DOES INFLATION TARGETING MATTER IN INDUSTRIALIZED COUNTRIES?

A Master's Thesis

by

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Economics
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Ankara
September 2006

To My Family

DOES INFLATION TARGETING MATTER IN INDUSTRIALIZED COUNTRIES?

The Institute of Economics and Social Sciences
of
Bilkent University

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In Partial Fulfillment of the Requirements for the Degree of
MASTER OF ARTS

in

THE DEPARTMENT OF ECONOMICS
BİLKENT UNIVERSITY
ANKARA

September 2006

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

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ABSTRACT

DOES INFLATION TARGETING MATTER IN

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September, 2006

After it was first adopted by the New Zealand in 1989, inflation targeting (IT) has became quite popular and several other countries have started to design their monetary policy strategies within the IT framework. In the literature, there are considerable amount of studies which discuss the underlying reasons of the popularity of IT and several of them come up with the conclusion that the increased macroeconomic performance of 1990s is attributable to the IT regime. In this thesis, we will try to discover the differing characteristics of the IT and non-IT countries in terms of their revealed aversion to inflation variability which is proposed in Cecchetti and Ehrmann (2000) (CE). Furthermore, we will investigate whether the path followed by the inflation in the aftermath of a demand shock for IT and non-IT countries are different from each other. All measures which we will be analyzed in this thesis will be estimated from a semi-structural dynamic time series model using extended Kalman filtering techniques.

ÖZET

SANAYİLEŞMİŞ ÜLKELERDE ENFLASYON

HEDEFLEMESİ FARK YARATIYOR MU?

Acar, Ozan

Yüksek Lisans, Ekonomi Bölümü

Tez Yöneticisi: Kıvılcım Metin Özcan

Eylül 2006

İlk olarak Yeni Zelanda tarafından 1989 yılında uygulanmaya başlanan enflasyon hedeflemesi rejimi, bu yıldan sonra birçok ülke tarafından benimsenmiş ve bu ülkeler para politikalarını enflasyon hedeflemesi rejimi çerçevesinde şekillendirmeye başlamışlardır. Literatürde enflasyon hedeflemesine olan artan ilginin sebeplerini araştıran birçok çalışma mevcuttur. Bu çalışmalar içerisinde 1990'lı yıllarda gözlenen makroekonomik performans artışını enflasyon hedeflemesi rejimi ile ilişkilendirenler vardır. Bu tezde enflasyon hedeflemesi yapan ve yapmayan ülkelerin enflasyondaki dalgalanmaya karşı duydukları isteksizlikte bir farklılık olup olmadığı sorusuna cevap aranacaktır. Enflasyondaki dalgalanmaya karşı duyulan isteksizlik Cecchetti ve Ehrmann (2000)'de (CE) ifade edildiği şekliyle hesaplanacaktır. Buna ek olarak, ekonomiyi vuran talep yönlü bir şokun enflasyon hedeflemesi yapan ve yapmayan ülkelerde enflasyonu nasıl etkilediği tartışılacaktır. Bu tezde analiz edilecek olan tüm değişkenler yarı yapısal dinamik bir zaman serisi modelinden, genişletilmiş Kalman filtresi tekniği kullanılarak tahmin edilecektir.

ACKNOWLEDGMENTS

I am grateful to my supervisor Kıvılcım Metin Özcan for her patience and support throughout my graduate study at Bilkent University.

I also want to express my gratitude to Ümit Özlale. In his very busy work days he set apart several hours to me in order to discuss this thesis. These discussions were very helpful to me and form the basis of this study together with my better understanding of monetary policy. I could confidently claim that working with him created a difference in my life.

I also appreciate Levent Özbek, Selin Sayek Böke, Bedri Kamil Onur Taş, Refet Gürkaynak, Serdar Sayan, Ashoke Kumar Sinha, and Çağrı Sarıkaya for their invaluable comments.

My precious friends; Tural Huseynov, Onur İnce, İbrahim Barış Esmerok, Mustafa Uysal, Bahar Tözün, Beyza Polat, Burcu Afyonoğlu, Ussal Şahbaz, Savaş Kuş, and Esen Çağlar (in order of getting acquainted), each of them deserves special thanks for their support and friendship.

I am also thankful to Banu Demir for her invaluable contributions to this thesis. She did not leave me alone and supported me at every stage. I feel so lucky for having the support of such a wonderful person. Her presence empowered me a lot.

Finally very special thanks go to my family, especially to my mother.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

After price stability has come to be primary goal of the monetary authorities in the last decade, a dense literature has emerged in order to analyze the general characteristics of effective monetary policy to see whether this goal is achievable. As stated in many papers including Woodford (2004) and Faust et al (2004), such effectiveness depends on the extent to which the expectations of the public are reshaped by the policy announced or implemented. In that sense, following transparent monetary policies and having commitment technologies to anchor inflation expectations are considered as two important objectives, which central banks should pursue.

Based on the above discussion, it is not surprising to see that most of the research in this field focuses on inflation-targeting regimes, in which transparency and commitment play dominant roles. As it is stated in Woodford (2004), the inflation targeting (IT) rule, ``a rule under which the central bank's commitment is defined by a target for certain variables at a certain distance in the future'', facilitates public understanding of the policy and thus has an effect on the expectations of the public. This type of a commitment to an announced target helps the public form more anchored expectations regarding the outcome that the policy is designed to influence. In addition to these characteristics, as stated in Bernanke et al. (1999), these regimes can be considered as "constrained discretion", where there is also room for stabilizing negative supply shocks as long as the long-run price stability objective is not distorted.

After its first adoption by New Zealand on the second quarter of 1989, many other central banks, have implemented IT and none of them abandoned this regime with their own consent. All of these banks have realized the importance of transparency, commitment and constrained discretion in the policy making process. In fact, several empirical studies provide results that are in favor of these regimes. One common finding in Siklos (1999), Corbo et al (2001), Petursson (2004) and Levin et al (2004) is that inflation persistence has significantly decreased after the adoption of IT. In addition, Dittmar et al (1999), Johnson (2002, 2003), Gavin (2003), Petursson (2004) and Levin et al (2004) find that IT has played a significant role in anchoring and lowering inflation expectations.

However, the success of IT regimes is criticized on a very important ground: As CE, Groenveld (1998) and Bernanke et al (1999) argue, the improvements in the inflation dynamics cannot be solely attributed to IT. CE show that, regardless of the implemented policy regime, the last decade witnessed a significant increase in inflation aversion. After deriving a measure from a pre-specified loss function of the central banks, they find evidence that there is not a significant difference between inflation targeters and their counterparts in terms of aversion to inflation. Also, Bernanke et al (1999) and Groenveld (1998) show that the implementation of IT does not exhibit any change in the actual inflation process. Consequently, while one strand of the literature provides evidence in favor of IT regimes, the other argues that the success in fighting inflation is the result of an overall increase in the inflation aversion in the world economy and adds that achieving price stability does not necessarily depend on a particular monetary policy regime.

This thesis takes the above discussion as its starting point and analyzes the differences between IT countries and their non-IT counterparts within a semi-structural dynamic time series model. Consistent with a Phillips Curve specification, the model can be described as a system of equations where the inflation and output gap dynamics are analyzed within a time-varying parameter framework. Such an approach, which has not been followed in the IT literature before, can better capture the macroeconomic dynamics of the economy, which vary to a significant extent depending on different policy regimes.

In particular, we extend the analysis on two grounds. First, we obtain two alternative measures of inflation aversion and investigate whether there is a significant difference between IT and non-IT countries. In other words, we investigate the same issue with CE within the context of a more dynamic framework. Our findings show that, similar to CE, there has been an increase in inflation aversion for both groups of countries. However, the results also show that, while the average value of the inflation aversion measure for IT countries was lower than the average value of their non-IT counterparts before implementing the regime, the situation is reversed after these economies adopted inflation targeting. More specifically, we find a statistically significant difference between the increases in the average values of the inflation aversions, in favor of the IT group. As a result, we can say that, in a macroeconomic framework, where the changing dynamics of the economy is accounted for, aversion to inflation for the IT countries has increased significantly more than the aversion for the non-IT countries.

Second, and more importantly, for the two sets of countries, we analyze the responses of inflation to output gap shocks that may disturb the price dynamics. Our reasoning for such an exercise is as follows: within an IT framework, commitment technologies induce monetary authorities to take pre-emptive actions and absorb the output gap shocks. In other words, bounded with a pre-announced inflation target, central banks follow more aggressive monetary policies to reduce any negative effects of output gap shocks on price stability. Furthermore, commitment mechanisms and transparency of the monetary policy may help to keep the inflation expectations in the economy within a certain band. Thus, augmented through the expectation mechanism, the reflection of the negative effects of the output gap shocks on inflation may be less in an IT framework.

The findings from the above-mentioned exercise constitute the crux part of this thesis. We find that, after economies switch to IT, there is a significant decrease in the response of inflation to output gap shocks. In other words, IT ensures that price stability becomes less prone to output gap shocks. However, for the non-IT countries, we do not observe such a finding in any part of the sample period. In that sense, this thesis reveals a very important characteristic of the IT regime, which has not been analyzed in the literature.

The rest of this paper comprises three chapters. The second chapter presents the estimation methodology of unobserved components used in the analysis of the subsequent chapters together with the data and sample. The third chapter gives the empirical results of the thesis. Mainly, the inflation variability aversions and response of inflation to a demand shock for the countries in our sample are present in this chapter. Finally, section four concludes.

CHAPTER II

ESTIMATION OF THE UNOBSERVED COMPONENTS

In this chapter we will present our methodology used in the estimation of the parameters and variables, which we use in the calculation of the degree of inflation variability aversion of the central banks and evolution of the inflation in response to a shock coming to output-gap.

One of the most important elements in the information set of the central bank in the conduct of monetary policy is the output-gap, which is defined as deviations of actual output from its potential level. Okun (1964) defines the potential output as the maximum amount of output produced without inflationary pressures. If the output exceeds the potential level then this signals rise in future inflationary pressures. In the seminal work of Taylor (1993), output gap is taken as an important determinant of the path of short term policy rates set by central banks pursuing price stability. Taylor (1993) proposes a policy rule. When output is above (below) potential level then policy requires a rise (decline) in the short--term interest rates. Output-gap is a sign of future demand pressures. Therefore, the importance of the measurement of the output-gap increases under IT regime. The sign of it calls for the required policy reaction which is necessary in order not to miss the target. However, the potential output and consequently the output-gap are unobservable variables. Therefore several techniques are devised in order to estimate them.

The most popular technique used in the estimation of the potential output is the Hodrick-Prescott (HP) filter. HP filter is a smoothing algorithm which decomposes the original series to its long-run trend and cyclical components. The long-run trend in the actual output data is assumed to be the potential output. However this technique has several shortcomings. First of all, it is a pure statistical filter and it does not take into account the other variables, which interact with the main variable of interest. Secondly, although the end sample estimate of the potential output is the most vital information for the conduct of monetary policy, HP filter's end sample performance is poor due to its reliance to lead information. In addition, it is well documented in Laxton and Tetlow (1992) and Harvey and Jaeger (1993) that the H-P filter, produces imprecise estimates even for the United States economy, which the fluctuation in economic activity is relatively scarce. In addition, as Graff (2004) mentions, when the multivariate HP filter is employed, the revisions to real-time output gap have been no smaller than had a standard HP filter been used. Several other shortcomings of the HP filter are given in Orphanides and van Norden (1999).

In addition to pure statistical techniques, production function approach is another way to estimate potential output. In the application of this methodology the assumptions regarding the production technology existing in the economy should be made. Afterwards, the real time data of endowments, such as capital and labor, are required to substitute into presumed production technology in order to derive the potential output. However, this method does not give precise estimates for emerging market economies due to unreliability of the data. As the reliability of the data increases output-gap measures derived via production function method becomes more reliable. Obviously, the quality of the data available for developed countries is higher than the ones available for emerging market economies. Therefore OECD's output-gap estimates which are obtained through production function method will allow us to make comparisons between OECD's estimates and ours.

One natural candidate for the estimation of the potential output which does not suffer from the above mentioned criticisms is to use statistical methods that have an economic content. Potential output is affected by the changes in microeconomic fundamentals such as productivity and labor supply. In the estimation of the potential output with bivariate filtering techniques, Kuttner (1994) rules out the microeconomic determinants of the potential output and deals with macroeconomic determinants. However, in this study it is assumed that the microeconomic variables, such as labor and capital productivity, remain unchanged for a long period. Given the rapidly changing macroeconomic dynamics as well as the characteristics of the monetary policy and fiscal policy, assuming a constant relationship between the macroeconomic variables can be a strong assumption. This study extends Kuttner (1994) in that direction and estimates a time-varying system of equations, where the output-gap and the potential output are treated as unobservable variables. By doing so, the changing macroeconomic dynamics can be clearly captured and the effects of different monetary policy regimes on output-gap can be analyzed. One similarity with Kuttner (1994) is that we rule out the micro determinants and focus on macroeconomic variables. However, as mentioned before, we will compare our estimates with the OECD's official output-gap estimates for robustness purposes. Another contribution of this thesis is that, unlike Laubach and Williams (2003), Kuttner (1994) and Gerlach and Smets (1999), we employ a more structured system: Different than specifying a time series process for the output-gap, we assume that the unobserved output-gap is affected by a set of exogenous variables. By doing so, we derive the output-gap from a more structured economic content. The next section describes our model.

II.1 The Model

We assume that the economy can be characterized with a set of equations which are given below. Quarterly seasonally adjusted consumer price index (CPI)[1] inflation rate is denoted by π_t (t denotes time), gap_t is the unobserved output gap, IP_t is the logarithmic difference of import price index, y_t is the seasonally adjusted logarithmic real gross domestic product, y_t^* is the unobserved potential output, μ_t is the potential output growth rate, and finally r_t is the ex-post real interest rate based on commercial bank rate or overnight lending rate. The detailed breakdown of the data sources are given in the data appendix. Shocks to the system are denoted by the disturbance terms, which are assumed to be i.i.d with zero mean and constant variance.

$$\pi_t = \alpha_{1,t}\pi_{t-1} + \alpha_{2,t-1}\pi_{t-2} + \alpha_{3,t-1}gap_{t-1} + \alpha_{4,t-1}IP_t + \nu_t \qquad (1)$$

$$y_t = y_t^* + gap_t \qquad (2)$$

$$y_t^* = y_{t-1}^* + \mu_{t-1} + \eta_t \qquad (3)$$

$$\mu_t = \left(1 - \rho_t\right)\mu_0 + \rho_t\mu_{t-1} + \varsigma_t \qquad (4)$$

$$gap_t = \gamma_{1,t}gap_t + \gamma_{2,t}r_t + \gamma_{3,t}IP_t + \xi_t \qquad (5)$$

[1] Since CPI is the most commonly observed price index, which is closely associated with the expectations about inflation in the economy, using annualized CPI inflation is thought to be appropriate.

The first equation of our system characterizes the inflation dynamics. It is a Philips curve specification, where the inertia is represented with two lagged values of inflation. In addition, the inflationary pressure of the aggregate demand is controlled by the lagged value of the output-gap, while the supply side cost effects of the exchange rate developments are taken into account by including the import price index. Existence of the output-gap with one period lag ensures the delay in the transmission of the demand shock to inflation.

As in Watson (1986), Kuttner (1994) and Harvey and Jaeger (1993) we decompose actual output as the sum of unobserved potential output and output-gap in the second equation. The third equation defines the potential output as a random walk with a drift. Since the coefficient of lagged potential output is equal to unity, shocks to the potential output have permanent effects, as implied in Blanchard and Quah (1989). The fourth equation describes the evolution of the potential output growth rate μ_t. With such a specification the μ_t is assumed to be a function of its own lagged value and a pre-determined steady state growth rate μ_0. The parameter ρ $(0 < \rho < 1)$ shows the degree of the persistence of the μ_t. In the one extreme, having ρ close to unity signals that potential output growth rate can diverge from the steady state growth value for substantially long periods, and vice-versa. As discussed by Orphanides and van Norden (1999), linear models which characterize μ_t as a cycle around a constant, μ_0 in our case, have large revisions due to parameter instability in the estimated μ_t. In addition, a large set of countries, including the industrialized economies in our sample have experienced structural transformations through the period being analyzed. These points provide the basis for assuming a time varying growth rate for the trend.

The final equation of the model describes the evolution of the output gap. As mentioned above, rather than specifying a pure time series process, we also include several macroeconomic variables that are thought to affect the output-gap. While setting these regressors, with a new Keynesian perspective, we included a monetary policy variable and a cost factor which may lead to deviation of actual output from its potential level in the short-run. As a result the regressors are the first lagged value of the output-gap, the real interest rate and the import price index. None of these regressors is assumed to affect the potential output. The real interest rate, as the policy instrument for the central bank, affects the output through the conventional monetary policy transmission mechanism. Any increase in the interest rate at time t causes a decrease in the actual output level through a decrease in investment and consumption. However, the role of import price index is less clear. The changes in the value of the domestic currency will have its effect directly in the import price index. A decrease in the import price index via appreciation of the domestic currency will lead to a decrease in the net exports and thus lower the aggregate demand. However, in such a case the consumption and the investment upsurge due to lower cost of imported intermediate and final goods. As a result, the net effect of import price index on the output-gap is ambiguous.

In addition to the above equations in the system, our model consists of eight more equations. The number of time varying parameters in the system is eight and for estimation purposes we have to specify a time series process for each of these time varying parameters. As it is stated in Evans (1991), one fundamental source of the variations in the economy is the changing views about the structure of the economy. Therefore, if we assume that the unexpected policy changes lead to a change in the relationship between two variables then it is appropriate to specify a random walk process for our system parameters. The next section gives the state-space form of the above system.

II.2 The State Space Representation

An unobserved components model can be estimated after the system of equations is presented in a state-space form where the standard Kalman filter emerges as the optimal estimation algorithm. However, in our model, the fact that time-varying parameters and the unobserved state variables in E1, E4, and E5 appear in multiplicative forms, rules out the linearity in the state-space. Therefore, standard Kalman filter is no longer appropriate to estimate the unobserved components. Formally the state-space form can be written as:

$$\begin{bmatrix}\pi_t \\ y_t\end{bmatrix}=\begin{bmatrix}1 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 1\end{bmatrix}\begin{bmatrix}\pi_t \\ \pi_{t-1} \\ y_t^* \\ \mu_t \\ gap_t\end{bmatrix} \tag{6}$$

$$\begin{bmatrix}\pi_t \\ \pi_{t-1} \\ y_t^* \\ \mu_t \\ gap_t\end{bmatrix}=\begin{bmatrix}\alpha_{1,t} & \alpha_{2,t} & 0 & 0 & \alpha_{3,t}\\ 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 1 & 1 & 0\\ 0 & 0 & 0 & \rho_t & 0\\ 0 & 0 & 0 & 0 & \gamma_{1,t}\end{bmatrix}\begin{bmatrix}\pi_{t-1} \\ \pi_{t-2} \\ y_{t-1}^* \\ \mu_{t-1} \\ gap_{t-1}\end{bmatrix}+\begin{bmatrix}\alpha_{4,t} & 0 & 0\\ 0 & 0 & 0\\ 0 & 0 & 0\\ 0 & 1-\rho_t & 0\\ \gamma_{3,t} & 0 & \gamma_{2,t}\end{bmatrix}\begin{bmatrix}IP_t \\ \mu_0 \\ r_t\end{bmatrix}+\begin{bmatrix}\upsilon_t \\ 0 \\ \eta_t \\ \varsigma_t \\ \xi_t\end{bmatrix} \tag{7}$$

In such cases the extended Kalman filter is used to estimate the state of a system which is governed by non-linear stochastic difference equations. More specifically, the state-space representation will be as:

$$x(t)=Fx(t-1)+Gu(t)+e_1(t) \tag{8}$$

$$z(t)=Hx(t)+e_2(t) \tag{9}$$

E6 and E7[2] are state and observation equations, respectively. Vector of state and control variables of our system are x_t and u_t, respectively. z_t is a vector and its first and second elements are π_t and y_t, respectively. The state vector contains both unobserved and observed variables. The matrix F relates the state at time t to the state at time $t-1$ and matrix G relates the control at time t to the state at time $t-1$. Both F and G matrices contains a priori unknown time varying parameters. Measurement and transition noises are e_1 and e_2, respectively. They are assumed to be independent of each other, white, and normally distributed.

[2] Henceforth we will use EX in order to refer to equation number X.

Before executing the extended Kalman filter algorithm, we first treat each time-varying parameter as a new state variable and form the extended state vector. Finally, we linearize the estimation around the current estimate using the partial derivatives of the state and observation functions[3]. The results are given in the section.

II.3 The Data and Sample

The data used in this thesis is mostly obtained from International Financial Statistics (IFS) of International Monetary Fund (IMF). However, for some variables we request the data from the central banks of the countries mentioned below. The detailed breakdown of the data sources is given in the data appendix.

In this thesis, our sample consists of industrialized countries, in which the central banks that adopted IT before 1999 are classified as IT countries while the ones that have not shifted to IT before 1999 are classified as non-IT countries. IT countries are; Australia, Canada, New Zealand, Spain, Sweden, and United Kingdom. Whereas Denmark, Italy, Japan, Netherlands, Norway, Switzerland, and the United States account for control group of non-IT countries.

We take the adoption dates of inflation targeting from Bernanke et al. (1999), which are available in Table 1 in the Appendix C. IT countries except Spain continue to design their monetary policy strategy under the IT framework. Spain has abandoned the targeting framework due to the advent of the Euro. Our sample consists of countries which are members of European Monetary Union (EMU), namely Spain,

[3] The details of the algorithm can be obtained from the book titled "Theory and practice of recursive identification" by Ljung and Soderstrom (1983).

Italy and the Netherlands. Membership of the EMU ties the individual central banks' hands in the conduct of independent monetary policy. In other words, EMU countries monetary strategies are based on fixing exchange rate and meeting convergence criteria. Therefore members of the EMU are not considered as IT countries. Switzerland and Norway adopted inflation targeting in 2000 and 2001, respectively. As in Ball and Sheridan (2003), we exclude these countries' brief targeting periods and treat them as non-IT countries.

CHAPTER III

EMPIRICAL RESULTS

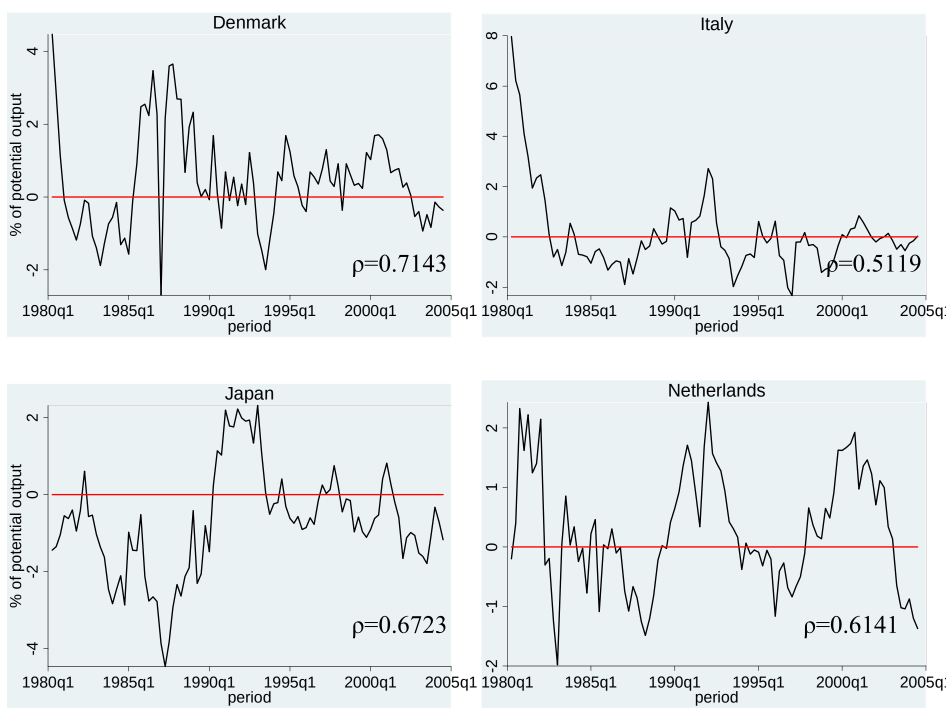
In this chapter we will first present our resulting estimates of the output-gap series together with their empirical fit for the countries in our sample. Secondly, we will calculate the inflation variability aversions of the countries in our sample, and investigate whether IT and non-IT countries have differing degree of aversion towards inflation variability. Furthermore, we will try to discover whether IT countries increased their revealed aversion to inflation variability more than non-IT countries after adoption of IT. Finally, we will discover the impact of IT on the evolution of the inflation in response to a demand shock.

III.1 Output-gap Estimates

The model that is introduced above can be criticized for lacking a pure structural content. Thus, we will test the empirical fit of our model on two grounds. Firstly, we will compare our output-gap estimates, with the OECD's officially announced estimates. Secondly, we will test whether our assumptions about the time-series specification of the parameters and the distribution of the error terms present in the system are satisfied or not.

The estimated output-gap series can be seen in figure 1a and 1b. Upper panel and lower panel of the figure contain IT and non-IT countries' output gap series, respectively. The empirical fit of the estimated series is going to be evaluated with direct comparison with the OECD's estimates. The correlation coefficient between the OECD's estimate and our estimate is given in the lower right corner of each plot. New Zealand has the lowest correlation coefficient which is approximately 0.30. In fact, the average value of correlation coefficient for the whole sample is 0.70, providing support for the empirical fit of the model. Furthermore, as a striking example we plot the Bank of Canada's[4] and ours estimate together in figure 2. In that sense, when our output gap estimate for Canada is compared with the Bank of Canada's official estimates, we see that the two series are almost identical.

Figure 1a: Output-gap estimates of non-IT countries



[4] Bank of Canada's output-gap estimate is publicly available on the web (www.bankofcanada.ca).

Figure 1a, cont.

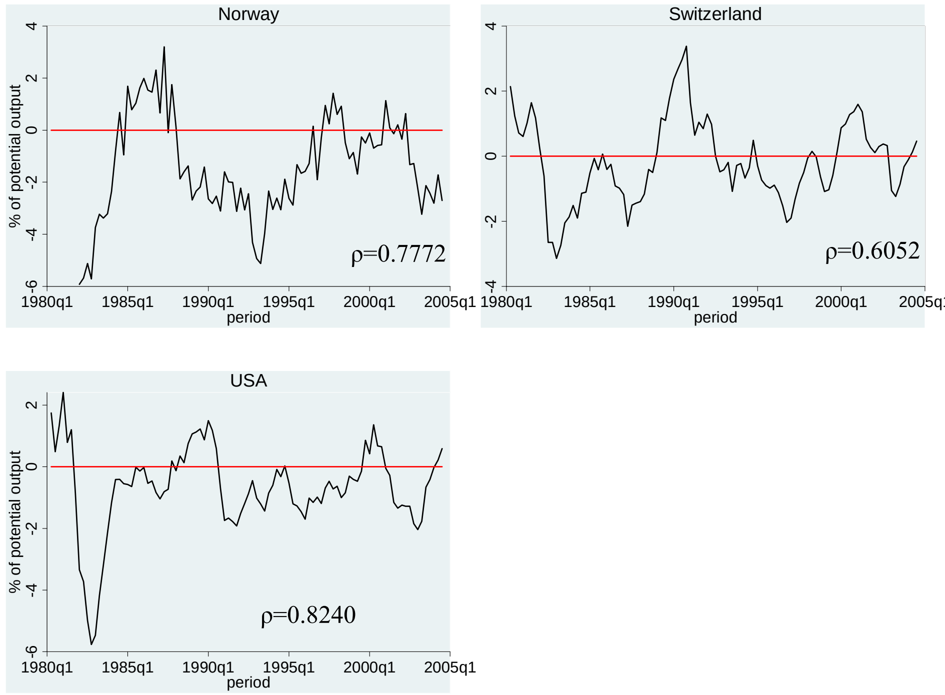
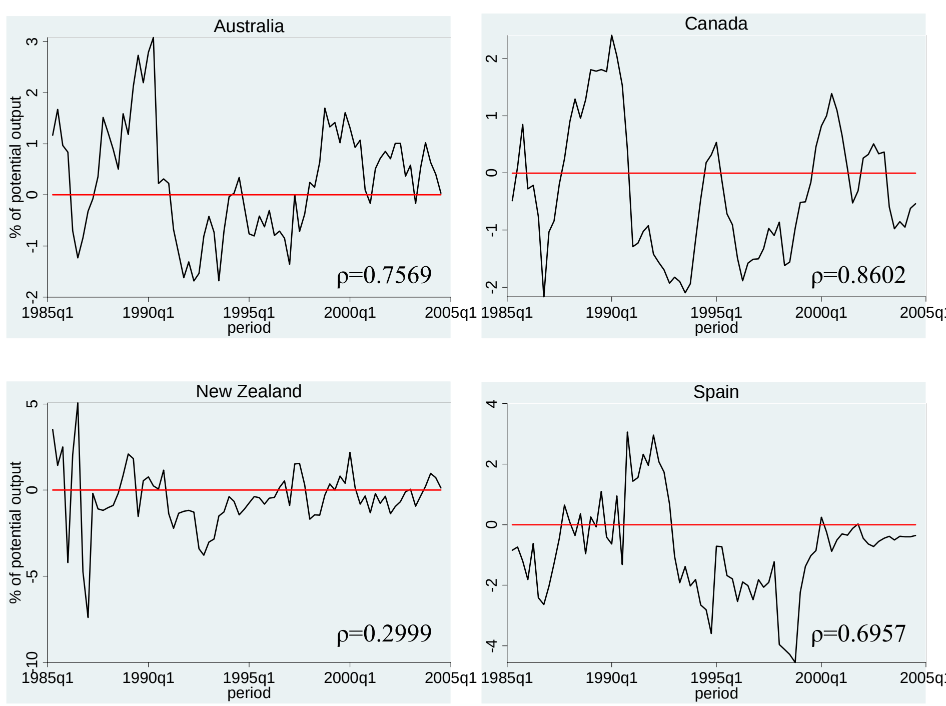
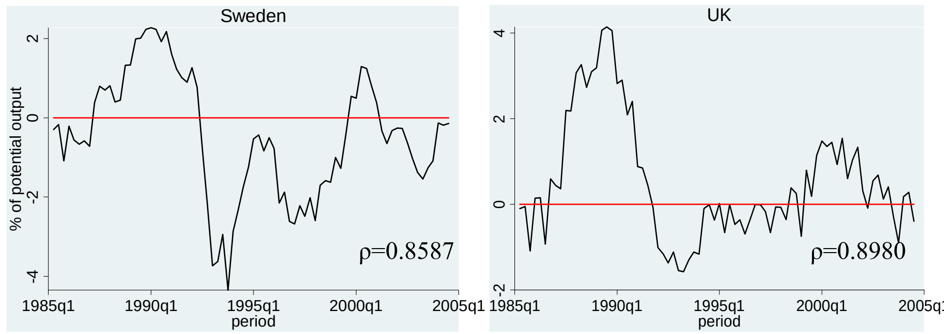


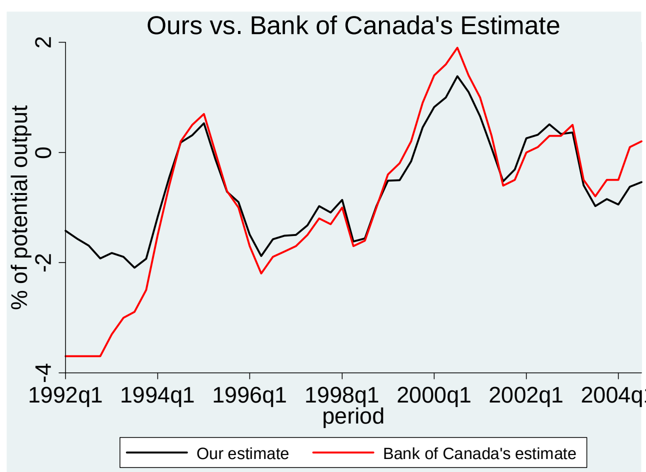
Figure 1b: Output-gap estimates of IT countries





Note: Above graphs are the output gap series of the non-IT and IT countries. Sample period is 1985q2-2004q3 for New Zealand and 1980q2-2004q3 for the remaining countries. The term ρ in the lower right corner of each graph is the correlation coefficient between OECD's estimate and ours. OECD publishes output gap estimates on a yearly basis and they are available from 1984 to 2003. We calculate the yearly output gap estimate as the weighted average of the quarterly output gap, $gap_{year} = \sum_{q=1}^{4} \frac{gap_q y_q^*}{y_{year}^*}$.

Figure 2: Comparison with Bank of Canada's official estimate



Next, we will test whether the time-varying parameters present in our system actually follow random-walk. As it can be seen in Table 2 of Appendix C, the resulting coefficient obtained after regressing each parameter to its own lagged value is close to unity. This and the comparison of output-gap estimates with officially announced estimates allow us to defend the empirical fit of our model. In the next chapter, we will discover whether IT actually matters in terms of degree of inflation variability aversion and evolution of the inflation in response to a demand shock in IT and non-IT countries.

III.2 Inflation Variability Aversion in IT and Non-IT Countries

This section explains the calculation of the inflation aversion coefficients of the countries in our sample. The formula used in the derivation of aversion coefficients is same as the one derived in Cecchetti and Ehrmann (2000) (CE). Before presenting our methodology and results, we will briefly discuss the model developed in CE.

In CE, it is assumed that the central banker has a quadratic loss function which is increasing in its two arguments; square of the deviation of actual output from the potential one, and the deviation of inflation from its desired level (in case of IT, it can be thought of as inflation target itself). The main interest of CE is to calculate the degree of aversion to inflation variability of the central banker. The actual output and the realized inflation (arguments of the loss function) are functions of interest rate, aggregate supply and aggregate demand shocks. The policy tool of the central bank which it uses to accommodate the adverse shocks is the short-term interest rate. In order to minimize the value of the loss function, central bank decides on the path of the interest rate. In CE, it is assumed that aggregate demand shocks affect the output and inflation in the same direction and central bank can fully accommodate it by changing interest rates. On the other hand, since aggregate supply shocks move the output and the inflation in the opposite directions, aggregate supply shocks create a trade-off in the policy action. By using its policy tools, the central bank is assumed to be capable of moving output and inflation in the same direction. Therefore, changing interest rates is analogous to an aggregate demand shock. Since aggregate demand shocks do not create a tradeoff, central bank is capable of fully accommodating it. On the other hand, the response to aggregate supply shocks is more complex. This complexity stems from the move of output and inflation in opposite directions in case of an aggregate supply shock. The magnitude of the interest rate response to an aggregate supply shock depends upon the slopes of the aggregate demand and supply curves together with the policymaker's aversion to inflation variability. Derivation of the optimal policy rule in such a setting gives the expression for the inflation aversion coefficient given in (10).

$$\frac{\sigma_y^2}{\sigma_\pi^2} = \left[\frac{\theta}{\beta(1-\theta)}\right]^2 \tag{10}$$

The arguments therein are the followings; σ_y^2 and σ_π^2 are the variances of the actual output and realized inflation, respectively. The terms β and θ denote the slope of inverse supply curve and the degree of aversion to inflation variability, respectively. During the calculation of the inflation aversion measure, CE calculates σ_y^2 and σ_π^2 from the data. For the inverse supply slope, they specify a Vector Autoregression Model (VAR) and obtain the impulse responses. Such an approach is adopted from King et al. (1991). As a result, having obtained these measures, they calculate the inflation aversion from the above formula. After we briefly explain the methodology used in CE, we will proceed with our methodology.

Including this thesis, in several studies like Corbo et al. (2001) and Tachibana (2004), the inflation variability aversion is calculated with the expression in (10). In that sense, the literature agrees upon a common formula. However, the calculation of β (slope of the inverse supply curve) differs in each study. In this thesis, we derive β from the system of equations devised in E1-E5. Such an approach leads us to obtain a model consistent measure. The exercise is conducted in two steps. First, we give a one percent shock to the interest rate. As we mentioned earlier, change in interest rate is analogous to an aggregate demand shock. Therefore, both the output and the inflation will be affected in the same direction due to the change in the interest rate. Next, in order to calculate β, we calculate the ratio of average of fifteen quarter change in the output to average of fifteen quarter change in the inflation. The derivation of equations used in the calculation of β is given in the Appendix 2.

This thesis also differs from CE in the calculation of σ_y^2. While CE calculates the "desired" trend using the HP filter, which has shortcomings as discussed in the previous sections, we derive the "desired" trend from our model, which is introduced above. In that sense, we utilize a more structured measure of output variability. Finally, we calculate σ_π^2 under two distinct assumptions which we make regarding the desired rate of inflation: In the first specification, following CE, we set the desired rate equal to two percent, while in the second one the desired rate is taken as the sample average. We separately report the resulting θs (inflation aversion coefficient) obtained under each assumption.

After obtaining the inflation aversion measures with the method specified above, we test whether inflation aversions for both groups of countries have changed significantly through time. In other words, we will analyze whether implementing IT has made a significant difference in terms of inflation aversion. For this purpose, we will first calculate the average value of IT countries' θ for the periods before and after the regime shift, whereas for non-IT countries we will calculate the average value of θ for the periods before and after the first quarter of 1993[5].

The results show that, the mean value of the IT countries' average θ before (after) the regime shift is less (greater) than the corresponding value of the non-IT countries (Table 3 of Appendix C). However, these results are not robust. When we do the same exercise excluding Italy and Japan from the sample of non-IT countries, the average value of non-IT countries' θ turns out to be greater than the average value of IT countries' θ in both periods being considered. Therefore, it may me misleading to reach a conclusion that IT countries were less (more) averse to inflation variability before (after) the regime shift compared to non-IT countries. Furthermore, after conducting two independent samples t-test[6] we also find that the average value of IT countries' θs before and after the shift to IT is not significantly different from the average value of non-IT countries' corresponding value before and after the first quarter of 1993, respectively. These findings are robust to the way we calculate the σ_π^2. The next exercise is to check whether IT countries increased their revealed aversion to inflation variability more than non-IT countries do after the regime shift occurred. Unlike the previous results the degree of the change in θ differs between IT and non-IT countries. The upper (lower) half of the Table 4 of Appendix C shows the change in the average value of θs in IT (non-IT) countries before and after the

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[5] The reason for taking the first quarter of 1993 as the benchmark for non-IT countries is that, except Spain, by this date all of the IT countries in the sample have shifted to their new policy regimes.
[6] Since we want to compare the means of two independent groups, two independent samples t-test emerges as an appropriate test.}},

adoption date (the first quarter of 1993). The magnitude of the change in the mean value of θ are significantly different from zero for all IT and in some of the non-IT countries except Japan and Switzerland. One other test to check whether the average value of θ of the countries available in our sample has increased is Wilcoxon-Mann-Whitney test[7] (Table 5 of Appendix C). The results are the followings; under the first method (desired rate of inflation is equal to 2%), all countries except Japan and Switzerland, have significantly increased their revealed aversion to inflation variability, while these two countries have significantly decreased their revealed aversion to inflation variability. When we conduct the same test under the second method (desired rate of inflation is equal to sample average) it seems that the change in the mean for the Australia's and Japan's revealed aversion to inflation variability have decreased, whereas the same magnitude has not changed in Norway, Switzerland, and the USA. The remaining IT countries seem to have increased their revealed aversion to inflation variability. In order to test whether these results are attributable to the shift in monetary policy regime, we finally check whether IT central banks have increased their revealed aversion to inflation variability more than non-IT countries. When the desired rate of inflation is assumed to be 2\%, the average increases in θ are 0.2069 and 0.0305 for IT and non-IT countries (Table 4 of Appendix C), respectively. Whereas, when the desired rate is assumed to be the sample average, the average increases in the θ are 0.0987 and 0.0047 for IT and non-IT countries, respectively. When we conduct two independent samples t-test once more, we find that IT central banks increased their revealed aversion to

[7] Basically, we test whether the average value of θ has increased after the adoption of IT. In order to test this, we treat the values of θ before and after the adoption of IT as two independent groups. Wilcoxon-Mann-Whitney test is the non-parametric version of the independent samples t-test and can be used when you do not assume that the dependent variable (θ) is a normally distributed interval dependent variable (the only assumption is that the variable is ordinal

inflation variability significantly more than non-IT countries. This finding is robust when we exclude the Italy and Japan from our sample.

As a result, the main message from this section is clear: Consistent with CE, almost every central bank in our sample has increased their revealed aversion to inflation variability during 1990s. However, our results differ in the sense that the magnitude of the change is greater in IT countries compared to non-IT countries. In CE, this difference is found to be modest. However, we conclude that the difference is far from being modest. Thus, we can claim that the characteristics of IT framework provide an extra support for achieving price stability incentives of the monetary authorities. In the next section, we will investigate additional features that can be ascribed to the IT regimes in terms of macroeconomic performance. The main emphasis will be on the evolution of shocks coming to gap on inflation.

III.3 Evolution of the Response of Inflation to Demand Shocks

The previous section shows that, although increasing aversion to inflation has been a common characteristic of the industrialized countries in the sample, the increase in the inflation aversion within an inflation targeting regime is found to be significantly higher. This section investigates another advantage of IT regimes in the policymaking process.

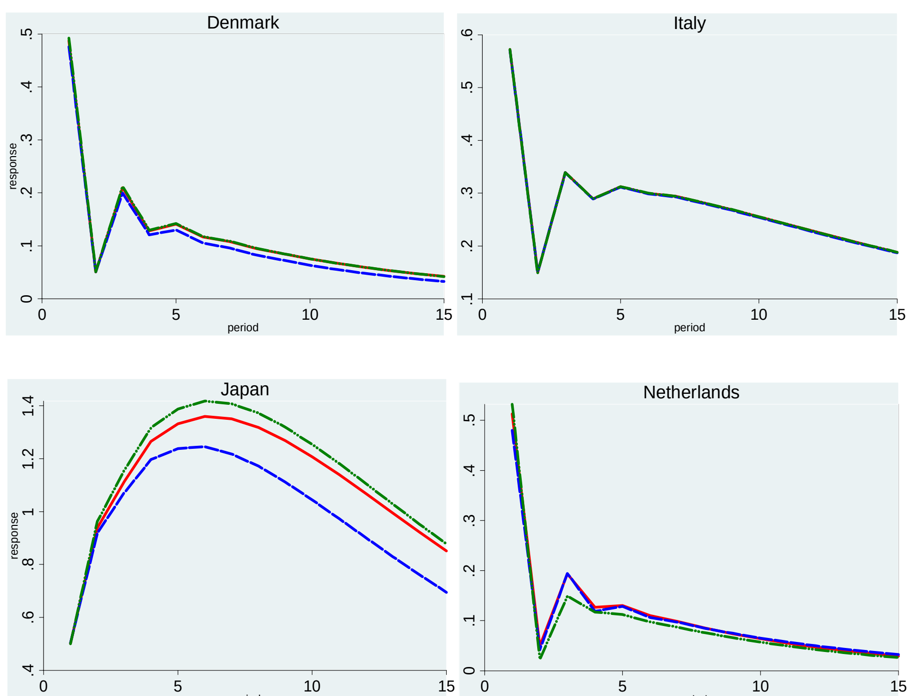
As mentioned in the first section, commitment and transparency are two of the identifying characteristics of IT regimes. While the former ensures that actual inflation will not deviate significantly from its pre-announced target, the latter helps to build the expectations of the public in a positive way. Thus, when faced with an inflationary shock that is temporary, IT central banks are expected to pursue an aggressive monetary policy to achieve the pre-announced target. Evenly important, during this process, increased communication with the public will serve the purpose of keeping inflation expectations anchored within a certain band. As a result, it can be expected that inflation dynamics will be less sensitive to temporary shocks in the economy.

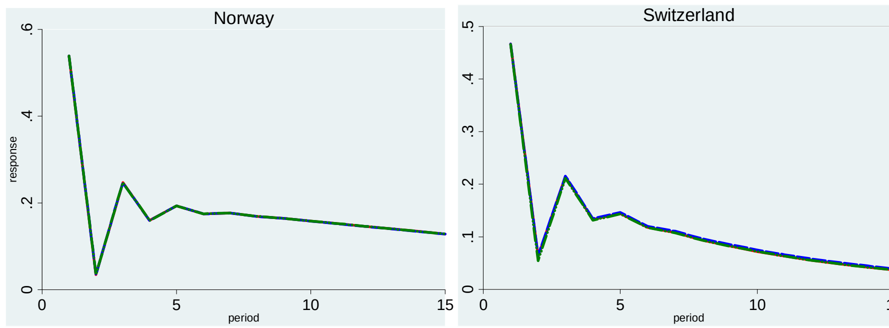
Based on the above discussion, this section displays another important characteristic of the inflation-targeting regimes, which has not been investigated in the literature before. Employing our semi-structural time series model, we show that the response of inflation to output gap shocks have been significantly lower after the countries have switched to IT regimes. However, we do not observe such a pattern for the other countries.

For achieving the above-mentioned result, we obtain the impulse responses of the inflation to an output gap shock. However, such an impulse response analysis is not trivial, since we handle the problem in a time-varying fashion. In addition, for comparison, we should derive the impulse responses for three different time spans: before inflation targeting, after inflation targeting and the last fifteen observations. The change in ξ_t (demand shock) creates a change in the output-gap and since the lagged value of the output-gap is available in E5, the effect does not die out immediately. Furthermore, in E1 (equation of π_t) the output-gap is available and the change in π_t occurs due to the change in output-gap. Iterating the system forwards will give us the impulse response funtions. Appendix 2 explains how the impulse responses are derived for these different time periods.

Figures 2a and 2b show the estimated impulse responses for the two sets of countries. Figure 2a presents the results for the non-IT countries. It is clear that, except Japan, the impulse responses of inflation to output gap shocks are almost identical for the three sample periods. For Japan, we actually find that inflation has become even more sensitive to temporary output gap shocks. Excluding the Japanese economy, another interesting result is that the shape of the impulse response functions for the non-inflation targeters are alike: Other than the initial increase in the response of inflation, we see a second hike within the first five quarters. Finally, we should add that, as expected, the effect of these temporary shocks die out in the long-run.

Figure 2a: Response of inflation in non-IT countries to a unit shock coming to output-gap





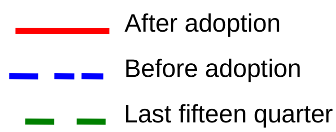
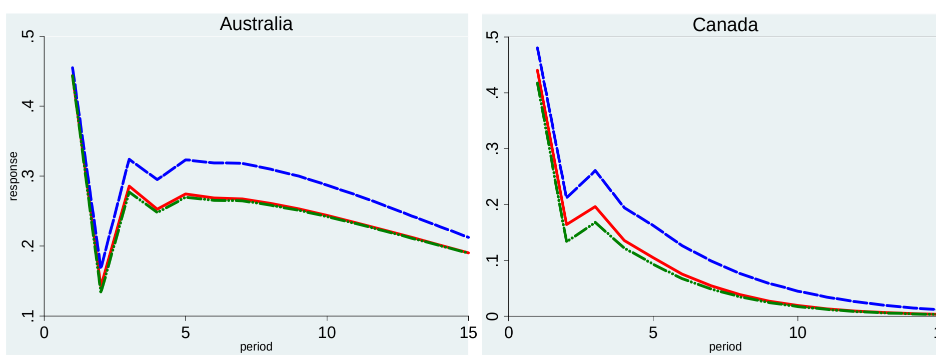
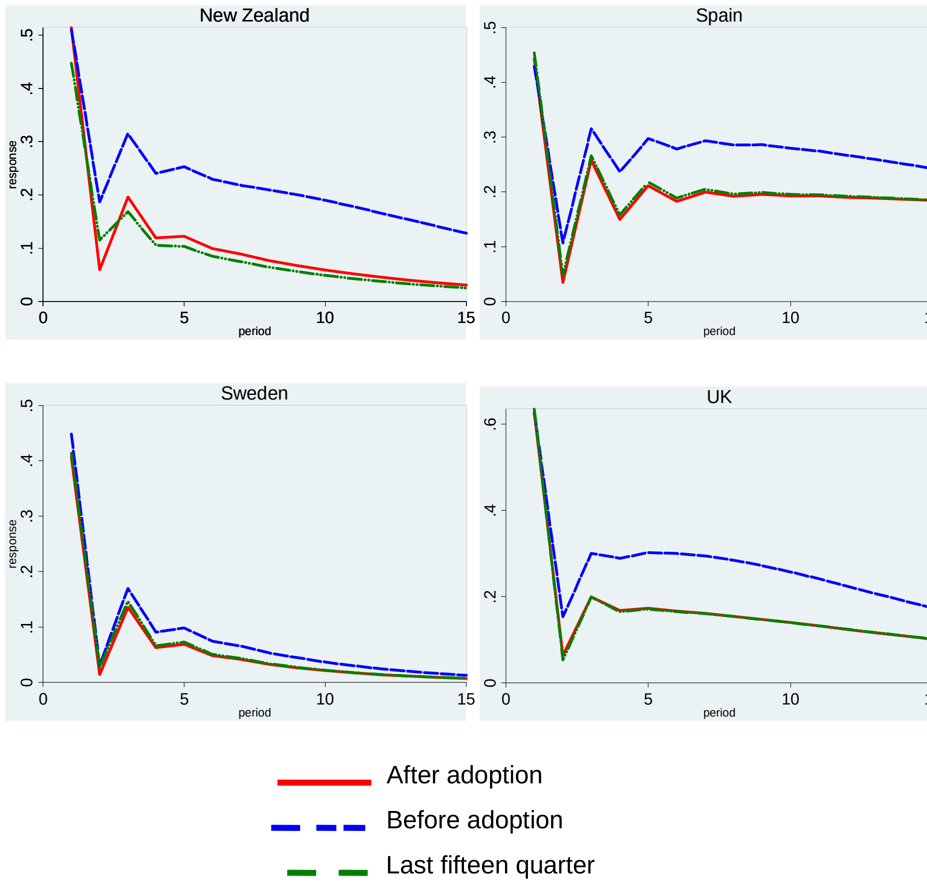


Figure 2b provides the most interesting result in this thesis. When the impulse response of the inflation to an output gap shock is estimated, it can be seen by visual inspection that all of the IT countries experience a downward level shift. Moreover, this result is robust to the sample selection in the post IT regime.

Figure 2a: Response of inflation in
IT countries to a unit shock coming to output-gap





In order to provide further support for the above findings, we also use the Wilcoxon signed-rank test[8] in order to see whether the difference between the impulse responses is statistically significant. Table 6 of Appendix C reports the test results. Under the null hypothesis that the difference between the median values of the response of inflation to an output gap shock do not differ between the two periods, we find that for all of the IT countries, the impulse responses significantly differs between the two periods. For the other group of countries, except Switzerland[9], we fail to reject the null hypothesis. As a result, we can conveniently claim that

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[8] We use the Wilcoxon signed-rank test because the difference of the magnitudes of the response of inflation to output-gap shocks among before adoption, after adoption and the last fifteen period can be classified as positive and negative.

[9] One major drawback of the Wilcoxon signed-rank test is that it does not take into account the magnitude of the difference. It takes the difference merely as positive and negative. Although the magnitude of the response of inflation to a shock coming to output-gap is negligible, it is negative. Therefore, we fail to reject the null hypothesis.

operating under an IT framework makes inflation dynamics less prone to temporary output gap shocks.

As mentioned before, such a finding has not been documented in the previous studies. In this respect, the closest study is Gurkaynak et al. (2006). Analyzing the effect of macroeconomic data releases and monetary policy announcements on long-term inflation expectations, they find that a credible IT framework helps anchor the inflation outcomes in the long run. More specifically, their results show that, after the United Kingdom and Sweden adopted IT, inflation expectations have became less sensitive to macroeconomic data releases and monetary policy announcements, while the same finding cannot be obtained for the United States, which is a non-IT country. Since macroeconomic data releases and monetary policy announcements can be regarded as anonymous to temporary output gap shocks, the findings in these two studies are consistent.

CHAPTER IV

CONCLUSION

Does IT matter in developed countries? In this thesis, on the contrary to several studies in the literature, our claim is that it matters. The emphasis given to transparency and commitment in the conduct of IT has a significant role in anchoring long-run inflation expectations. Increased aversion to inflation variability might be the one of the most important factors that might contribute to anchoring long-run inflation expectations. In the literature, several studies has focused on the inflation variability aversions of IT and non-IT countries. The pioneering work in this narrow field is Cecchetti and Ehrmann (2001) (CE). We calculate their model specific inflation aversion measure from our semi structural dynamic time series model and conclude that almost every country in our sample have increased their aversion to inflation variability. However, our results confirm CE's in the sense that IT countries have increased their aversion to inflation variability significantly more than non-IT countries in the 1990s and the difference is not modest as it is claimed in the CE. This difference may stem from not analyzing the same sample of countries in the same sample periods. The second and maybe the most important conclusion of this paper is the behavior of inflation in the aftermath of a demand shock. The evolution of the demand shock on inflation is not same as the one occurred before adoption of IT in IT countries. We observe a significant decrease in the magnitude of the change. However, in non-IT countries this difference is not present.

SELECT BIBLIOGRAPHY

Ball, Laurance and Sheridan Niamh. 2003. "Does Inflation Targeting Matter?," *IMF Working Paper,* No: 03/129

Bernanke, B.S., T. Laubach, F.S. Mishkin and A. Posen (1999), *Inflation Targeting: Lessons From The International Experience*, Princeton University Press, Princeton, NJ.

Blanchard, O and D Quah (1989), "The dynamic effects of aggregate supply and demand disturbances," *American Economic Review* 79: 655-673

Corbo, Vittorio, Oscar Landerretche, and Klaus Schmidt-Hebbel, 2001, "Assessing InflationTargeting After a Decade of World Experience," *International Journal of Finance and Economics*, Vol. 6: 343–68

Cecchetti Stephen G. and Ehrmann Michael. 2000. "Does inflation targeting increase output volatility? An international comparison of policymakers preferences and outcomes," *NBER Working Papers,* No:7426

Dittmar, R., W.T. Gavin and F.E. Kydland (1999), "Price-Level Uncertainty and Inflation Targeting," *Federal Reserve Bank of St. Louis Review*, 81(4): 23-33

Evans, M. (1991), "Discovering the Links Between Inflation Rates and Inflation Uncertainty," *Journal of Money, Credit and Banking*, 23(2): 169-184

Groenveld, J.M. (1998), *"Inflation Patterns and Monetary Policy: Lessons For The European Central Bank"*, Edward Elgar Press, Cheltenham

Graff, M. (2004), "Estimates of the Output Gap in Real Time: How Well Have We Been Doing?", *Reserve Bank of New Zealand Discussion Paper Series*, DP2004/04

Gurkaynak, Refet, Andrew Levin and Eric Swanson (2006), "Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the U.S., U.K., and Sweden," unpublished working paper

Harvey A.C. and A. Jaeger (1993), "Detrending, stylized facts and the business cycle," *Journal of Applied Econometrics*, 8(3): 231–247

Johnson, David R. (2002). "The Effect of Inflation Targeting on the Behavior of Expected Inflation: Evidence from an 11 Country Panel," *Journal of Monetary Economics* 49(8): 1521-1538

Johnson, D.R. (2003), "The Effect of Inflation Targets on the Level of Expected Inflation in Five Countries," *Review of Economics and Statistics* 85(4): 1076-1081

King Robert et al. (1987), "Stochastic Trends and Economic Fluctuations," *NBER Working Papers,* No: 2229

Kuttner, K. N. (1994), "Estimating Potential Output As A Latent Variable," *Journal of Business and Economic Statistics*, 12(3): 361-368

Laxton, D. and R. Tetlow (1992), "A Simple Multivariate Filter For The Measurement of Potential Output", *Technical Report No:59*, Ottawa: Bank of Canada.

Laubach, Thomas and Posen Adam. 1997. "Some Comparative Evidence on the Effectiveness of Inflation Targeting," *Federal Reserve Bank of New York Research Paper,* No: 9714

Levin, Andrew T., Natalucci, Fabio M. and Piger Jeremy M. 2004. "The Macroeconomic Effects of Inflation Targeting," *Federal Reserve Bank of St. Louis Review* 86(4): 51-80

Pétursson, Thórarinn G. 2004. "The Effects of Inflation Targeting on Macroeconomic Performance," *Central Bank of Iceland Working Papers,* No: 23

Pierre L. Siklos, 1999. "Inflation-target design: changing inflation performance and persistence in industrial countries," *Review, Federal Reserve Bank of St. Louis*, issue Mar: 46-58

Ozbek, Levent and Ozlale. Umit. 2005. “Employing the Extended Kalman Filter in Measuring the Output-gap,” *Journal of Economic Dynamics & Control* 29(9): 1611-1622

Orphanides Athanasios and Van Norden Simon (2002), “The Unreliability of Output Gap Estimates in Real Time,” *The Review of Economics and Statistics*, 84(4): 569-583

Svensson, Lars E. O. (1997), “Optimal Inflation Targets, “Conservative” Central Banks, and Linear Inflation Contracts,” *The American Economic Review,* 87(1): 98-114

Tachibana, Minoru. 2004. “Central Banks’ Preferences in Japan, the UK, and the US,” *Japan and the World Economy* 16(1): 81-93

Taylor, J (1993), “Discretion versus policy rules in practice,” *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214.

Woodford, Michael 2004. “Inflation targeting and optimal monetary policy,” *Review, Federal Reserve Bank of St Louis*, 86: 15–42

APPENDICES

APPENDIX A

DATA

The sources of the data used in this thesis are given below.

Australia: All data are taken from International Financial Statistics (IFS) catalogue of International Monetary Fund (IMF). Data for interest rate is available with the code *15660B..ZF...* Consumer price index is available with the code *15664…ZF…* Import prices index is available with the code *15675…ZF…* Finally, seasonally adjusted GDP volume with 2000 prices is available with the code *15699BVRZF*.

Canada: All data are taken from IFS catalogue. Overnight money market rate is given with the code 15660B..ZF… CPI is given with the code 15664.ZF… Import price index is given with the code 15675.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 15699BVRZF…

Denmark: All data are taken from the IFS catalogue. Call money rate is available with the code 12860B..ZF… CPI is available with the code 12864..ZF… Import price index is available with the code 12876.X.ZF… Finally, GDP volume with 2000 prices is available with the code 12899BVPZF…

Italy: All data are taken from the IFS catalogue. Money market rate is available with the code 13660B..ZF… CPI is available with the code 13464..ZF… Unit value of imports is available with 13675…ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 13699BVRZF…

Japan: All data are taken from the IFS catalogue. Call money rate is available with the code 15860B..ZF… CPI is available with the code 15864..ZF… Import price index is available with the code 15876.X.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 15899BVRZF…

Netherlands: All data except central bank's policy rate are taken from the IFS catalogue. Policy rate is obtained from the central bank of Netherlands. CPI is available with the code 13864..ZF… in the IFS catalogue. Import price index is available with the code 13875.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 13899BVRZF…

New Zealand: All data are taken from the IFS catalogue. Money market rate is available with the code 19660B..ZF… CPI is available with the code 19664..ZF… Import price index is available with the code 19676.X.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 15899BVRZF…

Norway: All data are taken from the IFS catalogue. Call money rate is available with the code 14260B..ZF… CPI is available with the code 14264..ZF… Import price index is available with the code 14275.ZF… Finally, GDP volume with 2000 prices is available with the code 14299BVPZF…

Spain: All data are taken from the IFS catalogue. Call money rate is available with the code 18460B..ZF… CPI is available with the code 18464..ZF… Import price index is available with the code 18475...ZF… Finally, Seasonally adjusted GDP volume with 2000 prices is available with the code 18499BVRZF…

Sweden: All data are taken from the IFS catalogue. Call money rate is available with the code 14460B..ZF… CPI is available with the code 14464..ZF… Import price index is available with the code 14476.X.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 14499BVRZF…

Switzerland: All data are taken from the IFS catalogue. Call money rate is available with the code 14660B..ZF… CPI is available with the code 14664..ZF… Import price index is available with the code 14676.X.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 14699BVRZF…

UK: All data are taken from the IFS catalogue. Overnight interbank interest rate is available with the code 11260B..ZF… CPI is available with the code 11264..ZF… Import price index is available with the code 11276.X.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 15899BVRZF…

USA: All data are taken from the IFS catalogue. Federal funds rate is available with the code 11160B..ZF… CPI is available with the code 11164..ZF… Import price index is available with the code 11176.X.ZF… Finally, seasonally adjusted GDP volume with 2000 prices is available with the code 11199BVRZF…

APPENDIX B

TECHNICAL

In this appendix, we will describe the method we employed in the calculation of the slope of the inverse supply curve and the evolution of the response of inflation to a shock coming to output-gap.

Appendix B.1: Calculation of the Inverse Supply Slope

B.1.1 and B.1.2 give the evolution of the effect of the interest rate shock on output and inflation, respectively. Interest rate change affects the output through its effect on the output-gap. The *gap* equation (E5) contains interest rate (r_t), lagged value of the output-gap (gap_{t-1}), and the import price index IP_t on the right. The interest rate change at time t affects the output-gap immediately by the amount of $\gamma_{2,t}$ (the parameter in front of the r_t). Existence of the lagged value of the output-gap in E5 ensures the transmission of the effect of the interest rate change to output-gap at time $t+1$ and onwards. Q_{t+i} (B.1.1) denotes the magnitude of the entire effect of interest rate change on the output-gap at time $t+i$. In other words, B.1.1 gives the coefficient in front of the gap_t in the equation of gap_{t+i}. Moreover, the same change in r_t affects the inflation. The right hand side variables in the inflation equation (E1) of our model are the followings; the first and the second lagged values of inflation, the first lagged value of the output gap, and the import price index. However, r_t does not show up in the inflation equation. Therefore the change in r_t does not affect π_t immediately ($P_t = 0$), rather the effect occurs with a period lag. This delay can be thought of as monetary policy lag. However, at time $t+j$, where $j \in [1,15]$, change in r_t starts to be effective on inflation through the parameters in front of the π_{t+i-1}, π_{t+i-2}, and gap_{t+i-1}. The total effect is given in B.1.2 by P_{t+j}. Finally, the β (slope of the inverse supply curve) is given in A.1.3 which is calculated by the ratio of the expected value of Q_{t+i} and P_{t+i}.

$$
\begin{aligned}
&Q_t = \gamma_{2,t} \;, i \in [1,15] \\
&Q_{t+i} = \gamma_{2,t+i} \prod_{k=t+1}^{t+i} \gamma_{1,k} && \text{(B.1.1)} \\
&P_{t+j} = \alpha_{1,t+j} P_{t+j-1} + \alpha_{2,t+j} P_{t+j-2} + \alpha_{3,t+j} Q_{t+j-1} && \text{(B.1.2)} \\
&\theta = \frac{E\left(Q_{t+i}\right)}{E\left(P_{t+j}\right)}
\end{aligned}
$$

Appendix B.2: Derivation of the Impulse Responses

The estimate of the response of inflation to a demand shock is derived from the model that we construct in order to obtain the output-gap series. As it is evident from B.2.1 (E1) and B.2.2 (E5), a shock coming to output-gap (demand shock), which hits the economy will create a change in the output-gap. Furthermore, the existence of the gap_{t-1} in B.2.1 will form a basis for the transmission of the demand shock to inflation. A unit increase in the ξ (a demand shock) at time t will be effective on the output gap immediately. However, since the output-gap is available in B.2.1 with a quarter lag, a one unit increase in the ξ will be effective on the inflation with a quarter lag. The existence of the lagged values of the π in the equation for itself will also contribute to the transmission of the demand shock. Therefore previous shocks which hit the economy will not die out immediately. Likewise, output-gap is a function of the lag value of itself. This implies that the demand shock at time t will also be effective on the output-gap in the future. The evolution of the effect of the demand shock on inflation is given below.

$$\pi_{t+1} = \alpha_{1,t+1}\pi_t + \alpha_{2,t+1}\pi_{t-1} + \alpha_{3,t+1}gap_t + \alpha_{4,t+1}\pi_{t+1} + \upsilon_{t+1} \qquad \text{(B.2.1)}$$

$$gap_t = \gamma_{1,t}gap_{t-1} + \gamma_{2,t}r_t + \gamma_{4,t}IP_t + \xi_t \qquad \text{(B.2.2)}$$

$$\Delta_{\pi,t+1} = \alpha_{3,t+1} \qquad \text{(B.2.3)}$$

$$\Delta_{\pi,t+2} = \alpha_{1,t+2}\Delta_{\pi,t+1} + \alpha_{3,t+2}\gamma_{1,t+1} \qquad \text{(B.2.4)}$$

$$\Delta_{\pi,t+3} = \alpha_{1,t+3}\Delta_{\pi,t+2} + \alpha_{2,t+3}\Delta_{\pi,t+1} + \alpha_{3,t+3}\gamma_{1,t+2}\gamma_{1,t+1} \qquad \text{(B.2.5)}$$

....

$$\Delta_{\pi,t+15} = \alpha_{1,t+15}\Delta_{\pi,t+14} + \alpha_{2,t+15}\Delta_{\pi,t+13} + \alpha_{3,t+15}\prod_{i=1}^{14}\gamma_{1,t+i} \qquad \text{(B.2.15)}$$

$\Delta_{\pi,t+i}$ denotes the effect of the change in ξ on inflation, at time $t+i$. The process starts with a unit change in the ξ (demand shock) at time t. As it was stated earlier, it immediately affects the gap. Whereas, since none of the variables on the right hand side of the π_t is affected from the demand shock, π_t remains unaltered at time t. However, at time $t+1$ the demand shock becomes effective on the inflation. The term gap_t which is available in the equation for π_{t+1}, provides the transmission of the demand shock to the π_{t+1}. However, the transmission will not be complete. The total change in π_{t+1} will be $\alpha_{3,t+1}$ times the magnitude of the demand shock (which is equal to one). Whereas, at time $t+2$, the transmission of the demand shock to π will be through the terms π_{t+1} and gap_{t+1} which are available on the right hand side of the equation for π_{t+2}. At time $t+3$, the transmission occurs through the first and the second lag values of π_{t+3} and the first lag value of gap_{t+3}. The effects of the demand shock on π_{t+2}, π_{t+1}, and gap_{t+2} partially transmits to the π_{t+3}. The parameters in front of the lagged values of the inflation and output-gap in the equation for π_{t+3} serve as discount factors (e.g. only $\alpha_{1,t+3}$ times the magnitude of the demand shock on π_{t+2} transmits to π_{t+3}).

APPENDIX C

TABLES

Table 1: Data of adoption and sample periods

	Date of adoption	Sample period
IT countries		
Australia	Q1 1993	Q1 1980-2005 Q4
Canada	Q4 1990	Q1 1980-2005 Q4
New Zealand	Q2 1989	Q1 1980-2005 Q4
Spain	Q4 1994	Q1 1980-2002 Q1
Sweden	Q4 1992	Q1 1980-2005 Q4
UK	Q3 1992	Q1 1980-2005 Q4
Non-IT countries		
Denmark	.....	Q1 1980-2005 Q4
Italy	.....	Q1 1980-2005 Q4
Japan	.....	Q1 1980-2005 Q4
Netherlands	.....	Q1 1980-2005 Q4
Norway	.....	Q1 1980-2000 Q4
Switzerland	.....	Q1 1980-1999 Q4
USA	.....	Q1 1980-2005 Q4

Table 2: Testing Random Walk Hypothesis

$$a_t = \delta_a a_{t-1} + \varepsilon_t \quad a \in \theta = \{\alpha_1, \alpha_2, \alpha_3, \alpha_4, \rho, \gamma_1, \gamma_2, \gamma_3\}$$

Countries	δ_{α_1}	δ_{α_2}	δ_{α_3}	δ_{α_4}	δ_{ρ}	δ_{γ_1}	δ_{γ_2}	γ_3
Australia	**0.9992** [12987.50]***	**0.9976** [5928.20]***	**0.9946** [2882.54]***	**0.9779** [209.55]***	**1.0005** [18692.28]***	**1.0003** [26238.99]***	**0.9545** [93.22]***	**0.9824** [622.41]***
Canada	**0.9974** [7153.51]***	**0.9940** [4010.26]***	**0.9906** [2652.79]***	**0.9970** [272.54]***	**0.9996** [14936.84]***	**1.0013** [9104.37]***	**1.0085** [326.85]***	**1.0012** [2883.03]***
Denmark	**1.0010** [5178.17]***	**1.0021** [3297.05]***	**1.0044** [611.99]***	**0.9343** [350.22]***	**0.9999** [215598.18]***	**1.0002** [76530.55]***	**1.0081** [451.91]***	**0.9998** [5483.04]***
Italy	**1.0000** [69854.32]***	**1.0001** [40618.90]***	**0.9997** [12638.81]***	**1.0054** [684.00]***	**1.0001** [39163.80]***	**1.0001** [105254.82]***	**1.0097** [262.06]***	**0.9946** [987.06]***
Netherlands	**1.0015** [5653.04]***	**0.9976** [1396.60]***	**0.9889** [301.67]***	**0.9857** [163.65]***	**1.0000** [127559.61]***	**1.0012** [18637.40]***	**1.0078** [619.54]***	**0.9995** [1172.38]***
New Zealand	**0.9982** [1169.27]***	**0.9932** [828.35]***	**0.9843** [223.52]***	**0.9209** [62.49]***	**0.9971** [1477.60]***	**1.0017** [6791.09]***	**1.0179** [271.03]***	**0.9304** [142.00]***
Norway	**0.9999** [1072951.06]***	**0.9999** [770248.84]***	**0.9997** [37708.44]***	**0.9998** [25200.41]***	**0.9996** [13968.86]***	**1.0003** [32470.12]***	**1.0064** [1317.90]***	**0.9922** [2955.50]***
Spain	**1.0013** [6118.28]***	**0.9993** [3481.43]***	**0.9733** [790.88]***	**1.0213** [96.87]***	**0.9999** [30245.03]***	**1.0012** [6400.65]***	**0.9898** [183.60]***	**0.9192** [245.00]***
Sweden	**0.9992** [4114.73]***	**0.9997** [3417.29]***	**0.9952** [429.90]***	**0.9920** [449.77]***	**1.0000** [177734.33]***	**1.0014** [8476.53]***	**1.0072** [626.63]***	**1.0014** [844.00]***
Switzerland	**1.0003** [13664.70]***	**1.0004** [9770.55]***	**1.0031** [815.91]***	**0.9732** [589.03]***	**1.0001** [88070.26]***	**1.0010** [10337.43]***	**1.0064** [379.00]***	**1.0052** [1798.44]***
UK	**0.9998** [9003.00]***	**0.9997** [3002.03]***	**0.9781** [1083.75]***	**0.9840** [217.78]***	**0.9995** [9782.67]***	**1.0005** [9877.77]***	**0.9956** [89.07]***	**0.9724** [1200.43]***
USA	**1.0004** [21074.61]***	**0.9997** [11545.28]***	**1.0007** [2546.93]***	**0.9577** [871.79]***	**1.0010** [7643.14]***	**1.0010** [10335.19]***	**1.0032** [287.56]***	**1.0012** [3669.55]***

Table 3: Average values of inflation variability aversion (θ)

	Before adoption	**After adoption**	**Full sample**	**Before adoption**	**After adoption**	**Full sample**
IT countries						
Australia	0.6623	0.7504	0.7106	0.8058	0.7567	0.7827
Canada	0.6381	0.7981	0.7161	0.7657	0.7988	0.7848
New Zealand	0.5695	0.8407	0.7619	0.5711	0.8267	0.7901
Spain	0.5857	0.9624	0.6753	0.7874	0.9248	0.8446
Sweden	0.8170	0.9597	0.8866	0.8915	0.9636	0.9262
UK	0.6879	0.8940	0.7733	0.7627	0.9055	0.8332
Average	**0.6600**	**0.8675**	**0.7540**	**0.7640**	**0.8627**	**0.8270**
Non-IT countries	**Before the 1st quarter of 1993**	**After the 1st quarter of 1993**	**Full sample**	**Before the 1st quarter of 1993**	**After the 1st quarter of 1993**	**Full sample**
Denmark	0.9149	0.9506	0.9310	0.9506	0.9568	0.95354
Italy	0.4741	0.7442	0.5960	0.7278	0.8194	0.77082
Japan	0.4224	0.2376	0.3390	0.4422	0.3579	0.4025
Netherlands	0.8872	0.9219	0.9029	0.9038	0.9259	0.9141
Norway	0.9122	0.9487	0.9287	0.9586	0.9480	0.9536
Switzerland	0.8864	0.8790	0.8831	0.9153	0.9179	0.9164
USA	0.8377	0.8806	0.8573	0.8927	0.8978	0.8951
Average	**0.7621**	**0.7946**	**0.7768**	**0.8273**	**0.8319**	**0.8294**

Table 4: The magnitude of the change in (θ) before and after adoption of IT

	y^* = *potential output* π^*=%2	y^* = *potential output* π^*=%2
	μ(*after*)-μ(*before*)	μ(*after*)-μ(*before*)
IT countries		
Australia	0.0881 [0.0176]***	**-0.0491** **[0.0132]**
Canada	0.1600 [0.0186]***	0.0331 [0.0148]***
New Zealand	0.2711 [0.0229]***	0.2556 [0.0230]***
Spain	0.3767 [0.0601]***	0.1374 [0.0267]***
Sweden	0.1426 [0.0115]***	0.0721 [0.0070]***
UK	0.2061 [0.3187]***	0.1428 [0.217]***
Average	**0.2069**	**0.0987**
Non-IT countries		
Denmark	0.0357 [0.0076]***	0.0062 [0.0035]**
Italy	0.2701 [0.0275]***	0.0917 [0.0250]***
Japan	**-0.1848** **[0.0130]**	**-0.0843** **[0.0190]**
Netherlands	0.0346 [0.0058]***	0.0221 [0.0052]***
Norway	0.0365 [0.0062]***	-0.0106 [0.0044]
Switzerland	**-0.00732** **[0.0084]**	**0.0026** **[0.0073]**
USA	0.0428 [0.0089]***	**0.0051** **[0.0074]**
Average	**0.0325**	**0.0047**

Table 5: Testing for the equality of the sum of the ranks of θ

	$\pi^* = 2\%$		$\pi^* = \overline{\pi}$	
	z-value	**Prob>|z|**	**z-value**	**Prob>|z|**
IT countries				
Australia	2.706	0.0068	-3.435	0.0006
Canada	6.866	0.0000	1.775	0.0759
New Zealand	4.766	0.0000	4.665	0.0000
Spain	6.093	0.0000	4.509	0.0000
Sweden	7.256	0.0000	7.018	0.0000
UK	7.236	0.0000	6.508	0.0000
Non-IT countries				
Denmark	5.054	0.0000	1.683	0.0923
Italy	7.058	0.0000	2.427	0.0152
Japan	-6.974	0.0000	-3.043	0.0023
Netherlands	4.966	0.0000	3.298	0.0010
Norway	5.17	0.0000	-1.337	0.1813
Switzerland	-1.897	0.0578	1.547	0.1220
USA	4.421	0.0000	-0.703	0.4820

Table 6: Wilcoxon-signed-rank test of the difference between inflation response to a unit shock coming to output-gap before and after adoption to of IT

IT countries	P-value (Prob>Binomial(n=15, x>= Y, p=0.5))
Australia	0.0000
Canada	0.0000
New Zealand	0.0005
Spain	0.0005
Sweden	0.0000
UK	0.0005
Non-IT countries	
Denmark	1.0000
Italy	1.0000
Japan	1.0000
Netherlands	0.5000
Norway	0.9935
Switzerland	0.0005
USA	1.0000

Ho: Median of response of inflation to output gap shock after IT (1993Q1)- Median of response of inflation to output gap shock before IT (1993Q1)= 0
Ha: Median of response of inflation to output gap shock after IT (1993Q1)- Median of response of inflation to output gap shock before IT (1993Q1)< 0
Y is the number of negatively signed observations (observation in this test corresponds to difference of the paired observations)