Central Bank Reaction Function
for selected group of countries

by

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Abstract

The topic covered in this paper is the performances of different reaction functions used as possible guidelines for the establishment of monetary policy. In exploring the nature of the reaction function, two alternative monetary policy rules have been considered, namely the monetary authority (1) targeting monetary aggregates or (2) targeting the interest rate. The former implies an indirect and the latter a direct inflation targeting. The latter monetary policy rule, the Taylor rule, has recently been given much attention and has extensively been evaluated in the context of a macroeconometric framework. Nevertheless, the development of modern macroeconomics requires an important amendment to make the original Taylor rule more realistic. Empirical evidence shows that a modified version of the Taylor rule performs very well in describing the behavior of central banks in the selected group of countries. The results imply that interest rate smoothing is preferable to money growth targeting, although the choice between other pairs of rules depends on preferences for controlling output and inflation variability.

Keywords: Reaction function, Interest rates, Monetary policy, Taylor rule

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1. Introduction

Over the last century, many central banks have had the social responsibility of regulating the financial system. After the collapse of the gold standard regime, the monetary authorities have been facing the question of how to conduct monetary policy to stabilize prices, output and employment.

Since the early nineteenth century, generally mainstream economists have adopted the quantity theory of money as a theoretical framework that establishes a link between money and prices. Yet, there has been much debate over the impact of the central bank rate on macroeconomic activities. Early nineteenth-century loanable funds theorists such as Henry Thornton and Thomas Joplin supported mainly the view that causality went from the bank rate to the money supply and not the reverse as others of the Currency School had defended (Eagly 1974, pp.84-86). Still others, such as Thomas Tooke and John Fullarton of the Banking School, totally rejected the view that the central bank could control any narrow monetary aggregate. These latter theorists questioned the traditional belief that movements in the money supply would have a predictable effect on the level of prices and, indeed, they argued that the opposite was much closer to the truth (Seccareccia 1998, p.181). The orthodox theory of monetary policy a generation ago held that the manipulation of interest rates was an undesirable policy, also that it was in some sense an unattainable or impossible goal, because it would lead to the 'indeterminacy' of the nominal price level (Sargent 1979).

With the monetarist breakdown of the early 1980s and the recognition that central banks are incapable of controlling monetary aggregates even within wide target ranges, monetary authorities had learned a hard lesson on the nature of endogenous money (Seccareccia 1998, p.192). Hence, there has ensued the Wicksellian position, that for the purpose of controlling inflation, central banks should pursue an appropriate bank rate policy that would produce equilibrium in the capital market by ensuring that the bank rate would be closely gravitating around the 'natural' rate of interest. But, how can central banks achieve their inflation targets without targeting monetary aggregates? In general, setting short-term interest rates through the administering of the overnight rate, together with the bank rate, is the effective instrument of monetary and credit control (Bank of Canada 1995-96). From the mid-1970s, the adoption of the Wicksellian mechanism of price-level stabilization had remained the preferred choice of central bankers internationally (Gavin 1990).

Numerous studies have employed reaction functions to model monetary policy. The reaction function, demonstrating how the central bank changes monetary policy in response to changes in the macroeconomic environment, can be useful in predicting actual monetary actions and in evaluating the current situation as well as the future direction of monetary policy. A reaction function relates a central bank's policy instrument to the objectives of monetary policy in order to quantify the central bank's response to changes in its target variables.

Following the high-inflation of the 1970s, several central banks experimented with monetarism. One of the more recent and main trends in monetary policy is inflation targeting. Low and stable inflation is the overriding goal of monetary policy. Inflation targets can be best characterized as focusing on containing inflationary pressures rather than reacting to current levels of inflation. The evidence shows that nations that have been engaged in efforts to limit future inflation tended to have the lowest average inflation rates (Seyfried W. and Bremmer D. 2003).

In recent studies of monetary policy, simple policy rules have attracted attention as a means to achieve more effective monetary policy. One such simple policy, originally proposed by Taylor (1993), is one that establishes a feedback rule in which the interest rate changes in response to current and lagged output gap, and inflation. The Taylor rule, one of the most popular descriptive accounts of contemporary interest rate operating procedures, has become a key component of the new consensus in macroeconomics (Taylor 2000). The Taylor rule states that the central bank sets the federal funds rate (or its equivalent) as a function of the output gap, current inflation, and the difference between current inflation and its inflation target. However, an interest rate relation with output and inflation does not identify a central bank reaction function (Minford P., Perugini F. and Srinvivasan N. 2002), because the interest rate behavior may seem to approximately follow the Taylor rule when, in fact, the central bank may be implementing quite different monetary policy rules. For example, for money supply rules, empirical results show that the nominal interest rate is stationary, and hence the error term is stationary. It is also serially correlated and contains endogenous variables. Supposedly, it is not distinguishable from the error in a Taylor rule which represents central bank reactions to other developments. All these quite different rules tend to result in a Taylor rule representation. Therefore, P. Minford, F. Perugini and N. Srinvivasan (2002) conclude that, while it is well known that these rules have different stochastic properties which are the subject of other research, the main evidence for their actual existence from interest rate equations is basically flawed.

The original Taylor rule has been carefully examined in recent studies at both theoretical and empirical levels. At the theoretical level, despite its simplicity, the Taylor rule seems to stabilize inflation and output close to optimal policy rules in many macroeconomic models (Taylor 1999). At the empirical level, it was extended in several directions. The first was interest rate smoothing, since central banks adjust interest rates gradually over time to their target levels (Goodfriend 1991). The second extension was the estimation of forward looking versions of the Taylor rule (Clarida, Galí, & Gertler 2000), in some cases adding variables, for example, including the real exchange rate. As a result of these two extensions, most estimates of central bank interest rate rules incorporate an adjustment mechanism to the interest rate target and expectations, at least, with regard to future inflation and output gaps.

While discussions of the transmission mechanism of monetary policy tend to assume a strong and negative link between real interest rates and real macroeconomic activity, the empirical evidence suggests that the link between real interest rates and macroeconomic aggregates such as consumption and investment is, in fact, tenuous. Also, evidence on the link between real interest rates and economic growth is mixed, and this may be related to non-linearities in the relationship (Mark P. Taylor 1999).

A monetary policy reaction function may have asymmetric properties, which means that the short-term interest rate asymmetrically responds to the expected departures of inflation from its targeted value and the expected output gap. The state of the business cycle matters for the conduct of the monetary policy in some countries. Thus, the shape of the reaction function is endogenously determined (Bec F., B. Salem M. and Collard F. 2002).

In this paper, I focus on the reaction function and demonstrate its feasibility and validity with regards to both theoretical and practical aspects. The remainder of the paper is organized as follows. Section 2 introduces theoretically how the reaction function generally evolved from 1970 to 2003 for four developed countries: Australia, Canada, Italy and the UK. Section 3 presents empirical evidence testing how well the reaction function models are fitted in the selected group of countries, indicating that the Taylor rule is a reliable guideline for implementing monetary policy. Finally, Section 4 offers the main conclusion.

2. The Evolution of Reaction Functions

2.1. *Functions of central banks*

Central banks are today seen as convenient instruments for the conduct of monetary policy and banking supervision. Central banks are evolving creatures, which respond to political and economic forces around them. Central banks' differing historical origins influence not only the tasks they carry out today, but also the way in which they think and operate. However, they are in common pursuit of monetary and financial stability. There have been rapid and substantial changes in their operation, and central banks have displayed significant economic power over the financial markets during the past three decades or so. It is these markets that central banks have to influence in pursuit of their objectives by means of monetary policy.

The New Palgrave: A Dictionary of Economics defines monetary policy as follows: 'the term monetary policy refers to actions taken by central banks to affect monetary and other financial conditions in pursuit of the broader objectives of sustainable growth of real output, high employment, and price stability' (Lindsey and Wallich 1987, p. 508). Traditionally researchers have assumed that policymakers should seek to minimize a weighted average of some measure of variability of inflation and of the output gap. But discussions of the practicalities of monetary policy become conditioned by the type of banking system. Chick (1986) has specified the different, distinct stages through which most banking systems proceed as they develop. She demonstrates that the form of monetary policy which is appropriate and feasible depends on the stage of development of the banking system. Monetary policy rules are being assessed by policy makers themselves drawing on their own practical experience using monetary policy rules as inputs to the policy making process.

2.2. *Historical background of the 1970s*

In August 1971, the abandonment of the US dollar's link to gold marked the end of the Bretton Woods system. Since then, the world monetary system has operated with fiat money which, to some, may be something lying in the space between a breakthrough and a dangerous experiment. The loss of gold as an anchor for monetary policy has stimulated monetary theorists and practitioners to search for a new strategy to ensure price stability in the medium and long term.

In late 1973, there happened the first OPEC (Organization of Petroleum Exporting Countries) oil price shock, which had the effect of dramatically pushing up the inflation rate to double-digit levels and further intensifying the unemployment problem in all Western countries. Believing that the inflationary forces in the late 1973 had been the result of central bank behavior that had led to an excessive expansion of the money stock (Sparks 1986, pp. 137-9), monetary authorities in

Canada and elsewhere started to implement policy in favor of price stability via the targeting of M1, M2 or unborrowed reserves.

2.2.1. *The reasons for and effects of high inflation during the 1970s*

Some have argued that monetary policy was not active enough in the seventies. It may be that the problem in the 1970s was not lack of knowledge that a higher value of the inflation coefficient in central bank reaction functions might have prevented the alleviation of inflation. Instead, that episode may have reflected a weakness in monetary policy institutions, which could not resist adapting to higher inflation expectations in a staggering economy.

The statements on inflation by Arthur Burns, who was chairman of the Federal Reserve in the 1970s, suggest that his failure to raise interest rates in accordance with a more aggressive Taylor rule did not reflect ignorance about the connection between money and inflation. He claimed that, instead, it was his fear of the social consequences of such an action that prevented him from implementing a high interest rate policy (Burns 1978). Thus, both history and theory suggest that credibility issues should also be considered when designing monetary policy rules.

One explanation of the high inflation experience of the 1970s is that it was the outcome of the central bank implementing the policy rule which permitted inflation expectations to be self-fulfilling. Prior to 1979, central banks kept short-term interest rates at or below the inflation rate. Real short-term rates accordingly hovered around zero and below. After 1979, however, real as well as nominal short-term rates moved up significantly in periods of high inflation. Though real rates change over the rest of the sample, they remain significantly above zero. The 1970s are thought to be a period when output and investment were generally low.

A number of factors had contributed to the slowdown of output growth in industrial countries after 1973. Firstly, it is suggested that a decline in the growth of total factor productivity accounted for much of the slowdown in growth. Lower growth in total factor productivity reflected a slowdown in technological advancement. Secondly, the slowdown in growth was also attributable to accelerated capital obsolescence following the 1973/4 and 1970/80 oil price shocks. Thirdly, in most countries, and especially in Europe, some have argued that reduced labor input was also a factor in explaining the slowdown in growth, as natural rates of unemployment rose during the 1970s and early 1980s and average hours worked continued to decline (Phelps Edmund S., Zoega Gylfi 1998 and Julius DeAnne 1999).

It has been argued that much of the great inflation during the 1970s was because of a misperception on the part of economic actors — both the private sector and central banks — concerning the trend pace of productivity growth. It was initially very difficult for the economy's participants to detect that the productivity slowdown had occurred — that is, agents (the private sector and central banks) had to learn about it.

The misperception caused the central banks to overestimate the size of the output gap, leading through a Taylor-type policy rule to lower-than-intended interest rates and, subsequently, higher-than-intended inflation.

Moreover, it has been suggested that the process driving productivity growth is actually non-stationary; the permanent shock occurs only rarely, not each period. In that period, there is structural change — permanent changes in key aspects of the economy, like the pace of productivity growth. It is found that a one-time, unexpected change in productivity growth observed in the early 1970s generates a lot of inflation, a large portion of the persistent inflationary acceleration during this period. And the observed output gap was quite large, which influenced policy appreciably. The effects of an unexpected slowdown in productivity perceived during the 1970s are that they render a sizeable increase in inflation following this type of shock. The increase in inflation following the productivity slowdown, while significant, is also far too persistent. The productivity slowdown could have generated much of the observed increase in inflation during the 1970s, since the misperception of the policy authorities concerning the nature of the balanced growth path was substantial during the 1970s (Bullard James and Stefano Eusepi 2004).

Understanding the degree of error in estimates if the output gap is available to policymakers in the 1970s is useful for the formulation of monetary policy and the study of inflation behavior. Errors in real-time estimates of the gap were severe. The errors peaked in the 1970s, and appear to have contributed substantially to monetary policy mistakes in that decade; nevertheless, policy appears loose in the 1970s even using real-time data, so other sources of error were also important (Nelson Edward and Nikolov Kalin 2003).

In making decisions on interest rates, an input in monetary policymakers' deliberations is the assessment of the current amount of spare capacity in the economy — the pressure of aggregate demand relative to the economy's productive potential. When expressed in terms of gross domestic product, a frequently used summary statistic for the degree of spare capacity is the output gap—the percentage difference between the actual level of real GDP, and the level of GDP consistent with the sustainable full employment of resources.

The output gap series that is available to policymakers when they make decisions is subject to two key sources of error. Firstly, the observation on actual GDP that is initially released by statistical agencies is consistently subject to revision in subsequent months and years, as a wider and more reliable set of data on the level of economic activity in the quarter become available. Secondly, the level of potential GDP is subject to revisions both because of new information on its possible value and because of changes in the preferred procedure for assessing productive potential, which is an unobserved variable.

Upward revisions to the potential output growth rate were made in 1972 (Edward Nelson and Kalin Nikolov 2003). As these revisions had the effect of exaggerating the extent to which output was below capacity, some have argued that they probably led to looser monetary policy than otherwise, and so exacerbated the inflation problem in those years. But measurement error in actual GDP was important too, in overstating the severity of the 1971-1972 recession and understating the speed of the late 1980s expansion. The worst period of output gap mismeasurement is the last 4 years of the 1970s.

The issue of output gap mismeasurement has been crucial to a great deal of recent analysis of monetary policy. Much of this has focused on what monetary policy should do in the presence of errors in the gap estimates, especially in the presence of hysteresis. For example, some authors have advocated monetary policy rules that do not rely on estimates of the output gap; while others have derived optimal monetary policy in models where the output gap is measured imperfectly. The examination of the UK policymaking record in the 1970s and 1980s indicated that policymakers did not take into account the possibility of measurement error in the data when forming policy. For future policy, thus, it may be useful for inflation-targeting central banks to design monetary policy so that decisions are isolated as much as possible from errors in estimating the output gap.

Of the many recent hypotheses for the 1970s inflation experience, the "misperceived change-in-trend" view has some policy implications. It suggests the possibility that even a determined and knowledgeable central bank — today's policymakers — could end up with a lot of inflation if they experience the same type of shock. The monetary authority is determined and knowledgeable in the sense that they are committed to using a Taylor-type policy rule that would be optimal or near-optimal in some stationary contexts where structural change never occurs (Bullard James and Stefano Eusepi 2004).

After nearly a decade of high inflation, a number of important central banks began in 1979 to control inflation. The effect was transition from a global environment where inflation seemed a virtually intractable problem to the current era where the major economies of the world have relative price stability. While monetary policy was largely viewed as being out of control during the 1970s, it is now, for the most part, held in high regard. In the early 1980s, there was disinflation, inflation remained relatively low to the end of the period although a slight fluctuation occurred at the end of that decade.

2.3. *Theoretical debate on targeting money supply vs. targeting interest rates*

Orthodox economists support that money is exogenously supplied by central banks. Most of macroeconomic theory of that period presumed that central banks exert complete control over the money supply through monetary policy. In fact, most economists show the money supply curve as vertical and any change in the money stock is represented as a horizontal displacement of this line. This displacement is due to exogenous monetary management on the part of the central bank. Thus, the money supply is considered to be exogenous so that it is unilaterally determined by the monetary authorities.

On the contrary, Post Keynesians consider the money supply to be credit driven and demand determined, that is, endogenous to the system. Some economists claim that as financial systems develop, central banks lose their power to control the money stock since the money supply becomes endogenous to the economic process. Others argue that, as long as the money supply is credit driven and demand determined, monetary policy becomes ineffective in controlling the money stock.

This endogeneity has sometimes been understood by orthodox economists as meaning that money does not matter. For orthodox theorists, any exogenous variable is automatically significant as a cause of disturbance from equilibrium; once a variable is endogenous it loses causal force.

However, the horizontalist position on money supply endogeneity is not supported by all Post Keynesians economists, since for some it is not enough to say that *demand creates its own supply*, but it must be explained *how the private sector commands the money supply it wants* (Chick 1973, p. 88). Some economists conclude that monetary authorities exert control by means of setting key interest rates, so that their control of monetary aggregates is indirect. For them, monetary policy of the form of controlling interest rates substitutes for monetary policy of the form of controlling money supply.

When inflation gets very high or negative, interest rate rules lose their usefulness because expectations of inflation shift around a lot and are hard to measure. In these circumstances, it is argued that interest rate rules lose their advantages over money supply rules and can break down completely (Taylor 1995). So, for some, it is useful for central banks to keep track of the money supply and perhaps monitor policy rules for the money supply or monetary base even when they are using interest rate rules as guideline.

2.4. *Central banks' action after 1979*

2.4.1. *The selection of monetary policy rules*

With some structural changes, there is the sharp disinflation of the early 1980s. As the productivity growth revival that began during 1979-1981 recession persisted into the expansion, policymakers' estimates of potential GDP growth was revised upward several times and culminated in 1989 (Edward Nelson and Kalin Nikolov 2003). An increase in the rate of productivity growth — the "new economy" of the 1990s — then causes a reduction in inflation.

Much research in monetary economics is stimulated by the burst of inflation experienced by a number of countries in the 1970s. This research addresses two questions: 'Why did this costly failure of monetary policy occur?' and 'What can be done to prevent it from happening again?'. I'll briefly review the evolution of thinking on these questions, from the focus on institutional reform in the 1980s to the focus on the design of monetary policy rules more recently. There was an inflation bias in monetary institutions and some sort of institutional reform was required to prevent a recurrence of 1970s-style inflation. Such institutional reform include legislative changes that focus a central bank's mission more sharply on inflation and that grant central banks more independence from the rest of the government.

Barro and Gordon (1983)'s analysis led to the prediction that, without such reform inflation would move up and down as the incentives to inflate moved up and down. To operationalize the theory, they made the assumption that the central bank's incentive to inflate is measured by the natural rate of unemployment. However, the Barro and Gordon theory lost some of its appeal in the two following decades. For example, in the United States, a major, persistent drop in the rate of inflation occurred starting in 1980, about three years before the unemployment rate started to come down. In Europe and other countries, the incentive to inflate stood at a post-war high in the 1980s and 1990s because the unemployment rate was so high, and yet inflation was very low.

As has been shown historically, most central banks switched during the 1980s from the policy of controlling monetary aggregates to targeting inflation rates through controlling short-term rates. The interest rate has been recognized as the main instrument of monetary policy of most central banks to reach inflation stability, output stability and perhaps exchange rate stability.

A monetary policy 'rule' is useful to explain the modern monetary institutions' behavior. Such a rule specifies how the monetary authority varies instruments at its command as a function of the state of the economy. The recent research focuses on identifying simple monetary policy rules that would reduce the possibility of a recurrence of a 1970s-style inflation outbreak. The poor economic outcomes of the 1970s were a consequence of the poor monetary policy rule at that time. Generations of policymakers have long emphasized an "impossible trinity" of policy objectives. Attempts to maintain simultaneously fixed exchange rates, perfect capital mobility, and independent monetary policy are bound to end with a bang. The thought that improvements in our understanding of the economy that have occurred since then, arising both from conceptual advances and from increased data, puts us in a position to design a better rule now.

In the quest for good monetary policy rules, rules for setting the interest rate have taken a particularly prominent role. Over the 1990s, there appears a rather different trinity which has been deemed "both feasible and desirable". It is the Taylor rule that is the trinity of flexible exchange rates, an inflation target, and a monetary policy rule.

It has been put forward by John Taylor, who has played an important role in popularizing this research. The work has attracted so much attention partly because the interest rate is what central bankers view as controllable. As a result, the research on interest rate rules has substantial potential practical relevance. Although this research is still fairly new, a consensus has already begun to emerge (Lavoie 2004).

The debate over rules versus discretion produced multiple developments. Many authors propose an activist rule for central banks with regard to the inflation objective. From the abundant literature, two principal activist rules are highlighted. The first presented by McCallum (1995) is a rule in terms of nominal GDP; the central bank intervenes on the monetary base according to the gap between the nominal GDP and its objective. The second has been recommended by Taylor (1993) for the case of the US over 1987-1992: the central bank deals with the interest rate according to both the output gap and inflation gap. It is believed that if central banks adopt Taylor-type rules, they will approach the degree of macroeconomic stabilization obtainable as if they had followed an optimal rule. However, these rules present a number of limits. As regards Taylor's rule, there are some uncertainties as to the determination of the levels of real neutral interest rate and output gap. This shows that divergent recommendations of monetary policy may be reached.

Over the last decade, the literature on the performance of interest rate rules in macroeconomic models has primarily focused on two types of rules, both extensively used in research and policy analysis in central banks. The first one generally referred to as the Taylor rule, proposed by Taylor (1993), in which a simple interest rate reaction function — which depends on contemporaneous values for inflation and the output gap — provides a useful example for thinking about monetary policy issues. The second type of monetary policy rule is the IFB (Inflation Forecast Based) rule, IFB rules are simply more "forward-looking" versions of the Taylor rule, as the short-term policy rate is assumed to respond to a forecast of future inflation rather than the contemporaneous level of inflation.

Taylor-style rules shed light on the fundamental role of monetary policy under a flexible exchange rate regime, which is to adjust the policy rate in response to movements in inflation so as to provide an anchor for inflation and inflation expectations. Specifically, in a class of linear rational expectations models the asymptotic response of the policy rate with respect to inflation has to be greater than one for these models to be stable, and response coefficients below one are associated with poor macroeconomic performance. This stability property is sometimes referred to as the Taylor principle (McCallum 2002 and Woodford 1999).

2.4.2. ***Some important variables and properties of monetary policy***

Fischer (2000) states that inflation targeting sets out clear goals for monetary policy and the framework with which to reach them, but leaves it to the central bank to use the appropriate instrument to hit the target. Recent research on interest rate rules shows that it is important to have the interest rate response coefficient on the inflation rate (or a suitable inflation forecast or smoothed inflation rate) above a critical 'stability threshold' of one. In fact, a simple way to characterize the better monetary policy performance in the United States in the 1980s and 1990s compared with the 1960s and 1970s is that this response coefficient increased from below this stability threshold to above the threshold (Taylor 1999). Central banks pay close attention to indicators that have predictive power of future inflation. Mishkin and Posen (1997, p. 96) conclude that 'inflation targeting has been highly successful in helping countries…to maintain low inflation rates' and that 'there is no evidence that inflation targeting has produced undesirable effects on the real economy in the long run; instead it has likely had the effect of improving the climate for economic growth'.

Nevertheless, even if the central bank official target is expressed in inflation, it is believed that output stabilization is still important to the monetary authorities. The output gap — the difference between actual and potential output — plays a crucial role in the monetary transmission mechanism, particularly in relatively closed economies such as the United States and the EMU (European Economic and Monetary Union) area. In a model estimated for an aggregate of five EU countries, Peersman and Smets (1998) show that even if the central bank focuses only on inflation and attaches zero weight on output, the efficient Taylor rule will include a strong response to the output gap because it influences future inflation. This suggests that central banks are likely to pay considerable attention to the output gap in their conduct of policy, even if its primary objective is to maintain price stability.

A common view among economists is that the short-term policy interest rate in many countries is changed at a very sluggish pace over several quarters. The evidence supporting this view is found in many monetary policy rules or reaction functions estimated in the literature with quarterly data. It is shown that the optimal policy rule of the Taylor-type exhibits a degree of interest rate smoothing (or policy inertia). That means the optimal interest rate rule should involve persistence in order to eliminate the persistent components of the fluctuations in inflation and output gap. The inclusion of the objective of interest rate smoothing is proposed to account for two phenomena. The first is the aversion that central banks have to often changing the direction of their strategy. The second is that central banks care about financial stability: interest rate instability can lead to the destabilization of the financial system (Rudebusch D. Glenn 2001).

A zero lower bound on the nominal interest rate is becoming a serious concern. There exist optimal monetary policies when interest rates are zero. Many central banks, especially in industrialized countries, have been successful in reducing average inflation rates to a range of 0-3% in recent decades. In this kind of low inflation era, especially when a central bank is faced with a severe recession, a zero lower bound on the short-term nominal interest rate — a policy instrument for most of the central banks — could be a serious constraint for the implementation of monetary policy.

When the nominal interest rate actually is zero, as happened in Japan in the 1990s, a central bank will no longer be able to stimulate the economy through the nominal interest rate — a phenomenon known as a *liquidity trap*. In such circumstances, standard monetary policy, by controlling the short-term nominal interest, will become totally ineffective and the economy will have to bear the cost of increased volatility (Kato Ryo and Nishiyama Shin-Ichi 2005).

The recent trend of low inflation accompanied by the issues stemming from a zero lower bound is the basic reason why it is becoming a realistic and serious concern for many central banks. It is shown that targeting too low an inflation rate will cause a central bank to be vulnerable to a deflationary spiral and suggests that the inflation rate should be targeted higher than 2% in the long run (Kato Ryo and Nishiyama Shin-Ichi 2005). The optimal policy reaction function which has the zero lower bound of nominal interest rates might interfere with the conduct of monetary policy.

Two principal goals of monetary policy are the stabilization of output growth and inflation at desired rates. However, in theory these goals might conflict — that is, a long-run trade-off between the variance of real growth and inflation might exist and is quite unreasonable. The estimated trade-off implies little room for central banks to trade-off between its two primary goals. Outside a narrow band, the efficient trade-off locus becomes quite steep. The variance trade-off is affected by the uncertainty about the appropriate way to model dynamic interactions among key macroeconomic variables, and by decisions to stabilize economic variables other than real growth and inflation. Although stabilizing real growth and inflation are central concerns of central banks, practical issues such as a lack of timely information and a desire for public accountability have induced the central banks to smooth, or to consider smoothing, alternative intermediate variables. These alternatives include interest rates, money growth, and nominal GDP growth. Adherence to such alternative rules produces variance combinations away from the efficient trade-off border (Defina Robert, H., Stark Thomas C. & Taylor Herbert E. 1996).

2.5. *Comparison of monetary policy rules*

As aforementioned there are two alternative monetary policy rules: targeting monetary aggregates (during the 1970s) and targeting the interest rate (from the early 1980s till now). Whereas the former targets the inflation rate indirectly, through the control of the money supply, the latter, also called the Taylor rule, implies direct inflation targeting. Although the two rules have some different stability properties, discretionary monetary policy, i.e. policy that responds to the state of macro variables, has stabilizing effects. Since both policy rules are feedback rules, they generate less instability than compared with studies that employ only exogenous policy shocks, for example, auto regressive processes for the monetary policy. This means that discretionary monetary policy that is following some feedback rule will be stabilizing (Flaschel Peter, Gong Gang & Semmler Willi 2001).

There is strong evidence that there is a long-run positive relationship between money supply growth rates and nominal interest rates. That is, given the real interest rate, the nominal interest rate increases with the expected inflation rate. According to mainstream theory, a higher money growth rate increases the inflation rate in the future, and thus, the nominal interest rate. In the short run, however, the relationship between money growth rates and nominal interest rates is much less clear. It is suggested that the nominal interest rate and money growth rate move in opposite directions in the short run (the liquidity effect). The existence of a liquidity effect can significantly influence how the monetary authority should react to a disturbance to the economy.

The Taylor rule should be "active" to obtain local determinacy of equilibrium; that is, the nominal interest rate should be raised more than proportionately when the inflation rate deviates from the target rate. But, with the liquidity effect, it has been argued that this claim may not hold. If such a liquidity effect exists and is strong enough, the Taylor rule ought to be "passive", since the nominal interest rate should respond less than proportionately to a deviation of the inflation rate from the target level (Woodford 2003). With a liquidity effect, a greater inflation rate in the future is associated with a lower nominal interest rate today.

Nevertheless, the response of the money supply growth rate to a money demand shock required to stabilize inflation is not affected by the existence of a liquidity effect.

When the monetary authority adopts a Taylor rule, whether or not it should be active to obtain determinacy depends on the existence of a liquidity effect. The above suggests that the monetary authority should be careful about the existence and the degree of the liquidity effect, particularly when the nominal interest rate serves as the policy instrument.

There are three possible policy rules: stabilization of interest rates, of money growth, and of nominal GDP growth. These rules have actually been followed in the past or have been seriously considered by policy makers. Interest rate smoothing or nominal GDP growth targets will generate outcomes that are not substantially worse than those arising under the optimal rule. Moreover, neither rule is preferable than the other. The choice between the two rules depends on whether real growth stability is weighted more heavily (interest rate smoothing is superior) or if inflation stability is weighted more highly (nominal GDP growth targets are superior). Monetary targets produce an outcome (historically high levels of real interest rates and unemployment rates throughout the last two decades, especially after 1979) that is inferior to interest rate smoothing, because controlling monetary aggregates even within wide target ranges is hard for central banks, and the choice between money growth and nominal GDP growth targets depends on policy makers' preferences for stability in inflation versus real growth.

The dominance of interest rate smoothing over money growth targets can be illuminated by reference to the analysis of optimal rules in an IS-LM framework. The analysis implies that adherence to money targets in periods of financial volatility leads to increased macro instability, while interest rate smoothing will reduce macro instability. In some sense financial instability is more predominant than IS instability, the combination of inflation and real growth variance afforded by money targets would be expected to be inferior to the combination afforded by interest rate smoothing, as it was. Therefore, the estimated inferiority of money growth targets supports the central bankers' general reliance on interest rate smoothing.

2.6. *The main objective of the paper*

From the recent literature, it would appear that monetary authorities have followed a 'discretionary rule'. There have been frequent changes in the stated policy rule in Italy and the UK, and to a lesser extent, in Canada. One of the advantages of having a rule is that it should allow agents to observe, judge and even predict the monetary authorities' actions. A discretionary rule is likely to be difficult for agents. The recent innovation of inflation targets may be seen as an attempt to formalize the *real* operation of discretionary rules. In the past, these monetary authorities have adopted formal and/or informal targets for nominal income, monetary aggregates, the exchange rate and inflation. Hence, it might be expected to find considerable variation in the importance of different variables in explaining changes in official interest rates both across countries and through time.

Broadly speaking, inflation was low in the early 1960s, then high in the 1970s and early 1980s, and then lower again during the last twenty years. Particularly in the 1970s and early 1980s inflation behaved quite differently in these four countries, giving rise to frequent and considerable exchange rate movements. The need to combat inflation and speculative attacks on the exchange rate caused high real interest rates. Second, some of these countries had quite large structural changes in the 1980s. For example, the entry of Spain to the European Union in 1986 signaled a period of liberalization and strongly increased integration with the other EU (European Union) countries, such as Italy and the UK. These considerations suggest that it would be inappropriate to use a long sample of aggregate data from these countries for estimation purposes.

In order to examine the behavioral differences, the policy instrument (the official interest rate) needs to be endogenized and we shall gauge its feedback from real and nominal variables. The objective of the paper is to analyze whether the extent to which central banks feed back from these variables *over the economic cycle* differs as a result of the authorities' announced policy rules. For example, it will be tested whether feedback variables display considerable parameter instability in the case of Australia, Canada, Italy and the UK. Also, it is to test whether the Taylor rule is a suitable monetary policy rule.

3. Empirical Study

3.1. *Original Taylor rule model*

The reaction functions estimated in this paper treat the nominal short-term interest rate as the instrument of monetary policy. Thus the nominal interest rate in the short run constitutes the endogenous variable of the equations considering that central banks handle it according to the state of the economy. It is necessary to determine what overall information on the state of the economy central banks are expected to react to.

Many recent studies have estimated models of central bank behavior. A large portion of these empirical policy rules or reaction functions follow John Taylor (1993), who proposed a simple rule for monetary policy that sets the quarterly average level of the short-term policy interest rate (r_t) in response to inflation (π_t) and output gap (y_t):

$$r_t = r_n + a_1(\pi_t - \pi_t^*) + a_2 y_t, \qquad (1)$$

where r_t is real interest rate at period t, r_n is the long-run equilibrium or neutral real rate of interest and it is defined as the real interest rate when the economy is in equilibrium, that is when output equals its potential, or y_t equals zero and inflation equals its target value, π_t and π_t^* are the actual inflation rate and the inflation target at period t respectively, y_t is the output gap at period t.

The coefficients on both output and inflation, the internal objectives, are expected to be positive. The emerging consensus is that a Taylor rule characterized by an aggressive response of the interest rate to high inflation and high output is likely to yield good results. If inflation equals its target value and output equals its potential level, central banks set the real interest rate r_t equal to the neutral real interest rate r_n, which is assumed to be 2 in this case. Furthermore, Taylor (1999) urges the implementation of a rule with $a_2 = 0.5$, $a_1 = 1.5$ and suggests that an alternative rule with an even larger value of a_2 (a_2=1) may be better, considering that central banks are likely to pay considerable attention to the output gap because it influences future inflation. The emerging consensus is that a Taylor rule characterized by an aggressive response of the interest rate to high inflation and high output is likely to yield good results (Taylor 1999a).

Central banks raise the real interest rate in response to a rise in inflation or output, while they reduce it otherwise. Consequently, the real rate of interest should be higher than the neutral rate if inflation is above its target value or output is above its potential level, and it should be lower than the neutral rate otherwise. In this way, central banks can keep the values of inflation and output as close as possible to their target or potential value. Central banks prefer a low and stable inflation rate. Taking into account the upward bias in measures of inflation, which is widely accepted to be less than two percent, a low inflation rate is a reasonable target for central banks. The bank of Canada, for example, sets 2 percent as inflation target.

The Taylor rule works remarkably well in the case of the United States. Some empirical studies, such as Howard and Owens (1996), also indicate that the Taylor rule works well in some other industrialized countries, except that the estimated coefficients are different. Here, "the Taylor rule" refers to the type of monetary policy rules that have the form of equation (1). In other words, in this paper the Taylor rule refers to the monetary policy rule in which the short term nominal interest rate is expressed as a linear function of inflation and the output gap. In this part, the Taylor rule will be tested for Australia, Canada, Italy, and the United Kingdom.

3.1.1. *The data of the original Taylor rule model*

In order to test equation (1), one needs to collect data on interest rates, inflation rates and output. Since the earliest target value of inflation obtainable is that of the first quarter in 1993, the data set of the test is quarterly seasonally adjusted data from 1993:1 to 2002:2 for Australia, and from 1993:1 to 2003:4 for others. The real interest rate is substituted by the nominal interest rate so as to avoid spurious correlation in the model. The nominal rate used in this paper is the interest rate of the 3-month discount rate (or bank rate), which is obtained from the *IMF (International Financial Statistics)*.

One cannot obtain directly the data on inflation rates. Instead, the data of the Consumer Price Index (CPI) can be obtained from the *IMF*. For example, the Bank of

Canada adopted an inflation target in February 1991; it uses a measure of "core" inflation as the guide for conducting the monetary policy, where "core" inflation is defined as the year-over-year rate of change of the CPI excluding food, energy and the effects of changes in indirect taxes (CPIXFET).

In May 2001, the Bank of Canada began to adopt a new measure of core inflation. This new measure is known as CPIX and it excludes the eight most volatile components of the CPI and the effects of indirect taxes. Despite some minor differences on the components they exclude, CPIXFET and CPIX move in a similar way over time. In order to be consistent, the CPIX data are used throughout in this paper. The quarterly data of CPIX can be accessed from the IMF. Thus, the inflation rate is measured by the percentage change (on a quarterly basis) in the CPI. The difference between the actual inflation rate and the target inflation rate is the "inflation gap".

For the output gap, the data of seasonally adjusted real GDP data from the IMF will be employed. Since there is an obvious trend in real GDP values, one first calculated the log trend of the real GDP by the Hodrick-Prescott (H-P) Filter and then supposed that the estimated data of each period is the potential level of GDP for that particular period. One then computed the deviations of the actual values of real GDP for each quarter from their estimated potential value to get the output gap. Hence, the current output gap is the difference of real GDP with respect to a log linear trend.

3.1.2. *The result of the original Taylor rule model*

First of all, the stationary tests have been done for all time series data used as independent variables and the results are shown in the Appendix 1. It can be seen that all variables are stationary. The regression result of equation (1) is reported in Table 1 (Appendix 4). Unfortunately, the estimated coefficient of the inflation gap has the wrong sign for Canada! One reasonable explanation is that central banks tend to smooth the nominal rate of interest rate. If the theoretical analysis is correct, a possible way is that Bank of Canada targets the forward inflation gap instead of the contemporaneous value.

3.2. *The optimal Taylor rule model*

Since monetary policy affects the economy with lags, it would be too late for the monetary authorities to adjust the short-term real interest rate when the inflation rate has started to rise or fall. It is reasonable for the monetary authorities to look ahead and implement monetary policy in response to future inflation.

Accurate data about current conditions are not available when central banks make policy decisions. Then it is not optimal for central banks to respond to these indicators very strongly, believing that the deviation of inflation from its target is only caused by unobservable demand and supply shocks. Central banks may respond too strongly to measurement errors to which it should not respond, and thus it may increase economic variability. Therefore, forward-looking versions of the Taylor rule are useful to explain the behavior of central banks in these countries.

A simple inflation-forecast-based (IFB) rule that does not rely on any direct estimates of the equilibrium real interest rate and places a relatively high weight on the inflation forecast may perform better in small open economies than conventional Taylor rules. Indeed, the contemporaneous output gap term in the Taylor rule has already reflected the forward-looking character. It is shown that output fluctuations affect inflation in the next period rather than within period. Thus the inclusion of the contemporaneous output gap in the Taylor rule implies that central banks are concerned with future inflation and are willing to act in advance.

After several tests about how many leads for inflation gap and output gap are chosen to be appropriate, taking Canada as the representative (refer to the Appendix 2), it is better to select two quarters ahead for inflation gap, and one quarter ahead for output gap. To simplify the analysis, it is assumed that central banks have "perfect expectations". That is, the forecast inflation rate of two quarters ahead equals the realized value in the future, and thus the regression equation has the following form:

$$r_t = r_n + a_1(\pi_{t+2} - \pi^*_{t+2}) + a_2 y_t \qquad (2)$$

The regression results are shown in Table 2 (Appendix 4). It can be seen that the estimated coefficients of the explanatory variables have correct signs once the inflation gap is changed from the current values to two periods ahead. This result suggests that central banks, except Australia where the inflation gap coefficient is not significant, focus more on the expected future inflation gap than on the current one for the purpose of controlling inflation. The possible reason for Australia is that the central bank followed other interest rate policy rather than inflation targeting between 1993 and 2002. As for the UK, the central bank seems not to care about output gap, since the coefficient is insignificant. The result mainly indicates that the assumption of central banks targeting future inflation gaps appears to be reasonable both theoretically and practically.

3.3. *The modified model based on the optimal one*

3.3.1. *The model*

Ball (1999) found that adding the exchange rate to the benchmark policy rule could improve macroeconomic performance in a small open economy model. He found that, for the same amount of inflation variability, output variability could be reduced by 17% by adding the exchange rate to the policy rule in this way. The overshooting of the interest rate forecast due to exchange rate deviations compensates the persistence effect of the interest rate. The interest rate suffered a substantial fall that was explained pretty well by exchange rate deviation.

The reaction function of the central banks is counter cyclical to exchange rate deviations from its parity value. This means that the nominal interest rate decreases each time that the exchange rate overvalues in relation to its parity value and it is tightened otherwise. Exchange rate is a constraining variable which in itself contains information that impact on the inflation rate. In some of the major interest rate cycles in the recent period, such as in Japan, the exchange rate has played a central role in explaining those cycles, particularly during the bubble period. The output gap has shown a minor role. On the other hand, the inflation rate has not been significant in explaining the interest rate cycles.

In a cross section analysis, countries where unemployment is more variable should have a higher average rate of price inflation. Previous literature usually assumed that the central banker targets a rate of unemployment strictly below the natural rate. This view has been recently challenged on both theoretical and operational grounds. McCallum (1997) argues that since, in equilibrium, unemployment equals the natural rate but inflation is larger than optimal, central bankers would finally understand that the unemployment target is unobtainable and revise its goal. On the other hand, King (1996) and Blinder (1998) suggest, on the basis of institutional evidence, that the monetary authority actually targets the expected natural rate of unemployment. And the basic insight due to Barro and Gordon (1983) is robust in allowing the monetary authority to target the natural rate of unemployment.

Therefore, there is the possibility of enlarging the model by including an exchange rate gap and an unemployment gap, and the regression equation now takes the following forms:

$$r_t = r_n + a_1(\pi_{t+2} - \pi^*_{t+2}) + a_2 y_t + a_3 e_t \quad (3)$$

$$r_t = r_n + a_1(\pi_{t+2} - \pi^*_{t+2}) + a_2 e_t + a_3 u_t \quad (4)$$

where e_t is the growth rate of exchange rate in period t, u_t is the unemployment gap, while other variables are defined as in Table 2.

3.3.2. *The data*

It is difficult to believe that the targeted inflation rate has remained constant over the whole sample. Indeed, the early eighties experienced high inflation rates compared to the remainder of the sample. As to the inflation target, between 1980:1-2002:2, Π*=2% for Australia; between 1980:1-2003:4, Π*=2% for Canada; between 1983:1-1998:4, Π*= 2% for Italy; and between 1983:1-2003:4, Π*=2% for the UK. The inflation target for the 1970s is the average rate of inflation, $\pi^*_{70:1-79:4} = 9.837$ (Australia), $\pi^*_{70:1-79:4} = 7.383$ (Canada), $\pi^*_{70-82} = 13.751$ (Italy), $\pi^*_{70-82} = 12.673$ (UK).

Ball (1999) presents the real exchange rate gap that is expressed as the deviation of the real exchange rate from its equilibrium value. Since it is hard to obtain the long-run equilibrium value of exchange rates, the growth rate data of the actual exchange rate is employed as an explanatory variable. The actual exchange rate is defined as National Currency per ECUs (European Currency Unit) for Italy (1979-1998:4) and the UK (1990:4-2003:4), because they focus more attention on this exchange rate when they implement the monetary policy and the economy of European countries has huge effects on the economy of the UK and Italy during these periods. Since the foundation of the EMS (Economic Monetary System) was in 1979, the actual exchange rate before that period for Italy was supposed to be the national currency per US dollar, and for the UK, because its membership in EMS began on Oct. 8th 1990, between 1970 and 1990:3, the actual exchange rate is assumed to be the national currency per US dollar. For Canada and Australia, the nominal exchange rates are measured as national currency per US dollar. A rise in the exchange rate represents an appreciation of the national currency.

The data of the growth rate of consumer prices, nominal rates of interest (that is, rate of discount or bank rate), GDP and actual exchange rates are from the *IMF (International Financial Statistics),* except for the raw unemployment rate that was taken from *OECD* (*Main Economic Indicators).* However, due to the limited access to quarterly data, between 1970 and 1982, annual data is used for Italy and the UK, and for other periods quarterly data is employed. Also because of the insufficient data on the discount rate, the data on the Treasury Bill Rate is used instead of the bank rate between 1981-2003 for the UK, 1999:1-2003:4 for Italy, and 1996:3-2002:2 for Australia.

As to the unemployment gap, since it is difficult to measure the natural rate of unemployment U*, one has first to calculate the trend of the unemployment rate using the H-P Filter, and then the gap can be obtained with the unemployment rate less this trend. And the GDP gap was calculated in a similar way.

The sample period was determined by the first and latest available observations of these variables in the database. Also because there is structural break in 1979 or 1982, two sub-periods were chosen: 1970:1-1979:4, 1980:1-2002:2 for Australia and 1970:1-1979:4, 1980:1-2003:4 for Canada, 1970-1982, 1983:1-1998:4 for Italy and 1970-1982, 1983:1-2003:4 for the UK. Tables 3-6 (Appendix 4) report the regression results.

3.3.3. *The empirical results*

The coefficients on output and inflation, the internal objectives, are expected to be positive. From the results, the coefficients of inflation and growth in output are positive, except for the UK that has the wrong sign for the output gap from 1983:1-2003:4. Also, upward revisions to the potential output growth rate were made in 1972 and 1989 that do not appear justified by the data for the UK and Italy, but it is obvious for Australia and Canada (refer to Appendix 3).

During the 1970s, most of the coefficients of inflation are too small and highly insignificant at a 95% confidence interval for these four countries. One possible explanation is that in the late 1970s, central banks were less concerned with inflation. More specifically, the p-value is 0.0121 for Canada, and it shows that the Bank of

Canada began to pay more attention to inflation. But most probably, because it still hadn't adopted official inflation targets during that time, the coefficient is quite small.

From the 1980s the coefficient of inflation began to be more than 1 (refer to Appendix 4: Table 5). As for the coefficient on output gap, it may be greatly biased by our measuring technique, but it is still able to partly explain the phenomenon. Estimated reaction functions typically indicate that central banks, including Italy and the UK, react to the output gap. When future rather than current inflation enters the regression, this suggests that central banks react to the output gap because it contains information about future inflationary pressures. Hence it is not possible to reject the hypothesis that they are 1.5 and 0.5 as posited by Taylor (1993). The results for at least the last decade reveal that monetary policy reacts to inflation in a similar way in these countries, as the actual rate of inflation closes on its target (refer to Appendix 3, p. 54-55).

Aggressiveness in a Taylor rule is a good idea, but only in response to inflation. Aggressiveness in response to deviations in output from trend is a bad idea in my model. It is found that Taylor's 'alternative' recommended value for a_2 (a_2=1) places too much weight on output, and result in explosiveness. According to the model, the policy rule implemented in the 1970s was insufficiently aggressive with respect to inflation.

The size of the policy parameters differs over time and across countries and these policy differences translate into differences in inflation stability much like the simple illustration model predicts. Inflation has been much less stable in the UK; other central banks respond to an inflation shock, but the Bank of England's response is, in contrast, minimal.

Conventional wisdom suggests that central banks were more permissive with inflation during the 70s than in the last two decades. Correspondingly, in this paper it is found that there is a less activist monetary policy in the 70s than in the 80s and 90s, since it is possible to reject the hypothesis that the response of short-run interest rates to inflation was very similar from 1970-2003. From 1985 onwards, inflation in the EMS country (Italy) began to converge.

The coefficient on the exchange rate would be speculated to be positive, particularly in a high inflation regime. However, it would be negative if the central bank has exchange rate movements. The response to the external objectives implies that the central bank responds to an increase in the exchange rate with a decrease in the discount rate, the interest rate is counter-cyclical to the exchange rate, which I expect in Canada (from 1970:1-1979:4), UK (from 1970-1982), Australia (from 1980:1-2002:2), and Italy (from 1983:1-1998:4).

The results also indicate that the exchange rate term has not much explanatory power:

most of the estimated coefficients are statistically insignificant for these four countries. That is, the exchange rate doesn't seem to play an important role in the central banks' behavior and Ball's rule works poorly for these countries. Therefore, the use of monetary policy rules that target inflation are superior to setting exchange rates and such rules help 'anchor' monetary policy and dampen inflationary pressures.

In terms of the unemployment gap, the estimated coefficients are statistically insignificant and show the wrong sign for Australia and Italy during the 70s and the UK from the 80s till 2003. Hence, in all likelihood, the central bank pays little attention to the unemployment rate when implementing monetary policy.

In some respects, the evidence for Italy and the UK is more unfavorable to the assumptions of the original Taylor rule (refer to Appendix 3, Appendix 4: Table 4-6). Monetary policy in Italy and the UK was generally less active and more accommodative until the mid 80s. Hence, the failure of the Taylor rule to explain the behavior of interest rates should be interpreted by taking into account the fact that EMS countries may have conducted their monetary policy with diverse sensitivities to inflation. Furthermore, most of these countries were engaged in the ERM (Exchange Rate Mechanism), at least for some of the sample years considered. In these circumstances, for some countries, interest rates could not reflect appropriately domestic macroeconomic conditions, as expected in the rule.

Although a revised version of the Taylor rule, in which the inflation gap of two quarters ahead replaces the original one, describes the behavior of the Bank of Canada pretty well from 1993:1-2003:4, it is wise to have a portfolio of rules to supplement the benchmark rule. Such a portfolio would include rules with higher and lower coefficients on output as well as lagged variables. Since there is uncertainty about the appropriate size of some of the coefficients in the benchmark policy rule and because the structure of the economies (especially in wage-price determination) of the EMS will change in unknown ways as a result of the formation of a single currency, it is better for the Taylor rule to be used in conjunction with a portfolio of other policy rules (Taylor 1999).

3.4. *Econometric methodologies*

3.4.1. *Unit root tests*

The first step of the time series analysis is to investigate the stationarity of the series used as independent variables in this paper. The traditional unit root tests are used, based on Dickey and Fuller (1979, 1981) and Phillips and Perron (1988), to determine the presence of unit roots (see Eviews 5.0 manual).

The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correction of the residuals by assuming that the series follows an AR (p) process and adding lagged difference terms of the dependent variables to the right–hand side of the regression:

$$\Delta y_t = \gamma y_{t-1} + \beta_1 \Delta y_{t-2} + \dots\dots\dots + \beta_{p-1} \Delta y_{t-p} + \varepsilon_t \qquad (5)$$

The null and alternative hypotheses are written as

H_0: γ=0; H_1: γ<0

Dickey and Fuller (1979) have shown that the distribution of the t-statistic under the null hypothesis is nonstandard, and it is independent of the number of lagged first differences included in the ADF regression. The critical values for the test depend on whether or not a constant (or/ and a trend) are included in the regression.

Phillips and Perron (1988) propose an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root. The PP method estimates the non-augmented DF test equation:

$$\Delta y_t = \alpha + \beta y_{t-1} + \varepsilon_t \qquad (6)$$

and modifies the t-ratio of the α coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic. The PP test is based on the statistic:

$$t_{pp} = t_\alpha \left(\frac{\gamma_0}{f_0} \right)^{\frac{1}{2}} - \frac{T(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{\frac{1}{2}} s} \qquad (7)$$

where $\hat{\alpha}$ is the estimate, and t_α the t-ratio of α, $se(\hat{\alpha})$ is coefficient standard error, and s is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance in (6). The remaining term, f_0, is an estimator of the residual spectrum at frequency zero.

In addition to specifying whether to include a constant, a constant and linear trend, or neither in the test regression as for ADF, in the PP test, one has to specify the truncation lag, that is the number of periods of serial correlation to include. The asymptotic distribution of the PP modified t-ratio is the same as that of the ADF statistic.

3.4.2. *LS test and significance of coefficients*

In this paper, a well-known econometric methodology (Least Squares estimation) has been employed to test the significance of the coefficients of the inflation gap and output gap, the exchange rate gap and unemployment rate gap, based on the data from 1970 to 2003. Econometricians have proposed many different approaches to estimate the parameter of the linear regression model. The method of Least Squares (LS) has long been the most popular. In this paper, the LS method is used for choosing the estimator so as to minimize the sum of the squares of the differences (called residuals) of the regression model and test the significance of the coefficients.

To test the significance of coefficients, there is a need to add the linear restriction in the model. The test of single variable significance of the regression is used in this paper. It is a t-test that is performed for every regression equation, since it tells one whether or not the single independent variable significantly affects the dependent variable. If the variable seems insignificant, it indicates that there is some problem to introduce this variable into the model. The null and alternative hypothesizes for this test is:

H_0: The slope coefficient of this variable is zero (or $\beta_i = 0$).

H_1: The slope coefficient of this variable is not equal to zero (or $\beta_i \neq 0$).

If the t-statistic is less than the critical value, determined by the significance level, i.e. the P-value is greater than 0.05 (the significance level is assumed to be 0.05), the null hypothesis can not be rejected. The independent variable does not significantly impact on the dependent variable. Otherwise, the null hypothesis can be rejected.

4. Conclusion

This paper provides some evidence that central banks respond to deviations from the trend of a standard set of macroeconomic variables when setting cyclical interest rates. Monetary authorities have characterized their regimes with a variety of formal and informal targets. These have involved one or more of the following: money, exchange rate, inflation and nominal income. A degree of similarity in the relationship and the respective policy rates across these four countries is found, and responses between countries are not well explained by stated monetary policy rules.

A common finding is that monetary authorities in these four countries seem to operate a policy of interest rate smoothing, and shocks to broad money have a limited role in explaining policy rate movements, in particular since monetary authorities in some countries have adopted money targets at least for part of the period analyzed in this paper. Inflation expectations are found to explain a significant part of cyclical changes in official interest rates in Canada, although less so in Italy, the UK and Australia. Cyclical movements in GDP play an important role across these four countries. There is no substantial evidence for parameter instability - this suggests little actual change in implicit feedback weights.

With respect to Taylor-style interest rate rules, a frequently asked question is whether the response of the instrument to inflation and output gap changes systematically with the degree of openness and the size of the economy. The above analysis also shows some differences in *cyclical feedback* by central banks.

But the cross-country differences do not seem to match different stated policy rules. One interpretation of these results is that authorities tend to exercise some degree of discretion in the *cyclical* operation of their stated policy rules. Over most of the period examined, monetary authorities seem to have practiced some form of state-contingent inflation target (or nominal income rule), rather than an intermediate target (such as money targets).

Interest rate smoothing is preferable to money growth targeting, and modified interest rate rule (Taylor rule) seems like an optimal policy; it can better explain the behavior of the modern central banks rather than central banks during the 1970s. It is found that rules perform well for Canada. But the original Taylor (1993) rule may be inefficient when it is applied to small open economies because it responds too weakly to forecasts of inflation and too strongly to movements in the output gap. However, it is shown that a simple modified Taylor rule that responds more strongly to the forecast of inflation may produce better macroeconomic performance in small, open economies.

There are still some limitations to my study. A major drawback is that I cannot provide sophisticated statistical measures of the inflation target (π^*), the natural rate of unemployment (U*) and the potential level of GDP (y*). Potential output and the output gap are unobserved variables that are difficult to estimate in a completely satisfactory manner. There is still great uncertainty about measuring the equilibrium real interest rate, though this is a problem for any monetary policy. And preference parameters (including the inflation target π^*) could change over time as different individuals take office, and institutional arrangements are revised. For example, it is possible that the reduction in the inflation rate in the 1990s is not only due to the smaller variability of the unemployment rate but also to institutional changes like the introduction of explicit inflation targets. All of these may lead to some uncertainties in the true statistical significance of my tests.

A number of extensions and refinements are left to future research. One of them is that it may be worthwhile to study the implications of alternative measures of the output gap based on a flexible-price measure of potential output.

Appendix 1: Stationarity tests

1993:1—2003:4 for Canada, Italy and UK; 1993:1—2002:2 for Australia

Variable	ADF statistic	10% critical value	result
Inflation gap (2) Aus	-2.948404	-2.612874	stationary
Inflation gap (1) Aus	-2.945842	-2.611531	stationary
Output gap (1) Aus	-3.361485	-2.611531	Stationary*
Inflation gap (2) CA	-3.281551	-2.606857	Stationary*
Inflation gap (1) CA	-3.327111	-2.605836	Stationary*
Output gap (1) CA	-3.408754	-2.605836	Stationary*
Inflation gap (2) Italy	-2.936942	-2.606857	stationary
Inflation gap (1) Italy	-2.935001	-2.605836	stationary
Output gap (1) Italy	-2.933158	-2.604867	stationary
Inflation gap (2) UK	-3.623650	-2.606857	Stationary**
Inflation gap (1) UK	-4.224881	-2.606857	Stationary**
Output gap (1) UK	-2.941145	-2.609066	stationary

1970:1-1979:4 for Australia and Canada

Variable	ADF statistic	10% critical value	result
Inflation gap (2) Aus	-2.943427	-2.610263	stationary
Inflation gap (1) Aus	-2.941145	-2.609066	stationary
Output gap (1) Aus	-2.941145	-2.609066	stationary
E Aus	-4.864555	-2.607932	Stationary**
Unemployment Aus	-2.973008	-2.609066	Stationary*
Inflation gap (2) CA	-3.403192	-2.625121	Stationary*
Inflation gap (1) CA	-2.943427	-2.610263	stationary
Output gap (1) CA	-2.941145	-2.609066	stationary
E CA	-3.587075	-2.607932	Stationary*
Unemployment CA	-2.697928	-2.609066	stationary

1970-1982 for Italy and UK

Variable	PP statistic	10% critical value	result
Inflation gap (2) Italy	-7.422408	-2.747676	Stationary**
Inflation gap (1) Italy	-3.283655	-2.728985	Stationary*
Output gap (1) Italy	-3.175352	-2.728985	stationary
E Italy	-3.144920	-2.713751	stationary
Unemployment Italy	-2.713751	-2.616038	stationary
Inflation gap (2) UK	-3.212696	-2.747676	stationary
Inflation gap (1) UK	-3.175352	-2.728985	stationary
Output gap (1) UK	-3.175352	-2.728985	stationary
E UK	-3.144920	-2.713751	stationary
Unemployment UK	-2.713751	-0.991973	stationary

1980:1-2002:2 for Australia, 1980:1-2003:4 for Canada, 1983:1-1998:4 for Italy, 1983:1-2003:4 for UK

Variable	ADF statistic	10% critical value	result
Inflation gap (2) Aus	-2.896779	-2.585626	stationary
Inflation gap (1) Aus	-2.896346	-2.585396	stationary
Output gap (1) Aus	-3.359982	-2.584738	Stationary*
E Aus	-7.515381	-2.584325	Stationary**
Unemployment Aus	-4.755419	-2.584738	Stationary**
Inflation gap (2) CA	-3.461691	-2.584325	Stationary*
Inflation gap (1) CA	-3.008676	-2.584126	Stationary*
Output gap (1) CA	-5.064293	-2.583553	Stationary**
E CA	-2.583553	-2.132992	stationary
Unemployment CA	-3.762744	-2.583371	Stationary**
Inflation gap (2) Italy	-2.910860	-2.593090	stationary
Inflation gap (1) Italy	-2.913549	-2.594521	stationary
Output gap (1) Italy	-3.040881	-2.592215	Stationary*
E Italy	-6.072924	-2.591799	Stationary**
Unemployment Italy	-2.592215	-2.128163	stationary
Inflation gap (2) UK	-2.702623	-2.586351	stationary
Inflation gap (1) UK	-2.901217	-2.587981	stationary
Output gap (1) UK	-3.346370	-2.586866	Stationary*
E UK	-7.540334	-2.585626	Stationary**
Unemployment UK	-3.659542	-2.586103	Stationary**

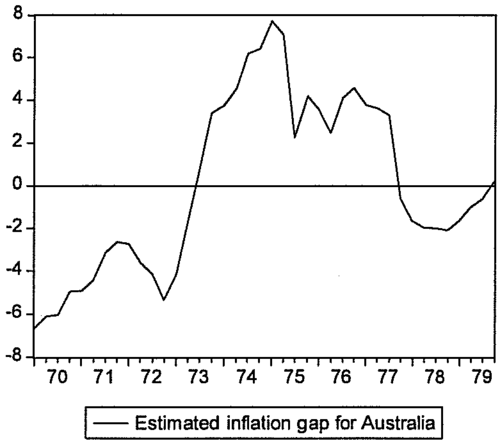
Note: * refers to the rejection of hypothesis of a unit root at 5% critical level;

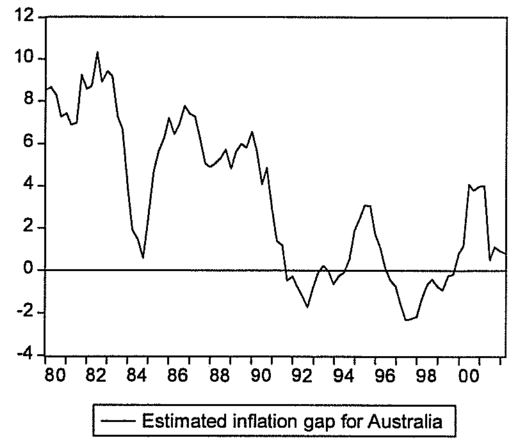
** refers to the rejection of hypothesis of a unit root at 1% critical level.

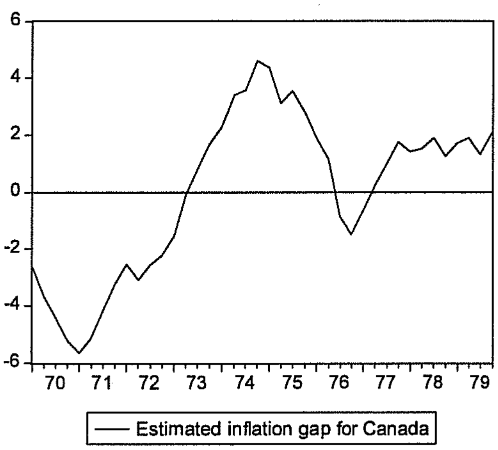
Appendix 2: The selection of the leads for inflation gap and output gap

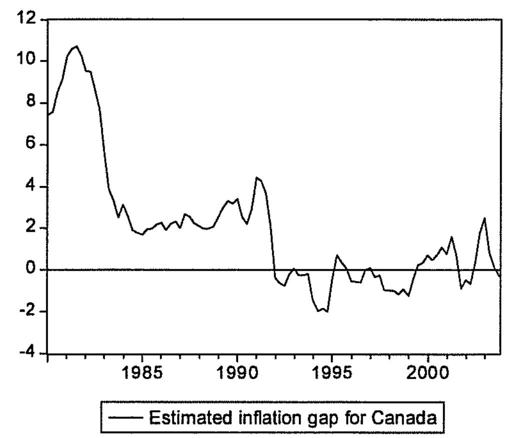
Variable	Coefficient	t-Statistic	Prob.
Inflation gap (1)	-0.514443	-2.296726	**0.0269**
Output gap (1)	50.64844	3.577861	**0.0009**
Inflation gap (2)	-0.515064	-2.232066	**0.0314**
Output gap (1)	50.73828	3.459133	**0.0013**
Inflation gap (3)	-0.408176	-1.816657	0.0772
Output gap (1)	44.08315	3.071284	0.0039
Inflation gap (4)	-0.239450	-1.123733	0.2684
Output gap (1)	35.05413	2.567133	0.0144
Inflation gap (5)	-0.111285	-0.528217	0.6006
Output gap (1)	34.34738	2.583702	0.0140
Inflation gap (6)	0.045946	0.206540	0.8376
Output gap (1)	35.70673	2.673872	0.0113
Inflation gap (2)	-0.371349	-1.551428	0.1289
Output gap (2)	35.85261	2.370371	0.0228
Inflation gap (3)	-0.415000	-1.684252	0.1003
Output gap (2)	37.25127	2.378797	0.0225
Inflation gap (4)	-0.338517	-1.433098	0.1602
Output gap (2)	31.54041	2.090228	0.0435
Inflation gap (5)	-0.222928	-0.991248	0.3282
Output gap (2)	23.84331	1.691749	0.0993
Inflation gap (6)	-0.057282	-0.249673	0.8043
Output gap (2)	23.48608	1.705467	0.0970
Inflation gap (3)	-0.292629	-1.176356	0.2468
Output gap (3)	24.05534	1.528036	0.1348
Inflation gap (4)	-0.325494	-1.275439	0.2101
Output gap (3)	24.42171	1.503029	0.1413
Inflation gap (5)	-0.274118	-1.111940	0.2735
Output gap (3)	19.18583	1.243308	0.2218
Inflation gap (6)	-0.121997	-0.507672	0.6149
Output gap (3)	11.85446	0.825727	0.4146
Inflation gap (4)	-0.245015	-0.973210	0.3368
Output gap (4)	15.72580	0.985678	0.3307
Inflation gap (5)	-0.268273	-1.022328	0.3134
Output gap (4)	14.99429	0.916290	0.3656
Inflation gap (6)	-0.140293	-0.536671	0.5949
Output gap (4)	7.973020	0.511335	0.6123
Inflation gap (5)	-0.247555	-0.967177	0.3399
Output gap (5)	13.47738	0.849531	0.4012
Inflation gap (6)	-0.167399	-0.600480	0.5521
Output gap (5)	9.382448	0.567248	0.5742
Inflation gap (6)	-0.241244	-0.897457	0.3756
Output gap (6)	18.71223	1.180457	0.2458

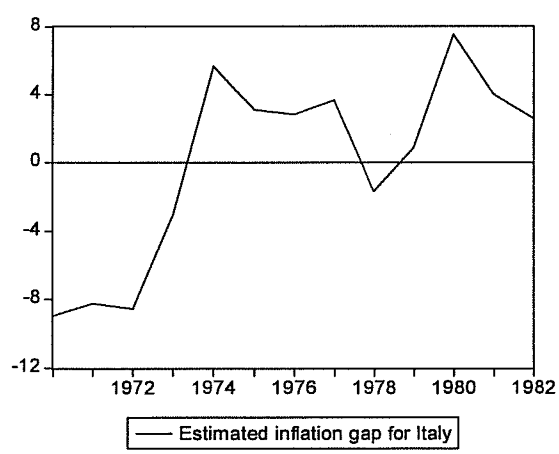
Appendix 3: Graphs for inflation gap, output gap, exchange rate gap and unemployment gap for these four countries

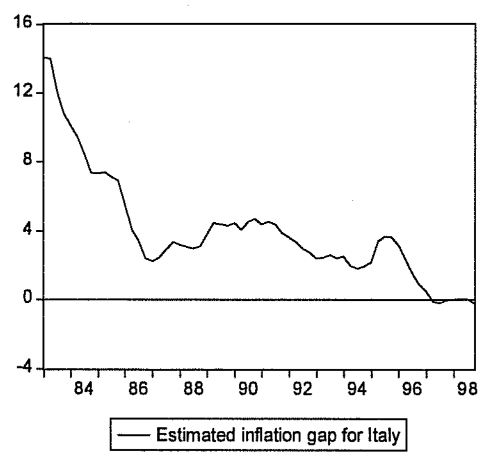


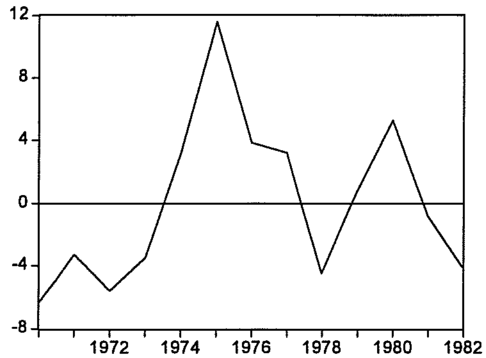




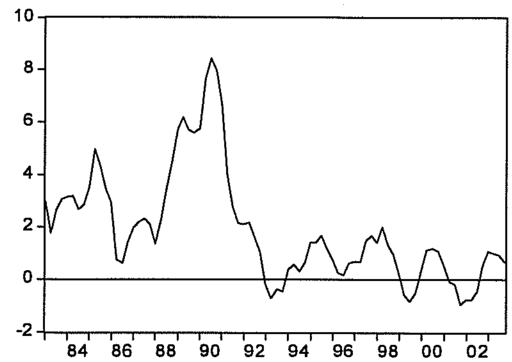




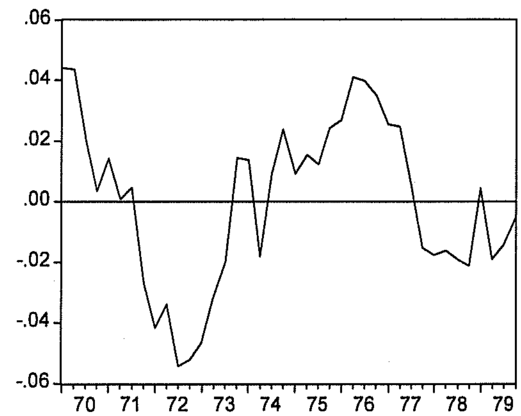




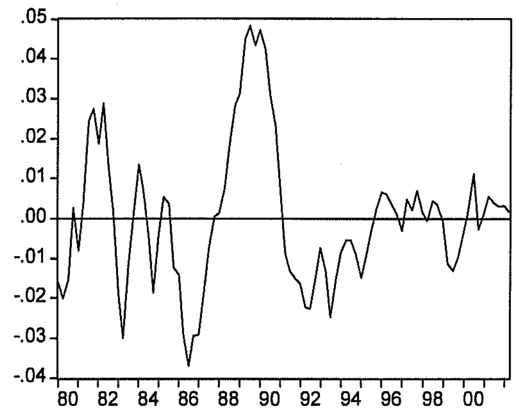
estimated inflation gap for UK



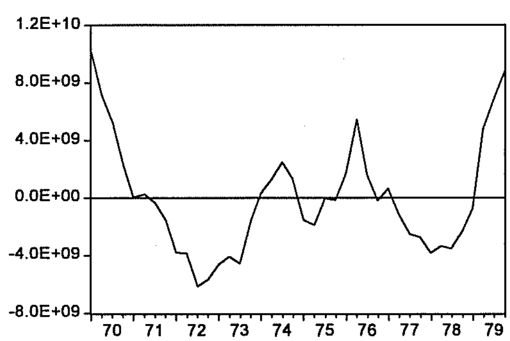
estimated inflation gap for UK



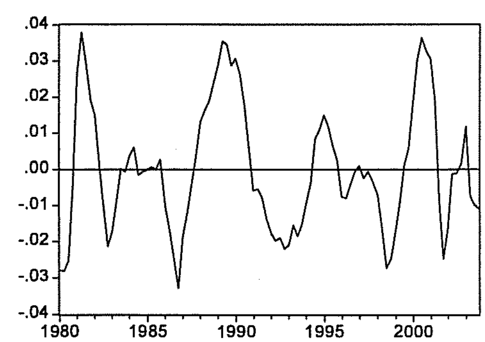
Estimated output gap for Australia



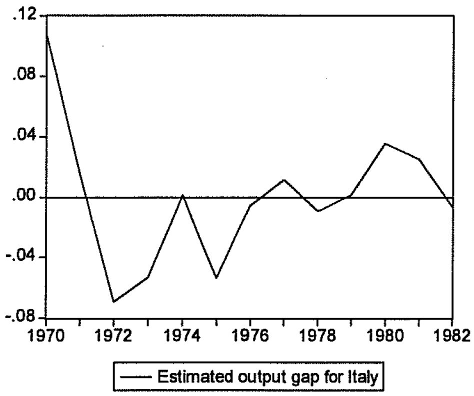
Estimated output gap for Australia



Estimated output gap for Canada



Estimated output gap for Canada


.12
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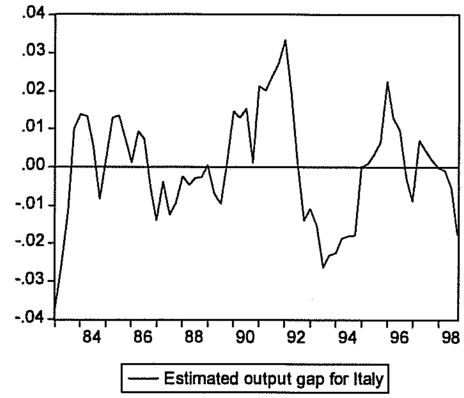
-.04
-.08
1970
1972
1974
1976
1978
1980
1982
Estimated output gap for Italy


.04
.03
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-.01
-.02
-.03
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84
86
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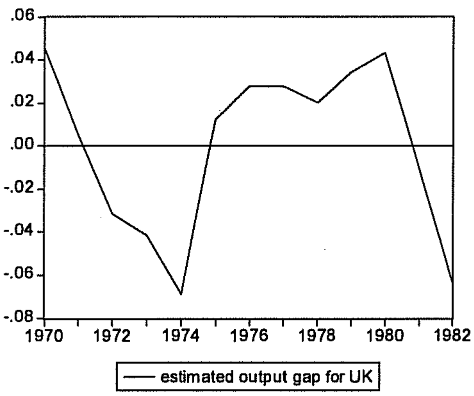
98
Estimated output gap for Italy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1970
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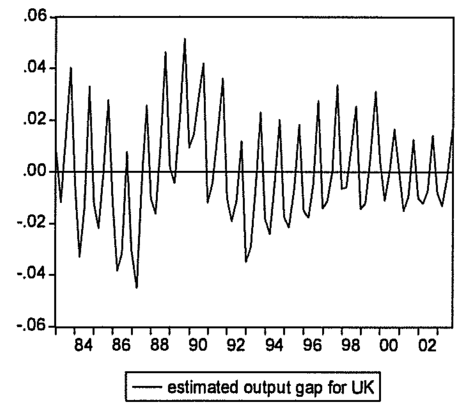
1982
estimated output gap for UK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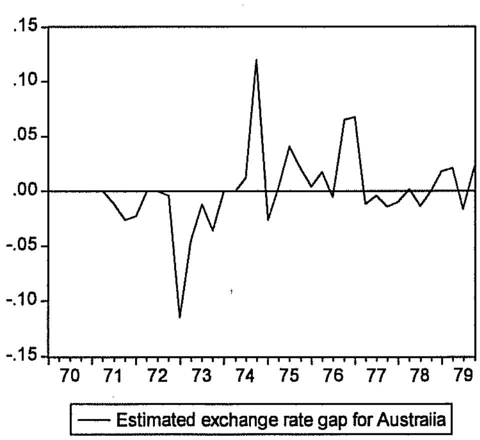
estimated output gap for UK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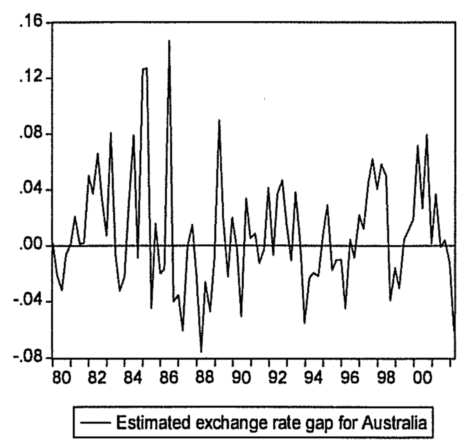
79
Estimated exchange rate gap for Australia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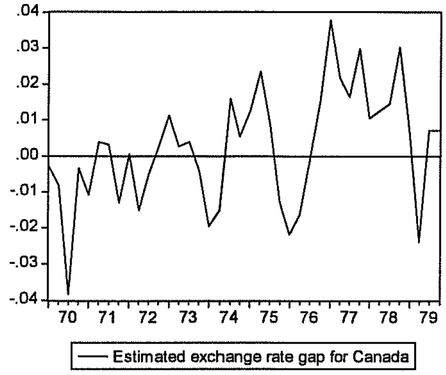
Estimated exchange rate gap for Australia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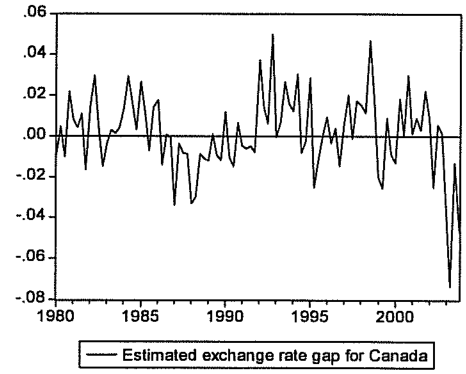
Estimated exchange rate gap for Canada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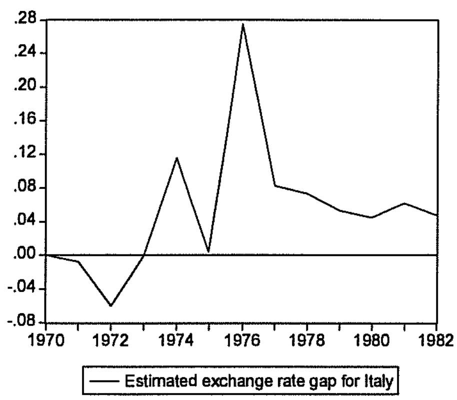
-.02
-.04
-.06
-.08
1980 1985 1990 1995 2000
Estimated exchange rate gap for Canada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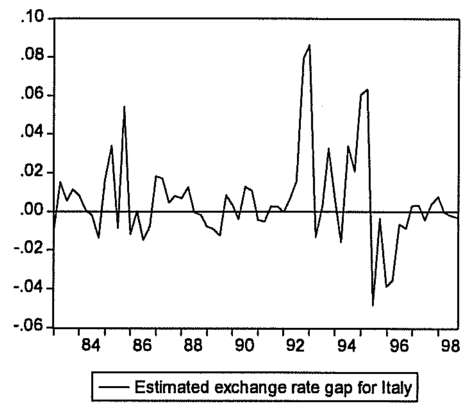
-.08
1970 1972 1974 1976 1978 1980 1982
Estimated exchange rate gap for Italy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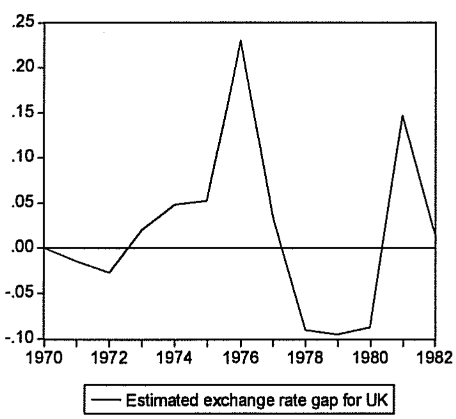
84 86 88 90 92 94 96 98
Estimated exchange rate gap for Italy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.20
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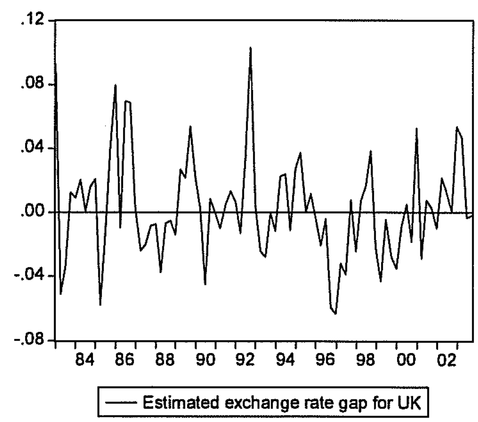
.10
.05
.00
-.05
-.10
1970 1972 1974 1976 1978 1980 1982
Estimated exchange rate gap for UK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-.04
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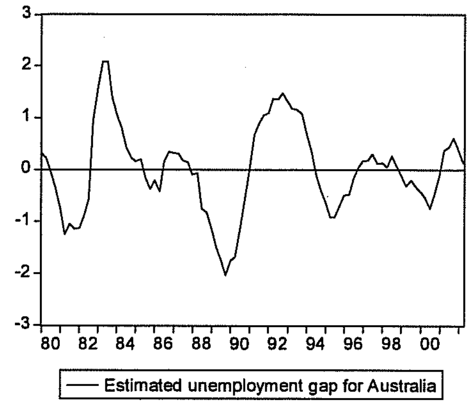
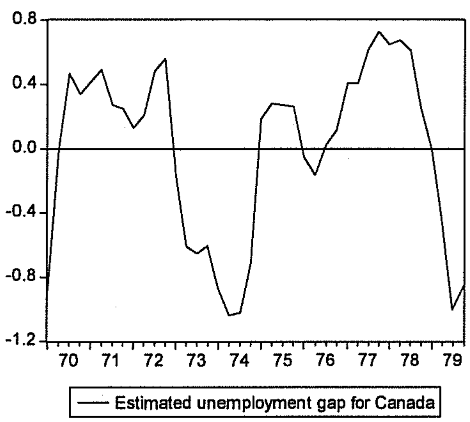
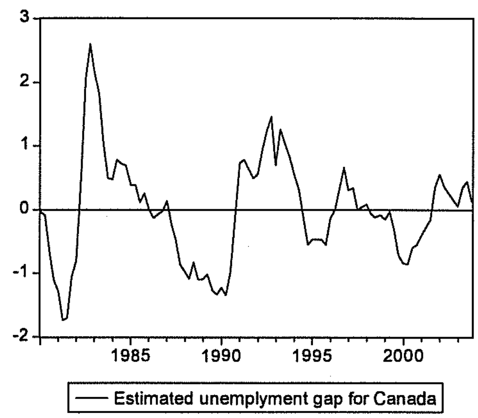
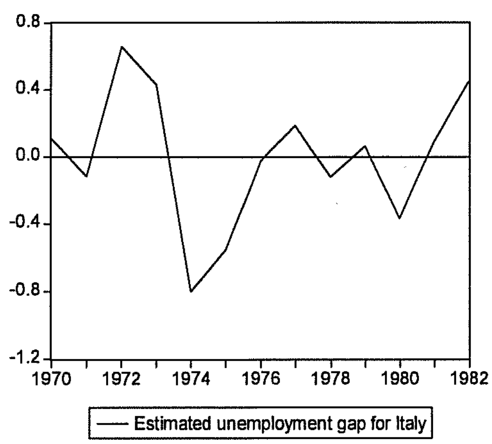
Estimated exchange rate gap for UK

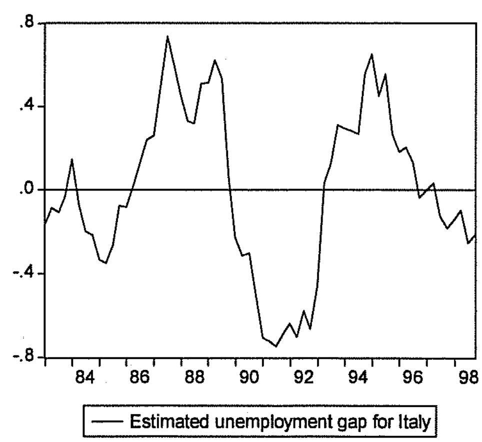

Estimated unemployment gap for Australia

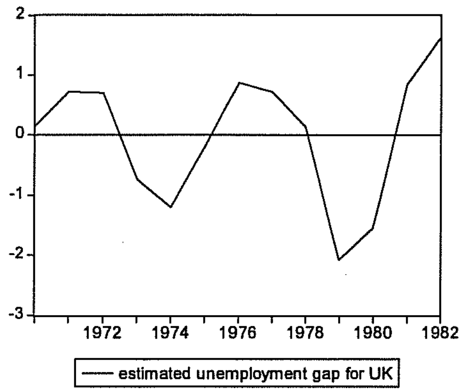

Estimated unemployment gap for Australia


Estimated unemployment gap for Canada


Estimated unemplyment gap for Canada


Estimated unemployment gap for Italy


Estimated unemployment gap for Italy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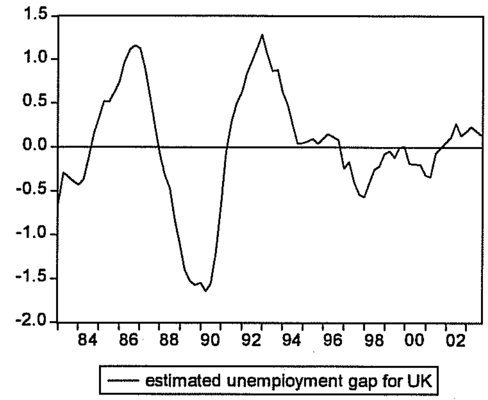
1972
1974
1976
1978
1980
1982
estimated unemployment gap for UK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86
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98
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estimated unemployment gap for UK

Appendix 4: Regression Results

Table 1.Regression results of equation (1) from 1993:1-2002:2 for Australia, from 1993:1-2003:4 for the others dependent variable: r_t

	Australia		Canada		Italy		UK	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
constant	5.383579	0.0000	4.708492	0.0000	16.73307	0.0000	5.061115	0.0000
		(50.02701)		(24.37348)		(11.04793)		(30.95939)
inflation gap(1)	0.097761	0.1069	-0.514443	0.0269	0.707236	0.0002	0.640520	0.0007
		(1.655975)		(-2.296726)		(4.127680)		(3.650596)
output gap (1)	10.29198	0.5775	50.64844	0.0009	-2.27E-14	0.0000	4.061792	0.6559
		(0.562512)		(3.577861)		(-8.465535)		(0.448960)
$\bar{R}^2$	0.038623		0.212744		0.836098		0.216356	

Note: t-statistics are in parenthesis. The above regression result is obtained by using Least Squares in Eviews 4.1.

Table 2.Regression results of equation (2) from 1993:1-2002:2 for Australia, from 1993:1-2003:4 for the others dependent variable: r_t

	Australia		Canada		Italy		UK	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
constant	5.430754	0.0000	4.739423	0.0000	18.11289	0.0000	5.211967	0.0000
		(51.50495)		(24.20606)		(10.55914)		(29.32720)
inflation gap(2)	0.076662	0.1842	0.515064	0.0314	0.479824	0.0175	0.410963	0.0375
		(1.356377)		(2.232066)		(2.480532)		(2.154244)
output gap (1)	17.94039	0.3133	50.73828	0.0013	2.48E-14	0.0000	5.706261	0.5588
		(1.023874)		(3.459133)		(8.098927)		(0.589753)
$\bar{R}^2$	0.023996		0.200458		0.787047		0.075720	

Note: t-statistics are in parenthesis. The above regression result is obtained by using Least Squares in Eviews 4.1.

Table 3.Regression results of equation (3) from 1970:1-1979:4 for Australia and Canada, from 1970-1982 for the others; dependent variable: r_i

	Australia		Canada		Italy		UK	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
constant	7.778655	0.0000	3.158316	0.0000	8.248767	0.0001	10.77279	0.0000
		(29.83371)		(4.656656)		(7.427649)		(8.930213)
inflation gap(2)	0.223137	0.0056	0.079621	0.3423	0.234177	0.2690	0.237535	0.3819
		(2.960314)		(0.963003)		(1.200436)		(0.932910)
output gap (1)	8.524619	0.4621	2.64E-11	0.0000	72.28457	0.0280	45.45193	0.2585
		(0.743760)		(6.696849)		(2.761969)		(1.229791)
E	15.93627	0.0570	-28.43227	0.0318	26.61628	0.0353	-1.723374	0.9018
		(1.970496)		(-2.239080)		(2.602715)		(-0.127960)
$\bar{R}^2$	0.370852		0.651663		0.636177		-0.133563	

Note: t-statistics are in parenthesis. The above regression result is obtained by using Least Squares in Eviews 4.1.

Table 4.Regression results of equation (4) from 1970:1-1979:4 for Australia and Canada, from 1970-1982 for the others; dependent variable: r_t

	Australia		Canada		Italy		UK	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
constant	7.751002	0.0000	7.535784	0.0000	7.177632	0.0021	10.21925	0.0000
		(29.51405)		(26.81027)		(4.752540)		(11.08750)
inflation gap(2)	0.259409	0.0025	0.338209	0.0121	0.237805	0.4274	0.079431	0.6685
		(3.265046)		(2.651996)		(0.842460)		(0.446815)
E	16.85643	0.0445	-5.144158	0.8140	34.53235	0.0551	14.45564	0.2406
		(2.086811)		(-0.237122)		(2.298282)		(1.282292)
U	0.224259	0.7114	-0.195285	0.7726	0.211516	0.9488	-2.965622	0.0224
		(0.373115)		(-0.291344)		(0.066537)		(-2.917243)
$\bar{R}^2$	0.363223		0.194200		0.240169		0.377876	

Note: t-statistics are in parenthesis. The above regression result is obtained by using Least Squares in Eviews 4.1.

Table 5.Regression results of equation (3) from 1980:1-2002:2 for Australia, from 1980:1-2003:4 for Canada, from 1983:1-1998:4 for Italy, from 1983:1-2003:4 for UK dependent variable: r_t

	Australia		Canada		Italy		UK	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
constant	7.047723	0.0000	6.173092	0.0000	7.608537	0.0000	5.711622	0.0000
		(16.29645)		(23.31684)		(20.41342)		(21.40779)
inflation gap(2)	1.006104	0.0000	1.042992	0.0000	1.064028	0.0000	1.178590	0.0000
		(10.90373)		(13.95777)		(12.99733)		(12.21889)
output gap (1)	28.90669	0.1055	30.23831	0.0245	16.32583	0.3259	-5.187867	0.6181
		(1.636323)		(2.287848)		(0.990812)		(-0.500577)
E	-2.778398	0.7156	32.00898	0.0092	-0.190995	0.9836	11.60530	0.0615
		(-0.365556)		(2.660289)		(-0.020632)		(1.897174)
$\bar{R}^2$	0.598797		0.712263		0.738784		0.673300	

Note: t-statistics are in parenthesis. The above regression result is obtained by using Least Squares in Eviews 4.1.

Table 6.Regression results of equation (4) from 1980:1-2002:2 for Australia, from 1980:1-2003:4 for Canada, from 1983:1-1998:4 for Italy, from 1983:1-2003:4 for UK dependent variable: r_t

	Australia		Canada		Italy		UK	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
constant	6.994336	0.0000	6.178639	0.0000	7.692578	0.0000	5.465981	0.0000
		(15.52732)		(22.91082)		(21.10248)		(19.12762)
inflation gap(2)	1.023996	0.0000	1.044911	0.0000	1.054021	0.0000	1.310831	0.0000
		(10.27776)		(13.54833)		(13.26093)		(11.54448)
E	-2.743851	0.7241	32.13982	0.0103	-3.970776	0.6576	10.87846	0.0637
		(-0.354223)		(2.620286)		(-0.445576)		(1.881275)
U	-0.105814	0.7924	-0.489041	0.0907	-1.150926	0.0374	0.748838	0.0409
		(-0.264082)		(-1.709922)		(-2.130477)		(2.079438)
$\bar{R}^2$	0.586352		0.705108		0.753642		0.689466	

Note: t-statistics are in parenthesis. The above regression result is obtained by using Least Squares in Eviews 4.1.

References:

Ball, L. (1999), 'Policy rules for open economies', In *Monetary Policy Rules*, 127-144, edited by Taylor, J.B. Chicago: University of Chicago Press.

Bank of Canada (1995-96), 'A proposed framework for the implementation of monetary policy in large value transfer system environment', *Bank of Canada Review,* Winter, 73-84.

Barro, R. and Gordon, D. (1983), 'A positive theory of monetary policy in a natural rate model', *Journal of Political Economy* 91, 589–610.

Bec Frédérique, Ben Salem Mélika and Collard Fabrice (2002), 'Asymmetries in Monetary Policy Reaction Function: Evidence for U.S. French and German Central Banks', in *Studies in Nonlinear Dynamics & Econometrics,* Vol. 6, The Berkeley Electronic Press.

Blinder, A.S. (1998), *Central Banking in Theory and Practice*, The MIT Press, Cambridge, MA.

Bullard James and Stefano Eusepi (2004), 'Did the great inflation occur despite policymaker commitment to a Taylor rule?', *Review of Economic Dynamics* 8 (2005) 324-359.

Burns, Arthur (1978), 'Reflections of an Economic Policy Maker, Speeches and Congressional Statements: 1969-1978,' American Enterprise Institute for Public Policy Research, Washington D.C.

Chick, V. (1973), *The Theory of Monetary Policy*, Oxford: Basil Blackwell.

Chick, V. (1986), 'The evolution of the banking system and the theory of saving, investment and interest', *Economics et Sociétés 20, Monnaie et Production,* **3**, 111-26.

Clarida, R., Galí, J., & Gertler, M. (2000), 'Monetary policy and macroeconomic stability: Evidence and some theory', *Quarterly Journal of Economics, 115(1)*, 147-180.

Defina Robert, H., Stark Thomas C. & Taylor Herbert E. (1996), 'The long-run variance of output and inflation under alternative monetary policy rules', *Journal of Macroeconomics*, vol. 18, no. 2, pp. 235-251.

Dickey, D.A., Fuller, W.A. (1979), 'Distribution of the estimators for autoregressive times series with a unit root', *Journal of the American Statistical Association*, 74, 427-431

Dickey, D.A., Fuller, W.A. (1981), 'Likelihood ratio statistics for autoregressive time series with a unit root', *Econometrica*, 49, 1057-1072

Eagly, R.V. (1974), *The Structure of Classical Economic Theory*, New York: Oxford University Press.

Fischer, S. (2000), '*Opening remarks by Stanley Fischer*', IMF Institute's High-Level Seminar on Implementing Inflation Targets, <http://www.imf.org/external/np/speeches/2000/032000.htm>

Flaschel Peter, Gong Gang & Semmler Willi (2001), 'A Keynesian macroeconomic framework for the analysis of monetary policy rules', *Journal of Economic Behavior & Organization*, vol. 46 (2001) 101-136.

Gavin, W.T. (1990), 'In defense of zero inflation', in R.C. York (ed.), *Taking Aim: The Debate on Zero Inflation*, Toronto: C.D. Howe Institute, pp. 43-62.

Goodfriend, M. (1991), 'Interest rate smoothing and the conduct of monetary policy', *Carnegie-Rochester Conference Series on Public Policy,* 7-30.

Howard, D. and A. Owens (1996), 'The Taylor rule', *Global Investor,* 4-5.

Julius DeAnne (1999), '*Back to the future of low global inflation*', The Maxwell Fry Global Finance Lecture, University of Birmingham,
< http://www.bankofengland.co.uk/publications/speeches/1999/speech57.pdf>

Kato Ryo and Nishiyama Shin-Ichi (2005), 'Optimal monetary policy when interest rates are bounded at zero', *Journal of Economic Dynamics & Control* 29 (2005) 97-133.

King, M. (1996), 'How should central banks reduce inflation: Conceptual issues', In: Hoenig, T.M. (Ed.) *Achieving Price Stability*, Federal Reserve Bank of Kansas City.

Lavoie Marc (2004), 'The New Consensus on Monetary Policy Seen from a Post-Keynesian Perspective', in Lavoie Marc and Seccareccia Mario(eds), *Central Banking in the Modern World: Alternative Perspectives*, Edward Elgar, pp. 15-34.

Lindsey, D.E and Wallich H.C. (1987), 'Monetary policy', in J. Eatwell, M. Milgate and P. Newman (eds), *The New Palgrave. A Dictionary of Economics,* Vol. 3, London: Macmillan, pp. 508-15.

McCallum, B. T. (1995), 'Rules for monetary policy', *NBER Reporter*, 5–8.

McCallum, B.T. (1997), 'Crucial issues concerning central bank independence', *Journal of Monetary Economics* 39, 99–112.

McCallum, B. (2002), 'Multiple solution indeterminacies in monetary policy analysis', *Carnegie-Rochester Conference Series on Public Policy*, November.

Minford Patrick, Perugini Francesco and Srinivasan Naveen (2002), 'Are interest rate regressions evidence for a Taylor rule?', *Economics Letters* 76 (2002) 145-150.

Mishkin, F.S. and Posen, A.S. (1997), 'Inflation targeting: Lessons from four countries', *Federal Reserve Bank of New York Economic Policy Review,* vol. 3, no.3, pp. 9-110.

Nelson Edward and Nikolov Kalin (2003), 'UK inflation in the 1970s and 1980s: the role of output gap mismeasurement', *Journal of Economics and Business* 55 (2003) 353-370.

Peersman, G., Smets, F. (1998), 'The Taylor rule: A useful monetary policy guide for the ECB?', Paper presented at the Banca D'Italia Workshop on Monetary Policy of the ESCB: *Strategic and Implementation Issues*, 6-7 July 1998.

Phelps Edmund S. and Zoega Gylfi (1998), 'Natural-rate theory and OECD unemployment', *The Economic Journal*, Vol. 108, pp. 782.

Phillips, P.C.B.and Perron, P. (1988), 'Testing for a unit root in time series regression', *Biometrika*, 75, 335-346.

Rudebusch Glenn D. (2001), 'Term structure evidence on interest rate smoothing and monetary policy inertia', *Journal of Monetary Economics* 49 (2002) 1161-1187.

Sargent, T.J. (1979), *Macroeconomic Theory*, New York: The Free press.

Seccareccia, M. (1998), 'Wicksellian norm, central bank real interest rate targeting and macroeconomic performance', in Philip Arestis and Malcolm C. Sawyer(eds), *The Political economy of Central Banking,* Edward Elgar, pp. 181.

Seyfried William and Bremmer Dale (2003), 'Inflation Targeting as a Framework for Monetary Policy: A Cross-Country Analysis', *The Australian Economic Review,* vol.36, no.3, pp. 291-9.

Sparks, G.R. (1986), 'The theory and practice of monetary policy in Canada: 1945-83', in J. Sargent (ed.), *Fiscal and Monetary Policy,* Toronto: University of Toronto Press, pp.119-49.

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

Taylor, J.B. (1995), 'Monetary policy implications of greater fiscal discipline', in: *Budget Deficits and Debt: Issues and Options*. A Symposium Sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, August 1995.

Taylor, J.B. (1999), *'The robustness and efficiency of monetary policy rules as guidelines for interest rate setting by the European Central Bank*', Standford University.

Taylor, J.B. (1999a), *Monetary Policy Rules*, University of Chicago Press.

Taylor, J.B. (2000), 'Teaching modern macroeconomics at the principles level', *American Economic Review*, 90(2), 90-94.

Taylor Mark P. (1999), 'Real interest rates and macroeconomic activity', *Oxford Review of Economic Policy*, vol. 15, no. 2, pp. 95-111.

Woodford, M. (1999), 'Optimal monetary policy inertia', *National Bureau of Economic Research Working Paper* 7261.

Woodford, M. (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton, NJ: Princeton University Press 2003.