainty, where almost 40 percent of the change in inflation uncertainty is explained by the shock in inflation from the third period ahead.

**Figure 15:** FEVD for inflation uncertainty




## 7. CONCLUSION

This research work has elicited interesting outcomes about inflation dynamics in Turkey. The inflation rate is a critical macroeconomic indicator and one of the key variables that most central banks around the world keep in view. Inflation is a major source of welfare costs as it causes relative distorted prices and resource allocation. Inflation series is obtained using CPI data.

Inflation uncertainty is the main determinant of high inflation that influences economic agents' decision-making since it negatively affects economic variables such as growth, consumption, investment, etc. The inflation uncertainty is seen as the core cost of inflation. The conditional variance is used as a proxy for inflation uncertainty which is derived from the AR (2)-GARCH (1,1) model in this study for the period of 1975:01-2005:12.

The relationship between inflation uncertainty and inflation is vital since it provides insight concerning the cost of inflation. The outcome of the analysis indicates several important findings that support well-known hypotheses in economic literature. The direction and the significance of the linkage between inflation and inflation uncertainty for Turkey have been analyzed using an F-test on the sum of lagged coefficients of each variable. The lag is determined at 9 to make it analogous to the VAR model. The application of the test denotes that there exists bi-directional causality between inflation and inflation uncertainty in Turkey. The overall effect of inflation on uncertainty is indeed positive, as stated by Friedman-Ball hypothesis, where the sum of the coefficients on lagged inflation is positive. Secondly, a negative causality relationship from inflation uncertainty to inflation is also obtained, as predicted by Holland hypothesis. Further, the IRF and FEVD results propose that the shock to inflation causes more uncertainty than the shock in inflation uncertainty impacting inflation.

Turkey's fiscal and monetary authorities put a robust effort to keep a low level of inflation over the period analyzed. The empirical results of the research confirm the consistency of stabilization. The test results contradict the hypothesis of Cukierman-Meltzer, who asserts that the rise in inflation uncertainty increases inflation. The effect of inflation uncertainty on inflation is indeed negative, confirming Holland hypothesis. Hence, the opportunistic incentives of the authorities are dominated by the attempts to stabilize inflation over the period analyzed.

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## APPENDIX

**Table A1:** ADF test regression trend for inflation:

| | | | | |
|---|---|---|---|---|
| **Call:** | | | | |
| lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag) | | | | |
| **Residuals:** | | | | |
| Min | 1Q | Median | 3Q | Max |
| -7.1971 | -0.9916 | -0.1408 | 0.7150 | 16.7480 |
| **Coefficients:** | | | | |
| | **Estimate** | **Std. Error** | **t value** | **Pr(>\|t\|)** |
| **(Intercept)** | 1.318e+00 | 2.829e-01 | 4.661 | 4.42e-06 *** |
| **z.lag.1** | -3.796e-01 | 5.195e-02 | -7.308 | 1.73e-12 *** |
| **tt** | 4.215e-05 | 1.027e-03 | 0.041 | 0.967 |
| **z.diff.lag** | -2.828e-01 | 5.026e-02 | -5.628 | 3.64e-08 *** |
| -- | | | | |
| Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 | | | | |
| | | | | |
| Residual standard error: 2.1 on 365 degrees of freedom | | | | |
| Multiple R-squared: 0.3235, Adjusted R-squared: 0.3179 | | | | |
| F-statistic: 58.17 on 3 and 365 DF, p-value: < 2.2e-16 | | | | |
| **Value of test-statistic is:** -7.3076 17.8131 26.7139 | | | | |
| **Critical values for test statistics:** | | | | |
| | 1pct | 5pct | 10pct | |
| tau3 | -3.98 | -3.42 | -3.13 | |
| phi2 | 6.15 | 4.71 | 4.05 | |
| phi3 | 8.34 | 6.30 | 5.36 | |

*Note*: *, ** and *** implies the coefficient is significant at 10%, 5% and 1% levels, respectively

**Table A2:** ADF test regression drift for inflation:

| | | | | |
|---|---|---|---|---|
| **Call:** | | | | |
| lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag) | | | | |
| **Residuals:** | | | | |
| Min 1Q Median 3Q Max | | | | |
| -7.2005 -0.9924 -0.1417 0.7194 16.7497 | | | | |
| **Coefficients:** | | | | |
| | **Estimate** | **Std.Error** | **t value** | **Pr(>\|t\|)** |
| **(Intercept)** | 1.32603 | 0.21291 | 6.228 | 1.30e-09 *** |
| **z.lag.1** | -0.37955 | 0.05186 | -7.319 | 1.59e-12 *** |
| **z.diff.lag** | -0.28288 | 0.05018 | -5.638 | 3.45e-08 *** |
| --- | | | | |
| Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | | |
| | | | | |
| Residual standard error: 2.098 on 366 degrees of freedom | | | | |
| Multiple R-squared: 0.3235, Adjusted R-squared: 0.3198 | | | | |
| F-statistic: 87.5 on 2 and 366 DF, p-value: < 2.2e-16 | | | | |
| | | | | |
| **Value of test-statistic is:** -7.3193 26.7919 | | | | |
| | | | | |
| Critical values for test statistics: | | | | |
| | 1pct | 5pct | 10pct | |
| tau2 | -3.44 | -2.87 | -2.57 | |
| phi1 | 6.47 | 4.61 | 3.79 | |

*Note*: *, ** and *** implies the coefficient is significant at 10%, 5% and 1% levels, respectively

**Table A3:** ADF test regression drift for inflation uncertainty

| | | | | |
|---|---|---|---|---|
| Call: | | | | |
| lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag) | | | | |
| | | | | |
| **Residuals:** | | | | |
| Min 1Q Median 3Q Max | | | | |
| -15.118 -2.324 -2.094 -1.394 169.914 | | | | |
| | | | | |
| Coefficients: | | | | |
| | **Estimate** | **Std. Error** | **t value** | **Pr(>\|t\|)** |
| **(Intercept)** | 2.82891 | 0.77511 | 3.650 | 0.000301 *** |
| **z.lag.1** | -0.45309 | 0.05072 | -8.934 | < 2e-16 *** |
| **z.diff.lag** | -0.03832 | 0.05224 | -0.733 | 0.463736 |
| --- | | | | |
| **Signif. codes:** 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 | | | | |
| | | | | |
| **Residual standard error:** 13.58 on 366 degrees of freedom | | | | |
| **Multiple R-squared:** 0.2366, **Adjusted R-squared:** 0.2325 | | | | |
| **F-statistic**: 56.73 on 2 and 366 DF, **p-value**: < 2.2e-16 | | | | |
| **Value of test-statistic is**: -8.934 39.9081 | | | | |
| Critical values for test statistics: | | | | |
| 1pct 5pct 10pct | | | | |
| tau2 -3.44 -2.87 -2.57 | | | | |
| phi1 6.47 4.61 3.79 | | | | |

**Table A4:** VAR Estimation Results:

| |
|---|
| ========================= |
| **Endogenous variables:** inf = inflation, inf_uncertainty = inflation uncertainty |
| **Deterministic variables:** const |
| **Sample size:** 362 |
| **Log Likelihood**: -2120.944 |
| **Roots of the characteristic polynomial:** |
| 0.9611 0.8208 0.8208 0.8094 0.8094 0.8059 0.8059 0.8003 0.7911 0.7911 0.7869 0.7869 0.7606 0.7606 0.7486 0.7486 0.7337 0.7337 |
| |
| **Call:** |
| VAR(y = data.frame(inf, inf_uncertainty), type = "const",  lag.max = 15, ic = "AIC") |

**Estimation results for equation inf:**

====================================

inf = inf.l1 + inf_uncertainty.l1 + inf.l2 + inf_uncertainty.l2 + inf.l3 + inf_uncertainty.l3 + inf.l4 + inf_uncertainty.l4 + inf.l5 + inf_uncertainty.l5 + inf.l6 + inf_uncertainty.l6 + inf.l7 + inf_uncertainty.l7 + inf.l8 + inf_uncertainty.l8 + inf.l9 + inf_uncertainty.l9 + const

| | **Estimate** | **Std. Error** | **t value** | **Pr(>\|t\|)** |
|---|---|---|---|---|
| **inf.l1** | 0.255129 | 0.053711 | 4.750 | 2.99e-06 *** |
| **inf_uncertainty.l1** | -0.024608 | 0.009772 | -2.518 | 0.012251 * |
| **inf.l2** | 0.295035 | 0.068561 | 4.303 | 2.20e-05 *** |
| **inf_uncertainty.l2** | 0.039404 | 0.010998 | 3.583 | 0.000389 *** |
| **inf.l3** | -0.121319 | 0.070351 | -1.724 | 0.085521 . |
| **inf_uncertainty.l3** | -0.036915 | 0.011160 | -3.308 | 0.001040 ** |
| **inf.l4** | 0.038050 | 0.069875 | 0.545 | 0.586416 |
| **inf_uncertainty.l4** | -0.007634 | 0.011337 | -0.673 | 0.501158 |
| **inf.l5** | 0.109548 | 0.070149 | 1.562 | 0.119293 |
| **Inf_uncertainty.l5** | 0.001053 | 0.011289 | 0.093 | 0.925755 |
| **inf.l6** | 0.16404 | 0.069888 | 2.347 | 0.019482 * |
| **inf_uncertainty.l6** | -0.004577 | 0.011014 | -0.416 | 0.677995 |
| **inf.l7** | -0.027316 | 0.068697 | -0.398 | 0.691146 |
| **inf_uncertainty.l7** | 0.006021 | 0.010949 | 0.550 | 0.582766 |
| **inf.l8** | 0.056748 | 0.066525 | 0.853 | 0.394233 |

| | | | | |
|---|---|---|---|---|
| **inf_uncertainty.l8** | -0.018310 | 0.010950 | -1.672 | 0.095396 . |
| **inf.l9** | 0.162731 | 0.065186 | 2.496 | 0.013015 * |
| **inf_uncertainty.l9** | 0.004971 | 0.008186 | 0.607 | 0.544057 |
| **const** | 0.491321 | 0.259246 | 1.895 | 0.058908 |
| --- | | | | |
| **Signif. codes:** 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | | |
| **Residual standard error**: 1.991 on 343 degrees of freedom | | | | |
| **Multiple R-Squared**: 0.3792, Adjusted R-squared: 0.3466 | | | | |
| **F-statistic**: 11.64 on 18 and 343 DF, **p-value**: < 2.2e-16 | | | | |

*Note*: *, ** and *** implies the coefficient is significant at 10%, 5% and 1% levels, respectively

**Estimation results for equation inf_uncertainty:**
==============================================
inf_uncertainty = inf.l1 + in f_uncertainty.l1 + inf.l2 + inf_uncertainty.l2 + inf.l3 + inf_uncertainty.l3 + inf.l4 + inf_uncertainty.l4 + inf.l5 + inf_uncertainty.l5 + inf.l6 + inf_uncertainty.l6 + inf.l7 + inf_uncertainty.l7 + inf.l8 + inf_uncertainty.l8 + inf.l9 + inf_uncertainty.l9 + const

| | **Estimate** | **Std. Error** | **t value** | **Pr(>\|t\|)** |
|---|---|---|---|---|
| **inf.l1** | 4.10177 | 0.29401 | 13.951 | <2e-16 *** |
| **inf_uncertainty.l1** | 0.50646 | 0.05349 | 9.468 | <2e-16 *** |
| **inf.l2** | -0.59029 | 0.37530 | -1.573 | 0.1167 |
| **inf_uncertainty.l2** | 0.07136 | 0.06020 | 1.185 | 0.2367 |
| **inf.l3** | -0.45723 | 0.38510 | -1.187 | 0.2359 |
| **inf_uncertainty.l3** | -0.03249 | 0.06109 | -0.532 | 0.5952 |
| **inf.l4** | -0.90987 | 0.38250 | -2.379 | 0.0179 * |
| **inf_uncertainty.l4** | 0.13962 | 0.06206 | 2.250 | 0.0251 * |
| **inf.l5** | 0.26037 | 0.38400 | 0.678 | 0.4982 |
| **inf_uncertainty.l5** | -0.11550 | 0.06179 | -1.869 | 0.0625 . |
| **inf.l6** | 0.16051 | 0.38257 | 0.420 | 0.6751 |
| **inf_uncertainty.l6** | 0.07901 | 0.06029 | 1.310 | 0.1909 |
| **inf.l7** | -0.75178 | 0.37605 | -1.999 | 0.0464 * |
| **inf_uncertainty.l7** | -0.04625 | 0.05994 | -0.772 | 0.4409 |

| | | | | |
|---|---|---|---|---|
| **inf.l8** | -0.02511 | 0.36416 | -0.069 | 0.9451 |
| **inf_uncertainty.l8** | 0.01590 | 0.05994 | 0.265 | 0.7909 |
| **inf.l9** | -0.68660 | 0.35683 | -1.924 | 0.0552 |
| **inf_uncertainty.l9** | 0.07068 | 0.04481 | 1.577 | 0.1157 |
| **const** | -1.96526 | 1.41912 | -1.385 | 0.1670 |
| --- | | | | |
| **Signif. codes:** 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 | | | | |
| **Residual standard error**: 10.9 on 343 degrees of freedom | | | | |
| **Multiple R-Squared**: 0.5654, **Adjusted R-squared**: 0.5426 | | | | |
| **F-statistic**: 24.79 on 18 and 343 DF, **p-value**: < 2.2e-16 | | | | |

*Note*: *, ** and *** implies the coefficient is significant at 10%, 5% and 1% levels, respectively

| **Covariance matrix of residuals:** | | |
|---|---|---|
| | **inf** | **inf_uncertainty** |
| **inf** | 3.966 | -1.602 |
| **inf_uncertainty** | -1.602 | 118.835 |

| **Correlation matrix of residuals:** | | |
|---|---|---|
| | **inf** | **inf_uncertainty** |
| **inf** | 1.00000 | -0.07379 |
| **inf_uncertainty** | -0.07379 | 1.00000 |

**Table A5:** Time series regression model for inflation uncertainty

<table>
<tr><td colspan="5">inf = inflation</td></tr>
<tr><td colspan="5">unc = uncertainty</td></tr>
<tr><td colspan="5">Call:</td></tr>
<tr><td colspan="5">dynlm (formula = unc ~ L (inf, 1:9) + L (unc, 1:9))</td></tr>
<tr><td colspan="5">Residuals:</td></tr>
<tr><td>Min</td><td>1Q</td><td>Median</td><td>3Q</td><td>Max</td></tr>
<tr><td>-25.614</td><td>-4.463</td><td>-1.057</td><td>2.264</td><td>103.795</td></tr>
<tr><td colspan="5">Coefficients:</td></tr>
<tr><td></td><td>Estimate</td><td>Std. Error</td><td>t value</td><td>Pr(>|t|)</td></tr>
<tr><td>(Intercept)</td><td>-1.96526</td><td>1.41912</td><td>-1.385</td><td>0.1670</td></tr>
<tr><td>L(inf, 1:9)1</td><td>4.10177</td><td>0.29401</td><td>13.951</td><td><2e-16 ***</td></tr>
<tr><td>L(inf, 1:9)2</td><td>-0.59029</td><td>0.37530</td><td>-1.573</td><td>0.1167</td></tr>
<tr><td>L(inf, 1:9)3</td><td>-0.45723</td><td>0.38510</td><td>-1.187</td><td>0.2359</td></tr>
<tr><td>L(inf, 1:9)4</td><td>-0.90987</td><td>0.38250</td><td>-2.379</td><td>0.0179 *</td></tr>
<tr><td>L(inf, 1:9)5</td><td>0.26037</td><td>0.38400</td><td>0.678</td><td>0.4982</td></tr>
<tr><td>L(inf, 1:9)6</td><td>0.16051</td><td>0.38257</td><td>0.420</td><td>0.6751</td></tr>
<tr><td>L(inf, 1:9)7</td><td>-0.75178</td><td>0.37605</td><td>-1.999</td><td>0.0464 *</td></tr>
<tr><td>L(inf, 1:9)8</td><td>-0.02511</td><td>0.36416</td><td>-0.069</td><td>0.9451</td></tr>
<tr><td>L(inf, 1:9)9</td><td>-0.68660</td><td>0.35683</td><td>-1.924</td><td>0.0552 .</td></tr>
<tr><td>L(unc, 1:9)1</td><td>0.50646</td><td>0.05349</td><td>9.468</td><td><2e-16 ***</td></tr>
<tr><td>L(unc, 1:9)2</td><td>0.07136</td><td>0.06020</td><td>1.185</td><td>0.2367</td></tr>
<tr><td>L(unc, 1:9)3</td><td>-0.03249</td><td>0.06109</td><td>-0.532</td><td>0.5952</td></tr>
<tr><td>L(unc, 1:9)4</td><td>0.13962</td><td>0.06206</td><td>2.250</td><td>0.0251 *</td></tr>
<tr><td>L(unc, 1:9)5</td><td>-0.11550</td><td>0.06179</td><td>-1.869</td><td>0.0625 .</td></tr>
<tr><td>L(unc, 1:9)6</td><td>0.07901</td><td>0.06029</td><td>1.310</td><td>0.1909</td></tr>
<tr><td>L(unc, 1:9)7</td><td>-0.04625</td><td>0.05994</td><td>-0.772</td><td>0.4409</td></tr>
<tr><td>L(unc, 1:9)8</td><td>0.01590</td><td>0.05994</td><td>0.265</td><td>0.7909</td></tr>
<tr><td>L(unc, 1:9)9</td><td>0.07068</td><td>0.04481</td><td>1.577</td><td>0.1157</td></tr>
</table>

| |
|---|
| --- |
| **Signif. codes:** 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 |
| **Residual standard error:** 10.9 on 343 degrees of freedom |
| **Multiple R-squared:** 0.5654, **Adjusted R-squared**: 0.5426 |
| **F-statistic:** 24.79 on 18 and 343 DF, **p-value**: < 2.2e-16 |

*Note*: *, ** and *** implies the coefficient is significant at 10%, 5% and 1% levels, respectively

**Table A6:** F-test on the sum of lagged coefficients of inflation:

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hypothesis:** | | | | | | |
| L(inf,9)1 + L(inf,9)2 + L(inf,9)3 + L(inf,9)4 + L(inf,9)5 + L(inf,9)6 + L(inf,9)7 + L(inf,9)8 + L(inf,9)9 = 0 | | | | | | |
| | | | | | | |
| **Model 1:** restricted model | | | | | | |
| **Model 2:** unc ~ L (inf, 1:9) + L (unc, 1:9) | | | | | | |
| | | | | | | |
| | **Res.Df** | **RSS** | **Df** | **Sum of Sq** | **F** | **Pr(>F)** |
| 1 | 344 | 41621 | | | | |
| 2 | 343 | 40760 | 1 | 860.44 | 7.2406 | 0.007476 ** |
| --- | | | | | | |
| **Signif. codes:** 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 | | | | | | |

*Note*: *, ** and *** implies the coefficient is significant at 10%, 5% and 1% levels, respectively

**Table A7:** Time series regression model for inflation

| | | | | |
|---|---|---|---|---|
| inf = inflation | | | | |
| unc = uncertainty | | | | |
| **Call:** | | | | |
| dynlm (formula = inf ~ L (unc, 1:9) + L (inf, 1:9)) | | | | |
| **Residuals:** | | | | |
| **Min** | **1Q** | **Median** | **3Q** | **Max** |
| -6.4194 | -0.9163 | -0.2584 | 0.6211 | 15.7554 |
| **Coefficients:** | | | | |
| | **Estimate** | **Std. Error** | **t value** | **Pr(>\|t\|)** |
| **(Intercept)** | 0.491321 | 0.259246 | 1.895 | 0.058908 . |
| **L(unc, 1:9)1** | -0.024608 | 0.009772 | -2.518 | 0.012251 * |
| **L(unc, 1:9)2** | 0.039404 | 0.010998 | 3.583 | 0.000389 *** |
| **L(unc, 1:9)3** | -0.036915 | 0.011160 | -3.308 | 0.001040 ** |
| **L(unc, 1:9)4** | -0.007634 | 0.011337 | -0.673 | 0.501158 |
| **L(unc, 1:9)5** | 0.001053 | 0.011289 | 0.093 | 0.925755 |
| **L(unc, 1:9)6** | -0.004577 | 0.011014 | -0.416 | 0.677995 |
| **L(unc, 1:9)7** | 0.006021 | 0.010949 | 0.550 | 0.582766 |
| **L(unc, 1:9)8** | -0.018310 | 0.010950 | -1.672 | 0.095396 . |
| **L(unc, 1:9)9** | 0.004971 | 0.008186 | 0.607 | 0.544057 |
| **L(inf, 1:9)1** | 0.255129 | 0.053711 | 4.750 | 2.99e-06 *** |
| **L(inf, 1:9)2** | 0.295035 | 0.068561 | 4.303 | 2.20e-05 *** |
| **L(inf, 1:9)3** | -0.121319 | 0.070351 | -1.724 | 0.085521 . |
| **L(inf, 1:9)4** | 0.038050 | 0.069875 | 0.545 | 0.586416 |
| **L(inf, 1:9)5** | 0.109548 | 0.070149 | 1.562 | 0.119293 |
| **L(inf, 1:9)6** | 0.164041 | 0.069888 | 2.347 | 0.019482 * |
| **L(inf, 1:9)7** | -0.027316 | 0.068697 | -0.398 | 0.691146 |
| **L(inf, 1:9)8** | 0.056748 | 0.066525 | 0.853 | 0.394233 |

| | | | | |
|---|---|---|---|---|
| **L(inf, 1:9)9** | 0.162731 | 0.065186 | 2.496 | 0.013015 * |
| --- | | | | |
| **Signif. codes:** 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | | |
| **Residual standard error:** 1.991 on 343 degrees of freedom | | | | |
| **Multiple R-squared:** 0.3792, **Adjusted R-squared:** 0.3466 | | | | |
| **F-statistic:** 11.64 on 18 and 343 DF, **p-value**: < 2.2e-16 | | | | |

**Table A8:** F- test on the sum of lagged coefficients of uncertainty:

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hypothesis:** | | | | | | |
| L(unc,9)1 + L(unc,9)2 + L(unc,9)3 + L(unc,9)4 + L(unc,9)5 + L(unc,9)6 + L(unc,9)7 + L(unc,9)8 + L(unc,9)9 = 0 | | | | | | |
| | | | | | | |
| **Model 1:** restricted model | | | | | | |
| **Model 2:** inf ~ L (unc, 1:9) + L (inf, 1:9) | | | | | | |
| | | | | | | |
| | **Res.Df** | **RSS** | **Df** | **Sum of Sq** | **F** | **Pr(>F)** |
| 1 | 344 | 1393.4 | | | | |
| 2 | 343 | 1360.3 | 1 | 33.094 | 8.3447 | 0.004114 ** |
| --- | | | | | | |
| **Signif. codes:** 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | | | | |