THE IMPACT OF INFLATION TARGETING ON
INFLATION VOLATILITY

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SIGNATURE PAGE

THESIS: THE IMPACT OF INFLATION TARGETING ON INFLATION VOLATILITY

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Abstract

This paper works closely with literature to investigate the impact of inflation targeting on inflation variance, used as a proxy for inflation uncertainty. An analysis of previous work and related economic theory is posed. A GARCH methodology is implemented to measure inflation volatility, utilizing a variable to measure the presence of inflation targeting in relation to inflation variance. Also, a study of the impact of inflation levels on inflation volatility is conducted, in which the Friedman hypothesis is in question. It is found that most countries studied had significantly lower inflation variance after adoption of targeting. In half of the countries studied, the Friedman hypothesis could not be discredited.
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Introduction

Inflation targeting as a tool of monetary policy has increased in popularity steadily since its inception in 1990 by New Zealand. Many economic authorities submit that the primary objectives of a nation’s economic decision makers are to maintain high, sustainable output and low, stable inflation (Dornbusch, Fischer, and Startz, 2004). This paper specifically discusses the impact of inflation as it effects the macro-economy, and the potential ability a nation may have in reducing inflation volatility by adopting an inflation-targeting regime. The paper provides a study of the economic theory of inflation with respect to wages, output and interest rates. It discusses the mechanisms of transmission between aggregate values in the labor market and subsequent changes in price levels, known as inflation. The paper then discusses theories that relate inflation to output, unemployment, and economic welfare, such as the Phillips curve. Within that section, the paper develops the role of inflation expectations in influencing output and inflation levels. Next, the idea of inflation targeting and its ability to influence these inflation expectations is elaborated upon. Comparisons are drawn between inflation targeting and other methods of monetary policy targeting.

In the subsequent section, this paper develops a framework for analysis of inflation targeting by discussing many of the recent works in related areas of study. Several works are highlighted which call for an inclusion of other variables worthy of targeting, such as relative price variability, employment, and short-term nominal interest rates (Giannoni and Woodford, 2005). In the latter part of this section, works are highlighted which conduct studies of the impact of inflation targeting on inflation variance. Their research provides a valuable framework for the development of the methodology utilized in this paper. Linear models of mean inflation values are estimated, along with GARCH estimations of variance equations. These methods provide the precedence necessary to carry out statistical
techniques in this paper in similar ways. These studies largely show a discovery that the adoption of inflation targeting has led to a decrease in inflation levels and inflation volatility, measured as variance (Tas, 2012).

The following empirical section represents this paper’s research, utilizing the works of previous related studies. Monthly CPI data, obtained from the Federal Reserve Bank of St. Louis (2014) are measured for the inflation-targeting economies of Canada, Iceland, Switzerland, United Kingdom, Chile, Israel, Mexico, and South Korea. The data are analyzed to show differences in variance before and after a regime change toward inflation targeting. ARIMA models are formed for a mean equation of each country’s inflation, and a GARCH(1,1) estimation is imposed on the variance in each country’s inflation, to model heteroskedasticity (Engle, 2001). Consistent with previous work, variance equation estimators are included: a dummy variable that represents the presence of inflation-targeting, and a one period lag of inflation levels, representing the potential effect of the Friedman hypothesis. Examination of each country’s model shows confirmation of the negative impact of inflation targeting on inflation variance for all nations except Iceland, Switzerland, and Chile. Examination of the models shows confirmation of the positive impact of past inflation levels on inflation variance, known as the Friedman hypothesis for all nations except Canada and South Korea, while United Kingdom and Israel were also rejected due to a lack of economic interpretation attributable to a first differenced value.

Finally, it is concluded that the paper is able to confirm the presence of an negative impact of inflation targeting on inflation variance for a majority of the nations studied. In a small sample of nations, no broad conclusions or suggestions can be made about advocacy toward an inflation targeting regime. Limitations, such as lack of data availability and the countervailing impact of the Pourgerami–Maskus–Ungar–Zilberfarb (PMUZ) hypothesis are posed (Payne, 2009).
The paper proceeds in the following structure. The following section describes the economic theory behind inflation targeting. Section III provides a review of the related literature. Section IV provides the data, methodology, and results of the empirical study. Section V offers limitations and conclusions.
Economic Theory

Price Indexes and Inflation

One of the primary objectives of a nation’s economic policy is to achieve moderate levels of economic growth (Dornbusch et al., 2004). In doing so, the nation increases incomes and welfare, while reducing unemployment within the economy (Branson, 1989). As a concurrent goal, policymakers strive for low inflation and stable price levels (Branson, 1989). Increases in price levels may cause distortions in market equilibria, and discourage economic activity (Mishkin and Schmidt-Hebbel, 2007a). To combat this, policymakers enact various regulation methods to bring these economic variables toward a desired objective. In order to effectively develop policy, accurate measures of this economic information must be developed and standardized (Dornbusch et al., 2004). As such, measurements have been developed that incorporate various segments of a nation’s economy to reflect trends and changes in overall price levels (Dornbusch et al., 2004).

While several price indexes exist, three main indexes are used in developing price levels for the macro-economy: GDP deflator, producer price index (PPI), and consumer price index (CPI) (Dornbusch et al., 2004). The GDP deflator is defined as the ratio of nominal GDP for a given year to the real GDP of that year (Dornbusch et al., 2004). In a hypothetical example, a comparison of the value of 2013 GDP in 2013 prices to 2008 prices could be made in which the ratio yielded a value of 1.20. In this case, an price level increase of 20 percent would be considered inflation over the period 2008 to 2013 (Dornbusch et al., 2004). Producer price index values reflect the costs of goods and services purchased by producers (Burton, Nesiba, and Brown, 2010). PPI measures the cost of a given basket of goods that include raw materials and unfinished goods in the early segments of commercial transaction (Dornbusch et al., 2004). As such, movements in PPI levels often give an early signal of potential changes in the other price indexes (Peters and
Grynbaum, 2007). Consumer price index values reflect the cost of goods and services purchased by consumers Burton et al. (2010). CPI values include the values of a fixed basket of goods purchased at the retail level (Dornbusch et al., 2004). Each measurement may exhibit noticeable differences in dynamics due to their differences in included items (Peach, Rich, and Linder, 2013). GDP deflator measurements include a broad range of items within the economy which may vary each year, while CPI uses a more restrictive basket of goods that are fixed for a period of time (Dornbusch et al., 2004).

Each of the discussed price indexes may be used to measure changes in price levels over time (Burton et al., 2010).

Inflation can be defined as the rate of change in price levels (Dornbusch et al., 2004). This identity relationship can be shown by equation 1

$$\pi \equiv \frac{P_t - P_{t-1}}{P_{t-1}}$$ (1)

where $\pi$ represents the inflation rate, $P_t$ represents a current period price level, and $P_{t-1}$ represents one previous period’s price level (Dornbusch et al., 2004). Price levels found in CPI or PPI may be used in equation 1 to calculate inflation (Dornbusch et al., 2004). Price levels can be calculated as shown in equation 2

$$P_t = P_{t-1} + (\pi \times P_{t-1})$$ (2)

where $P_t$ is shown to be an accumulation of past inflation (Dornbusch et al., 2004).

**Aggregate Demand Curve**

An aggregate supply (AD) curve depicts the combinations of price and output levels that correspond with equilibria in the goods and money markets (Dornbusch
et al., 2004). A demand for output in AD is determined by the amount of output $Y$ that can be produced by the labor force $N$, for a given level of capital (Branson, 1989). A profit maximizing firm will hire workers until the marginal value product of labor is equal to the nominal wage, shown in equation 3

$$W = P \times \frac{\delta Y}{\delta N}$$

which can be rewritten in terms of real wages as a function of labor with equation 4 (Branson, 1989).

$$w = \frac{W}{P} = \frac{\delta Y}{\delta N} = f(N)$$

### Aggregate Supply Curve

An aggregate supply (AS) curve depicts the quantity of output firms are willing to supply at each given price level (Dornbusch et al., 2004). A supply of output is determined by a level of labor that workers are willing to offer $N$, contingent upon their expectations of future prices $P^e$, and their nominal wage $W$ (Branson, 1989). This relationship is shown by equation 5,

$$W = P^e \times g(N)$$

which can then be converted to a real wage form in equation 6 (Branson, 1989).

$$w = \frac{P^e}{P} \times g(N)$$

### Labor Market Equilibrium

An equilibrium in the labor market occurs at the intersection of AD and AS, where equations 4 and 5 are equal (Branson, 1989):
\[ P \times f(N) = P^e \times g(N) \quad (7) \]

Implied in these equations is the notion that, after a price level increase, a rapid adjustment in future price expectations toward actual prices would create little disturbance to equilibrium employment \( N \) and real wage \( w \) (Branson, 1989). In a purely classical view, this rapid expectations adjustment does occur such that labor demand and supply move together and always clear the market (Farmer, 2013). In a purely Keynesian view, a change in price level does not adjust price expectations at all (Branson, 1989). According to Keynesian theory, this example would cause labor demand to shift upward along the given labor supply curve, causing an increase in equilibrium employment and nominal wages (Branson, 1989).

The adjustment toward equilibrium depends heavily on the shape of the AS curve and the time period considered (Dornbusch et al., 2004). Keynesian economists believe the aggregate supply curve to be relatively horizontal, implying that firms will supply any amount of goods at the current price level (Dornbusch et al., 2004). This is a characteristic of the short-run, where there is insufficient time for prices to adjust to economic shocks or increases in aggregate demand (Branson, 1989). All of the impacts of an AD increase are manifested in an increase in output and employment (Branson, 1989). Lack of price movement may also arise from price rigidities or structural difficulties in changing prices (Goldberg and Hellerstein, 2007). In contrast, classical economists believe the AS curve to be relatively vertical, implying that the same amount of goods will be supplied at any price (Dornbusch et al., 2004). This is characteristic of the long-run, where firms are maximizing all of their factors of production and cannot produce more, or use more labor (Dornbusch et al., 2004).
Inflation-Output Relationship and the Phillips Curve

Price and output levels possess an integral relationship with each other through their interaction in the labor market (Dornbusch et al., 2004). Labor market equilibria determine wages, which eventually determine price levels (Sylla, 2013). The quantity of labor exchanged in this market determines total output in the economy and denotes unemployment levels (Sylla, 2013). Measurements and subsequent theory of these dynamic processes have evolved substantially throughout recent history (Granger and Jeon, 2011).

Basic short-run Phillips curve. From the labor market equilibrium discussion, it is evident that an outward shift in the \( P \times f(N) \) curve would cause excess labor demand, measured by \( N^d - N^s \), which bids the wage rate upward (Branson, 1989). This is shown in equation 8

\[
\dot{W} = f(N^d - N^s) \quad ; \quad f > 0 \tag{8}
\]

where \( \dot{W} \) represents a percentage rate of increase in the wage rate (Branson, 1989). Since excess labor supply is simply the negative of excess labor demand, we can rewrite equation 8 as the following:

\[
\dot{W} = -f(N^s - N^d) \tag{9}
\]

There may be dissent among economists about whether unemployment can be a trusted measure to depict labor surpluses, particularly in developing economies (Sylla, 2013). Some authors assert that a large presence of marginally attached and discouraged workers tends to cause unemployment measures to be underestimated (Sylla, 2013). Despite this, much of economic literature considers the unemployment rate to be a valid proxy for excess supply (Rao, 1990). If \( U \) represents total unemployed persons, and \( L \) represents the total labor force, then the unemployment
rate $u$ is given by $u = U/L$ (Branson, 1989). We can substitute this unemployment rate into equation 9 for excess supply to retrieve equation

$$\dot{W} = g(u); \ g < 0$$

(10)

which shows that as unemployment falls, the rate of increase of wages increases (Branson, 1989). Money wage rates represent the price of labor services (Phillips, 1958). Generally, when the demand for a good or service exceeds supply, it is expected that its price will rise (Phillips, 1958). Money wage rates represent the price of labor services. This relationship forms the basis of the short-run Phillips curve, shown in figure 1, where the y-axis represents wage rate changes and the x-axis represents unemployment.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Short-run Phillips curve}
\end{figure}

The function's convex shape arises from the exponential increase in wage rate that occurs as unemployment falls by constant amounts (Branson, 1989). Some theory suggest that, due to this convex shape, the economy will experience less cost-push inflation pressure if unemployment fluctuations are narrow than if unemployment fluctuations vary widely around a given mean (Branson, 1989).

\textbf{Expectations-augmented Phillips curve.} Equation 9 on the facing page represented a Keynesian assumption that money wage demands do not respond to inflation expectations (Dornbusch et al., 2004). In a more classical view, higher
inflation expectations $\dot{P}^e$ will cause money wage demands to increase, for a given unemployment rate (Farmer, 2013). This relationship can be shown by equation 11 (Branson, 1989):

$$\dot{W} = g(u) + \dot{P}^e$$

(11)

The expectations-augmented Phillips curve of figure 11 is depicted in figure 2, where the y-axis represents levels wage rate changes, and the x-axis represents levels of unemployment. Assuming inflation expectations are exogenous, an increase in $\dot{P}^e$ from $\dot{P}^e = 0\%$ to $\dot{P}^e = 5\%$ would cause the entire Phillips curve to shift upward from $U$ to $W$ (Branson, 1989). These shifts may also occur because of an increase in the demand for leisure, leading to a reduction in the labor supply and an increase in wages to entice the same amount of labor (Branson, 1989).

Source: (BizEd, 2012)

Figure 2. Expectations-augmented Phillips curve

**Long-run Phillips curve.** For a long-run evolution of the Phillips curve, a price equation with constant income shares is developed:

$$\dot{P} = \dot{W} - \frac{y}{N} + \epsilon$$

(12)

where $\epsilon$ represents a cost-push error term, expected to be zero (Branson, 1989).
Assuming the absence of persistent cost-push disturbances and presence of constant income shares, equation 12 will link wages and prices such that the Phillips curve can be interpreted with wage and inflation rates interchangeably (Branson, 1989).

To derive the long-run Phillips curve, we combine equations 11 and 12, which retrieves the following:

\[ \dot{P} = g(u) + \dot{P}^e - \frac{y}{\dot{N}} + \epsilon \]  

(13)

Most economic authorities state that, in long-run equilibrium, expected inflation rates \( \hat{P}^e \) will eventually equal actual inflation rates \( \hat{P} \), when inflation is relatively constant (Friedman, 1976). However, dissent to this theory is exist in literature that find prices to have two unit roots, such that shocks have permanent effects on inflation (Baillie, Chung, and A., 2006). Assuming that inflation expectations converge toward actual inflation in the long-run, and that disturbance terms are zero, we find that \( \hat{P} = \hat{P}^e \) such that equation 13 simply becomes (Branson, 1989):

\[ g(u) - \frac{y}{\dot{N}} = 0 \]  

(14)

This equation will determine the natural unemployment rate \( u_n \) for a given productivity growth rate (Branson, 1989). From equation 13, it is evident that for any unemployment other than \( u_n \) or NAIRU, \( \hat{P} \neq \hat{P}^e \) (Branson, 1989). Equation 15 shows this relationship:

\[ \dot{P} - \dot{P}^e = g(u) - \frac{y}{\dot{N}} \]  

(15)

As seen in figure 2 on the preceding page, a short-term increase in inflation from \( \dot{P} = 0\% \) to \( \dot{P} = 5\% \) causes a movement from point \( U \) to point \( V \), where unemployment is below the natural rate. As inflation expectations converge back
toward actual inflation, unemployment is drawn back to its natural rate, by moving from point $V$ to point $W$. All such inflation changes, resulting in movement along a vertical line, are referred to as the long-run Phillips curve (Farmer, 2013).

**Expectations adjustment processes.** The movement from inflation expectations $\hat{P}^e$ toward actual inflation $\hat{P}$ can occur in different ways. Adaptive expectations reflect a proportional adjustment of expectations by a fraction of recent error (Branson, 1989). This can be shown by equation 16, where $0 < \lambda < 1$ is a fractional adjustment to previous error:

$$t \hat{P}_{t+1} - t-1 \hat{P}_t = \lambda \hat{P}_t - t-1 \hat{P}_t$$

(16)

or by equation 17, where $0 < \lambda < 1$ gives current expectations as an infinite sum of all past errors (Branson, 1989).

$$t \hat{P}_{t+1} = \sum_{i=0}^{\infty} (1 - \lambda)^i \hat{P}_{t-i}$$

(17)

By lagging equation 16 one period and substituting into equation 13, we find that:

$$\dot{P}_t = g(u) - \eta/N + \lambda \dot{P}_{t-1} + (1 - \lambda)_{t-2} \dot{P}_{t-1}, \text{ or}$$

(18)

$$\dot{P}_t = g(u) - \eta/N + \sum_{i=1}^{\infty} (1 - \lambda)^{i-1} \dot{P}_{t-i}$$

(19)

From this, we can deduce that the change in inflation rate over one period is a function of the difference between unemployment and its natural rate, multiplied by the adjustment factor (Greene, 2008). This is shown in equation

$$\dot{P}_t - \dot{P}_{t-1} = \lambda g \left( u_0 - u_n \right)$$

(20)
such that $\lambda = 1$ implies an immediate expectations adjustment, and $\lambda = 0$ implies that expectations do not adjust at all (Branson, 1989). The value of $\lambda$ and its inherent suggestion about the inflation-adjustment characteristic of the economy is debated (Friedman, 1967).

Rational Expectations provide an alternative to adaptive expectations in which forecasts from the model are unbiased and errors are random (Branson, 1989). This is shown in equation 21.

$$t-1\dot{P}_t = \dot{P}_t - \eta$$

(21)

Substituting $\dot{P}_e$ from equation 13 yields

$$g(u) - \eta/N + \epsilon - \eta = 0$$

(22)

where the unemployment rate is expected to be equal to the natural rate when $\eta = \epsilon = 0$ (Branson, 1989). Based on this assumption, all non-random inflation is anticipated by the model, so any unemployment level other than the natural rate is random (Branson, 1989). However, most economic evidence would point out that rational expectations do not accurately represent inflation expectations because unemployment levels historically have been highly correlated with demand shifts (Dornbusch et al., 2004).

**Inflation Targeting as a Policy**

From the development of expectations-augmented Phillips curves, it is evident that an expectation of inflation can greatly influence the adjustment process and overall stability of the aggregate economy (Mishkin and Schmidt-Hebbel, 2007a). Persistent inflation levels above or below inflation expectations can have a significant impact on national unemployment and output levels (Krueger, 1980).
Therefore, it is in the best interest of a monetary policymaker to carefully employ a target toward a goal of inflation that yields the most favorable outcomes for both inflation and output (Dornbusch et al., 2004).

**Benefits of inflation targeting.** Mishkin and Schmidt-Hebbel (2007), find that inflation targeting significantly reduces the volatility of inflation expectations. Similar works further this assertion by posing that inflation targeting creates a credible anchor of inflation, leading to increased stability in price expectations (Gurkaynak, Levin, Marder, and Swanson, 2007). In making inflation expectations more stable, inflation targeting succeeds in reducing risk and uncertainty in an economy, thereby improving the ease of transactions, investment, and consumption (Dornbusch et al., 2004). Inflation targeting also provides a level of simplicity that makes practical action towards an optimal goal of inflation relatively easy (Dornbusch et al., 2004). As seen in the investigation of Phillips curve, low inflation volatility and increased policy credibility contribute to reduced price uncertainty (Levin, Natalucci, and Piger, 2004).

The perceived benefits of inflation targeting are not without debate (Willard, 2012). Some studies find little evidence that inflation targeting causes an improvement in a nation’s economy (Ball and Sheridan, 2004). Their research points to a lack of evidence that developed inflation targeting countries achieve any statistically significant reduction in inflation when compared to non-targeters (Ball and Sheridan, 2004). It may be simply that economies which utilize inflation targeting may enact interest rate monitoring policies that are nearly identical to those in more developed economies (Ball and Sheridan, 2004). Many non-targeting countries adopt monetary policy that mimics the prescriptions of the Taylor rule, resulting in similar results to the U.S. (Ball and Sheridan, 2004). Despite these findings, conclusions rarely exist that find inflation targeting to be harmful to an economy, only a possible inability to support assertions of its benefits in small cases.
Alternative targeting policies.

Exchange rate targeting. Prior to the adoption of inflation targeting, many nations employed some form of exchange rate targeting (Dornbusch et al., 2004). Under exchange rate targeting, policymakers attempt to reduce the fluctuations in currency valuation, improve the volume of exports with respect to imports, or guard against inflation (Dornbusch et al., 2004). Dollar-pegging, where a domestic currency is traded at a fixed rate to a foreign currency, may prevent inflation if pegged to a stable currency, but can cause financial instability when the foreign currency appreciates (Dornbusch et al., 2004). With a regime of intervention, a central bank buys or sells inventories of currencies (Branson, 1989). Economic literature points out that this strategy may become significantly limited when the country runs persistent balance of payment deficits (Branson, 1989). In another case, dollarization occurs when a nation abandons its currency and adopts the currency of a foreign economy (Tas and Togay, 2011). While this regime completely limits a country’s ability to intentionally conduct exchange rate policy, it may be shown to significantly reduce inflation and inflation uncertainty when a stable currency is dollarized (Tas and Togay, 2011).

Output targeting. Output targeting is the process by which policymakers attempt to achieve a prescribed level of economic output, thereby achieving a desired level of welfare (Giannoni and Woodford, 2005). Output targeting can be an appealing strategy for many nations, due to the direct impact output has on income and unemployment (Dornbusch et al., 2004). Directly targeting the most primary objective of welfare may provide the benefit of accurate achievement of an optimal level of welfare (Giannoni and Woodford, 2005). However, defining the measure of output, as well as determining an optimal output level, given the absence of perfect information, may prove difficult to estimate and pursue (Dornbusch et al., 2004).
Real GDP targeting involves attempting to reach an actual level of GDP near potential GDP (Dornbusch et al., 2004). Given the Phillips curve’s stipulation that the natural rate of unemployment is equal to actual unemployment when inflation is equal to anticipated inflation, an accurate target of real GDP would ensure low, stable inflation (Branson, 1989) However, an incorrectly estimated potential GDP growth target would cause actual growth to exceed the real potential level, leading to an acceleration of inflation (Dornbusch et al., 2004).

Nominal GDP targeting involves attempting to grow nominal GDP at an equal rate as potential GDP (Branson, 1989). Under this regime, an accurate estimate of potential GDP will maximize welfare while minimizing inflation and inflation uncertainty (Dornbusch et al., 2004). However, an incorrect target would potentially lead to one-period inflation, but no acceleration of inflation into future periods (Dornbusch et al., 2004).

**Taylor’s rule.** Taylor’s rule is a formula that represents the theoretical tradeoffs that exist between output, inflation, and interest rates (Dornbusch et al., 2004). This is shown in equation 23:

\[ i_t = \pi_t + r_t^* + \alpha_\pi (\pi_t - \pi_t^*) + \alpha_y (y_t - \bar{y}_t) \]

(23)

where \( i_t \) is the interest rate targeted in the short-run, \( r_t^* \) is the real interest rate, \( \pi_t^* \) is the target inflation rate, and \( \bar{y}_t \) is the potential output (Dornbusch et al., 2004). As can be seen by this formula, inflation higher than its target, or output higher than its natural rate can be remedied by an increase in nominal interest rates (Dornbusch et al., 2004). While this rule can be a useful guideline for stabilization of an economy, some researches warn of the negative consequences of remedying multiple targets with only one instrument (Drumond and Porcile, 2012). When targeted variables begin to move in more unpredictable ways, the ability of the instrument to stabilize the economy weakens and an abandoning of a targeted
variable often occurs (Drumond and Porcile, 2012)

Given the risks associated with alternative targeting methods, the impetus toward inflation targeting regimes becomes more clear. The ability of inflation targeting to provide strong levels of credibility, or belief that monetarists can maintain stable inflation levels into the future, gives inflation targeting regimes a large amount of efficacy (Petursson, 2004). Central bank independence and credibility contribute heavily to the accuracy and effectiveness of inflation targets (Mishkin and Schmidt-Hebbel, 2007b). It has often been found that inflation-targeting nations are able to maintain stable levels of inflation near targeted levels (Mishkin and Schmidt-Hebbel, 2007a). Given the high likelihood of generating stable inflation levels with minimal uncertainty, many nations have opted away from other targeting methods in favor of inflation targeting policies (Dornbusch et al., 2004).


Literature Review

This section provides a discussion of several works that support the basis for study in this paper. These works support the assertion that inflation variance contributes to inflation uncertainty, and investigate the impact inflation targeting may have on variance. Other works provide views in contrast, which urge for the consideration of various economic indicators when constructing monetary policy. These works enhance the understanding of the study, and provide context with which to interpret the final results. Their findings are presented here.

Contrasting Views

Several works acknowledge the effectiveness of inflation targeting, yet point out the relevance of other related variables in constructing monetary policy. These works explore the dynamic effects of inflation targeting with regards to macroeconomic indicators that may be varied by the inflation targeting regime. Since the adoption of inflation targeting policies has began and gradually increased, the importance of a comprehensive understanding of its full implications has become increasingly necessary (Drumond and Porcile, 2012). Theory and practice behind inflation targeting continue to evolve, demonstrating a need for accurately directed policy (Mishkin and Schmidt-Hebbel, 2007a).

Choi, Kim, and O’Sullivan. The work of Chi-Young Choi, Young Se Kim and Roisin O’Sullivan (2011) points out that aggregate inflation often leads to variability in relative prices (Choi, Kim, and O’Sullivan, 2011). Prior to their work, much of the literature assumed a monotonic relationship (Choi et al., 2011). More recent investigations have shown evidence that this relationship between aggregate inflation and relative price variability is significantly dependent on the nature of the inflation regime (Choi et al., 2011). Their study uncovers the significance of the monetary policy adopted by a country’s central bank in influencing the relationship
between inflation and relative price variability (Choi et al., 2011). The authors note that inflation’s distortion of the relativity of prices leads to inefficient resource allocation, resulting in welfare costs (Choi et al., 2011). In their study, Choi et al. explore whether a monetary policy of inflation targeting impacts the relative price variability, measured as standard deviations of specific inflation rates with respect to aggregate inflation rates (2011).

This study is of significant importance because of its implications for the impetus toward an inflation targeting monetary policy (Choi et al., 2011). Assuming a monotonic positive relationship, an inflation targeting regime that is successful in reducing inflation will also experience a reduction in relative price variability (Choi et al., 2011). The effectiveness of inflation targeting is therefore put into question, depending on the level of development of the nation. The authors find that countries with high initial levels of inflation experience both a fall in inflation and relative price variability after adoption of an inflation targeting regime (Choi et al., 2011). However, nations with low initial inflation may experience an increase in relative price variability after inflation targeting (Choi et al., 2011). While a reduction in inflation volatility is of great concern to many nations, the literature by Choi et al. points out that the relative price variability has been seldom addressed in developing inflation targeting policies (Choi et al., 2011). This potential negative consequence of inflation targeting is an issue that some regimes must place more value on than others.(Choi et al., 2011) It is their ultimate assertion that inflation targeting is likely more beneficial for developing countries with high initial inflation levels than industrialized nations with initially low inflation (Choi et al., 2011).

**Drumond and Porcile.** The work of Carlos Eduardo Drumond and Gabriel Porcile (2012) focuses on the effectiveness of inflation targeting as a policy to improve stability, and whether low, stable inflation should be the only focus of a central bank (Drumond and Porcile, 2012). Specifically, they investigate whether
other objectives that relate to employment and output should also be considered (Drumond and Porcile, 2012). The authors pose that a monetary policy that focuses on both high employment and low inflation may be more likely to improve economic stability than one that merely focuses on low inflation, in many circumstances (Drumond and Porcile, 2012). Their work, among others, define an interest rate operation procedure (IROP) as a policy to manage monetary policy, which may or may not be characterized by an inflation targeting regime in all cases (Drumond and Porcile, 2012). An IROP may also focus on employment (Drumond and Porcile, 2012). The authors investigate various regimes and their stability, such as a solely inflation-motivated regime or a solely employment-motivated regime.

Drumond and Porcile show that a mixed regime that focuses on employment and inflation leads to stable system with a medium-run tradeoff between the two objectives. They also demonstrate that central banks that set higher employment targets in their objective functions experience higher real wages and output growth (Drumond and Porcile, 2012). The authors assert that a monetary policy which utilizes only one instrument to attain two objectives violates the Tinbergen rule, which stipulates that the number of monetary policy objectives and instruments should equal (Drumond and Porcile, 2012). If one tool were used to target two objectives, it becomes impossible to attain two targets simultaneously (Drumond and Porcile, 2012). Subsequently, expectations of inflation and output would be distorted, causing the central bank to use inflation targeting to anchor inflation expectations (Drumond and Porcile, 2012). The authors highlight the importance of multiple objectives in order to effectively impact the economy in more desired ways (Drumond and Porcile, 2012). Their results show that a higher inflation target may lead to a lower interest rate and a lower real exchange rate in equilibrium (Drumond and Porcile, 2012). They demonstrate that in the long run, when expectations are altered, equilibria may no longer hold (Drumond and Porcile, 2012). Consequently,
nations will likely abandon one of their targets of inflation or employment (Drumond and Porcile, 2012).

**Giannoni and Woodford.** The work by Marc P. Giannoni and Michael Woodford (2005) provides a comprehensive analysis of the most appropriate tools a nation could utilize when targeting macro-economic variables (Giannoni and Woodford, 2005). In their work, the authors state that inflation-forecast targeting has become increasingly popular (Giannoni and Woodford, 2005). Under this policy, central banks will adjust short-term nominal interest rates in order to maintain inflation levels near their target for a short period into the future (Giannoni and Woodford, 2005). The authors cite lower inflationary bias and increased stability as benefits of such a policy, in contrast with a policy guided by a targeting of social welfare improvements (Giannoni and Woodford, 2005). In their work, additional variables to include in inflation targeting policies are investigated. The authors seek to uncover which inflation measure, output gap, time horizon, and history dependence should be considered when utilizing an inflation targeting policy (Giannoni and Woodford, 2005).

First, Giannoni and Woodford investigate policies that consider a welfare targeting output gap in addition to an inflation target (2005). This method of measurement is often found in monetary policy evaluation, and represents the stabilization method of many central banks that have adopted inflation targeting policies (Giannoni and Woodford, 2005). In their work and building upon previous studies, Giannoni and Woodford use a “New Keynesian Phillips curve” shown in equation 24,

\[ \pi_t = kx_t + \beta E_t \pi_{t+1} + u_t \]  

(24)

where \( \pi_t \) represents the inflation rate, \( x_t \) the output gap measured as the difference in log real GDP from a variable natural rate, \( u_t \) a cost-push disturbance
term (Giannoni and Woodford, 2005). $0 < \beta < 1$ is the discount factor of a representative household, and $k > 0$ is a function of several structural characteristics, such as the average frequency of price adjustment (Giannoni and Woodford, 2005). The authors assume an objective to minimize the expected value of a loss function in equation 25,

$$W = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t L_t \right\}$$

(25)

where $\beta^t$ is the same as in equation 24 (Giannoni and Woodford, 2005). The loss in each period is noted in equation 26 as:

$$L_t = \pi_t^2 + \lambda (x_t - x^*)^2$$

(26)

where $\lambda$ is a relative weight factor, and the optimal output gap $x^* > 0$ (Giannoni and Woodford, 2005). The authors pose that an approximation to the expected utility of the representative household is a decreasing function of equation 25:

$$\lambda = \frac{k}{\theta}$$

(27)

where $\theta > 1$ represents the substitution elasticity between alternative goods, and $x^*$ is a function tax distortion size and market power prevalence (Giannoni and Woodford, 2005).

Disturbances such as the cost-push shocks noted as $u_t$ in equation 24 cause a conflict between the goals of inflation stabilization and output gap stabilization shown in equation 26 (Giannoni and Woodford, 2005). Giannoni and Woodford postulate that a monetary policymaker can setup a Lagrangian for this relationship shown by equation 28 on the facing page, with choice variables $\pi_t$ and $x_t$ that will minimize equation 25, with loss function given by equation 26, constrained by
equation 24 (Giannoni and Woodford, 2005).

\[ L_{t_0} = E_{t_0} \sum_{t=t_0}^{\infty} \beta^{t-t_0} \frac{1}{2} \left[ \pi_t^2 + \lambda_x (x_t - x^*)^2 \right] + \varphi_t [\pi_t - k x_t - \beta \pi_{t-1}] \]  

(28)

where \( \varphi_t \) is a multiplier related to the constraint in equation 24 on page 21 on the possible choice variables (Giannoni and Woodford, 2005). First differencing of equation 28 with respect to inflation and output yields the following first order conditions:

\[ \pi_t + \varphi_t - \varphi_{t-1} = 0 \]  

(29)

\[ \lambda (x_t - x^*) - k \varphi_t = 0 \]  

(30)

for any period \( t \geq t_0 \) (Giannoni and Woodford, 2005). The authors state that these conditions, with equation 24 on page 21, have a nonexplosive solution for inflation and output, as well as the Lagrangian multiplier (Giannoni and Woodford, 2005). They state that this solution implies an optimal path for both inflation and output that policymakers may target (Giannoni and Woodford, 2005). However, this solution does not accurately reflect real market conditions because it assumes private sector participants do not consider recent economic history when deciding to raise prices, but only react to disturbances in \( u_t \) (Giannoni and Woodford, 2005). Giannoni and Woodford note that a policymaker commitment to respond in the future to shocks in the current period would likely cause a change in current expectations, moving inflation levels closer to the target (Giannoni and Woodford, 2005). The result is a lesser difference in the output gap needed to stabilize a given inflation deviation (Giannoni and Woodford, 2005).

The authors describe a policy that involves an incorporation of inflation
Inertia. In their view, this model would more realistically reflect central bank actions because an inflation rate that depends on recent inflation levels would be assumed (Giannoni and Woodford, 2005). To model this, the authors depict a model similar to equation 24, including a one-period lag of inflation, as shown in equation 31:

\[ \pi_t - \gamma \pi_{t-1} = k x_t \beta E_t [\pi_{t+1} - \gamma \pi_t] + u_t \]  

(31)

where \( 0 \leq \gamma \leq 1 \) represents a degree of automatic indexation to the aggregate price index. In solving the Lagrangian that results from equation 31, it is found that the value of \( \gamma \) determines the length of time that high inflation persists, such that higher \( \gamma \) values correspond to higher inflation persistence (Drumond and Porcile, 2012).

Giannoni and Woodford also look to improve the the realistic character of the common models by incorporating an interest rate stabilizing objective. In many cases, central banks consider the volatility of interest rates when considering optimal paths for inflation and output gaps (Giannoni and Woodford, 2005). In doing so, the authors develop a model that results in a Lagrangian shown in equation

\[ L_t = \pi_t^2 + \lambda_x (x_t - x^*)^2 + \lambda_i (i_t - i^*)^2 \]  

(32)

where \( i_t \) represents a nominal short term interest rate and \( i^* \) represents a level of nominal interest that is relatively stable (Giannoni and Woodford, 2005).

In each of the previous examples, Giannoni and Woodford utilized macroeconomic variables that may be of interest to policymakers beyond a strict focus on inflation. The models the authors developed provide an optimal path toward a stable inflation rate for a forward-looking inflation targeting regime, while maintaining relative stability in the welfare-influencing output gap and the transaction-influencing nominal interest rate (Giannoni and Woodford, 2005). An
in-depth study of inflation targeting regimes and the entirety of their optimal targeting strategies would likely include the work Giannoni and Woodford contribute.

**Related Works**

This section provides a discussion of related works that involve an analysis of inflation targeting in relation to inflation volatility. These authors cite that inflation volatility may lead to increases in inflation uncertainty (Gurkaynak et al., 2007). Their efforts give foundation and guidance to the overall direction in which this work proceeds. Investigation of the work by authors who analyze inflation targeting countries, and comparison between targeting countries and non-targeting countries is provided here.

**Bedri Tas.** The research conducted by Bedri Kamil Onur Tas in his work studying inflation and inflation volatility (2012) provides the primary source of literature in developing the model of inflation used here (Tas, 2012). In it, Tas measures the impact of inflation targeting on inflation uncertainty by estimating PGARCH and GARCH equations of the conditional variance found in inflation (Tas, 2012). Tas complements this with an analysis of a possible confirmation of the Friedman hypothesis, and a construction of panel data to further confirm his findings (Tas, 2012). Tas cites that well-guided monetary policy should pursue the goals of both low inflation levels and low inflation uncertainty (Tas, 2012). While many works have concluded that inflation targeting has helped targeting countries reduce inflation levels and expectations, they lack comprehensive empirical studies of inflation variation (Tas, 2012). Tas remedies this disparity by providing an investigation that measures inflation volatility before and after IT regimes began (Tas, 2012). The author does so by implementing both PGARCH and GARCH methods that produce coefficients for the factors that contribute to inflation
variability (Tas, 2012). The author’s model formulation and analysis are instrumental in understanding the methods to implement estimates of inflation volatility.

Tas investigates nineteen of the then 26 inflation targeting countries, excluding only those that do not provide sufficiently high frequency data or adopted IT policies too late to be adequately measured before the submission of his work (Tas, 2012). From these countries, the author extracts their respective monthly data of inflation rate, calculated as the log difference in CPI. In preliminary analysis of the data, Tas finds that most countries exhibit lower variance of inflation after inflation targeting policies have been enacted (Tas, 2012). To estimate inflation uncertainty, Tas develops an ARMA(p,(1,12))-PGARCH(1,1) model with the following structure:

\[ \pi_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 \pi_{t-2} + \ldots + \beta_p \pi_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-12} \tag{33} \]

\[ \sigma_t^\delta = \alpha_0 + \alpha_1 (|\varepsilon_{t-1}| - \psi \varepsilon_{t-1})^\delta + \beta_1 \sigma_t^\delta + \beta_2 IT dummy_t + \beta_3 \pi_{t-1} \tag{34} \]

where \( \pi \) signifies an inflation rate and \( \varepsilon \) is an error term for the mean equation 33 (Tas, 2012). In equation 33, the AR structure is determined by optimizing for Akaike and Schwarz criteria., while the MA(1,12) is chosen by its ability to reduce AR terms and correct for possible seasonality (Tas, 2012). In the variance equation 34, \( \sigma \) represents the standard deviation in inflation, \( \psi \) represents PGARCH inflation-volatility asymmetry, \( \delta \) denotes a power transmission vehicle, \( IT dummy \) is a dummy variable that allows for the estimation of the change in inflation variance after inflation targeting, and \( \pi_{t-1} \) is a one-period lag of inflation (Tas, 2012).

To provide more robust results, Tas also implemented an ARMA(p,(1,12))-GARCH(1,1) model estimation, in which the mean equation can be determined and interpreted in a similar fashion as equation 33 (Tas, 2012). The
variance equation takes the form of:

\[
\sigma_t = \lambda_0 + \lambda_1 \sigma_{t-1} + \lambda_2 \varepsilon_{t-1} + \lambda_3 ITdummy_t + \lambda_4 \pi_{t-1}
\]  

(35)

where \(\sigma_{t-1}\) is a GARCH term to reflect current variance as a result of previous variance, \(\varepsilon_{t-1}\) is an ARCH term to reflect current variance as a result of previous error, while \(ITdummy\) and \(\pi_{t-1}\) maintain the same interpretation as equation 34 (Tas, 2012).

To complement these results, the author also estimates a panel-data equation based on the PARCH specification in equation 34:

\[
Variance_{i,t} = \rho_0 + \rho_1 ITdummy_{i,t} + \rho_2 DEdummy_{i,t} + \gamma_i + \varepsilon_{i,t}
\]  

(36)

where \(DEdummy\) represents a dummy variable that differentiates developing economies from developed ones, \(\rho_1\) effectively represents the impact inflation has on the inflation variance in all inflation targeting economies, and \(\gamma\) provides a random effect determined from the Hausman test. (Tas, 2012).

From his investigation of both the PGARCH and GARCH models, Tas finds that most inflation targeting nations see a significant difference in inflation variance after the implementation of inflation targeting (Tas, 2012). The author finds the coefficient corresponding to \(ITdummy\) to be significant and negative for most economies, implying that inflation variance becomes lower after IT (Tas, 2012). Tas is also able to conclude that the value of \(ITdummy\) is greater for developing economies than developed ones, suggesting that IT adoption is more effective in reducing inflation uncertainty for emerging economies (Tas, 2012). Tas also finds the coefficient corresponding to \(\pi_{t-1}\) to be positive and significant for some countries, indicating a confirmation of the Friedman hypothesis (Tas, 2012). Panel data investigation conducted by the author supports these results (Tas, 2012). Tas
finds the $IT_{dummy}$ coefficient to be significantly non-zero and negative, suggesting that inflation variance decreased after IT (Tas, 2012). Despite very few results to the contrary, Tas is able to conclude that the adoption of inflation targeting is effective in achieving the goal of lower inflation volatility (Tas, 2012).

**Gurkaynak, Levin, Marder, and Swanson.** In the work by Refet S. Gurkaynak, Andrew T. Levin, Andrew N. Marder, and Eric T. Swanson (2007), a study of the impact of inflation targeting on inflation expectations is conducted. Specifically, Western Hemisphere economies of Canada, Chile, and United States are considered. Canada and Chile have been formal inflation targeting nations, while the United States has not formally declared an inflation target. The authors use daily bond yield for the three nations to determine the effectiveness inflation targeting may have in minimizing variances in inflation expectations (Gurkaynak et al., 2007). In defining inflation expectations, the authors utilize forward inflation compensation, or the difference between forwards on nominal and indexed bonds (Gurkaynak et al., 2007). The authors postulate that a market will have a relatively stable expectation of long-term inflation if forward inflation compensation remains relatively unchanged in response to shocks (Gurkaynak et al., 2007). It is their assumption that credible inflation targeting policy should produce an increase in insensitivity to these shocks (Gurkaynak et al., 2007).

In order to perform their analysis, Gurkaynak et al. utilize two variations of the macroeconomic model given in equations 37 and 38

\[
\pi_t = \mu_\pi E_t \pi_{t+1} + (1 - \mu_\pi) A_{\pi} (L) \pi_t + \gamma y_t + \varepsilon^\pi_t \quad (37)
\]

\[
y_t = \mu_y E_t y_{t+1} + (1 - \mu_y) A_{y} (L) y_t - \beta (i_t - E_t \pi_{t+1}) + \varepsilon^y_t \quad (38)
\]

where $\pi$ represents an inflation rate, $y$ represents an output gap, $i$ is the
short-term nominal interest rate, and $\varepsilon^\pi$ and $\varepsilon^y$ are exogenous disturbance shocks (Gurkaynak et al., 2007). The $\mu_\pi$ and $\mu_y$ terms determine the amount of forward-looking behavior that exists, while lags $A_\pi(L)$ and $A_y(L)$ give historical dependence parameters (Gurkaynak et al., 2007). The authors consider purely new Keynesian interpretations of this model, where $\mu_\pi = 1 = \mu_y$, such that historical values hold no significance, and hybrid new Keynesian interpretations that include inflation and output lags and lower $\mu$ values (Gurkaynak et al., 2007). The authors introduce an interest rate relationship of the form shown in equation 39

$$i_t = (1-c)(1+a)\pi_t + by_t + ci_{t-1} + \varepsilon^i_t$$  \hspace{1cm} (39)$$

where $\bar{\pi}$ represents a moving average of inflation over four quarters, $\varepsilon^i$ is an exogenous disturbance, and $a$, $b$, and $c$ are parameters whose values were determined by previous research (Rudebusch, 1998). Gurkaynak et al. utilize the exogenous interest rate disturbance $\varepsilon^i$ to introduce one-percent impulse shocks into their model (Gurkaynak et al., 2007). From this model, the authors show that in the pure new Keynesian interpretation, economic news impact short-term interest rates for a short time before dying out within about a year (Gurkaynak et al., 2007). Under the hybrid historical-contingent model, economic shocks have effects on short term interest rates that persist for a maximum of ten years (Gurkaynak et al., 2007).

A benefit of their daily data on forwards and high frequency of economic news in Canada and United States provides a large sample size to draw from (Gurkaynak et al., 2007). However, the authors note that limited information on macroeconomic data in the model for Chile results in less reliable findings in that particular study (Gurkaynak et al., 2007). Gurkaynak et al. conclude that U.S. forwards and inflation compensation excessively responsive to shocks and macroeconomic news (Gurkaynak et al., 2007). They also conclude that Canada forwards and inflation compensation are much less sensitive to similar economic news (Gurkaynak et al.,
2007). Despite a limitation in data size mentioned previously, the authors find Chile to lack an excessively responsive relationship between economic news and forward interest rates coupled with inflation compensation (Gurkaynak et al., 2007). As Gurkaynak et al. note, the Chilean economy is still in transition toward a more stable financial system, which could explain some of the persistent volatility that exists in their data set (Gurkaynak et al., 2007). Based upon these findings, the authors assert that a transparent inflation targeting policy can help to reduce volatility in inflation expectations (Gurkaynak et al., 2007).

**Levin, Natalucci, and Piger.** In the work of Andrew T. Levin, Fabio M. Natalucci, and Jeremy M. Piger (2004), a study of the macroeconomic effects of inflation targeting is carried out. The authors measure the impact inflation targeting imposes upon inflation expectations. The authors do so by comparing five industrialized inflation targeting nations with seven industrialized non-inflation targeting nations, and measure their respective long-term inflation expectations (Levin et al., 2004). Levin et al. utilize poll data that measure inflation forecasts by individuals to develop mean inflation expectation values (Levin et al., 2004).

Levin et al. conclude that their findings are consistent with the implications that an expectation-augmented Phillips curve, shown in equation 40 would suggest

\[ \pi_t = \hat{\pi}_{t+1} + \phi y_t + \varepsilon_t \]  

(40)

where \( \hat{\pi}_{t+1} \) represents inflation expectations for one period ahead, \( y_t \) is an output gap, and \( \varepsilon_t \) is an exogenous supply shock (Levin et al., 2004). Implied in this model, inflation target credibility will maintain an inflation expectation near the prescribed target (Levin et al., 2004). Therefore, the majority of remaining inflation would be a result of output gap persistence. The authors find that the adoption of inflation targeting in developing economies does not result in rapid reduction in
inflation expectation fluctuations (Levin et al., 2004). Levin et al. postulate that although developing economies have seen inflation reductions, inflation volatility has not been reduced significantly (2004). Finally, the authors recommend additional studies to improve the understanding and execution of inflation targeting policy (Levin et al., 2004).

**Petursson.** The work conducted by Thorarinn Petursson (2004) analyzes the relative success of inflation targeting policies in the targeting countries, by measuring various economic effects. The author defines successful inflation targeting monetary policy as one that brings inflation levels down to a stable rate, and maintains that level for significant periods of time (Petursson, 2004).

Table 1
*Inflation Before and After Inflation Targeting*

<table>
<thead>
<tr>
<th>Countries</th>
<th>Average inflation the 3 years prior to adoption</th>
<th>Average inflation the year prior to adoption</th>
<th>Average inflation after adoption</th>
<th>Inflation 2007</th>
<th>Average inflation 1981-90</th>
<th>Average inflation 1991-03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>5.0</td>
<td>6.9</td>
<td>2.6</td>
<td>3.0</td>
<td>5.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>462.2</td>
<td>2.6</td>
<td>7.1</td>
<td>8.4</td>
<td>699.8</td>
<td>507.4</td>
</tr>
<tr>
<td>Canada</td>
<td>4.5</td>
<td>4.8</td>
<td>2.1</td>
<td>2.4</td>
<td>6.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Chile</td>
<td>19.6</td>
<td>22.3</td>
<td>9.2</td>
<td>2.5</td>
<td>26.5</td>
<td>8.4</td>
</tr>
<tr>
<td>Colombia</td>
<td>19.2</td>
<td>18.8</td>
<td>8.0</td>
<td>6.4</td>
<td>23.8</td>
<td>17.9</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>10.6</td>
<td>9.3</td>
<td>4.7</td>
<td>1.8</td>
<td>–</td>
<td>10.6</td>
</tr>
<tr>
<td>Hungary</td>
<td>14.3</td>
<td>9.9</td>
<td>6.8</td>
<td>5.3</td>
<td>12.0</td>
<td>18.2</td>
</tr>
<tr>
<td>Iceland</td>
<td>2.8</td>
<td>5.1</td>
<td>5.8</td>
<td>4.9</td>
<td>35.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Israel</td>
<td>18.5</td>
<td>19.0</td>
<td>7.7</td>
<td>5.7</td>
<td>121.0</td>
<td>8.6</td>
</tr>
<tr>
<td>Korea</td>
<td>5.2</td>
<td>5.7</td>
<td>3.2</td>
<td>3.0</td>
<td>6.3</td>
<td>4.8</td>
</tr>
<tr>
<td>Mexico</td>
<td>22.8</td>
<td>16.1</td>
<td>9.2</td>
<td>9.0</td>
<td>69.8</td>
<td>16.5</td>
</tr>
<tr>
<td>New Zealand</td>
<td>11.3</td>
<td>5.7</td>
<td>2.2</td>
<td>2.7</td>
<td>19.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Norway</td>
<td>2.3</td>
<td>3.1</td>
<td>2.8</td>
<td>1.4</td>
<td>7.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Peru</td>
<td>5.0</td>
<td>2.0</td>
<td>0.2</td>
<td>0.2</td>
<td>1,064.7</td>
<td>200.7</td>
</tr>
<tr>
<td>Philippines</td>
<td>6.6</td>
<td>6.0</td>
<td>3.1</td>
<td>3.1</td>
<td>148.8</td>
<td>8.1</td>
</tr>
<tr>
<td>Poland</td>
<td>22.0</td>
<td>12.8</td>
<td>6.4</td>
<td>1.9</td>
<td>129.3</td>
<td>24.5</td>
</tr>
<tr>
<td>South Africa</td>
<td>7.3</td>
<td>5.0</td>
<td>6.9</td>
<td>9.4</td>
<td>14.7</td>
<td>8.7</td>
</tr>
<tr>
<td>Sweden</td>
<td>6.9</td>
<td>2.3</td>
<td>1.6</td>
<td>2.2</td>
<td>7.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.8</td>
<td>0.9</td>
<td>1.1</td>
<td>0.7</td>
<td>3.4</td>
<td>1.8</td>
</tr>
<tr>
<td>Thiland</td>
<td>4.9</td>
<td>0.1</td>
<td>1.3</td>
<td>0.7</td>
<td>4.4</td>
<td>4.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6.4</td>
<td>4.0</td>
<td>2.5</td>
<td>1.7</td>
<td>6.6</td>
<td>2.8</td>
</tr>
<tr>
<td>All countries</td>
<td>31.4</td>
<td>7.2</td>
<td>4.5</td>
<td>3.4</td>
<td>113.1</td>
<td>40.8</td>
</tr>
</tbody>
</table>


As Table 1 illustrates on the current page, Petursson finds that mean inflation levels have fallen significantly since the adoption of inflation targeting regimes (Petursson, 2004). However, the author notes that a portion of the inflation reduction process began in the year prior to the initiation of inflation targeting,
shown in the second column of Table 1, most noticeably in the more developed economies (Petursson, 2004). Petursson concedes that some of the inflation reduction can be attributed to a gradual movement among emerging economy legislation with an increased emphasis on price stability (Petursson, 2004).

To gain more clear understanding of the impact of inflation targeting policy, Petursson introduces a model of panel data shown by equation on this page

\[ \pi_{it} = \alpha_{\pi i} + \beta_{\pi IT_{it}} + \gamma_{\pi \pi_{it-1}} \mu_{\pi y_{it-1}} + \lambda_{\pi0} \pi_{it}^{w} + \lambda_{\pi1} \pi_{t-1}^{w} \varepsilon_{\pi it} so \]  

where \( \pi_{it} \) represents inflation in a targeting country \( i \) at time \( t \), \( y_{it} \) represents output growth in the targeting country, \( \pi_{it}^{w} \) denotes the mean inflation in six non-targeting economies selected by Petursson, \( IT_{it} \) is a dummy variable to differentiate the periods before and after inflation targeting adoption, and lagged inflation to account for correlation between high inflation and a likeliness to adopt inflation targeting procedures (Petursson, 2004). In this work, Petursson is able to show significant evidence that inflation targeting impacts mean inflation levels (Petursson, 2004). Even after accounting for a downward trend in inflation globally, and accounting for business cycles, the author finds that inflation targeting leads to roughly a 3 percentage decrease in inflation (Petursson, 2004).

**Mishkin and Schmidt-Hebbel.** Frederic S. Mishkin and Klaus Schmidt-Hebbel provide a comprehensive analysis of the impact inflation targeting poses on various economic variables. Specifically, their work seeks to determine if inflation, inflation volatility, interest rates, and output volatility have declined as a result of inflation targeting (Mishkin and Schmidt-Hebbel, 2007a). They also provide a comparison of these results with respect to a control group of non-targeting countries to determine if the results of the inflation targeting data is merely coincidental (Mishkin and Schmidt-Hebbel, 2007b).

The work of Mishkin and Schmidt-Hebbel begins by measuring inflation levels
for each targeting country in comparison to their respective explicit inflation targets (Mishkin and Schmidt-Hebbel, 2007b). Inflation rates are given as 12 month differences in CPI (Mishkin and Schmidt-Hebbel, 2007b). Inflation targets are defined in two ways: Stationary targets are goals for a nation’s inflation rate that remain constant, while target convergence is a dynamic goal for national inflation that usually decreases over time toward a final stationary target (Mishkin and Schmidt-Hebbel, 2007b). Preliminary analysis of their data suggests that inflation targeting economies have successfully reached their target levels (Mishkin and Schmidt-Hebbel, 2007b). The authors choose their control group as a set of advanced economic nations whose monetarists systems are thought to be well developed, including Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, Portugal, and the United States (Mishkin and Schmidt-Hebbel, 2007b). After comparison of the two groups, the authors found that a large difference in inflation rates during the late 1980’s was nearly closed by 2004 (Mishkin and Schmidt-Hebbel, 2007b). During this period, inflation targeting regimes began taking place in rapid succession (Levin et al., 2004). Panel data estimation conducted by Mishkin and Schmidt-Hebbel utilized dummy variables to specify inflation targeters and differentiate between inflation targeting regimes and their predecessors (Mishkin and Schmidt-Hebbel, 2007b). With these specifications, the authors are able to generate separate groups that signify pre-targeting as opposed to post-targeting, and targeters as opposed to non-targeters (Mishkin and Schmidt-Hebbel, 2007b). To test for the presence of credible, stable inflation anchoring as a result of IT, the authors introduce an estimation of oil supply shocks to their model (Mishkin and Schmidt-Hebbel, 2007b). In theory, a stable inflation targeting regime would exhibit less volatility in response to an oil price shock than a pre-targeting regime if inflation targeting did in fact create an inflation anchoring effect (Levin et al., 2004). To test for the
presence of a pass-through of exchange rate devaluation to inflation rate changes, the authors introduce a measure of exchange rate changes into their model (Mishkin and Schmidt-Hebbel, 2007b). Theoretically, downward changes in exchange rate, or devaluation, may lead to a perceived increase in import prices, resulting in inflationary effects (Krueger, 1980). To test for the prevalence of inflation sensitivity to interest rate shocks, Mishkin and Schmidt-Hebbel also introduce a measure of interest rate changes into their model (Mishkin and Schmidt-Hebbel, 2007b).

Theory would suggest that a high sensitivity of inflation to interest rate changes would indicate low levels of monetary independence of the domestic monetary regime (Mishkin and Schmidt-Hebbel, 2007b). Furthermore, it is expected that inflation targeting would reduce inflation volatility relative to interest rate changes, due to the presence of a persistent goal of inflation (Mishkin and Schmidt-Hebbel, 2007b). To test for the correlation between output-gap volatility and inflation volatility, the authors measure these variables and their movements together (Mishkin and Schmidt-Hebbel, 2007b). In theory, output gap volatility would correspond to inflation volatility because of their Phillips curve relationship (Branson, 1989). In practice, however, it may be seen that non-targeting economies experience smaller output shocks on average, resulting in misleading correlations between real output and inflation (Mishkin and Schmidt-Hebbel, 2007b).

Research by the authors has found that there is only weak evidence that the adoption of inflation targeting regimes has led to a sudden decrease in inflation expectations (Mishkin and Schmidt-Hebbel, 2007b). However, Mishkin and Schmidt-Hebbel find that the persistence of long-term inflation is lower for inflation targeting economies than non-targeters, and that inflation expectations are less volatile in response to supply shocks for inflation targeters (Mishkin and Schmidt-Hebbel, 2007b). The authors also find that exchange rate pass-through is lower for nations that develop stationary inflation targets, meaning that exchange
rate shocks exhibit less inflationary pressure on stable inflation targeting monetarists (Mishkin and Schmidt-Hebbel, 2007b). It is found that inflation rate sensitivity to interest rate changes actually increases for developed IT nations, while a negative relationship exists for emerging economies (Mishkin and Schmidt-Hebbel, 2007b). In their research, Mishkin and Schmidt-Hebbel find output gap volatility to be positively correlated with inflation volatility for IT nations (Mishkin and Schmidt-Hebbel, 2007b). The authors note that while conclusions drawn from their work and many others may differ significantly, this is primarily the result of varying group specification and not necessarily different methodology an specification (Mishkin and Schmidt-Hebbel, 2007b). Their work provides valuable analysis of macroeconomic impacts that result from inflation targeting (Mishkin and Schmidt-Hebbel, 2007b). While the authors acknowledge the limited scope of their findings, they maintain that expanded studies on the macroeconomic effects of inflation targeting would yield similar results (Mishkin and Schmidt-Hebbel, 2007b).
Empirical Study

Data

For this research, data were collected monthly in the periods shown in Table 2. The industrial nations selected for study are the Canada, Iceland, Switzerland and the United Kingdom. The developing nations include Chile, Israel, Mexico, and South Korea. Selection of these nations for study is primarily a result of a desire to provide robust inferences that include nations that began targeting at many different periods of time. Data selection was also limited by the availability of monthly data. An availability of high frequency data is necessary for responsible analysis of data using GARCH methods, which will be described in the following section (Engle, 2001). For all countries, CPI was taken from the Federal Reserve Bank of St. Louis FRED database as monthly, non-seasonally adjusted CPI (2014). Data sources can be found later within this work. As is consistent with the literature, particularly that of Bedri Kamil Onur Tas (2012), inflation was calculated by the author as the month-to-month log-difference in CPI (Baillie et al., 2006). Some works prescribe calculating inflation as the 12-month difference in monthly CPI in order to reduce 12 period lag correlation (Levin et al., 2004). Others, such as Payne (2009), employ a log difference, multiplied by a factor of 100 (Payne, 2009). In this work, it has been decided to closely mimic the data selection of Tas, since the subsequent methodology most closely resembles his work. Start dates of inflation targeting are not always clearly defined (Mishkin and Schmidt-Hebbel, 2007a). Some measure inflation targeting start dates as the first period in which a stable, stationary target was announced, while others choose the first period in which any inflation target was explicitly announced (Ball and Sheridan, 2004). Consistent with the literature of Tas, this work denotes initiation of IT as the first period of explicitly announced targeting (Tas, 2012). The start dates for inflation targeting, as well as the dates of first and last observations are shown in Table 2 on the next page.
Table 2

**Inflation Targeting: Key Dates**

<table>
<thead>
<tr>
<th>Country</th>
<th>Targeting Start Date</th>
<th>First Observation</th>
<th>Last Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Nations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>February 1991</td>
<td>February 1955</td>
<td>December 2013</td>
</tr>
<tr>
<td>Iceland</td>
<td>March 2001</td>
<td>February 1976</td>
<td>December 2013</td>
</tr>
<tr>
<td>Switzerland</td>
<td>January 2000</td>
<td>February 1955</td>
<td>December 2013</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>December 1991</td>
<td>February 1955</td>
<td>December 2013</td>
</tr>
<tr>
<td>Developing Nations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>September 1990</td>
<td>February 1970</td>
<td>December 2013</td>
</tr>
<tr>
<td>Mexico</td>
<td>January 1999</td>
<td>February 1969</td>
<td>December 2013</td>
</tr>
<tr>
<td>South Korea</td>
<td>January 1998</td>
<td>February 1955</td>
<td>December 2013</td>
</tr>
</tbody>
</table>

Source: Generated by author, based on work of Bedri Tas (2012) and Federal Reserve Bank of St. Louis (2014).

Table 3 shows mean inflation values, gathered from the untreated data. Mean inflation values are listed for the entire period, the period before inflation targeting, and the period after inflation targeting respectively. Standard deviation of inflation is listed in similar fashion in Table 4, along with F-test values measuring the difference in variance between pre-targeting and post-targeting periods. From Table 3, preliminary analysis of mean inflation before and after inflation targeting shows that for each country, mean inflation had decreased in the period after IT adoption. Investigating standard deviation in the same way, it is evident in Table 4 that standard deviation of inflation was significantly reduced after IT adoption for all countries except Switzerland, which saw a slight increase in inflation volatility following IT adoption. These results are supported by the F-test statistics shown in Table 4. An F-test is essentially a test of equality between multiple sets of data (Greene, 2008). In this case, the variance of the pre-targeting period is measured in comparison to the variance of the post-targeting period, as conducted in several works that incorporate variance equality tests (Tas, 2012). The null hypothesis of the F-test stipulates that the variance of the pre-targeting period is equal to the variance of the post-targeting period (Tas, 2012). For any p-value less than 0.05, we
can be 95% confident that the two variances are not equal to each other, resulting in a rejection of the null hypothesis (Greene, 2008). For all countries listed, we can reject the null hypothesis of variance equality, except for the Switzerland data. Given that a trend toward variance reduction seems to be evident for most inflation-targeting economies, this study intends to investigate the role inflation targeting plays in impacting inflation variance.

Table 3

*I*flation *T*argeting: *M*ean *S*tatistics

<table>
<thead>
<tr>
<th>Country</th>
<th>Inflation Mean</th>
<th>Inflation Mean</th>
<th>Inflation Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>entire period</td>
<td>pre-targeting</td>
<td>post-targeting</td>
</tr>
<tr>
<td><strong>Industrial Nations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>0.001329</td>
<td>0.001770</td>
<td>0.000636</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.004664</td>
<td>0.006985</td>
<td>0.002038</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.000908</td>
<td>0.001122</td>
<td>0.000223</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.001836</td>
<td>0.002465</td>
<td>0.000789</td>
</tr>
<tr>
<td><strong>Developing Nations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>0.009597</td>
<td>0.018208</td>
<td>0.002001</td>
</tr>
<tr>
<td>Israel</td>
<td>0.009231</td>
<td>0.016916</td>
<td>0.001575</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.007159</td>
<td>0.009839</td>
<td>0.001815</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.003021</td>
<td>0.003761</td>
<td>0.001035</td>
</tr>
</tbody>
</table>

Source: Generated by author.
Methodology

In this work, an investigation of inflation data is intended to show whether or not the adoption of inflation targeting regimes has led to a decrease in inflation volatility. In accordance with the literature, a GARCH specification can be used to model inflation uncertainty (Tas, 2012). A GARCH (generalized autoregressive, conditionally heteroskedastic) model is one that compensates for an OLS (ordinary least squares) inability to model variance (Engle, 2001). An OLS makes an assumption that the expected squared value of errors will be the same at all points, known as homoskedasticity (Engle, 2001). However, many macroeconomic data are inherently heteroskedastic (Greene, 2008). While many econometric steps may be taken to correct this heteroskedasticity, situations occur in which there exists a desire to measure and model this error volatility (Engle, 2001). Heteroskedasticity is usually prevalent in cross-sectional data, such as the measurement of income to consumption (Branson, 1989). It would be expected that higher levels of income correspond to higher variation in levels of consumption, resulting in larger errors for higher income levels (Branson, 1989). However, this phenomenon is not exclusive to cross sectional data (Engle, 2001). There are many instances where heteroskedasticity appears in time-series data as well (Engle, 2001). One specific example is the measurement of inflation volatility. It is hypothesized that a reduction in inflation should correspond to reduced levels of inflation volatility (Giannoni and Woodford, 2005). This occurrence can potentially be the result of the Friedman hypothesis which in part, stipulates that high levels of inflation have an increasing impact on inflation variability (Friedman, 1976). The phenomenon can also be represented by a possible tendency of inflation errors to correspond to the errors of their lagged values and the lagged values of their error terms (Tas, 2012). This is manifested in the form of volatility clustering, where high volatility instances are often grouped near each other and not normally distributed (Engle,
It can also be the result of a reduction in credibility at higher levels of inflation (Mishkin and Schmidt-Hebbel, 2007b), as well as a temporary breakdown of the relationship between inflation and output gap in the short term (Friedman, 1976). A GARCH model can reflect some of these tendencies, by displaying the effect these factors impart upon the inflation volatility variable (Tas, 2012).

Before GARCH techniques were developed, econometricians used a rolling standard deviation to estimate the variance of a future value, based on an equally weighted average of the squared errors for a fixed amount of lags (Engle, 2001). However, the equal weight placed upon both recent and past residuals was undesirable, as was the model’s zero-weight placement on errors beyond its lag specification (Engle, 2001). To remedy this, Robert Engle (1982) proposed an autoregressive, conditionally heteroskedastic (ARCH) model. In it, the weights of these lags are allowed to become parameters that may be estimated (Engle, 2001). Of the tools available to measure optimal model structure, the Akaike Information Criterion (AIC) and Schwarz Information Criterion are most prominent (Greene, 2008). Essentially, analysis of AIC or Schwarz involves finding the model structure with the lowest respective value (Nau, 2014). However, care must be taken when evaluating AIC and Schwarz to avoid violating economic theory, or adding terms that cancel each other out (Nau, 2014).

In practice, the selection of a GARCH model structure involves the inclusion of ARIMA terms (Engle, 2001). The autoregressive (AR) component represents lags of the dependent variable to be included in the mean equation of the model (Engle, 2001). The moving average (MA) component represents lags of the error term to be included in the mean equation of the model (Engle, 2001). For example, an AR(1) process would include a one time period lag of the dependent variable, while a MA(2) process would include a one period lag of the error term, plus a two period lag of the error term (Greene, 2008). A first differencing (I) component may also be
introduced, which transforms the dependent variable into a measure of its rate of change, which can often remove persistent trends at level (Greene, 2008). Before specification of a model, data must first be found to be stationary (Greene, 2008). Stationarity is the evidence of the absence of a unit root (Greene, 2008). Essentially, the presence of a unit root essentially means that a dependent variable is heavily dependent upon its own lagged levels (Greene, 2008). As a result, shocks remain in the model and never phase out (Greene, 2008). The unit root is effectively the coefficient associated with this lag, so the absence of a unit root implies stationarity (Greene, 2008). Much of the literature tests for unit roots by performing an augmented Dickey-Fuller test (Tas, 2012). Once the dependent variable is stationary, model structure can be applied (Greene, 2008). The values to select for this ARIMA(p,d,q) structure depend heavily on the nature of the underlying economic theory, adjusted r² values, model F-statistics, the spike significances of the corresponding correlogram, and the model evaluation criteria, such as AIC and Schwarz (Nau, 2014). Correlogram analysis involves investigating the significance of correlation between the dependent variable and lags of itself (ACF) and partial correlation between the dependent variable and lags of itself (PACF) (Nau, 2014).

After determination of the ideal structure, a mean equation may be formulated such as equation 42 below:

\[
\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 \pi_{t-2} + \ldots + \beta_p \pi_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-q}
\] (42)

where, similar to the work of Bedri Tas, \(\pi\) signifies an inflation rate and \(\varepsilon\) is an error term for the mean equation, \(\pi_{t-1,p}\) represent AR(p) terms, and \(\varepsilon_{t-1,q}\) represent MA(q) terms determined by analysis of potential ARIMA(p,d,q) (2012).

Since this equation measures inflation, we expect its variance to be heteroskedastic (Tas, 2012). To measure this, there are many tests of homoskedasticity that can be employed (Greene, 2008). In accordance with similar
literature, an ARCH-LM test will be conducted which regresses the squared error of the mean equation on lagged squared errors to determine if past errors contribute to current errors, known as heteroskedasticity (Greene, 2008). The null hypothesis stipulates that the coefficients of lagged squared errors are zero, or essentially that homoskedasticity cannot be refuted (Greene, 2008). A rejection of the null hypothesis stipulates that these coefficients are significantly non-zero, implying an effect on current squared errors known as ARCH effect (Greene, 2008). If ARCH effect is present, then it is permissible to implement an ARCH or GARCH model onto the equation (Greene, 2008).

The goal of the GARCH model is to provide a measurement of volatility for inflation (Engle, 2001). As such, a development of the mean equation must be modeled against regressors that impact its variance. The literature indicate that a dummy variable can be used to differentiate between periods of inflation targeting and periods of non-targeting (Tas, 2012). The dummy will simply be zero for all non-targeting periods and one for all targeting periods (Tas, 2012). The expectation is that after inflation targeting, inflation variance will decrease, so a negative coefficient is anticipated (Mishkin and Schmidt-Hebbel, 2007b). Literature also indicate that a lagged value of the dependent variable (inflation) may be used to determine if inflation variance in this period are influenced by inflation levels of last period, known as the Friedman hypothesis (Tas, 2012). The expectation is that higher levels previous-period inflation will contribute to higher volatility (variance) of inflation in the current period, so a positive coefficient is anticipated (Tas, 2012). Including these variance regressors results in a GARCH(1,1) model of the form in equation 43:

\[
\sigma_t = \lambda_0 + \lambda_1 \sigma_{t-1} + \lambda_2 \varepsilon_{t-1} + \lambda_3 IT dummy_t + \lambda_4 \pi_{t-1}
\] (43)

where, similar to the work of Bedri Tas, \( \sigma_{t-1} \) is the GARCH term to reflect
current variance as a result of previous variance, $\varepsilon_{t-1}$ is the ARCH term to reflect current variance as a result of previous error, while $IT_{\text{dummy}}$ represents the dummy variable mentioned above, and $\pi_{t-1}$ represents the lagged dependent variable of the mean equation, to signify Friedman hypothesis (Tas, 2012). The literature suggests formulating GARCH of order (1,1) to model monthly data measured in this way, so this work follows the suggestion of Bedri Tas article of similar interest (Tas, 2012).

It should be noted that a PGARCH (asymmetric power, generalized autoregressive, conditionally heteroskedastic) model could have also been used (Tas, 2012). As noted by Bedri Tas, utilization of PGARCH instead of GARCH has the benefit of its specification of volatility that differs with time, as well as its ability to display effects that impact inflation asymmetrically (Tas, 2012). Also, PGARCH models can account for the clustering of conditional variances associated with inflation (Tas, 2012). However, a GARCH specification is simply a version of a PGARCH where the coefficient attached to asymmetric effects is brought to zero, and the standard deviation is squared (Tas, 2012). In his work, Bedri Tas found the results between GARCH and PGARCH specifications to be quite similar. In consideration of this, and in interest of simplicity, only a GARCH model is postulated in this work.

**Results**

This section chronicles the steps taken in the methodology section above, with respect to the specific data of this work. In pursuit of robust findings, nations are selected from the categories of both developed and developing economies (Tas, 2012). Models are selected individually for each nation based on the specific characteristics of each data set. A discussion of model selection, analysis, and performance are provided in the area that follows.
Developed Nations. The developed nations investigated in this study include Canada, Iceland, Switzerland, and the United Kingdom. Their results are presented here.

Canada. First inspection of the untreated inflation variable, by performing the ADF test, shows the presence of a unit root at level. After first differencing, the data become stationary, shown in Table 5. Figure 3 shows the correlogram. One large significant ACF spike and several gradually decreasing PACF spikes would suggest the introduction of a moving average (MA) process (Nau, 2014). Consistent with the work of Bedri Tas(2012), a mean equation with ARIMA (1,1,12) structure is chosen (Tas, 2012). This mean equation is represented by Table 6 on page 62, based on minimization of Akaike (AIC) and Schwarz Information Criterion, also shown in Table 6. After determining the proper ARIMA structure, the heteroskedasticity test ARCH LM is conducted. Results are shown in Table 6 on page 62. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 4. From this, it can be seen that errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. In accordance with related literature, variance regressors are added to the GARCH estimation, represented by $IT_{dummy}$ and $Friedman$, with coefficients $\lambda_3$ and $\lambda_4$ respectively (Tas, 2012). Their values are also listed in Table 7. $\lambda_3$ shows significance and the expected negative sign. This evidence suggests that the adoption of inflation targeting has led to a reduction in
inflation variance in Canada (Tas, 2012). $\lambda_4$ is not significant, suggesting that the Friedman hypothesis does not hold (Tas, 2012). This evidence suggests that the level of inflation in Canada does not impact the amount of inflation variance (Tas, 2012). However, it should be noted that inflation in this data set was first-differenced. The interpretation of $\lambda_4$, which now represents the impact of changes in inflation on inflation variance, may no longer valid in investigating the Friedman hypothesis (Tas, 2012).

<table>
<thead>
<tr>
<th>Sample: 1955M01 2013M12</th>
<th>Included observations: 795</th>
</tr>
</thead>
<tbody>
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<td>Autocorrelation</td>
<td>Partial Correlation</td>
</tr>
<tr>
<td>1</td>
<td>0.524</td>
</tr>
<tr>
<td>2</td>
<td>0.049</td>
</tr>
<tr>
<td>3</td>
<td>0.054</td>
</tr>
<tr>
<td>4</td>
<td>0.079</td>
</tr>
<tr>
<td>5</td>
<td>0.032</td>
</tr>
<tr>
<td>6</td>
<td>-0.008</td>
</tr>
<tr>
<td>7</td>
<td>-0.013</td>
</tr>
<tr>
<td>8</td>
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</tr>
<tr>
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<td>10</td>
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</tr>
<tr>
<td>11</td>
<td>-0.084</td>
</tr>
<tr>
<td>12</td>
<td>0.171</td>
</tr>
</tbody>
</table>

Source: Generated in Eviews by author

*Figure 3.* Correlogram of Canada inflation changes

![Correlogram of Canada inflation changes](image)

Source: Generated in Eviews by author

*Figure 4.* Canada mean residuals

![Canada mean residuals](image)

**Iceland.** First inspection of the untreated inflation variable, by performing the ADF test, shows the absence of a unit root at level, making first-differencing unnecessary, shown in Table 5 (Greene, 2008). Figure 5 shows the correlogram.
Several significant PACF and ACF spikes would indicate a combination of AR and MA terms (Nau, 2014). A mean equation with ARIMA (1,0,12) structure is chosen, based on minimization of AIC and Schwarz, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 6. It is evident that errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. In accordance with the literature, variance regressors are added to the GARCH estimation, represented by $IT_{dummy}$ and Friedman, with coefficients $\lambda_3$ and $\lambda_4$ respectively (Tas, 2012). Their values are listed in Table 7. $\lambda_3$ is insignificant and also unexpectedly positive. This evidence suggests that the adoption of inflation targeting has not led to a reduction in inflation variance in Iceland (Tas, 2012). $\lambda_4$ is significant and positive, implicating that the Friedman hypothesis holds (Tas, 2012). This evidence suggests that the level of inflation in Iceland impacts the amount of inflation variance (Tas, 2012).

Figure 5. Correlogram of Iceland inflation
Switzerland. First inspection of the untreated inflation variable, by performing the ADF test, shows the absence of a unit root at level, making first-differencing unnecessary, shown in Table 5 (Greene, 2008). Figure 7 shows the correlogram. Several significant PACF and ACF spikes would indicate a combination of AR and MA terms, and significant spikes on the 12th lags would suggest MA(12) (Nau, 2014). A mean equation with ARIMA (1,0,12) structure is chosen, based on minimization of AIC and Schwarz, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 8. It is evident that errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. Consistent with
previous work, variance regressors are added to the GARCH estimation, represented by $IT_d\text{ummy}$ and $Friedman$, with coefficients $\lambda_3$ and $\lambda_4$ respectively (Tas, 2012). Their values are listed in Table 7. $\lambda_3$ is significant but unexpectedly positive. This evidence suggests that the adoption of inflation targeting has led to an increase in inflation variance in Switzerland (Tas, 2012). $\lambda_4$ is significant and positive, suggesting that the Friedman hypothesis holds (Tas, 2012). This evidence suggests that the level of inflation in Switzerland impacts the amount of inflation variance (Tas, 2012).

![Table 7](image)

Source: Generated in Eviews by author

*Figure 7*. Correlogram of Switzerland inflation

![Switzerland mean residuals](image)

Source: Generated in Eviews by author

*Figure 8*. Switzerland mean residuals

**United Kingdom.** First inspection of the untreated inflation variable, by performing the ADF test, shows the presence of a unit root at level. After
first-differencing, the data become stationary, shown in Table 5 (Greene, 2008). Figure 9 shows the correlogram. One significant ACF spike and several significant PACF spikes would indicate inclusion of an MA term (Nau, 2014). However, the literature also recommend a large AR term of AR(12) or above (Tas, 2012). Consistent with the literature, a mean equation with ARIMA (12,1,1) structure is chosen, based on minimization of AIC and Schwarz, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 8. It is evident that errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by \( \lambda_1 \), is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by \( \lambda_2 \), is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. Consistent with previous literature, variance regressors are added to the GARCH estimation, represented by \( IT_{dummy} \) and \( Friedman \), with coefficients \( \lambda_3 \) and \( \lambda_4 \) respectively (Tas, 2012). Their values are listed in Table 7. \( \lambda_3 \) is significant and negative. This evidence suggests that the adoption of inflation targeting has led to a decrease in inflation variance in the United Kingdom (Tas, 2012). \( \lambda_4 \) is significant and positive, suggesting that the Friedman hypothesis holds (Tas, 2012). This evidence suggests that the level of inflation in the United Kingdom impacts the amount of inflation variance (Tas, 2012). However, it should be noted that inflation in this data set was first-differenced. The interpretation of \( \lambda_4 \), which now represents the impact of changes in inflation on inflation variance, may no longer valid in investigating the
Friedman hypothesis (Tas, 2012).

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</tbody>
</table>

Source: Generated in Eviews by author

*Figure 9.* Correlogram of United Kingdom inflation changes

Source: Generated in Eviews by author

*Figure 10.* United Kingdom mean residuals

**Developing Nations.** The developing nations investigated in this study include Chile, Israel, Mexico, and the South Korea. Their results are presented here.

**Chile.** First inspection of the untreated inflation variable, by performing the ADF test, shows the absence of a unit root at level, making first-differencing unnecessary, shown in Table 5 (Greene, 2008). Figure 11 shows the correlogram. Several significant PACF and ACF spikes would indicate a combination of AR and MA terms (Nau, 2014). A mean equation with ARIMA (1,0,1) structure is chosen, based on minimization of AIC and Schwarz, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results
of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 12. It is evident that some errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. In accordance with the literature, variance regressors are added to the GARCH estimation, represented by $IT\text{dummy}$ and $Friedman$, with coefficients $\lambda_3$ and $\lambda_4$ respectively (Tas, 2012). Their values are listed in Table 7. $\lambda_3$ is predictably negative, but insignificant. This evidence suggests that the adoption of inflation targeting has not led to a reduction in inflation variance in Chile (Tas, 2012). $\lambda_4$ is significant and positive, implicating that the Friedman hypothesis holds (Tas, 2012). This evidence suggests that the level of inflation in Chile impacts the amount of inflation variance (Tas, 2012).

<table>
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<tr>
<th>Sample: 1955M01 to 2013M12</th>
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<td>Included observations: 527</td>
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<table>
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<th>PAC</th>
<th>Q-Stat</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
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<td>0.668</td>
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</tr>
<tr>
<td>2</td>
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<td>0.289</td>
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</tr>
<tr>
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<td>0.608</td>
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<td>0.530</td>
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</table>

Source: Generated in Eviews by author

Figure 11. Correlogram of Chile inflation

51
First inspection of the untreated inflation variable, by performing the ADF test, shows the presence of a unit root at level, making first-differencing necessary, shown in Table 5 (Greene, 2008). Figure 13 shows the correlogram. A few significant PACF and ACF spikes in the first two lags and 12th lag would indicate a combination of AR and MA terms (Nau, 2014). A mean equation with ARIMA (1,1,2) structure is chosen, based on minimization of AIC and Schwarz, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 14. It is evident that some errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. In accordance with the literature, variance regressors are added to the GARCH
estimation, represented by IT\(_{dummy}\) and Friedman, with coefficients \(\lambda_3\) and \(\lambda_4\) respectively (Tas, 2012). Their values are listed in Table 7. \(\lambda_3\) is significant and predictably negative. This evidence suggests that the adoption of inflation targeting has not led to a reduction in inflation variance in Israel (Tas, 2012). \(\lambda_4\) is significant and positive, implicating that the Friedman hypothesis holds (Tas, 2012). This evidence may suggest that high levels of inflation in Israel impact the amount of inflation variance (Tas, 2012). However, it should be noted that inflation in this data set was first-differenced. The interpretation of \(\lambda_4\), which now represents the impact of changes in inflation on inflation variance, may no longer valid in investigating the Friedman hypothesis (Tas, 2012).

<table>
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<th>PAC</th>
<th>Q-Stat</th>
<th>Prob</th>
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<td>0.238</td>
<td>186.96</td>
</tr>
</tbody>
</table>

Source: Generated in Eviews by author

*Figure 13.* Correlogram of Israel inflation changes

Source: Generated in Eviews by author

*Figure 14.* Israel mean residuals
Mexico. First inspection of the untreated inflation variable, by performing the ADF test, shows the absence of a unit root at level, making first-differencing unnecessary, shown in Table 5 (Greene, 2008). Figure 15 shows the correlogram. One large significant PACF spike and several decreasingly significant ACF spikes would indicate the inclusion of an AR term (Nau, 2014). However, a mean equation with ARIMA (1,0,12) structure is chosen based on minimization of AIC and Schwarz, and based on previous literature, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 16. It is evident that some errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. In maintaining compatibility with cited works, variance regressors are added to the GARCH estimation, represented by ITdummy and Friedman, with coefficients $\lambda_3$ and $\lambda_4$ respectively (Tas, 2012). Their values are listed in Table 7. $\lambda_3$ is significant and negative, as expected. This evidence suggests that the adoption of inflation targeting has contributed to a reduction in inflation variance in Mexico (Tas, 2012). $\lambda_4$ is significant and positive, implicating that the Friedman hypothesis holds (Tas, 2012). This evidence suggests that the level of inflation in Mexico has an impact on the amount of inflation variance (Tas, 2012).
Figure 15. Correlogram of Mexico inflation

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<th>P-Value</th>
<th>Q-Stat</th>
<th>Prob</th>
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</tr>
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</table>

Source: Generated in Eviews by author

Figure 16. Mexico mean residuals

**South Korea.** First inspection of the untreated inflation variable, by performing the ADF test, shows the absence of a unit root at level, making first-differencing unnecessary, shown in Table 5 (Greene, 2008). Figure 15 shows the correlogram. A few significant PACF and ACF spikes would indicate a combination of AR and MA terms (Nau, 2014). A mean equation with ARIMA (1,0,2) structure is chosen, based on minimization of AIC and Schwarz, shown in Table 6 (Tas, 2012). After determining the proper ARIMA structure, the ARCH-LM test is conducted. Results of this test are also shown in Table 6. To confirm this heteroskedasticity, an eyeball test is conducted on the mean equation residual, shown in figure 18. It is evident that some errors remain clustered together in groups, suggesting heteroskedasticity (Greene, 2008). Given the presence of a significant ARCH-LM
statistic, a GARCH estimation is permissible (Engle, 2001). The GARCH effect, represented by $\lambda_1$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation variances (Greene, 2008). The ARCH effect, represented by $\lambda_2$, is significant and positive. This suggests current inflation variances are positively correlated with previous-period inflation errors (Greene, 2008). Their values are listed in Table 7. Working closely with related studies, variance regressors are added to the GARCH estimation, represented by $ITdummm$ and $Friedman$, with coefficients $\lambda_3$ and $\lambda_4$ respectively (Tas, 2012). Their values are listed in Table 7. $\lambda_3$ is significant and negative, as expected. This evidence suggests that the adoption of inflation targeting has contributed to a reduction in inflation variance in South Korea (Tas, 2012). $\lambda_4$ is positive but insignificant, implicating that evidence cannot confirm the Friedman hypothesis (Tas, 2012). This evidence suggests that the level of inflation in South Korea does not have an impact on the amount of inflation variance (Tas, 2012).

![Correlogram of South Korea inflation](image)

Source: Generated in Eviews by author

*Figure 17*. Correlogram of South Korea inflation
Limitations

From the results, it is noted that for Canada and South Korea, the coefficient $\lambda_4$ is insignificant. This suggests that these countries do not experience increased inflation uncertainty as a result of higher inflation levels, known as the Friedman hypothesis (Payne, 2009). This coefficient insignificance may partially result from the presence of the Pourgerami–Maskus–Ungar–Zilberfarb (PMUZ) hypothesis (Payne, 2009). The PMUZ hypothesis poses that as inflation levels are increased, market actors begin using more tools to forecast inflation, which may lead to decreases in inflation uncertainty (Payne, 2009). The effectiveness of this countervailing theory may explain some of the lack of significant $\lambda_4$ values (Payne, 2009). Additionally, a greater size of countries under study would greatly improve the robustness of these results. The research was limited by the availability of inflation-targeting countries with monthly data listed on the Federal Reserve Bank of St. Louis (2014) database.

Despite close modeling of this study to the work of Tas (2012), some key differences should be noted. Firstly, Tas used data from January 1957 to October 2008 (Tas, 2012). The data in this work span February 1955 to December 2013, so some variable characteristics may differ. Furthermore, some of the data in this
study were shown to be non-stationary at level. Tas’ work found all untreated inflation data to be stationary (2012). Due to non-stationarity, some data in this work were first differenced to achieve stationarity (Greene, 2008). Consequently, analysis of the Friedman hypothesis could not be validated for all data.
Conclusion

This paper investigates the impact of inflation targeting on inflation volatility. A discussion of relevant economic theory and literature are provided. From this, argument is made for the importance of inflation control and stabilization. The paper notes that inflation stability may lead to improvement in the measures of various economic objectives and indicators. As a proxy for volatility, variance of inflation is studied using a GARCH model to estimate the conditional variance of inflation. A discussion of the proper statistical techniques and economic theory permitting this methodology is offered. From this, a dummy variable is included in the variance estimation, representing the presence of an inflation targeting regime. For the countries of Canada, United Kingdom, Israel, Mexico, and South Korea, it can be concluded that inflation targeting did significantly contribute to reductions in inflation variance. For the nations of Iceland and Chile, no significant relationship could be found. For Switzerland, a significantly positive relationship was found between inflation targeting and inflation variance. A variable denoting the impact of the Friedman hypothesis was also included in the variance equation. For the countries of Iceland, Switzerland, Chile and Mexico, the Friedman hypothesis could be confirmed. For South Korea, the Friedman hypothesis could not be proved statistically significant. For Canada, United Kingdom and Israel, variable first-differencing to achieve stationarity rendered interpretation of the Friedman coefficient useless.

From this study, it can be concluded that inflation targeting may play a significant role in impacting inflation volatility. It may also be shown that the Friedman hypothesis can be confirmed for select economies. Analysis of recent research underscores the importance of careful consideration of many macro-economic indicators when determining monetary policy. Further study of these additional factors would be necessary for any prescriptive analysis to be done.
in this work. Despite some limitations, this work serves to complement the volume of literature on the macroeconomic impacts of inflation targeting by providing an updated study of the impact of inflation targeting on inflation variance.
Table 4

**Inflation Targeting: Variance Statistics**

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<tr>
<th>Country</th>
<th>S. D. of Inflation entire period</th>
<th>S. D. of Inflation pre-targeting</th>
<th>S. D. of Inflation post-targeting</th>
<th>F-test of variance</th>
</tr>
</thead>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>0.001892</td>
<td>0.002010</td>
<td>0.001442</td>
<td>1.942 (0.00)***</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.007107</td>
<td>0.008529</td>
<td>0.002511</td>
<td>11.479 (0.00)***</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.001697</td>
<td>0.001648</td>
<td>0.001674</td>
<td>1.031 (0.82) *</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.002675</td>
<td>0.002977</td>
<td>0.001604</td>
<td>3.444 (0.00)***</td>
</tr>
<tr>
<td><strong>Developing Nations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>0.019440</td>
<td>0.025674</td>
<td>0.002779</td>
<td>85.337 (0.00) ***</td>
</tr>
<tr>
<td>Israel</td>
<td>0.015243</td>
<td>0.018487</td>
<td>0.002519</td>
<td>53.863 (0.00) ***</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.008759</td>
<td>0.009608</td>
<td>0.001690</td>
<td>32.342 (0.00) ***</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.006791</td>
<td>0.007748</td>
<td>0.001863</td>
<td>17.302 (0.00) ***</td>
</tr>
</tbody>
</table>

Source: Generated by author.

*Not Significant; **Significant at 5%; ***Significant at 1%
P-values are displayed in parentheses next to F-statistics.
Table 5
Unit Root Test of Inflation

<table>
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<th>Countries</th>
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<th>Augmented DF Test first difference, if needed</th>
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<tr>
<td>Canada</td>
<td>-2.587 (0.0961)*</td>
<td>-17.394 (0.00)***</td>
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<td>Iceland</td>
<td>-4.253 (0.0006)***</td>
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<tr>
<td>Switzerland</td>
<td>-3.033 (0.033)***</td>
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<td>-13.612 (0.000)***</td>
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<tr>
<td>Chile</td>
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<tr>
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<td>-7.399 (0.00)***</td>
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<tr>
<td>South Korea</td>
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<td>n/a</td>
</tr>
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</table>

*Not significant; **Significant at 5%; ***Significant at 1%

Table 6
The Inflation Mean Equations

<table>
<thead>
<tr>
<th>Country</th>
<th>AR(p)</th>
<th>I(d)</th>
<th>MA(q)</th>
<th>Akaike</th>
<th>Schwarz</th>
<th>ARCH-LM</th>
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<td>-9.631</td>
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<td>-7.393</td>
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<td>12</td>
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<td>-10.201</td>
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<tr>
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<td>1</td>
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<td>-9.564</td>
<td>1.97 (0.049)**</td>
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<tr>
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<td>0</td>
<td>1</td>
<td>-5.868</td>
<td>-5.844</td>
<td>8.23 (0.004)***</td>
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<td>1</td>
<td>1</td>
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<td>-6.685</td>
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<td>Mexico</td>
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<td>0</td>
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<td>-7.345</td>
<td>-7.325</td>
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Source: Author generated based on work of Bedri Tas(2012).
(p-value in parenthesis)
*Not Significant; **Significant at 5%; ***Significant at 1%
<table>
<thead>
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<th>$\lambda_2ARCH$</th>
<th>$\lambda_3ITdummy$</th>
<th>$\lambda_4Friedman$</th>
<th>Akaike</th>
<th>Schwarz</th>
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<td></td>
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<tr>
<td>Canada</td>
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<td>0.1546 (0.00)***</td>
<td>-2.98e^{-7} (0.025)**</td>
<td>6.77e^{-6} (0.958)*</td>
<td>-9.690</td>
<td>-9.639</td>
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<tr>
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<td>0.066 (0.004)***</td>
<td>5.02e^{-8} (0.573)*</td>
<td>0.0002 (0.007)***</td>
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<td>-8.416</td>
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<tr>
<td>Switzerland</td>
<td>0.862 (0.00)***</td>
<td>0.031 (0.030)**</td>
<td>9.98e^{-8} (0.029)**</td>
<td>0.0001 (0.001)***</td>
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<td>0.0001 (0.037)**</td>
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<tr>
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<tr>
<td>Chile</td>
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</tr>
<tr>
<td>Israel</td>
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<td>0.151 (0.00)***</td>
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<td>Mexico</td>
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<td>-7.20e^{-7} (0.000)***</td>
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<tr>
<td>South Korea</td>
<td>0.910 (0.00)***</td>
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<td>2.1e^{-5} (0.658)*</td>
<td>-8.387</td>
<td>-8.334</td>
</tr>
</tbody>
</table>

*Not Significant **Significant at 5%; ***Significant at 1%
Data Sources

Canada
Monthly CPI, not seasonally adjusted. Index 2010=100. 1955-01-01-2013-12-01.
Organization for Economic Co-operation and Development
http://research.stlouisfed.org/fred2/series/CANCPILLMINMEI/downloaddata

Iceland
Organization for Economic Co-operation and Development
http://research.stlouisfed.org/fred2/series/ISLCPIALLMINMEI/downloaddata

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http://research.stlouisfed.org/fred2/series/GBRCPIALLMINMEI/downloaddata

Chile
Organization for Economic Co-operation and Development
http://research.stlouisfed.org/fred2/series/CHLCPIALLMINMEI/downloaddata

Israel

Organization for Economic Co-operation and Development

http://research.stlouisfed.org/fred2/series/ISRCPIALLMINMEI/downloaddata

Mexico

Organization for Economic Co-operation and Development

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South Korea

Monthly CPI, not seasonally adjusted. Index 2010=100. 1955-01-01-2013-12-01.
Organization for Economic Co-operation and Development

http://research.stlouisfed.org/fred2/series/KORCPIALLMINMEI/downloaddata
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