VOLATILITY COSTS OF INFLATION TARGETING: ANALYSIS OF NINE INFLATION TARGETING COUNTRIES

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

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ABSTRACT

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This thesis tries to investigate the impact of inflation targeting as a monetary policy on the volatility of output and inflation, interest rate, exchange rate, and money growth in the nine countries that adopted inflation targeting prior to 1994: Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden and United Kingdom. The thesis also compares four inflation targeting countries to non-inflation-targeters to figure out the relative effectiveness of inflation targeting as a monetary policy. Structural break tests are made on the monetary aggregates. The main finding of the thesis is, inflation targeting countries well managed to improve their performance in terms of the volatilities of monetary aggregates. Despite the fact that there are upward movements in the volatilities of monetary aggregates at the time of the regime shift, after the adoption of inflation targeting, in general, the volatilities declined. However, there isn't any clear pattern of how inflation targeting countries perform relative to the benchmark countries.

ÖZET

ENFLASYON HEDEFLEMESİNİN MALİYETİ:
ENFLASYON HEDEFLEMESİ UYGULAYAN DOKUZ ÜLKENİN ANALİZİ

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Bu çalışma, bir para politikası olan enflasyon hedeflemesinin, üretim, enflasyon, faiz oranları, parasal büyüme ve döviz kuru değişkelerine olan etkisini incelemektedir. İncelenen dokuz ülke 1994'ten once enflasyon hedeflemesine geçmiş olan Avustralya, Kanada, Şili, Finlandiya, İsrail, Yeni Zelanda, İspanya, İsveç ve Birleşik Krallık'tır. Ayrıca bu dokuz ülkeden dördü enflasyon hedeflemesi uygulamayan dört ülkeyle karşılaştırılarak, enflasyon hedeflemesinin diğer para politikalarına oranla ne derece etkili olduğu saptanmaya çalışılmıştır. Üretim, enflasyon, faiz oranları, parasal büyüme ve döviz kuru verilerine yapısal değişim testleri uygulanmıştır. Tezin temel bulgusu, enflasyon hedeflemesi uygulayan ülkelerin, makroekomik göstergelerin değişkesi ölçüt alındığında performaslarını iyileştirmiş olduklarıdır. Enflasyon hedeflemesine geçiş sürecinde bahsi geçen makroekonomik göstergelerin değişkelerinde artışlar olmuş olsa da, enflasyon hedeflemesine geçildikten sonar değişkeler genelde düşmüştür. Fakat, enflasyon

hedeflemesi uygulayan ülkelerin uygulamayanlarla karşılaştırılması sonucunda enflasyon hedeflemesinin göreceli başarısına karar verilememiştir.

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“That which does not kill me, makes me stronger”

Nietzsche

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Introduction

After initial adoption by New Zealand in 1990, inflation targeting has been the choice of a growing number of central banks in industrial and emerging economies. Many more countries are considering future adoption of this new monetary framework. Mishkin and Hebbel (2001) count eighteen countries that have adopted inflation targeting by 2000. The earliest countries to adopt inflation targeting are New Zealand in 1990, Chile and Canada in 1991, Israel and United Kingdom in 1992, Sweden and Finland in 1993 and Spain and Australia in 1994.

Inflation targeting is a relatively new monetary regime that has been and is increasingly being adopted by central banks. There is an ongoing debate on the benefits and costs of inflation targeting and some theoretical and empirical studies try to investigate whether inflation targeting is better than monetary targeting. The studies on inflation targeting are mainly concerned with the effects of inflation targeting on output variability and the relation between inflation and output volatility. In this thesis, we try to investigate the impact of inflation targeting not only on the volatility of output and inflation but also on interest rate, exchange rate, and money growth in the nine countries that adopted inflation targeting until 1994: Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden and United Kingdom. We also compare four inflation targeting countries to non-inflation-targeters to figure out the relative effectiveness of inflation targeting as a monetary policy.

The inflation targeting countries studied in this thesis vary in terms of target price index, target width and horizon, accountability of target misses and overall transparency and accountability regarding conduct of policy under inflation targeting. Despite these differences in implementation features, there is a consensus on the pillars of inflation targeting. Mishkin and Savastano (2000) define inflation targeting as a monetary policy strategy that includes five main elements: 1. the public announcement of numerical inflation targets, 2. commitment to price stability as the primary goal of monetary policy; 3. an information-inclusive strategy in which many variables and not just monetary aggregates or the exchange rate are used for setting the policy instruments; 4. a transparent monetary policy in which communicating with the public about objectives and the rationale for the decisions of the central bank plays a central role; 5. central bank accountability for attaining its inflation objectives. These pillars make inflation targeting much more than a public announcement of numerical targets for inflation. Inflation targeting is easily understood by the public and thus is highly transparent and an explicit numerical target for inflation increases the accountability of the central bank and allows the central bank to focus on controlling inflation. Also, stability in the relationship between monetary aggregates and inflation is not crucial to its success. Despite its advantages such as increased transparency and accountability for central bank actions, there are also concerns regarding the problems that inflation targeting may cause.

There is an ongoing debate on the costs of inflation targeting and whether inflation targeting is better than monetary targeting. The studies on inflation targeting are mainly concerned with the effects of inflation targeting on output variability and the relation between inflation and output volatility. A number of studies summarize the experience gained with inflation targeting. Bernanke et al (1999), Mishkin and Hebbel (2001), Cecchetti and Ehrmann (1999) are the most prominent ones. There are theoretical studies that compare inflation targeting with other monetary regimes, in most cases monetary targeting. Rudebusch and Svensson (1999) and Svensson (1998) basically search for the optimality of inflation targeting rules and are concerned with output gap and inflation volatility. Similarly, Callum and Nelson (1999) try to investigate the optimality of different monetary policies, Levin et al. (1999) search for the relation between interest rate volatility and inflation-output volatihity. Ball (1999) searches for optimal rules for open economies and shows how exchange rate can affect the inflation-output variability relation. Rotemberg and Woodford (1999) search for the tradeoff between inflation and output gap variability within the framework of Taylor rules.

There are two particular differences of this thesis other than the works in the literature. First, the method in searching for volatility changes is different. In the literature, mainly Taylor rules and vector autoregression models are used to calculate the variability of inflation and output in inflation targeting countries. We do not estimate a theoretical model to explain the effects of inflation targeting on the monetary aggregates. We included these theoretical models in Chapter 2 and they serve as a benchmark for analysis. Instead of forming a policy model and estimating the parameters of that model, we analyse the monetary aggregates and search for the existence of structural changes in the volatilities of these monetary aggregates. We make structural break tests. The results tell us whether there is a structural break in the monetary aggregate analysed as well as what the effect of the structural break is if there exists one. We also interpret these changes and try to figure out whether the changes in volatility are the results of the changes in the level or not. This is particularly important for output growth and inflation volatilities since it is desirable to have a high level of output growth with a low volatility and a low level of inflation with a low volatility. However, a decline in output volatility might be the consequence of a decline in output growth and a decline in the level of inflation not always implies a decline in the volatility of inflation.

The second difference of this thesis from the studies in the inflation targeting literature is, we not only look at the changes in inflation, output and interest rate variability but also search for changes in exchange rate and money variability. Since there are no empirical studies on especially the volatility of exchange rates and money in inflation targeting countries, the results provide important insights on whether inflation targeting central banks excessively use money and exchange rate to control inflation and whether this can be attributed to the introduction of inflation targeting. The interest rate volatility results when considered together with output-inflation volatilities explain whether inflation targeting central banks sacrifice from interest rate volatility to create a more efficient inflation-output variability trade-off if they could have created one. The countries that we analyze are the first nine countries that adopted inflation targeting; Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden and United Kingdom. We compare the results of

Canada with United States, United Kingdom with France, Sweden with Denmark and Finland with Norway.

The main finding is, inflation targeting countries well managed to improve their performance in terms of the volatilities of monetary aggregates. Despite the fact that there are upward movements in the volatilities of monetary aggregates at the time of the regime shift in inflation targeting countries, after the adoption of inflation targeting, in general, the volatilities declined. After the adoption of inflation targeting, the most notable declines are in the volatilities of exchange rates and interest rates. While there aren't increases in inflation and production growth volatility in any of the countries analyzed, there are decreases in inflation and production growth volatility in some of the countries. Furthermore, producing decreased inflation and output volatility does not come with the cost of increased interest rate volatility or exchange rate volatility. This suggests that inflation targeting countries well managed to control inflation without using interest rates and exchange rates excessively. The results on the relationship between the volatilities and the levels of monetary aggregates are mixed. All inflation targeting countries managed stable low inflations and interest rates but not all of them managed to sustain high output growth levels. The results on the levels of exchange rates and money growth rates are inconclusive.

When we compare Canada with U.S., we see that Canada does not perform as well as U.S. in terms of volatilities before and after the introduction of inflation targeting except for exchange rate. After the introduction of inflation targeting Canada successfully achieves a lower CPI inflation than the U.S. and also the differences between the levels of interest rate and production growth in Canada and

U.S. are either declining or negative which implies that the relative performance of Canada has been improving after the adoption of inflation targeting. For Finland there is a change in trend when compared to Norway after the introduction of inflation targeting. Production growth is bigger and interest rate and inflation levels are smaller when compared to Norway after the introduction of inflation targeting. Production growth volatility and interest rate volatility are smaller but inflation volatility and exchange rate volatility are usually higher than in Norway. When Sweden is compared to Denmark, it is seen that after Sweden introduced inflation targeting, Sweden has a lower inflation level than Denmark with a higher volatility. Moreover, Sweden manages to have a higher production growth with a lower volatility than Denmark however interest rates do not follow the decline in inflation. After inflation targeting is implemented, Sweden has also lower volatility in interest rates and money growth but lower volatilities cannot be safely attributed to the regime change. Exchange rate is more volatile in Sweden at all times. When we compare U.K. with France, we find that the volatility and the level of inflation is almost always lower in the U.K. before and after inflation targeting, exchange rate is always more volatile in U.K., money growth is always more volatile in France. After the introduction of inflation targeting in U.K. there is a clear evidence of declining production and interest rate volatility, however production growth level is also lower in the U.K. especially after mid-1996 and the relative interest rate volatility increases after mid-1996.

So, the results clearly suggest that inflation targeting countries successfully lowered their inflation levels below the benchmark countries' inflation levels. However, except U.K. inflation volatilities are higher in inflation targeting countries.

Sweden and Finland manage to sustain high production growth levels with low production growth volatilities compared to the benchmark countries but this is not the case for U.K. and Canada. Interest rate level differences are declining in Canada and Finland but not in the U.K. and Canada. There is a relative improvement in interest rate volatility after the regime change in all countries except Canada. Exchange rate is always more volatile in the inflation targeting countries. Money growth is less volatile in the U.K., Sweden and Finland but not in Canada. So there isn't any clear pattern of how inflation targeting countries perform relative to the benchmark countries and the relative success of the regime changes from one country to another.

The remainder of the thesis is as follows: in the first chapter we discuss the literature on inflation targeting that investigate the impacts of inflation targeting on inflation, output, exchange rate and interest rate volatility. In chapter 2, we give examples of the theoretical models used to analyze the impacts inflation targeting. These models are simplified versions of the policies that inflation targeting central banks use to conduct monetary policy. The models are chosen to reflect the effects of inflation targeting on the variability of output, interest rates and exchange rate. The models do not include money because especially after the leading work of Taylor (1993) money is not used as an instrument to set up monetary policy. Instead, interest rate is used in response to output, inflation and exchange rate. In chapter 3 we explain the data and methodology that we use in the thesis and give a brief overview of Bai and Perron (2003) structural break test. In chapter 4, we explain the results from the structural break point tests made for the nine inflation targeting countries as well as the comparisons of inflation targeting countries with the four benchmark countries. Chapter 5 briefly concludes.

CHAPTER 1

Literature on inflation targeting

To investigate the impacts of a monetary policy, its effects on monetary aggregates must be explored. Generally, changes in standard deviations, rather than changes in average levels, are used to analyse the effects of a monetary policy. The most analysed changes are those of inflation variability and output variability. Recently, there are also studies including interest rates since variability in interest rates is a signal of central bank credibility and increased variability of interest rates can make small open economies vulnerable to financial crisis. Exchange rate variability is as important as interest rate variability for small open economies for the same reason. Below the literature on the effects of inflation targeting on inflation variability, output growth variability, exchange rate variability and interest rate variability is summarised. The results in the literature serve as a benchmark for the results that we find.

1.1 Inflation targeting and volatility of inflation

Cecchetti and Ehrmann (2000), in their analysis comparing nine inflation targeting countries with fourteen industrialised and developing countries, show that standard deviation of inflation fell more for the inflation targeting countries than other countries analysed. In the sample, comparing late 1980s to the mid 1990s, it can be seen that volatility in both output and inflation fell in all countries, suggesting 1990s have been relatively shock free. They make a distinction between the types of shocks and define two kinds of shocks to the economy; demand and supply shocks. They argue that demand shock moves output and inflation in the same direction, whereas supply shock moves in reverse directions. Aggregate supply movements create a dilemma for the policy makers. Defining these shocks, they form a simple model, estimate the responses of inflation and output to increases in interest rates and calculate the inflation aversion of the countries. The estimated five-year moving coefficient shows that there is a striking difference among targeters and non-targeters. For seven of nine inflation targeting countries, the estimate of the aversion of inflation variability rises substantially either prior to or immediately following the regime shift. The fact that the increase in the average level of inflation aversion in inflation targeting countries is much higher than non-targeting countries analysed reveal that the increase in inflation aversion can be ascribed to the targeting regime itself.

Mishkin and Hebbel (2002) conclude in their cross-country panel analysis that inflation targeting countries reduce their long-run inflation below the levels they would have attained in the absence of inflation targeting. They also argue that inflation targeting has been tested favourably by adverse shocks. 1997 Asian crisis had adverse effects on financial markets and on terms of trade in Australia, Chile, Israel and New Zealand and led to major exchange rate devaluation in these countries. These countries were successful not to let pass through from devaluation to inflation. Similarly, Mishkin (1999) argues that shortly after adopting inflation targeting, Canada faced a negative supply shock because of the increase in value added tax. This supply shock led only a one-time increase in the price level and was not passed through to a persistent rise in the inflation level. Another example is the experience of United Kingdom and Sweden. These countries quitted ERM exchange rate pegs in 1992 and faced devaluations. Mishkin (1999) argues that devaluation would normally have stimulated inflation because of the direct effects on higher export and import prices and subsequent effects on price-setting behaviour. Inflation targeting in these countries prevented second and later-round effects of devaluation and there were not inflationary responses.

Early studies by Ammer and Freeman (1995) present vector autoregression models for real GDP, price levels and interest rates for comparing inflation forecasts generated by their vector autoregression models with actual results in New Zealand, Canada and United Kingdom. They find that inflation fell by more than predicted under inflation targeting. Mishkin and Posen (1997) similarly compare their vector autoregression model estimations of inflation, output growth and short-term central bank rates with the actual results in New Zealand, Canada and United Kingdom. They find that inflation remained below their estimations in these countries. In particular, actual inflation did not rise with the upswing in business cycle, as it would have been without inflation targeting. Debelle (1997) notes the decline in inflation rates after the introduction of inflation targeting in Australia, Canada, Finland, Spain, Sweden and United Kingdom. He also points to the fact that other countries also achieved reductions in inflation rates. Siklos (1999) analyses the first order auto-correlation of inflation in inflation targeting countries and argues that the persistence of inflation has declined in Australia, Canada and Sweden and lost statistical significance in Finland, Spain and United Kingdom after the introduction of inflation targeting. Corbo et al. (2001) show that inflation aversion increased most notably in Israel and Chile after inflation targeting is employed. They also note that inflation persistence has declined substantially among inflation targeters. The decline in the persistence level of inflation suggested by Siklos (1999) and Corbo et al. (2001) can be an explanation of how inflation targeting countries prevented second and later-round effects of devaluation in Asian crisis and ERM crisis and there were not inflationary responses.

Neumann and Von Hagen (2002) compare Australia, Canada, Chile, New Zealand, Sweden and United Kingdom with a group of non-inflation targeting countries consisting of Germany, Switzerland and United States and search for volatility changes in interest rates, inflation and output gaps. It results that average inflation in inflation targeting countries has come down to the level of observed for non-inflation targeting countries. Similar to average inflation, the volatility of inflation has fallen in both groups and the volatility of inflation in inflation targeting countries converged from high levels to the levels observed in non-inflation targeters. Analysis with monthly Taylor rules show that there is a substantial increase in the long-run response to inflation in inflation targeting countries and central banks of inflation targeting countries converged to the behaviour of Bundesbank and Swiss National Bank, the two banks that showed the strongest determination to keep inflation down in the 1970s and 1980s. Neumann and Von Hagen (2002) also compare the results of 1978 and 1998 oil price shocks and find that inflation targeting countries managed to cope with 1998 oil price shock better than the control group, which was not the case with 1978 oil price shock.

1.2 Inflation targeting and output stability

The analysis of the relationship between output and inflation dates back to 1958, the original Phillips curve in which the benefits of lower inflation have to be balanced by the costs in terms of higher unemployment. Phelps (1967) and Friedman (1968) predicted that the Phillips curve would shift as expectations of inflation adjusted to actual inflation so unemployment could not be kept below its natural rate by producing inflation. This destroyed the theoretical basis for assuming a long-run trade-off between inflation and unemployment. With the addition of rational expectations, Lucas (1973) destroyed even the short-run Phillips curve trade-off. Fischer (1995) argues that there is econometric evidence that predictable monetary policy affects output, not only the prices and Fischer adds that short-run Phillips curve is flatter in a low inflation economy than in a high inflation economy. So in the short-run there is always the possibility of increasing output by generating inflation. Fischer (1993) shows a consistently negative association between inflation and output growth. Analysing the performance of Germany and United States for the period 1960-1992, he argues that there remains a trade-off between inflation and output stability.

Cecchetti and Ehrmann (2000) in their analysis comparing nine inflation targeting countries with fourteen industrialised and developing countries, conclude output variability fell in both of the inflation targeting countries and non-inflation targeters. However, output variability fell less for the targeters than for non-targeters. They also find evidence that output deviations have a positive weight in all objective functions of inflation targeters.

Mishkin and Hebbel (2001) argue that inflation targeting has helped in reducing sacrifice ratios and output volatility to levels close to those in industrial non-inflation targeters. Similarly, Corbo et al. (2000) conclude that sacrifice ratios have declined in emerging market countries after adoption of inflation targeting. They also find that output volatility has fallen in inflation targeting countries to levels observed in industrialised non-inflation targeting countries. Mishkin (1999) note that although disinflation is associated with low output growth, once low inflation levels are achieved output returns to its previous level. He also points to the fact that after the adoption of inflation targeting, strong economic growth levels were achieved and this can be attributed to the success of inflation targeting in promoting real economic growth in addition to controlling inflation. Mishkin and Posen (1997) compare vector autoregression estimations with actual data and find that output did not fall under inflation targeting regime in New Zealand, Canada and United Kingdom. Neumann and Von Hagen (2002) in their analysis on Australia, Canada, Chile, New Zealand, Sweden and United Kingdom find that the volatility of output gaps for these countries significantly decreased after the adoption of inflation targeting.

In their theoretical work, Svensson and Rudebusch (2002) make a comparison of monetary targeting and inflation targeting and find that monetary targeting is much more inefficient in the sense of inducing more variable inflation and output than inflation targeting. This result holds even when the sample period is chosen so that a very well behaved stable money demand equation comes out. So counter to conventional wisdom, monetary targeting is inefficient when money demand is stable and controllable. This is a consequence of the fact that money growth is a poor indicator of future inflation.

1.3 Inflation targeting and interest rates

In the early work of inflation targeting countries, Freeman and Willis (1995) find that long-term interest rates fell in New Zealand, Canada and United Kingdom however rose back a few years later. For these countries Mishkin and Posen (1997) estimate that interest rates remained at lower rates after the introduction of inflation targeting than otherwise would be. Kahn and Parrish (1998) note that the volatility of central bank interest rates has declined after the introduction of inflation targeting.

Neumann and Von Hagen (2002) in their analysis on Australia, Canada, Chile, New Zealand, Sweden and United Kingdom, find that both the level and the volatility of interest rates has fallen in inflation targeting countries as well as non-inflation targeters. Using the method of double differences for the oil price shocks of 1978 and 1998, they find that inflation targeting countries managed to prevent long-term bond rates from rising in 1998 better than in 1978 and this points to the fact that the introduction of inflation targeting has produced significant gains in credibility. For short-term interest rates, the results are more striking. While the average increase in short-term interest rates in 1978 oil shock is 9.99 percent in inflation targeting countries, it is 2.65 percent in 1998 oil price shock. So, inflation targeting central banks managed to reduce their response to the increase in oil prices more than non-inflation targeting countries.

1.4 Inflation targeting and exchange rate volatility

Exchange rate movements can have a major impact on inflation particularly in small open economies. While, depreciation leads to a rise in inflation as a result of the pass through from higher import prices and lower export prices, appreciation of the domestic currency makes domestic business uncompetitive because of increased export prices. Although, exchange rate movements play a vital role in a country's monetary policy, there are only a few theoretical studies and there aren't any empirical studies on the effects of inflation targeting on exchange rate volatility.

Gali and Monacelli (1999) compare domestic inflation targeting, CPI targeting and exchange rate peg. They define domestic inflation as the rate of change in the index of domestic goods prices and CPI as the weighted average of the price of domestic goods and the price of foreign goods. Gali and Monacelli show that these monetary policy rules can be ranked in terms of their nominal and real exchange rate volatility. Domestic inflation targeting can achieve simultaneous stabilisation of the output gap and domestic inflation but implies a substantially higher volatility of both nominal and real exchange rates than the CPI targeting and exchange rate peg. CPI targeting can be seen as a hybrid regime between domestic inflation targeting and exchange rate peg because of its equilibrium dynamics. CPI targeting coincides with domestic inflation targeting in the case of a closed economy while it coincides with exchange rate peg when the economy converges to its maximum level of openness.

Mishkin and Hebbel (2002) give examples of effects of exchange rate targeting in inflation targeting countries. Israel, as part of its inflation targeting regime, has an intermediate target of a quite narrow exchange band and Mishkin and Hebbel suggest that this slowed Israel's efforts to win support for disinflation and lowering of the inflation targets. Another example of the negative effects of targeting on exchange rate is the experience with New Zealand. New Zealand was targeting on a Monetary Conditions Index, a weighted average of exchange rate and short-term interest rates, at the time of the Asian crisis. Limiting exchange rate fluctuations have led New Zealand to respond in a wrong manner to the Asian crisis starting in 1997. After the devaluation of the Thai baht, MCI began a sharp decline causing the central bank of New Zealand to increase interest rates more than 200 basis points. This in turn led to a recession in 1998. The central bank of New Zealand reversed its course and sharply lowered interest rates in July 1998 and abandoned using Monetary Conditions Index in 1999. The response of Chile to Asian crisis was similar. Chile was using an exchange rate band with a crawling peg at the time of the crisis and not letting peso to devaluate caused a mild recession in late 1998. After the recession has started, interest rates were lowered and the peso was allowed to decline. Chile abolished its exchange rate band in September 1999. In contrast to New Zealand and Chile, central bank of Australia lowered its interest rates when faced with the devaluation in Thailand in July 1997. This way, Australia kept its output growth strong throughout the crisis and inflation remained under control. The writers conclude that targeting on an exchange rate within the inflation targeting regime is likely to worsen the performance of inflation targeting countries. Countries that only target inflation have a better performance when faced with shocks.

CHAPTER 2

Inflation Targeting As A Monetary Policy

It is argued that inflation targeting should be implemented through a "Taylor rule" in which interest rates are adjusted in response to output, inflation and lagged interest rate.

We can define a Taylor rule as follows:

(1.1) $$r_t = r^* + \pi_{t-1}^{av} + \mu_1(\pi_{t-1}^{av} - \pi^*) + \mu_2\tilde{y}_t .$$

r_t is the quarter t value of an interest rate instrument, r^* is the steady state value of interest rate implied by the policy rule, π_{t-1}^{av} is the average inflation rate over the four periods prior to t, π^* is the target inflation rate and $\tilde{y}_t = y_t - \bar{y}_t$ is the difference between the logs of real GDP and its natural rate value. The policy feedback parameters μ_1 and μ_2 are positive and each of them equals 0.5 in Taylor's (1993: 195-214) example. The interest rate is raised in response to inflation and output gaps relative to their targets.

Taylor rules that involve a lagged interest rate are:

(1.2) $$r_t = \rho r_{t-1} + \mu_1(\pi_t - \pi^*) + \mu_2\tilde{y}_t ,$$

r_t, the nominal interest rate used as the instrument, responds to inflation rate at period t, the difference between the logs of real GDP and its natural rate value and lagged interest rate. This allows for interest rate smoothing.

Taylor rules that only respond to lagged values:

(1.3) $$r_t = \rho r_{t-1} + \mu_1(\pi_{t-1} - \pi^*) + \mu_2 \tilde{y}_{t-1} .$$

With this modification, the central bank operations are more transparent since the policy only responds to previous period's values that are publicly known.

Forward-looking Taylor rules:

(1.4) $$r_t = \rho r_{t-1} + (1-\rho) r_t^* + \mu(E_t \pi_{t+j} - \pi^*) ,$$

where, r_t^* denotes the equilibrium value of real interest rates and π^* is the inflation target. The policy choice variables are j, ρ and μ. ρ dictates the degree of interest rate smoothing, j is the target horizon and μ is the policy feedback parameter.

Rudebusch and Svensson (1999) make a distinction between instrument rules and targeting rules. They define an explicit instrument rule (e.g. Taylor rules defined above) as a rule that expresses the monetary policy instrument as an explicit function of available information. They also claim that no central bank follows an explicit instrument rule and these rules can only serve as a baseline for comparison of the policies actually followed. Targeting rules are represented by the assignment of a loss function over deviations of a goal variable from a target level. This way, a targeting rule is an implicit instrument rule and the first order conditions of the optimization problem will yield the explicit instrument rule. Inflation targeting means having a loss function for monetary policy where deviations of inflation from target are always given positive weight but not necessarily all the weight. The loss function to be minimized is $E[L_t] = \mathrm{var}(\overline{\pi}_t) + \mu\,\mathrm{var}(\tilde{y}_t) + \rho\,\mathrm{var}(r_t - r_{t-1})$, $\overline{\pi}_t$ is the average four period deviation of inflation from the target, $\tilde{y}_t$ is the percentage gap between actual real output and potential output and r_t is the deviation from the average nominal interest rate.

Rudebusch and Svensson (1999), define flexible inflation-forecast targeting rule as:

$$\bar{\pi}_{t+T|t}(r_t) = c\bar{\pi}_{t+1|t} \quad (1.5)$$

where c and T fulfil $0 \le c \le 1$ and $T \ge 2$. $\bar{\pi}_{t+T|t}$ is the average of the forecast of four period inflation T periods ahead conditional on the current state of variables and the corresponding reaction function (e.g. a Taylor rule). $\bar{\pi}_{t+T|t}(r_t)$ is the forecast of an average of four period inflation T periods ahead conditional on a given constant current and future interest rate. This rule is a first-order condition for the minimization of a loss function with nonnegative weight on output stabilization but zero weight on interest rate smoothing and the corresponding explicit interest rate rule is solved for.

Similarly, a strict inflation-forecast targeting rule is a solution to

$$\bar{\pi}_{t+T|t}(r_t) = 0 \quad (1.6)$$

These rules can be considered under smoothing of the interest rate where the corresponding implicit instrument rules depend on the lagged interest rate as well as the solutions to the equations (1.5) and (1.6). They are denoted as flexible/strict inflation forecast targeting rules with smoothing. Rudebusch and Svensson (1999) compare Taylor rules, flexible inflation forecast targeting rules and strict inflation forecast targeting rules with the optimal rule they find. They first set ρ=0.5 in the loss function above and compute the variances of inflation, output and interest rate together with the losses with μ=1, 0.2 and 5. Then with μ=1, they change ρ to 0.1

and 1. They find that simple forward-looking Taylor rules of type (1.4) are extremely close to matching the optimal rules. Inflation forecast targeting rules without interest rate smoothing perform very poorly overall. Although the performance regarding inflation and output variability are not bad within these rules, interest rate variability is very high. Strict inflation forecast targeting rules with smoothing perform poorly in terms of total loss as μ increases but flexible inflation forecast targeting rules with smoothing perform close to the optimal rule when especially $\mu=1$, and $\mu=0.2$. Strict inflation forecast targeting rules with smoothing and with a short forecast horizon, consistently achieve the minimum variability of inflation among all the rules analysed, with a huge sacrifice in output and interest rate variability. As the forecast horizon increases, inflation variability increases and output and interest rate volatility decrease. As μ increases, variance of output decreases and variance of inflation increases in all of the rules. With flexible inflation forecast targeting rules with smoothing, variances of interest rates increase with increasing μ. Keeping in mind that ρ is constant when μ varies, this shows that within flexible inflation targeting rules with smoothing, there is a tradeoff between inflation-interest rate variability and output variability. Varying ρ when μ is 1 shows us that, as ρ increases both inflation and output variability increase under flexible inflation forecast targeting with smoothing. Strict inflation targeting with smoothing performs better as ρ increases and forecast horizon is enlarged. Flexible inflation forecast targeting rules with smoothing are again close to the optimal rule. The responses of inflation targeting rules to positive inflation or output shocks reveal that inflation targeting rules without interest rate smoothing show large initial interest rate spikes in response to positive inflation or output shocks. The mildest response belongs to the flexible inflation forecast targeting rule with interest rate smoothing.

Callum and Nelson (1999) using a Taylor rule of type (1.2) try to investigate the optimality of different monetary policies. They solve a household optimization problem assuming sticky prices. The parameters on inflation and output gap variability in the resulting loss function depend on the optimization itself; they are not choice parameters of the monetary policy. They consider cases with $\rho=1$ to reflect interest rate smoothing. Simulation results on U.S. data show that for a given value of the smoothing parameter ρ, higher values of μ_1 or μ_2, lead invariably to lower standard deviations of that variable. They claim that this suggests that if there were no concern for the variability of the interest rate, the central bank could perfectly achieve good macroeconomic performance by responding to deviations of output and inflation from their target values. With a lagged Taylor rule like (1.3) simulation results indicate a trade-off between inflation and output gap variability. Rules with interest rate smoothing perform better with respect to inflation and output gap variability as well as interest rate variability itself.

A similar analysis is by Rotemberg and Woodford (1999). They provide a framework for analyzing different types of Taylor rules using a rational expectations model derived from intertemporal optimization. Comparing rules of type (1.1), (1.2), (1.3) with different weights given to inflation and output stabilization and interest rate smoothing, they find that rules that have smaller standard deviations of inflation tend to involve larger standard deviations of output and vice versa. Rules without interest rate smoothing are dominated because they induce a higher standard deviation of inflation without reducing the standard deviation of output. They also find that standard deviations of interest rate and inflation move together so that a policy that comparatively induces a lower standard deviation of interest rate also has a lower standard deviation of inflation. Standard deviations of inflation and long-run price level also move together.

Ball (1999) searches for optimal rules for open economies. He shows the inflation-output variability tradeoff and how exchange rate can affect this tradeoff. He also finds that strict inflation targeting induces large fluctuations in exchange rate but this could be remedied by targeting to long-run inflation.

Ball (1999) develops a model for open economies that includes exchange rate. The model is:

$$y = -\beta r_{t-1} - \delta e_{t-1} + \lambda y_{t-1} + \varepsilon \tag{2.1}$$

$$\pi = \pi_{t-1} + \alpha y_{t-1} - \gamma(e_{t-1} - e_{t-2}) + \eta \tag{2.2}$$

$$e = \theta r + \nu \tag{2.3}$$

where y is the log of real output, r is the real interest rate, e is the log of real exchange rate, π is inflation and ε,η and ν are white noise shocks. All variables are measured as deviations from average levels.

The first equation is an open economy IS curve. The second equation is an open economy Phillips curve. The change in inflation depends on the lag of output, the lagged change in exchange rate and a shock. The change in exchange rate affects inflation because it is passed directly into import prices. The third equation links exchange rate to interest rate. The central bank chooses the real interest rate r. the policy affects inflation through two channels. The first channel is through Phillips curve that takes two periods, a monetary contraction raises r and e

contemporaneously but it takes a period for these variables to affect output and another period for output to affect inflation. However, it takes one period for an exchange rate change to affect inflation.

Ball uses parameters obtained from medium to small open economies including Canada, Australia and New Zealand. He assumes that λ=0.8, α=0.4 and β+δθ=1 where λ corresponds to output persistence, α to the slope of the Phillips curve and β+δθ to the total output loss from a 1-point rise in the interest rate. The other parameters depend on the economy's degree of openness and based on he assumes γ=0.2, θ=2.0 and β/δ=3.0. He eliminates *r* from the model by substitution.

(2.4) $$y_{+1} = -(\beta/\theta + \delta)e + \lambda y + \varepsilon_{+1} + (\beta/\theta)v$$

(2.5) $$\pi_{+1} = \pi + \alpha y - \gamma(e - e_{-1}) + \eta_{+1}$$

Optimal rule is:

(2.6) $$wr + (1-w)e = ay + b(\pi + \gamma e_{-1})$$

where w and b, a are constants that depend on m, n, β, α, θ, and λ.

This expresses the optimal rule as an average of *r* and *e* with constants *m* and *n* to be determined. So, optimal policy uses monetary conditions index (MCI) as the instrument, a combination of inflation and lagged exchange rate. In equation (2.6) the rationale for using a monetary conditions index is that it measures the stance of the policy, policymakers shift the MCI when they want to ease or tighten. Also in equation 2.6, inflation π is replaced with a combination of inflation and exchange rate, c. This can be interpreted as the long-run inflation forecast of inflation under the assumption that output is at its natural level. While in a closed economy this forecast would equal the current inflation, in an open economy inflation will change in order exchange rate to return to its long-run level that is normalized to zero. For example, if *e* was positive in the previous period, there will be depreciation in *e* starting at some point in the current period and this will in turn raise current inflation by γe_{-1}. This adjustment from inflation to γe_{-1} is similar to the calculations of core inflation in central banks that filter out the transitory effects of temporary influences. Ball claims that Canada, New Zealand and Sweden follow the approach of monetary conditions index.

The policymaker's objective is to minimize $\text{var}(y)+\mu\,\text{var}(\pi)$. Ball computes the *m* and *n* that make the policy efficient for different values of μ; the variances of output and inflation form the output-inflation variability frontier. The set of efficient *m* and *n* depends on the coefficients in the equations (2.1) (2.2) and (2.3) but not on the shocks. In the resulting frontier, as μ increases var(π) decreases and var(y) increases. As $\mu \to \infty$ $\text{var}(\pi) \to 0$ and $\text{var}(y) \to \infty$ and as $\mu \to 0$, $\text{var}(\pi) \to \infty$ and $\text{var}(y) \to 0$. However, using an inefficient rule causes the variances of output and inflation to be affected from the variances of the shocks. In his setting, using *r* as the policy instrument is most inefficient if there are large shocks to the *r/e* relation and the corresponding variances of output and inflation are infinite.

Ball defines strict inflation targeting as a policy that minimizes the variance of inflation and that does not put any weight on output variance in the loss function. So the policymaker minimizes var(π). When inflation deviates from its target, strict targeting eliminates the deviation as quickly as possible. Policy can affect inflation in one period through exchange rate channel. Hence, strict inflation targeting implies that next period's inflation is set to zero.

(2.7) $$E\pi_{+1} = 0 .$$

The efficient policy now implies a huge sacrifice in output stability for a small gaij in inflation variability. Equation (2.7) also implies large fluctuations in exchange rate because next period's inflation can only be controlled by this period's exchange rate. Large shifts in import prices are needed to move the average price level. Large fluctuations in exchange rate in turn imply output fluctuations through (2.1). Therefore, after a unit shock to (2.2), inflation returns to its target after one period but the shock triggers oscillations in exchange rate and output. Oscillations arise because the exchange rate must be used to offset the previous period's inflationary or deflationary effects of the first shock. This drawback of strict inflation targeting can be eliminated through long-run inflation targets.

Strict long-run inflation targeting is defined as the policy that minimizes $\pi^* = \pi + \gamma e_{-1}$. Now equation (2.2) can be rewritten as

(2.8) $$\pi^* = \pi^*_{-1} + \alpha y_{-1} + \eta .$$

This equation is the same as the closed economy Phillips curve. Policy affects inflation only through the output channel. The exchange rate channel is eliminated and the policy affects π^* with a two period lag and strict targeting implies

(2.9) $$E\pi^*_{+2} = 0 .$$

Targeting π^* produces more stable output than targeting π because it eliminates the oscillations of output and exchange rate caused by using exchange rate to control inflation. Ball also considers gradual adjustment of π^* where

(2.10) $$E\pi^*_{+2} = qE\pi^*_{+1} , \;\; 0 \le q \le 1 .$$

The motivation for adjusting slowly is to smooth the path of output. Strict long-run inflation targeting, with or without a gradual adjustment mechanism, produces smaller variances of output than strict short-run inflation targeting. However, for a given inflation variance, output variance can be made smaller by putting a nonnegligable weight on output in the optimization problem. Flexible-inflation targeting produces less output and inflation variance compared to strict long-run inflation targeting, this means that the output-inflation variance frontier defined by flexible inflation targeting dominates the output-inflation variance frontier defined by strict long-run inflation targeting. As q is increased, strict long-run inflation targeting with gradual adjustment more closely matches the efficient frontier defined by flexible inflation targeting. For example, for equal weights on inflation and output variances so that $\mu = 1$, optimal flexible inflation targeting produces variances of output and inflation that are 2.50 and 2.44 and with strict long-run inflation targeting the optimal policy produces output and inflation variances that are equal to 2.48 both when q=0.66.

CHAPTER 3

Data and Methodology

In the lights of above arguments I try to find out whether after the adoption of inflation targeting the volatilities in CPI inflation, exchange rate, interest rate, money growth and production growth have changed. I analyze nine countries that adopted inflation targeting: Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden and United Kingdom (U.K.). Among these countries, I compare Canada with United States (U.S.), Finland with Norway, Sweden with Denmark and U.K. with France. The historical relations, geographical proximity and being important import and export partners are the main reasons for choosing the comparison countries.

3.1 Data

The shift dates to inflation targeting are taken as in Mishkin and Hebbel (2001). The dates are defined by the first month of the first period for which inflation targets are announced previously. The shift dates are reported in the structural break results tables in the appendix. All data are taken from IMF International Finance Statistics (IFS) unless otherwise stated. Data starts from January 1980 except Israel. Israel interest rate data starts at June 1984 and the period between June 1984 and January 1986 is not included in the analysis because of the hyperinflationary period and as a consequence very high interest rates. Data ends for most of the countries in the second half of 2001. Important exceptions are; CPI inflation data for Australia ends at June 1997, data for interest rates in New Zealand ends at October 1999, data for money base in Spain ends at December 1998 with the introduction of the European System of Central Banks, industrial production data for Sweden ends at January 2000. When analyzing, all except interest rates are calculated as the twelve-month log differences. If there is no monthly data on consumer prices, then relevant price indexes are used to measure inflation. If available, money base is taken when calculating money growth rate, otherwise broad money is used, however it must be noted that there are differences in the definitions of broad money among countries. All exchange rates are national currency versus U.S. dollars.

For Australia, interest rate is 13 week's Treasury bill rate. There is no monthly data for consumer prices, so manufacturing output prices available until June 1996 is used. For Canada interest rate is Treasury bill rate and the data for monetary base that is seasonally adjusted is taken from Datastream. For Chile, interest rate is the deposit rate and production data is manufacturing production. The data for monetary base that is seasonally adjusted is taken from Datastream. For Finland interest rate is the average cost of central bank debt rate. Money is calculated by adding currency in circulation and demand deposits and there is an implausible break with the introduction of Euro in 1999 that is due to changed definitions of data on IFS. There is data for monetary base in Datastream that does not have this problem but starts from 1987. For Israel, the data for money is seasonally adjusted, interest rate is the Treasury bill rate and inflation is measured using the prices of industrial products. For New Zealand, the data for exchange rate and 3-month Treasury bill rate are taken from IFS, data on M1 that is not seasonally adjusted is taken from Datastream. There is no monthly data for consumer prices and industrial production. For Spain, money supply is M1 and interest rate is the call money rate. For Sweden, the data for money is money plus quasi-money that is seasonally adjusted and interest rate is 3-months treasury discount notes. For U.K., seasonally adjusted money base and Treasury bill rate are used. The data is summarized in Table 14.

3.2 Methodology

First we made ARCH estimation both for full sample data and for the full sample divided into two at date of adoption of inflation targeting. The results are not reported for two reasons. First, the resulting ARCH processes are so complicated that there does not exist any tool to test for breaks and second, even if there was a tool to test for breaks then the results would be biased because ARCH estimation is based on the assumption that the sample is uniform. Making an estimation based on the uniformity assumption and then testing the results of the estimation for differences in the sample would bias the results.

To do structural break tests on the samples, we calculated the twelve-month moving average standard deviations of the data and used Bai and Perron (2003) structural break tests to test for breaks in the data. The results of the structural break tests for standard deviations of the variables are reported in tables in the appendix along with the break dates. All country tables include the test results of the standard deviations of CPI inflation, exchange rate, interest rate, money growth and industrial production growth rate. Since the recommended maximum number of breaks allowed in the test is five breaks, the tables display a maximum of six entries. The coefficients and the standard errors of the coefficients are displayed, the latter in brackets. For sudden breaks the logic behind the coefficients is as follows: the first coefficient is an approximation of the level of the variable tested from the start of the data up to the date when the first structural break occurs if there exists one. In our setup the level of the variable is the level of the standard deviation of CPI inflation, exchange rate and so on. Similarly, the second coefficient is the approximation of the level of the standard deviation between the first break and the second break. For gradual breaks it is assumed that there is an underlying persistence level of the variable and the first coefficient is that persistence in the data. The second coefficient is then the additional change of the variable from the start of the data until the first break, taking the first coefficient as the basis level.

The structural break dates suggested by the test that are listed in the tables are interpreted together with the moving average and standard deviation figures. In the tables, first we check whether there is a break around the date of shift to inflation targeting. If there is a break, then it is important whether the subsequent coefficients suggested by the test are smaller or larger than the previous period. It is important to keep in mind that the test results might not be solely meaningful and that even the small changes sometimes appear as structural breaks. So, in the analysis greater emphasis is put on the general trend rather than the dates and the numbers themselves. We include the figures of the twelve-month moving average and standard deviation data for all of the variables in the analysis and visually inspect the structural break dates suggested by the test with actual data. The moving averages of the variables are used to analyze the level changes especially for inflation and production growth. In the country analysis starting from section 4.1 with Australia, the first figures included are the moving averages of the variables and the second figures are the standard deviation of the variables.

We tested for sudden shifts as well as gradual breaks. As suggested in Bai and Perron (2003), the leading criteria for assuring a break is an at least 2.5 percent level confidence for the existence of breaks in the structural break test results. Then the coefficients between break dates are taken from the information criterion, BIC. If the resulting 90 percent confidence intervals for break dates of BIC are sufficiently narrow then the break dates are taken from BIC results, otherwise they are taken from the optimization results listed in the structural break test results. Breaks are in the first place taken from 10 percent trimming of the data, which means that data is searched for breaks in the 10 percent of the original data. If there is data for 240 months, then changes are searched in 24 months periods and the search is repeated for every month. If 10 percent trimming does not reveal any breaks then 5 percent trimming is done which is denoted by an asterix. This lets us to catch sudden and short-lived shocks as well as the longer-lived changes but induces the possibility of size distortions. This is because, 5 percent of the sample may be too small for estimations such as variances. As discussed in Bai and

Perron (2000), a trimming as small as 5% of the total sample can lead to tests with substantial size distortions when allowing different variances of the errors across segments or when serial correlation is permitted. This is because one is then trying to estimate various quantities using very few observations

To make the idea of structural break tests clear and to explain the importance of Bai and Perron (2003) test that I use in the thesis, I introduce a brief review of structural break tests in the next section.

The comparisons of the countries are based on the differences of the variables of interest between the countries. As an example, the comparison of the standard deviation of CPI inflation in Canada with that of in the U.S. is based on the analysis of the standard deviation of CPI inflation in Canada minus the standard deviation of CPI inflation in the U.S. We also included the ratios of the variables but especially when twelve month moving averages of some variables are close to zero, the ratios tend to be very high or very low which makes the interpretation of the results difficult. Hence, hardly any use of the ratios has been made. The difference and ratio tables are included in the appendix.

3.3 Structural Break Tests

There are a vast number of structural break tests; the earliest is due to Chow (1960). The Chow test is for stationary variables and allows for one break with a known break point. In the linear regression (3.1) and (3.2) where the errors are assumed to be independent and normally distributed and X_1 and X_2 matrices are assumed to be nonsingular, testing the equality of $\gamma_1 = \gamma_2 = \gamma$ where the alternative is $\gamma_1 \neq \gamma_2$ implies testing for a structural break with a known break point..

(3.1) $$y_1 = X_1 \beta_1 + \varepsilon_1 = Z_1\gamma_1 + W_1\delta_1 + \varepsilon_1$$

(3.2) $$y_2 = X_2 \beta_2 + \varepsilon_2 = Z_2\gamma_2 + W_2\delta_2 + \varepsilon_2$$

Quandt (1960) discusses testing the null hypothesis of constant coefficients against a structural change at an unknown point in time. Kim and Siegmund (1989) examined likelihood ratio tests to test for a structural change in a simple linear regression against two alternatives; the alternative of the intercept change and the alternative of intercept and slope change.

Brown, Durbin and Evans (1975) suggest the CUSUM test that is aimed at detecting systematic movements of coefficients. They also proposed CUSUM of squares test to search for whether the change is random or systematic. In the regression (3.3) the errors are assumed to be independent and normally distributed with mean zero and variances σ^2_t. the hypothesis of constancy over time is $\beta_t = \beta \ \forall t$.

(3.3) $$y_t = X_t \beta_t + \varepsilon_t \qquad \text{where } t = 1,2,\ldots,T \text{ denotes time.}$$

Define the recursive residual w_r where $r = k+1,\ldots T$ as

(3.4) $$(y_r - x_r b_{r-1}) / \sqrt{ (1 + x_r' (X_{r-1}' X_{r-1})^{-1} x_r)'}$$

where b_r is the least squares estimate of β based on the first r observations and X_r is the stacked x matrices up to time r. Now, the sum of squares of w_r's divided by the estimated standard deviation is the CUSUM quantity with an expected value of zero under the null hypothesis.

Extensions of the CUSUM test have been made by Ploberger et.al. (1989). Deriving the appropriate asymptotic distribution of the test statistic is the main problem in these tests and Andrews (1993) derives the asymptotic distribution of the Quandt, Wald and Lagrange Multiplier tests for one structural change with an unknown change point. Andrews' test applies to nonlinear models with no deterministic trends whereas CUSUM test applies only to linear models. Andrews and Ploberger (1994) develop tests with stronger optimality properties than Andrews' test. Andrews et al. (1996) present a Monte Carlo simulation comparing these tests.

The case of multiple unknown breaks has been discussed by Kim and Maddala (1991). A commonly used method to test for multiple breaks is the Markov switching regression model. With multiple structural break tests, there is the problem of estimation the number of breaks. This is a model selection problem noted as in Kim and Maddala (1991). Bai and Perron (1995) also analyzed this problem.

Kim and Maddala (2000) list the most important points to consider in tests for structural change. The first is determining the number and location of break points, second there is a problem of consistent estimation of the break point that is dealt in Bai and Perron (1995). Third, since the switch from one regime to the other is rarely sudden, gradual structural change must be considered.

Bai and Perron (2003) address the problem of the estimation of break dates. The multiple structural break model with *m* breaks is:

$$y_t = X_t \beta + Z_t \delta_1 + \varepsilon_t \qquad t = 1,2,\ldots,T_1$$

$$y_t = X_t \beta + Z_t \delta_2 + \varepsilon_t \qquad t = T_1+1,\ldots, T_2 \tag{3.5}$$

……………………….

$$y_t = X_t \beta + Z_t \delta_{m+1} + \varepsilon_t \qquad t = T_{m+1}+1, \ldots, T$$

The break points $T_1, T_2, \ldots, T_{m+1}$ are treated as unknown and are estimated together with the coefficients β and δ_j. In the presence of β, this is a partial structural change model whereas if $\beta = 0$ the model becomes a pure structural change model where all the parameters are subject to change.

First, they present an efficient algorithm to obtain global minimizers of the sum of squared residuals by using dynamic optimization. β and δ_j's are estimated by least squares given the *m* partition $(T_1, T_2, \ldots, T_m)$. Substituting the estimates of β and δ_j's into the minimization of sum of squared residuals and denoting the resulting sum of squared residuals as $S_T(T_1, \ldots, T_m)$, the estimated break points $(\hat{T}_1, \ldots, \hat{T}_m)$ are such that $(\hat{T}_1, \ldots, \hat{T}_m) = \operatorname{argmin}_{T_1, \ldots, T_m} S_T(T_1, \ldots, T_m)$, where the minimization is taken over all partitions $(T_1, \ldots, T_m)$ such that $T_i - T_{i-1} \geq q$ and q is the dimension of the Z matrix. The break points are the global minimizers of the objective function and can be estimated by searching possible number of segments in the data when *m* is given.

Second, they consider the problem of forming confidence intervals for break dates by allowing the data and errors to have different distributions across segments or imposing a common structure and the problem of estimating the number of breaks. The limiting distribution of the break dates is shown under some regulatory conditions.

Third, Bai and Perron (2003) construct tests for the existence of breaks and they also discuss methods based on information criteria and a method based on a sequential testing procedure for the estimation of the number of breaks. One important aspect of the

Bai and Perron (2003, 1995) structural break tests is that the tests can be constructed allowing different serial correlation in the errors, different distribution for the data and the errors across segments or imposing a common structure.

Following Andrews (1993), they consider the supF type test of no structural break $m = 0$ versus $m = k$ known breaks. To test the existence of an unknown number of breaks, Bai and Perron (1995) have introduced two tests of the null hypothesis of no structural break against an unknown number of breaks given some upper bound M. These are called the double maximum tests. Double maximum tests are used in Bai and Perron (2003). The first double maximum test is an equal weighted version of the F test defined by:

$$(3.6) \qquad UDmaxF_T(M,q) = max\ F_T\ (\lambda_1,\lambda_2,\ldots,\lambda_m;q)$$

where $1 \leq m \leq M$ and $\lambda_j = T_j/T$ ($j = 1, \ldots, m$) are the estimates of the break points obtained using the global minimization of the sum of squared residuals. The second test, $WD\ max\ F_T(M, q)$ applies weights to the individual tests such by equating the marginal p-values across values of m. common procedure to select the dimension of a model is to consider an information criterion. In addition to supF and double maximum tests, they use a sup Wald type test for the null hypothesis of no change versus an alternative containing an arbitrary number of changes and they use this procedure to test the null hypothesis of l changes, versus the alternative hypothesis of $l + 1$ changes.

For estimating the number of breaks, Bai and Perron (2003) use both the Bayesian Information Criterion (BIC) and modified Schwarz criterion (LWZ) which is proposed by Liu *et al.* (1997). Bai and Perron (2003) claim that the BIC and LWZ perform reasonably well in the absence of serial correlation in the errors but chooses a much higher value than the true one in the presence of serial correlation. The method suggested by Bai and Perron (2003, 1995) is the sequential application of the sup$F_T(l + 1|l)$.

To conclude, Bai and Perron (2003) structural break test proposes solutions to the three most important problems that are listed in Kim and Maddala (2000). These are, determining the number and location of break points, the problem of consistent estimation of the break point and the issue of gradual structural change.

CHAPTER 4

Analysis

4.1 Australia

Structural break test results are listed in Table 1. There are structural breaks for CPI inflation, exchange rate and interest rate. There is no monthly data on industrial production so the test could not be performed. For money growth rate, there are not any structural changes. Since Australia shifts to inflation targeting in September 1994, the results on CPI inflation, exchange rate and interest rate are meaningful.

There was a structural change around the shift date for inflation. It can be viewed that the volatility of CPI inflation rapidly falls from June 1989 to February 1994. After February 1994, there is a slight increase in the standard deviation of inflation. As seen in Figure 1.a.1, these are the episodes of rapid disinflation. After disinflation is completed, inflation is relaxed to swing at the 2%-3% percent band as intended in inflation targeting.

For exchange rate, there is a fall in standard deviation between April 1989 and April 1994 compared to the preceding 5 years. This matches with the disinflation period of Australia. It can be argued that relatively lower volatility of exchange rate made the disinflation period more successful and rapid since the central bank was not targeting on exchange rate at the period of disinflation. An increase in standard deviation follows this, which is followed by a decrease after two years.

The changes in interest rates are the most dramatic findings for Australia. From March 1987 to November 2000 where data ends, there is a rapid decrease in interest rate volatility. This also follows the lines of disinflation period; a remarkable drop in the volatility of interest rates comes along with disinflation. However it can be seen from Figure 1.c.1 that the drop starts two years after disinflation has started which states that not until disinflation was credible that interest rates started to fall. After the adoption of inflation targeting this trend does not change and volatility does not increase.

To sum up, within the two years before the adoption of inflation targeting, there are increases in inflation volatility and exchange rate volatility. After the adoption of inflation targeting, there is no change in inflation volatility, a decrease in exchange rate volatility and a decrease in interest rate volatility.

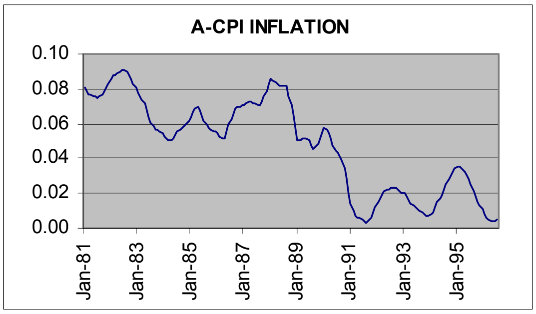


Figure 1.a.1 CPI inflation

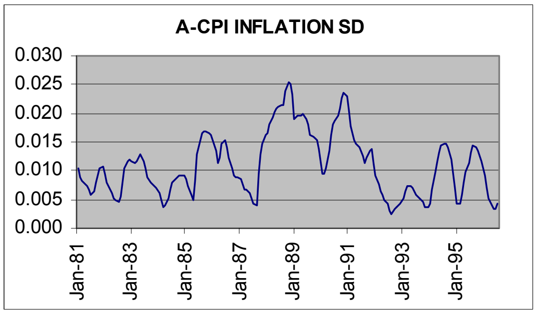


Figure 1.a.2 CPI inflation std. dev.

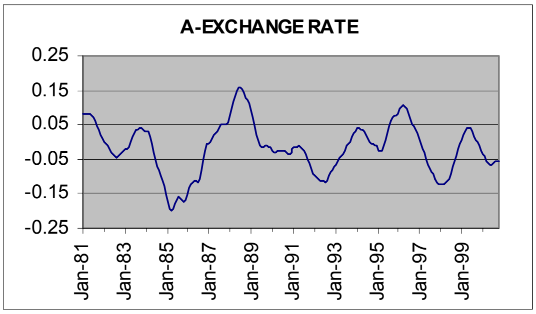


Figure 1.b.1 Exchange rate

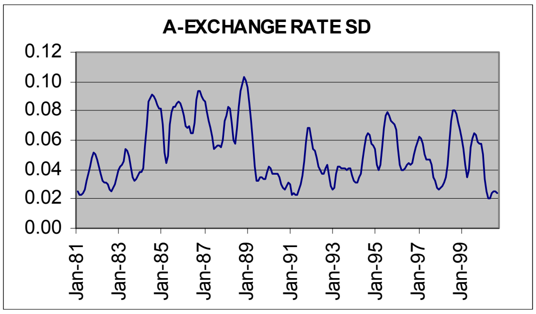


Figure 1.b.2 Exchange rate std. dev.

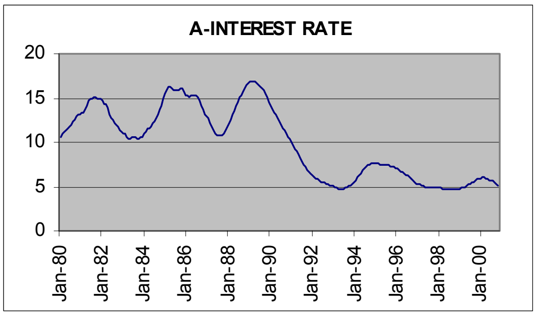


Figure 1.c.1 Interest rate

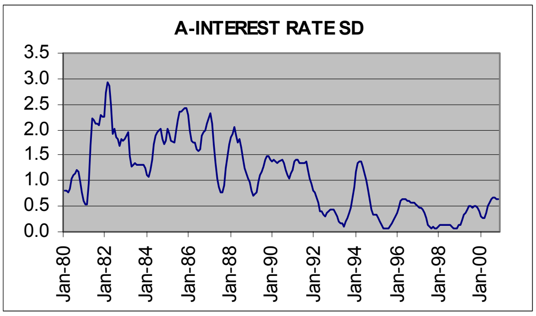


Figure 1.c.2 Interest rate std. dev.

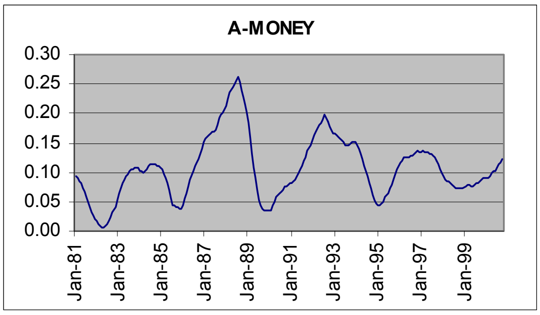


Figure 1.d.1 Money growth

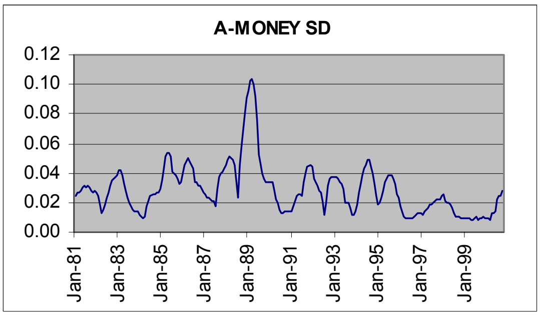


Figure 1.d.2 Money growth std. dev.

4.2 Canada

Structural break test results are summarised in Table 2 and Canada shifts to inflation targeting at February 1991. The results suggest that there are sudden shifts in CPI inflation, interest rate, money growth rate and industrial production growth rate.

CPI inflation volatility results reveal that after a period of low volatility between 1983 and 1990, there is a gradual and significant increase in volatility until the end of 1991. Since then, there are no structural breaks which suggest that one year after the adoption of inflation targeting there has not been any significant structural changes in the volatility of inflation and inflation volatility remained low throughout the 1990s. This in turn suggests that shifting from monetary targeting to inflation targeting by 1991 was successful in terms of decreasing inflation volatility. The increase in inflation volatility between 1990 and 1992 is most likely due to the slight increase in inflation level and the consequent disinflation efforts.

The test does suggest no break for exchange rate, however it is visible from Figure 2.b.1 that there is a gradual decline in volatility from the start of 1980s to 1987 and it seems that until then there has not been any significant change in exchange rate volatility. This might be due to the fact that, before adopting inflation targeting Canada was targeting multiple monetary aggregates containing exchange rate, after the adoption of inflation targeting Canada targeted on monetary conditions index that includes a weighted index of exchange rate and inflation. This must have induced the continuous trend in exchange rate volatility.

After starting 1980s with a high level, volatility of interest rates gradually decline until 1990. Between January 1990 and November 1992, for about three years, there is a spike in interest rate volatility. This corresponds to the times inflation targeting is introduced. By the start of 1993, the volatility falls and by mid-1996 it reaches its minimum of the last twenty years.

With money supply, there is a trend similar to interest rate volatility except the money supply shock of 1998. A decline in money supply volatility starts by the start of 1987 and volatility of money reduces as low to 0.7 % by mid 1995. With a shock in 1998, money supply volatility jumps. This probably is the consequence of exchange rate appreciation against U.S. dollar, the appreciation causes real money demand to increase thus central bank increases money supply not to let Canadian dollars to appreciate more. Careful examination of exchange rate and money supply figures, Figure 2.b.1 and Figure 2.d.1 reveal that they are counter cyclical.

There are three structural breaks for industrial production, all of which are in 1980s. There is a gradual decline in industrial production growth volatility and after June 1988, production growth is stabilised with a volatility of 1.5 %. This tells us that inflation targeting did not cause production growth volatility to increase. Checking the actual growth rates tell us that inflation targeting does not cause production growth to decrease either. After 1992, production growth stays within the band 2-7 percent.

So, in Canada, within the two years before the introduction of inflation targeting, there are increases in inflation volatility and interest rate volatility, there are no changes for other monetary aggregates. After the new regime is employed, inflation volatility, interest rate volatility and money growth volatility decreases; money growth volatility increases after 1998 and production growth volatility does not change with the new regime.

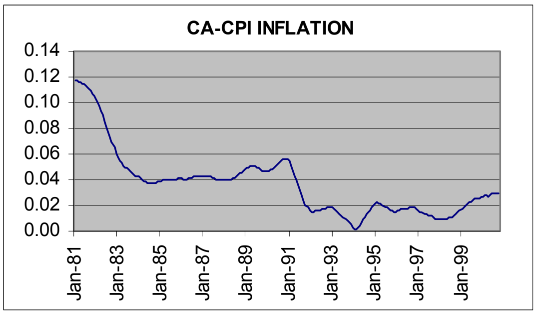


Figure 2.a.1 CPI inflation

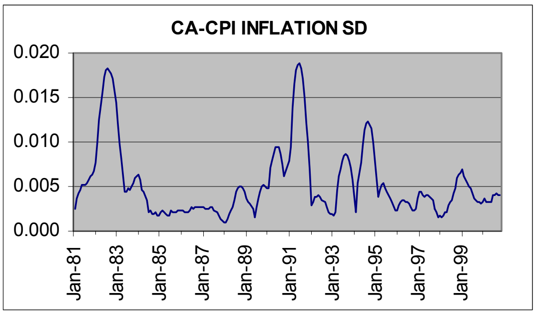


Figure 2.a.2 CPI inflation std. dev.

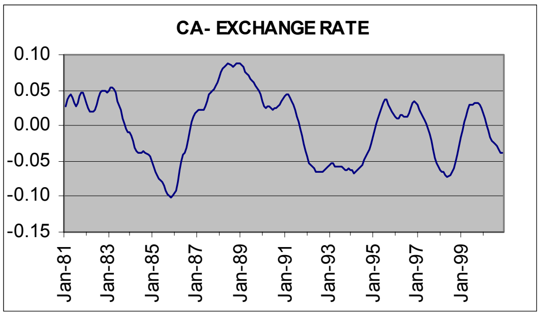


Figure 2.b.1 Exchange rate

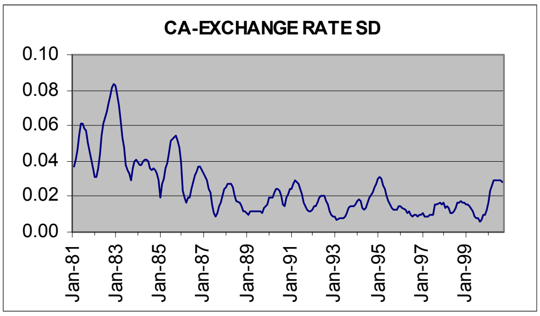


Figure 2.b.2 Exchange rate std. dev.

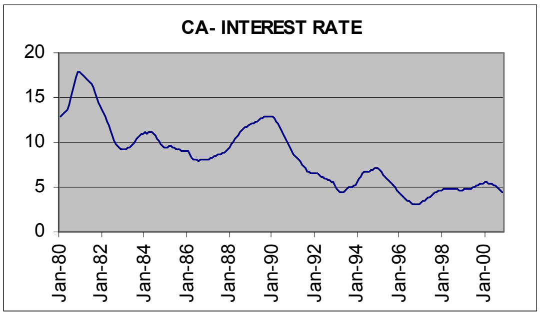


Figure 2.c.1 Interest rate

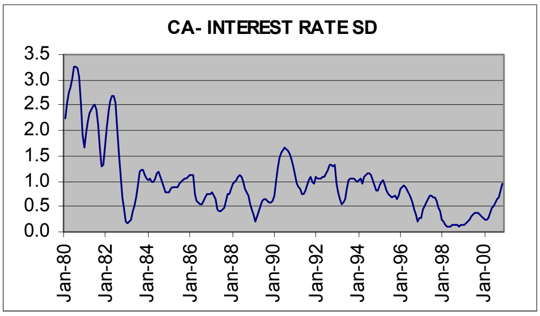


Figure 2.c.2 Interest rate std. dev.

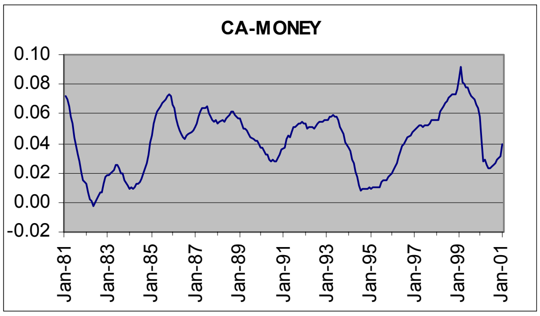


Figure 2.d.1 Money growth

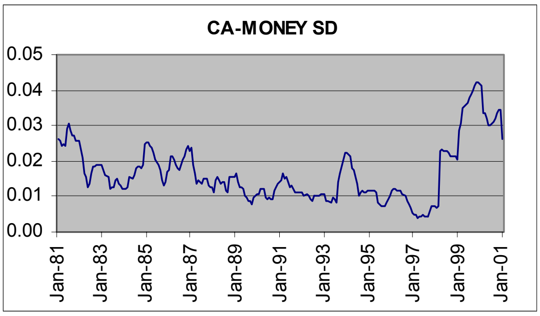


Figure 2.d.2 Money growth std. dev.

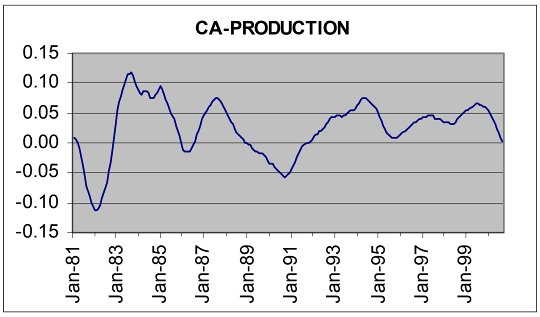


Figure 2.e.1 Production growth

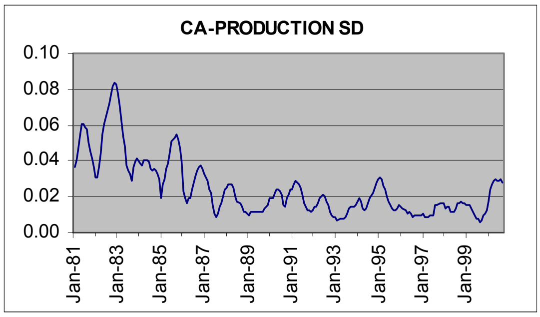


Figure 2.e.2 Prod. growth std.dev.

4.3 United States

Structural break test results summarised in Table 3 suggest that there are sudden shifts in CPI inflation, exchange rate, money growth rate and industrial production growth rate. Comparison of the difference between the variables of Canada with the U.S. is summarised in Figures 14.a-14.e, the ratios of the variables are in the Figures 15.a-15.e. All comparison figures are in the appendix.

U.S. CPI inflation volatility results reveal that after a period of low volatility between 1982 and 1985, there is an increase in volatility until the start of 1987, which is followed by a decrease that lasts until the end of 1989. Since mid 1991, there are no structural breaks and the volatility of inflation is at its minimum of the last twenty years. The structural breaks in the U.S. inflation are similar to Canada and both countries did not have structural changes after the start of 1990s. We can see from the figures that inflation in Canada is smaller than in the U.S. since July 1991 but this is not the case for the volatility of inflation. The largest inflation volatility gap between Canada and the U.S. is in August 1991 where the volatility of inflation in Canada is 1.4 percent higher than in the U.S. Between 1991 and 1995 the volatility of inflation in Canada is higher than in the U.S. After 1995 the difference is less than 0.2 percent.

There are breaks for exchange rate, which is the U.S. dollar versus SDR. Exchange rate volatility is stable between 1985 and 1995 with an increasing trend in the mean exchange rate. We can also see two structural breaks afterwards however the volatility change is very small and it is not clear from Figure 3.b.1 and Figure 3.b.2 that these are structural changes. When we compare Canada with the U.S., it is hard to conclude whether there is a change in the difference of exchange rate volatilities between Canada and the U.S. after Canada introduced inflation targeting. The difference between the exchange rate standard deviations is fluctuating before and after the regime change in Canada.

There are no structural breaks for interest rates in the U.S. We can see from Figure 3.c.1 that average interest rate is gradually decreasing since the start of 1980s. In contrast to the U.S. there are structural changes for interest rates in Canada. However we can see that the gradual declines in the average interest rates are very similar to each other. The mean difference of interest rates between Canada and the U.S. is decreasing since 1990 and the difference between the volatility of interest rates in the two countries is almost always positive between 1985 and 1997. This suggests that interest rates decline more rapidly in Canada than in the U.S., thus the volatility of interest rates in Canada is higher than in the U.S. until 1998. Since 1998, Canada has a lower volatility of interest rates than the U.S.

With money growth rate, there are four gradual breaks but since the correlation between money supply at time *t* and at time *t-1* is around 99 percent, the structural break results are not reliable. The results for money growth are clearly different from Canada. Since 1992, the difference between money growth rate in Canada and the U.S. is increasing. While money growth volatility difference moves around zero until 1997, Canada has a bigger volatility than the U.S. after 1998.

In the U.S., there are three structural breaks for industrial production, four of which are before 1992. It can be seen that there is a gradual decline in production volatility starting from 1983 until 1999. The minimum of production volatility is achieved between 1992 and 1999. When we compare production growth of the U.S. and Canada we can see that the peaks and troughs are at the same years. We can also see that Canada has generally a smaller production growth rate than the U.S., which is not necessarily because of the regime shift in Canada; the production growth is less in Canada than in the U.S. from 1988 onwards. We can also see that the difference between the production volatilities is smaller after 1988 than it was between 1981 and 1988 but still production volatility in Canada is almost always greater than in the U.S. so it is hard to conclude whether inflation targeting has any effect on Canada's performance in terms of production volatility.

So, the comparisons suggest that after the regime shift, Canada successfully kept inflation lower than the inflation in the U.S. but the volatility of inflation is generally higher in Canada. Until 1996 interest rates in Canada is always higher than in the U.S. and interest rate volatility is higher in Canada at all times. Money growth volatility and exchange rate volatility differences do not point to a regime shift in Canada when compared to the U.S. Canada has a lower production growth than the U.S. with a higher volatility which does not change with the new regime.

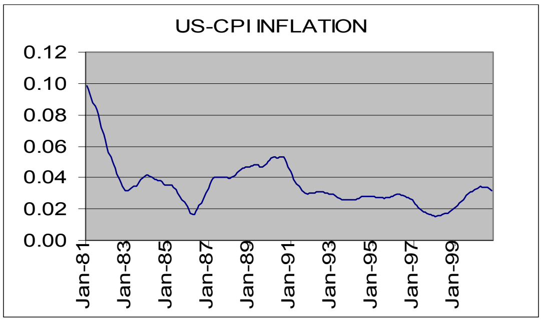


Figure 3.a.1 CPI inflation

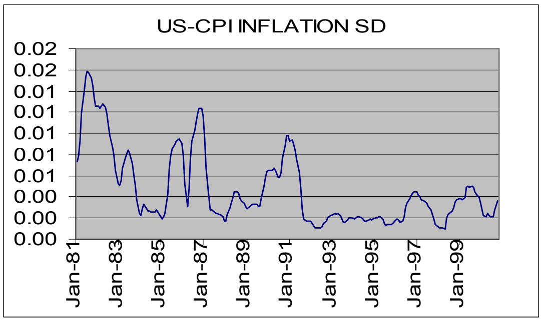


Figure 3.a.2 CPI inflation std. dev.

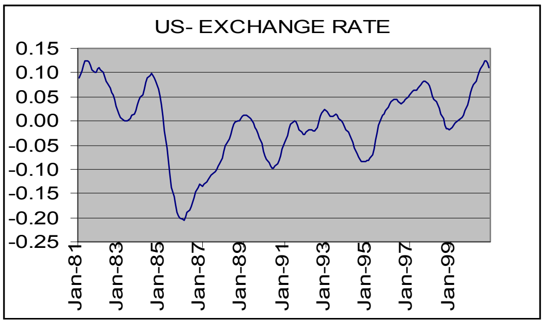


Figure 3.b.1 Exchange rate

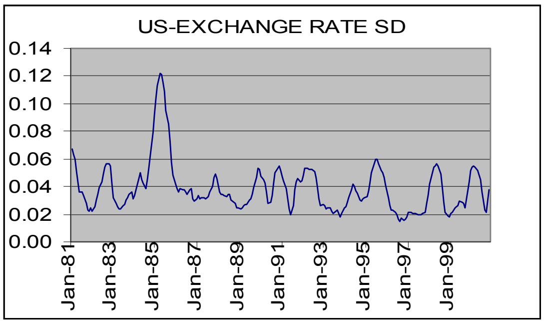


Figure 3.b.2 Exchange rate std. dev.

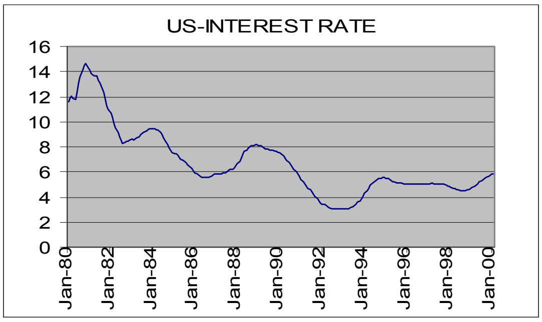


Figure 3.c.1 Interest rate

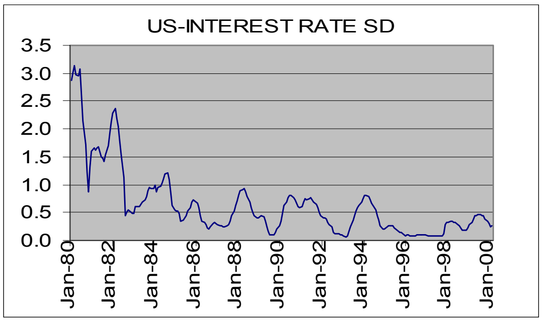


Figure 3.c.2 Interest rate std. dev.

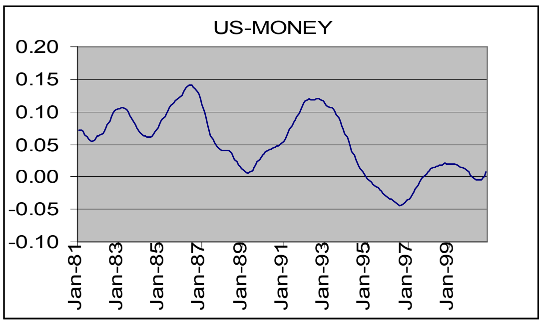


Figure 3.d.1 Money growth

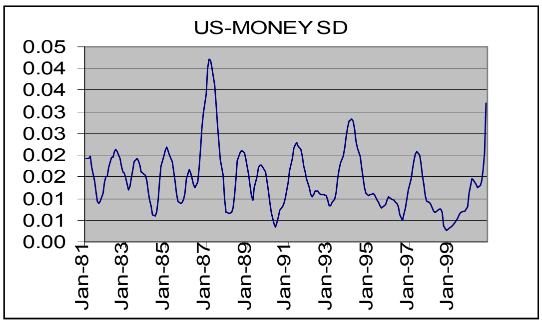


Figure 3.d.2 Money growth std. dev.

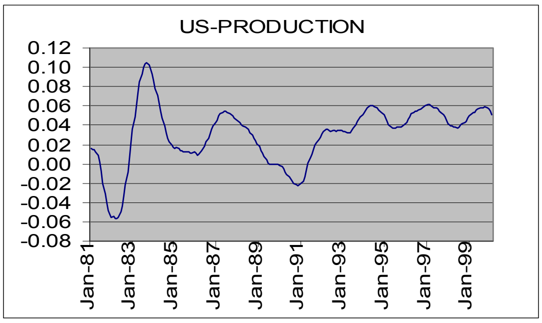


Figure 3.e.1 Production growth

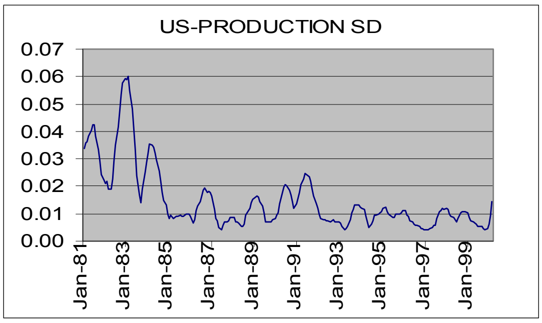


Figure 3.e.2 Prod. growth std.dev.

4.4 Chile

Table 4 summarises the results of structural break tests for Chile. Chile shifts to inflation targeting at January 1991.

For CPI inflation there are three structural breaks. Volatility of inflation gradually declines over the last twenty years. The first break is at November 1982, the second at March 1986 and the third at April 1992, about one year after inflation targeting is introduced. It can be viewed from Figure 4.a.1 that there is gradual disinflation starting from 1991 and the volatility of inflation reduces to as low as 0.6 percent after this date.

For exchange rate, there are two breaks that are both at 1980s. Exchange rate volatility does not show any significant changes after 1986, which tells us that the introduction of inflation targeting did not cause exchange rate to become more volatile for Chile.

Interest rate volatility is the monetary aggregate that shows significant upward and downward movements for Chile. By the start of 1980's there are four structural changes in interest rate. Between 1986 and 1995 Bai-Perron test reveals that there is a stable trend in volatility, however it can be viewed from the graphs that around 1990 there is a large increase in interest rates as well as in interest rate volatility. After about a year, interest rate is back to its 1989 value. With the adoption of inflation targeting, interest rate volatility drops to its minimum with an average of 3 percent volatility.

Money growth rate has five structural breaks. Between January 1981 and August 1988, there is a gradual decline in money growth volatility. There is a slight increase after 1988 and between March 1991 and April 1993, money growth volatility reaches its maximum of the twenty years analysed here. This increase is consistent with the time inflation volatility and interest rate volatility increase. We can see that production growth is at its trough at mid-1990 and interest rate and inflation are at their peak. The central bank successfully reverses this trend after the adoption of inflation targeting by the start of 1991. Disinflation starts, interest rates start to fall, production starts to increase and money growth increases. Since April 1993, there are not any structural changes for money growth, which assures that money is not used aggressively to control inflation.

Production growth volatility decreases continuously from the start of 1981 until October 1990. Between October 1990 and September 1992 there is a slight increase in production growth volatility. After September 1992 there is no structural change and the volatility reaches its minimum of the last 15 years as well. What is more important is that this is not because that production growth stops; it stays around 4-5 percent until mid-1997. Since mid-1997 it is around zero, but this cannot be due to inflation targeting because the previous six years' production growth with inflation targeting is well above zero. The drop in production growth can be attributed to the effects of the Asian crisis.

Within the two years before the introduction of inflation targeting in Chile, there are no changes in inflation volatility, exchange rate volatility and interest rate volatility. There are increases in money growth volatility and production growth volatility. After the new regime is employed, inflation volatility, interest rate volatility, money growth volatility and production growth volatility drops, there are no changes in exchange rate volatility.

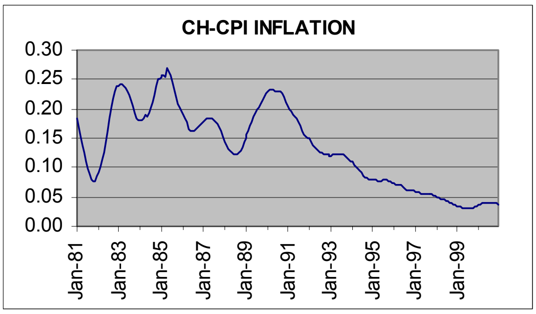


Figure 4.a.1 CPI inflation

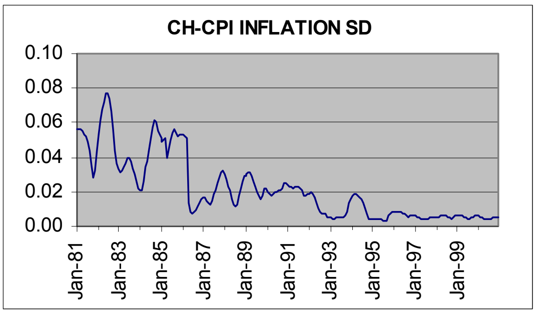


Figure 4.a.2 CPI inflation std. dev.

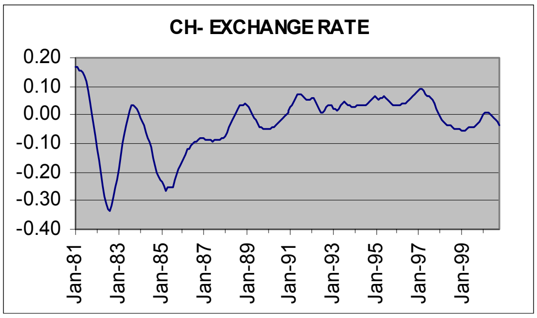


Figure 4.b.1 Exchange rate

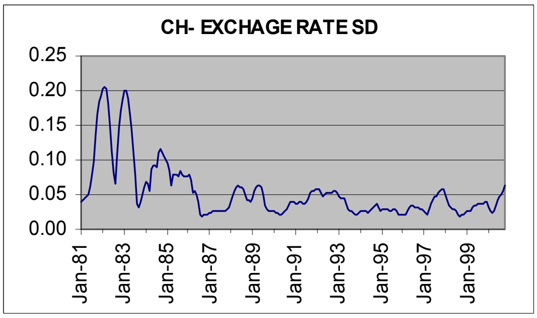


Figure 4.b.2 Exchange rate std. dev.

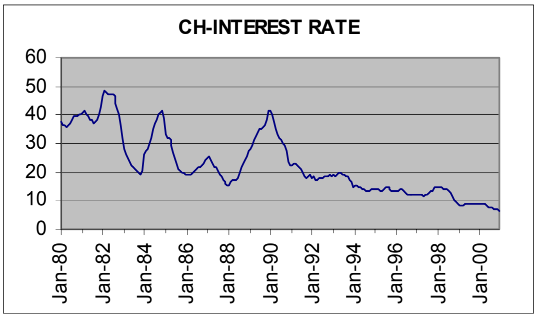


Figure 4.c.1 Interest rate

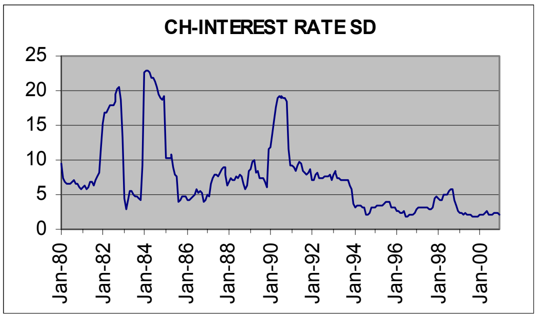


Figure 4.c.2 Interest rate std. dev.

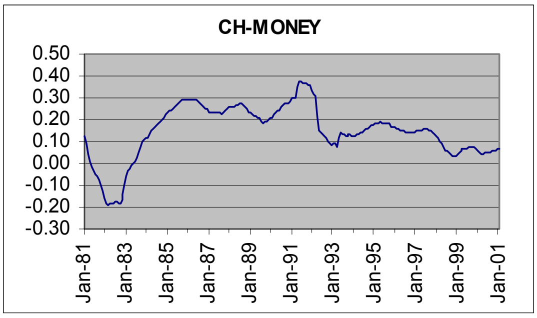


Figure 4.d.1 Money growth

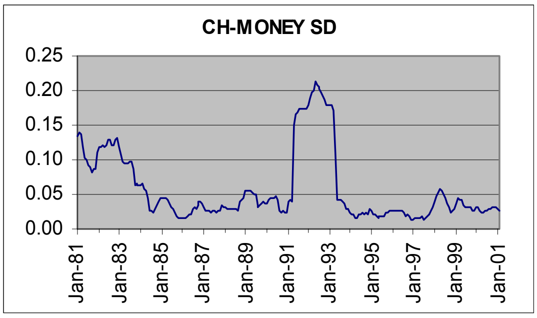


Figure 4.d.2 Money growth std. dev.

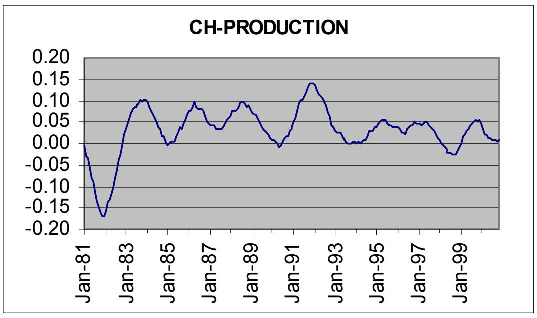


Figure 4.e.1 Production growth

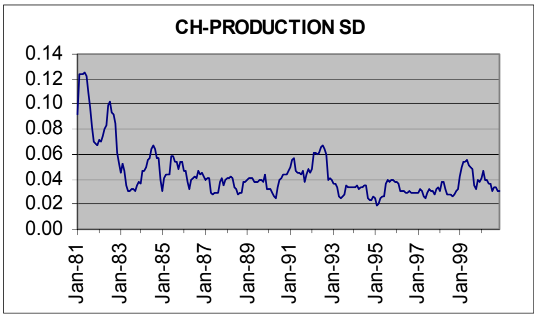


Figure 4.e.2 Prod. growth std. dev.

4.5 Finland

Except production growth, tests reveal structural breaks. The results are shown in Table 5. Finland shifts to inflation targeting at February 1993.

For CPI inflation, there are five structural breaks. Until June 1987, there is a fall in inflation volatility. Between June 1987 and May 1995, there is a slight increase compared to the previous period but this also shows us that neither before inflation targeting is introduced nor after the first two years with the new monetary regime there are not any structural changes in inflation volatility. After May 1995, there is a decrease again that lasts until 1999. That is the time Finland has moved to the European Monetary System. The increase after 1999 is probably due to this new regime.

There are five structural breaks for exchange rate; there is an increase in exchange rate volatility between 1990 and 1993, a further increase until the end of 1993. The test successfully captures 1992-1993 exchange rate crisis. There is a decrease in volatility for the year 1994, which is followed by an increase for the year 1995. After 1995, exchange rate volatility does not change and stays well below the volatility between 1990 and 1995.

For interest rate, there are five breaks; the results show that the volatility changes are remarkable. Starting from May 1983 until January 1993, interest rate volatility increases every time there is a structural change compared to the previous period. Interest rate volatility peaks for the year 1992. After January 1992, interest rate volatility does not change and is the minimum of the time span analysed here. This is because after the start of 1992, there is a more than 5-point reduction in interest rates and interest rates stay at the level of 3-5 percent. So there is a drastic increase in interest rate volatility one year before inflation targeting is introduced which is offset after inflation targeting is employed.

With money growth, there aren't any structural breaks until 1989. There is an increase in volatility of money growth rate at the year 1989, a decrease for the years 1990 and 1991, and attains its minimum level between 1992 and 1998. After 1998, there is a break that is due to passing to European Monetary System.

Careful inspection of the production growth graph reveals the recession from 1990 to 1994 but since this recession is gradual, there is not a structural break in the standard deviation of the production growth. Production growth stops at mid-1990 and declines thereafter, the economy starts to recover by the start of 1993 and returns back to its production level before recession at 1994. Production growth swings around 5 percent after 1995, which indicates that inflation targeting does not reduce production growth as well as not inducing any increase in volatility compared to its before-inflation-targeting value.

Within the two years before the introduction of inflation targeting in Finland, there is an increase in exchange rate volatility, a spike in interest rate volatility that may be due to the efforts to compensate the effects of the exchange rate crisis, and a decrease in money growth volatility. After the new regime is employed, inflation volatility, interest rate volatility and exchange rate volatility decreases; exchange rate volatility increases for the year 1995 and decreases again. Production growth volatility is slightly higher than the pre-inflation targeting values but production growth is on average higher after the regime change.

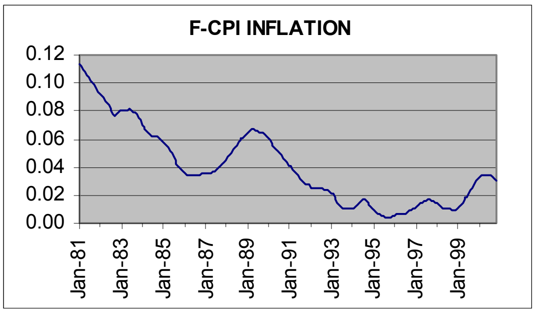


Figure 5.a.1 CPI inflation

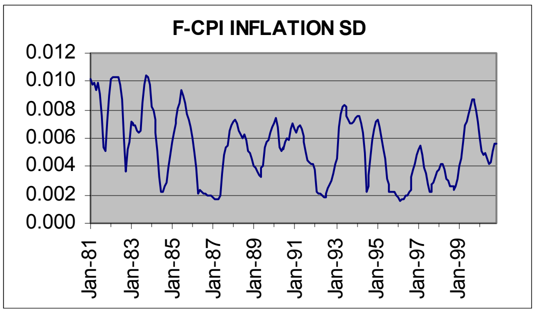


Figure 5.a.2 CPI inflation std. dev.

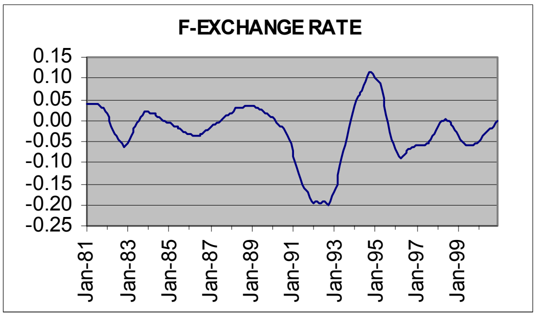


Figure 5.b.1 Exchange rate

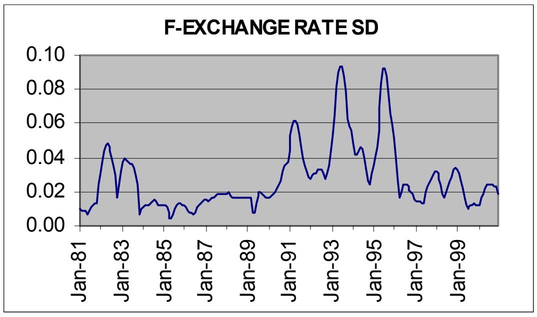


Figure 5.b.2 Exchange rate std. dev.

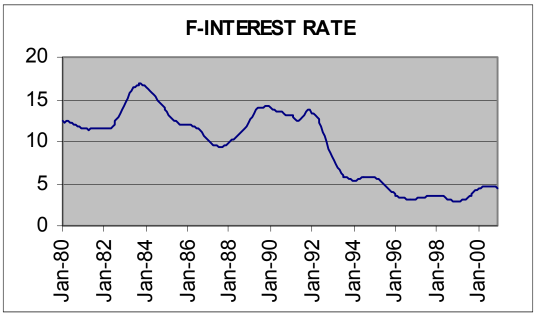


Figure 5.c.1 Interest rate

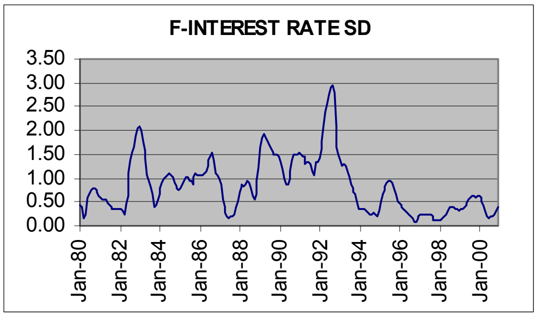


Figure 5.c.2 Interest rate std. dev.

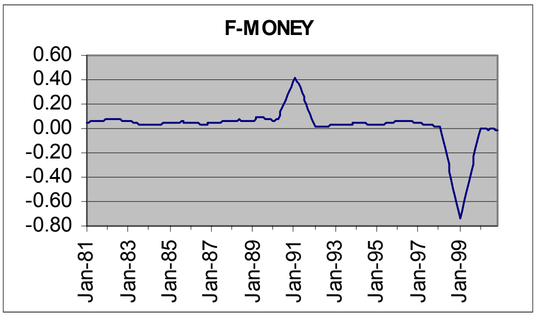


Figure 5.d.1 Money growth

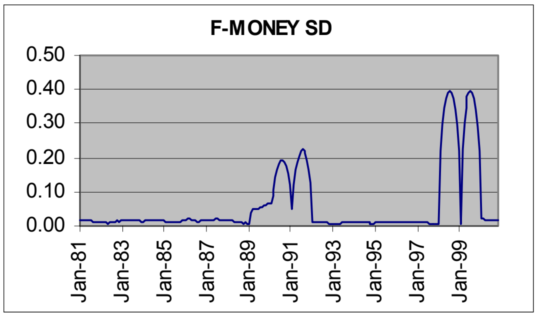


Figure 5.d.2 Money growth std. dev.

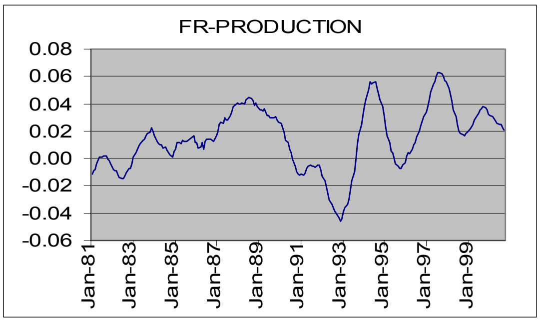


Figure 5.e.1 Production growth

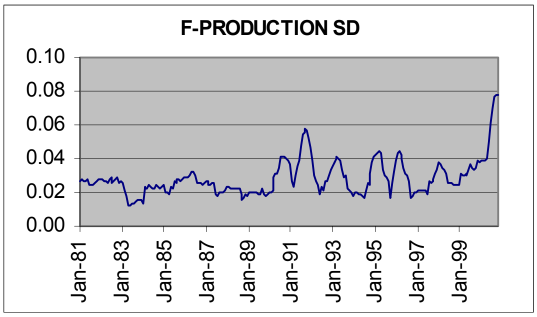


Figure 5.e.2 Prod. growth std. dev.

4.6 Norway

The structural break tests' results are listed in Table 6. The comparisons with Finland are listed in the Figures 16-17. There are structural breaks only for money and production growth. We can see from the figures that Norway has a gradual disinflation starting from 1980s up to the start of 1990s that is similar to Finland. Different from Finland, structural break tests do suggest no break for inflation in Norway. Norwegian economy is dependent on oil and natural gas production and is vulnerable to fluctuations in foreign oil prices. We can see the upward movement in inflation variability around 1987 because of the oil price shock of 1985-86. Since 1992 inflation is around 2 percent with a low volatility. From the difference tables it is apparent that inflation falls relatively more rapidly in Finland than in Norway from 1989 onwards. This makes the volatility of inflation in Finland higher than in Norway at all times after 1989 except in 1996.

Exchange rate figures suggest us that since 1993 there is an appreciation of the exchange rate. Similar to inflation volatility, we cannot see this change in structural break test results. However, Norway is not severely affected by the exchange rate crisis in 1993 so the overall performance of Norway in 1990s in terms of exchange rate volatility is better than of Finland.

Interest rate starts to decline from a peak of 14 percent in mid 1987 to as low as 5 percent at the end of 1999. The decline is gradual and we can see from the figures that with the exception around 1993, interest rate volatility is low. Interest rate volatility is more stable than in Finland throughout the 1980s until the beginning of 1993. Afterwards, Finland has a lower interest rate at all times with similar or lower volatility of interest rates most of the time.

Money growth results show us that there are five structural breaks; however the break in 1988 is caused by the lack of data between January 1987 and August 1987 which in turn implies a lack of data between January 1987 and August 1988 for the log difference and even more for the standard deviation of the log difference. There is a spike in volatility between 1992 and 1994; afterwards volatility falls to the minimum of the twenty years. After 1997 it slightly increases. We can see that Finland has a more stable money growth volatility compared to Norway except in 1991.

There are five structural breaks for industrial production four of which are before 1990. Between 1983 and 1987 there is an increase in volatility, between 1987 and 1996 volatility declines and after 1996 it is the lowest of the twenty years. When we compare Finland and Norway we can see that Finland has a less volatile industrial production growth than Norway almost always. It is also true that the production growth of Finland is relatively higher than that of Norway starting from 1993 onwards.

So, Finland has a lower inflation level than Norway after the new regime is adopted but it comes with the cost of higher inflation volatility most of the time. Norway exchange rate volatility is lower at all times but we can safely say that Finland performs better in terms of interest rate levels and volatility after inflation targeting is introduced. Money growth volatility is more stable in Finland than in Norway at all times. Industrial production growth levels are higher in Finland than in Norway with a lower volatility in general after inflation targeting is employed in Finland.

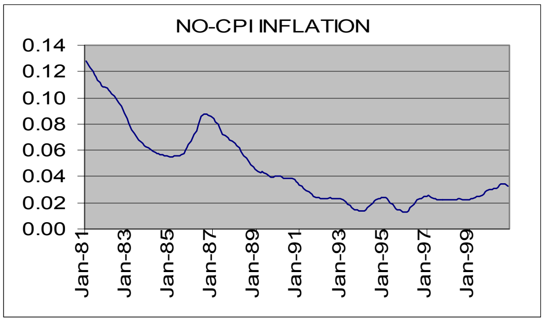


Figure 6.a.1 CPI inflation

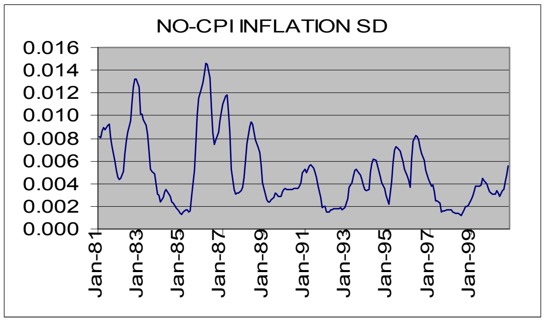


Figure 6.a.2 CPI inflation std. dev.

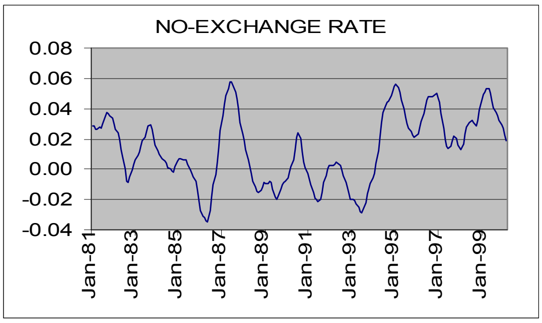


Figure 6.b.1 Exchange rate

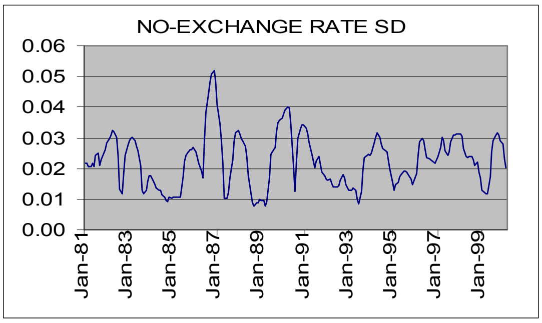


Figure 6.b.2 Exchange rate std. dev.

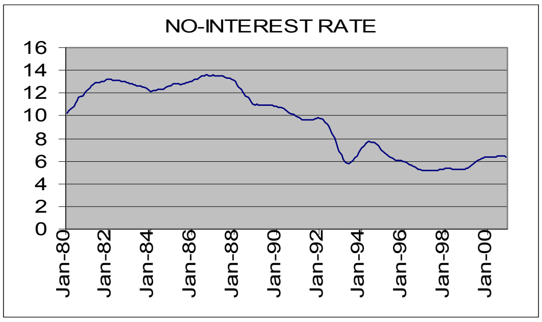


Figure 6.c.1 Interest rate

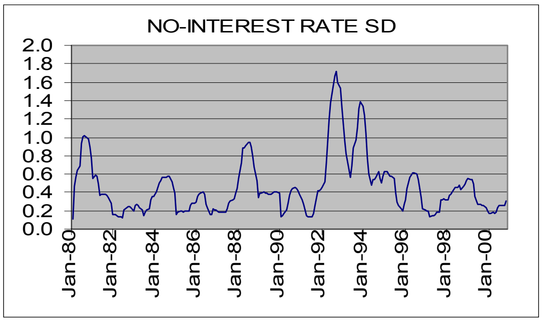


Figure 6.c.2 Interest rate std. dev.

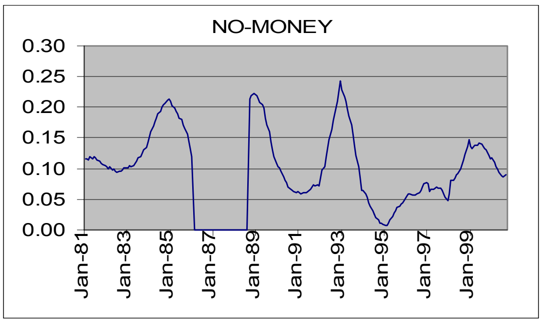


Figure 6.d.1 Money growth

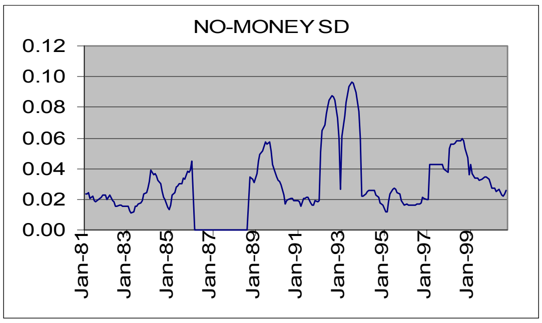
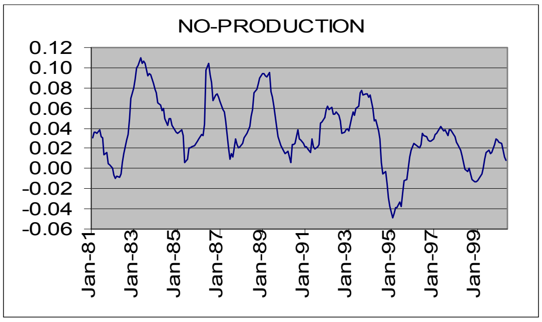


Figure 6.d.2 Money growth std. dev.



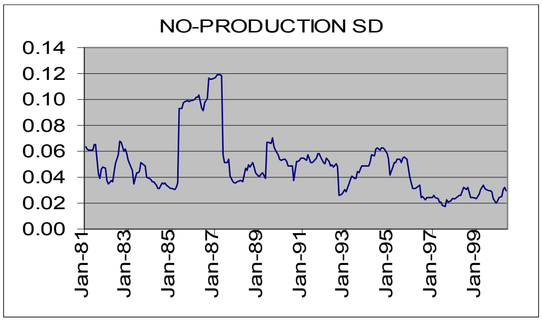
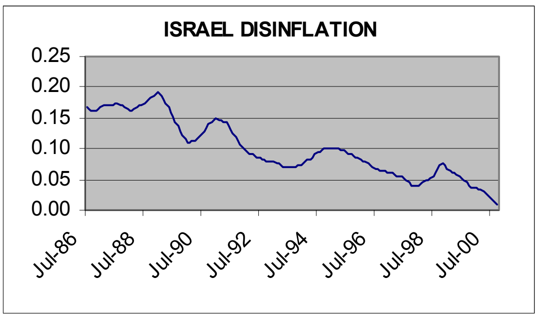


Figure 6.e.1 Production growth

Figure 6.e.2 Prod. growth std.dev.

4.7 Israel

Israel shifts to inflation targeting at January 1992. As can be seen from Table 7, there are 5 breaks for CPI inflation, all of them are before 1987 and they are related to the hyperinflation period. With a peak of 184% in November 1984, a rapid disinflation period starts. By July 1986 inflation is 20% and after this date there is a gradual decline in inflation. By January 1990 inflation is 10% and by July 1998 it is 1.7%. To see the progression of disinflation a figure of inflation starting with July 1986 is taken here. Figure 7.a.1 is 12-month moving average of inflation. Figure 7.a.2 is 12-month moving average standard deviation of inflation. We can see that there is a permanent increase in volatility of inflation between 1989 and 1990 that fades away by 1992.



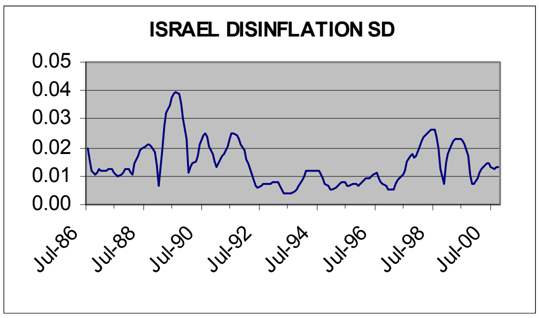


Figure 7.a.1 Inflation after 1988

Figure 7.a.2 Inflation std. dev. after 1988

There are three devaluations in Israel that affect exchange rate volatility, in 1987, in 1989 and in 1991. Since we take the 12-month log difference of exchange rates when calculating moving averages, these devaluations point to the times when the 'price' of exchange rate suddenly increases at Figure 7.b.1 below. Between 1991 and 1993, there is an increase in volatility of exchange rates, which is followed by a decrease until 1997. There is another devaluation at September 1998. The sudden decrease in 1998 is when exchange rate drops from 114 at August 1998 to 97 at October 1998 and then starts to increase gradually. That is why exchange rate volatility has increased after October 1997.

There aren't any structural breaks for interest rate after 1986. The break at 1986 points to the time when disinflation is successfully completed. I did not include figures before 1986 with a concern about scaling.

Money growth figures closely match inflation figures. At the times of hyperinflation, money growth rates make a peak and when inflation starts to fall money growth rate also starts to fall. Between 1986 and 1995 volatility does not change and after 1995 it decreases to its minimum value.

Production growth has three structural breaks before 1992. Between May 1989 and January 1992 there is a slight increase in production growth volatility compared to its level between June 1986 and May 1989. From January 1992 to April 1998, volatility further decreases and reaches its minimum value. It can be said that introduction of inflation targeting does not cause production growth volatility to increase but causes it to decrease instead. It is important to note that between 1991 and 1996, production growth is around 7 percent and between 1996 and 1998 around

2 percent. These growth rates are consistent with the finding of the other countries analysed here that inflation targeting does not come at the cost of reduced production growth rates.

So, within the two years before the introduction of inflation targeting in Israel, there is an increase in exchange rate volatility and there are no changes for other monetary aggregates. After inflation targeting is introduced, there is a decrease in exchange rate and a decrease in production growth volatility and there are no changes in the volatility of inflation, interest rates and money growth.

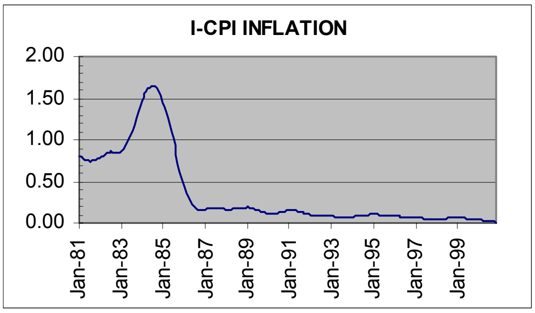


Figure 7.a.3 CPI inflation

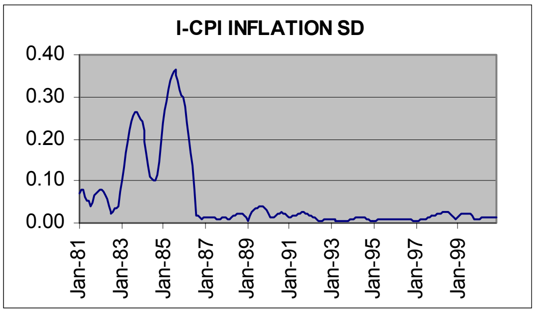


Figure 7.a.4 CPI inflation std. dev.

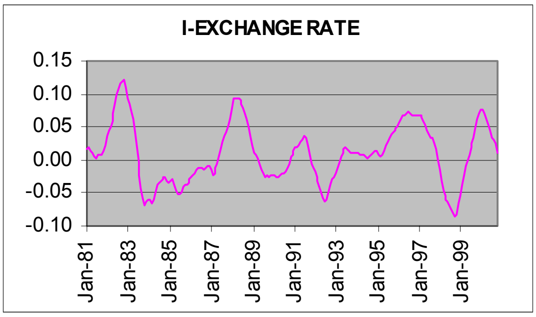


Figure 7.b.1 Exchange rate

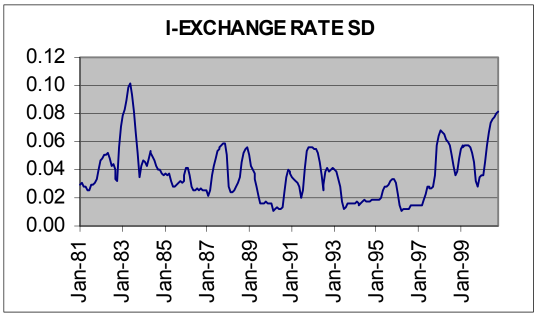
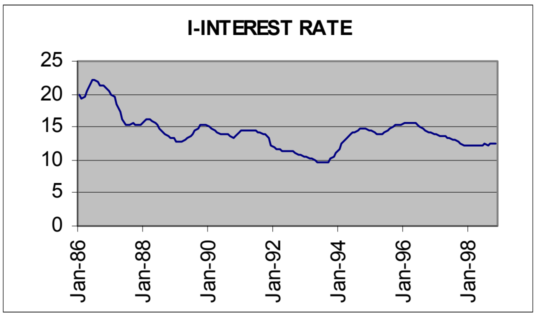


Figure 7.b.2 Exchange rate std. dev.



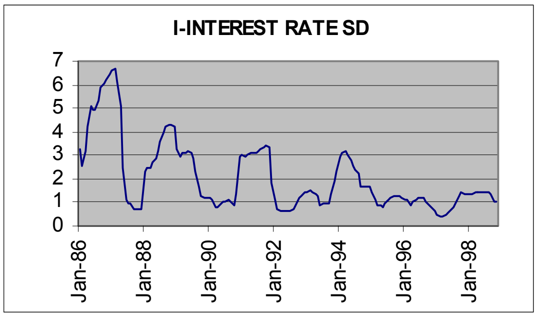
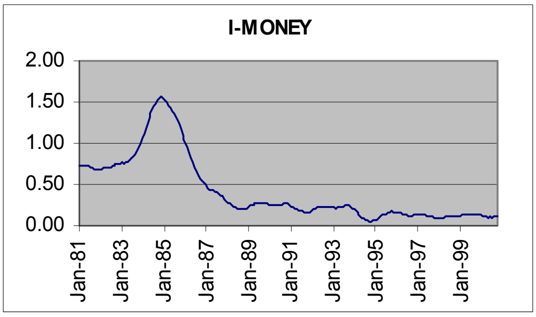


Figure 7.c.1 Interest rate

Figure 7.c.2 Interest rate std. dev.



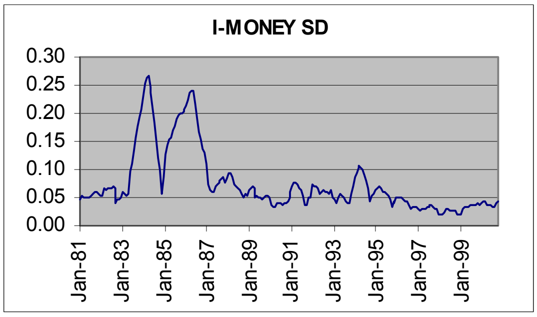
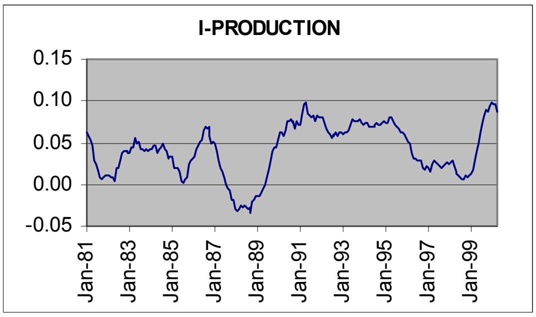


Figure 7.d.1 Money growth

Figure 7.d.2 Money growth std. dev.



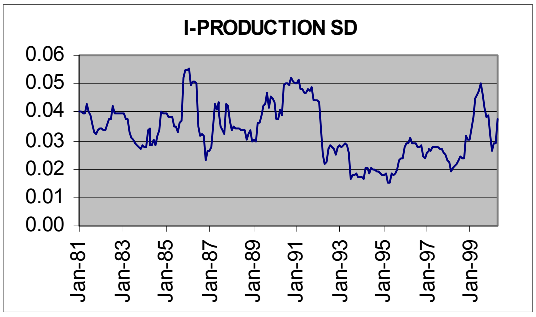


Figure 7.e.1 Production growth

Figure 7.e.2 Prod. growth std. dev.

4.8 New Zealand

New Zealand shifts to inflation targeting at March 1990. There is no monthly data for CPI and production for New Zealand so the analysis cannot be done. The results are summarised in Table 8. For exchange rate there are five breaks three of which are before inflation targeting is introduced and the other two after. After

September 1986, there is a continuous decline in exchange rate volatility with breaks at August 1988, April 1993 and September 1996. After the last break there is an increase in exchange rate volatility.

For interest rate, there are three breaks, all of which are before the introduction of inflation targeting. Since December 1988, interest rate volatility did not change. However, it is readily seen from Figure 8.b.1 that this does not mean that interest rates stayed at 15 % but this means that interest rates fell gradually to 7 percent level.

Money growth rate has five breaks. Three of the breaks are at June 1987, June 1988 and October 1989. There is an increase between October 1989 and August 1991, which is followed by a decrease that endures until 1998.

So, for New Zealand, within the two years before the introduction of inflation targeting, there is an increase in money growth volatility and there are no changes in exchange rate and interest rate volatility. After the adoption of inflation targeting, exchange rate and money growth volatility decrease. Interest rates decline but the volatility of interest rates remains unchanged.

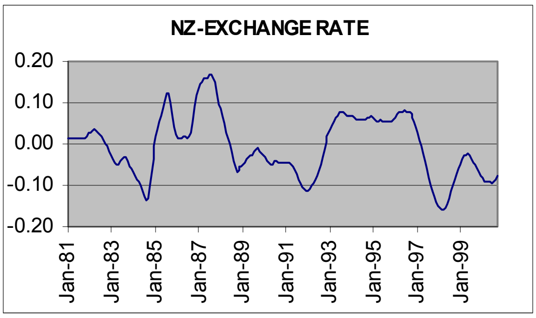


Figure 8.a.1 Exchange rate

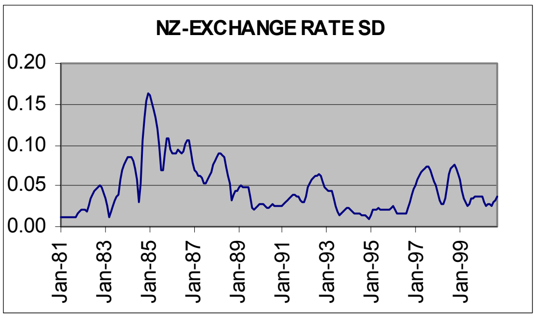


Figure 8.a.2 Exchange rate std. dev.

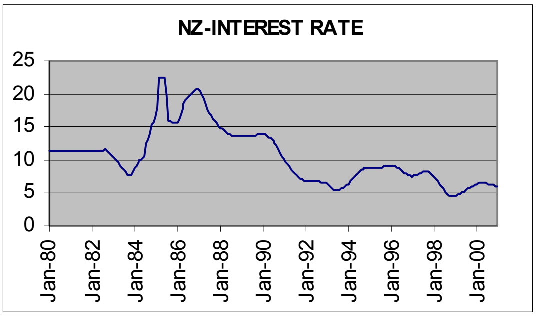


Figure 8.b.1 Interest rate

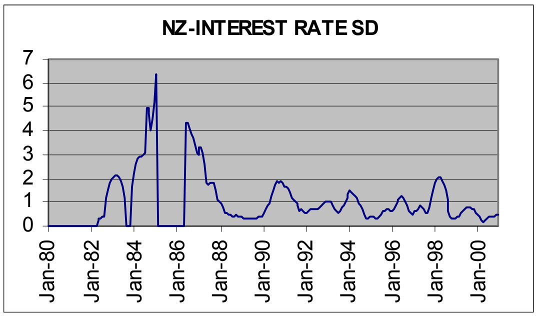


Figure 8.b.2 Interest rate std. dev.

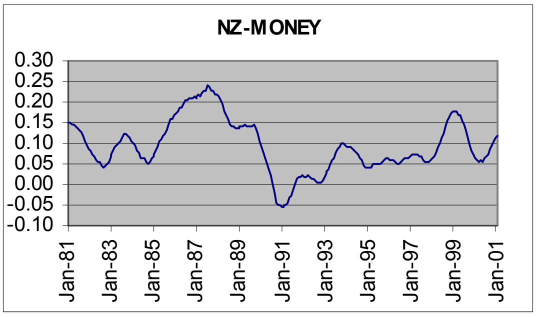


Figure 8.c.1 Money growth

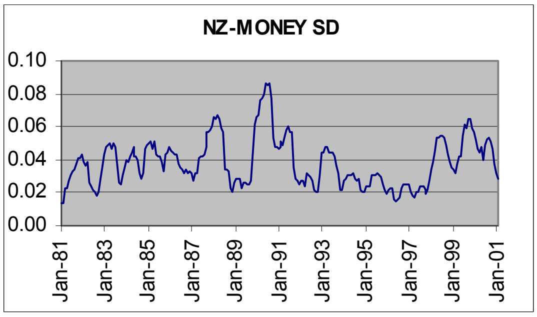


Figure 8.c.2 Money growth std. dev.

4.9 Spain

Spain shifts to inflation targeting at November 1994. There are structural breaks for CPI inflation, exchange rate and interest rate as can be seen from Table 9. For inflation, all of the breaks are prior to inflation targeting. After November 1988, there are no significant standard deviation changes and inflation lies around 5 % with a minimum volatility compared to previous periods.

For the exchange rate, the test successfully captures the speculative attacks of 1993 and 1995. After a shock free period between 1984 and 1992, there is an increase in exchange rate volatility that lasts until March 1994. After March 1994, there is a decrease in exchange rate volatility that is followed by another decrease at May 1996. Since May 1996, volatility is at its minimum value.

For the interest rate, the changes are dramatic. The test captures the massive lending rate increase by the Bank of Spain at 1987. Between July 1987 and December 1988, there is an increase in interest rate volatility compared to the previous period. After December 1988 until February 1995, there is a decrease in volatility and volatility is the minimum of the period 1980-1995. After 1995 there is a further decrease in interest rate volatility and volatility becomes as low as 0.54 %. The interest rate levels drop gradually starting from 1992.

There are no structural breaks for money growth rate and there are two gradual breaks for production growth rate that is taken from two-year moving average standard deviation test. Close inspection of Figure 9.d.1 and Figure 9.e.1 tells us the adverse effects of the speculative shocks to the economy in 1993 and 1995. Production growth becomes as low as –7.6 % at September 1992 and money growth hits –2.4% at December 1992. The gradual break that the test offers for production growth just covers these dates. After January 1993, production growth volatility declines to 0.08 %, but the persistence of production growth volatility must be taken into account for 0.08 % to be meaningful. The gradual break test suggests a high degree of persistence in volatility with the first coefficient in the table being 95.6 %. This indicates that 95 percent of the volatility of production is passed from the previous period to the current one.

So, for Spain, within the two years before adoption of inflation targeting, there are no structural changes in inflation volatility, an increase in exchange rate volatility due to exchange rate crisis of 1992-93, no changes for interest rate volatility and an increase in production growth volatility. After the adoption of inflation targeting, there are decreases in exchange rate, interest rate and production growth volatility. Inflation volatility and money growth volatility remains unaltered.

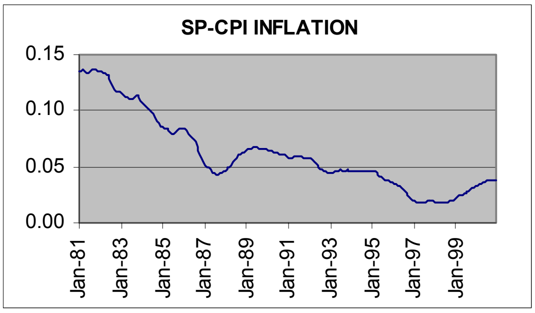


Figure 9.a.1 CPI inflation

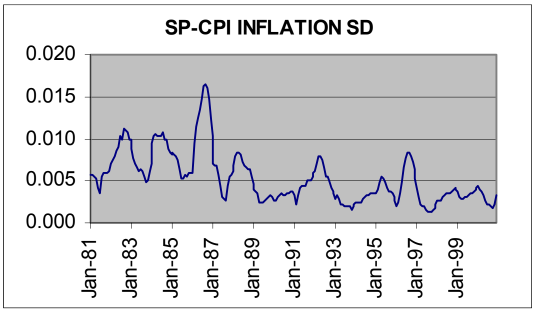


Figure 9.a.2 CPI inflation std. dev.

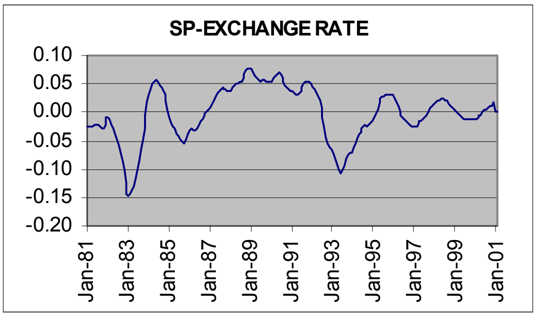


Figure 9.b.1 Exchange rate

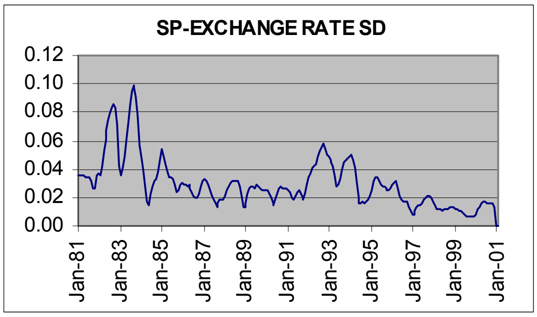


Figure 9.b.2 Exchange rate std. dev.

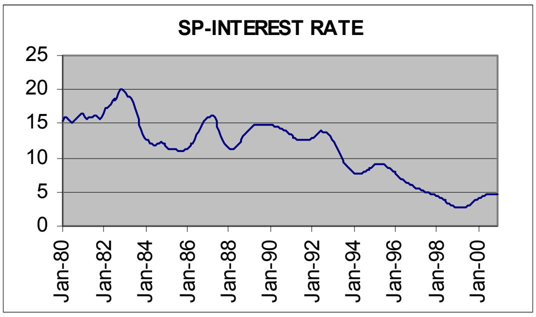


Figure 9.c.1 Interest rate

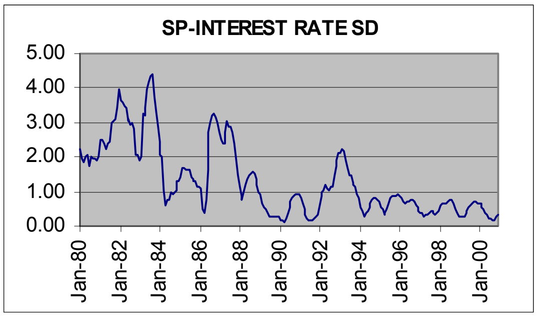


Figure 9.c.2 Interest rate std. dev.

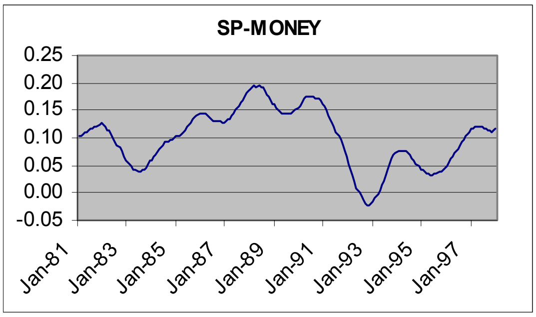


Figure 9.d.1 Money growth

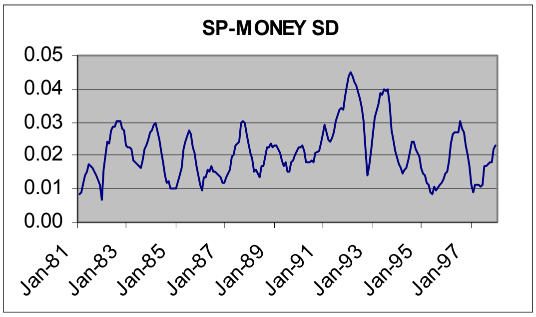


Figure 9.d.2 Money growth std. dev.

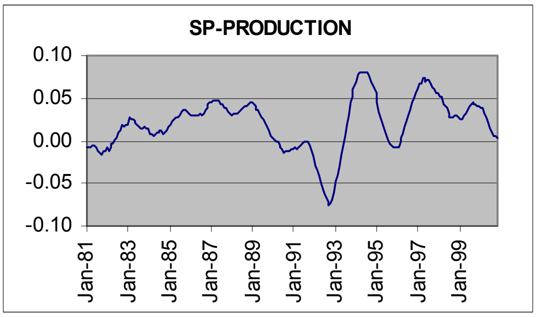


Figure 9.e.1 Production growth

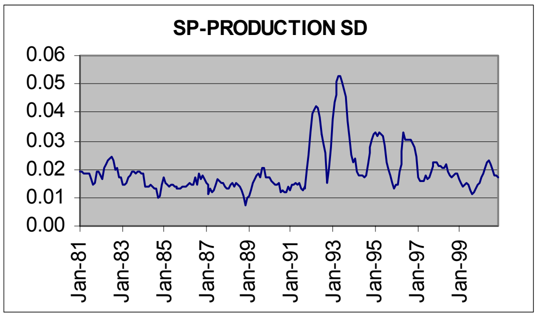


Figure 9.e.2 Prod. growth std. dev.

4.10 Sweden

Sweden shifts to inflation targeting at January 1993. The results of the structural break tests are listed in Table 10. There are structural breaks for all of the monetary aggregates.

For CPI inflation, four breaks are between 1989 and 1993. After a period of low volatility between 1982 and 1989, there are two increases in volatility that lasts until December 1991. It must noted that there are tax reforms in 1990 and 1991 when the VAT base is widened and prices then adjust to reflect these reforms. Between December 1991 and November 1993 there is a decrease in volatility and after November 1993 there are no structural changes and the inflation volatility is at its lowest level. We can see that after 1993, inflation stays between 0-2 percent.

For exchange rate, there are four breaks and the test captures the 1992-1993 exchange rate crisis. After a period of low volatility between 1983 and January 1992, there is a significant increase in volatility that is persevered until the end of 1993. Between November 1993 and October 1996 there is a decrease and further decrease after October 1996.

For interest rate there are five breaks. After an era of low volatility, volatility increases for the period July 1990 and November 1992. The increase is consistent with the exchange rate crisis. Volatility starts to decline attaining its minimum value after July 1996. Similarly, the level of interest rates starts to decrease at the beginning of 1992 and after July 1996 interest rates stay at the band 3.5-4.5 percent.

There are 5 gradual breaks for money growth. The first coefficient shows the persistence of the money growth volatility. The subsequent terms are period coefficients. After the period between September 1983 and February 1989, there is an increase in money growth volatility, and another increase follows that lasts until June 1991. After this date, there are no structural breaks and money growth volatility stays at 0.5 percent.

There are four breaks for production growth; the first two are at 1981 and 1984. There is an increase in volatility after the period between 1984 and 1991 ends. There is a decrease in production volatility after the break at August 1993 and no further structural change exists. The dates of structural changes successfully capture the recession between 1990 and 1993. With production growth hitting the minimum of the twenty years analyzed here in 1991, it seems hard to claim that the subsequent good production growth performance would have been even better without inflation targeting. After 1993, the level of production growth ranges from 5 to 10 percent until 1998.

So, for Sweden, within the two years before the adoption of inflation targeting; there is first an increase then a decrease in inflation volatility, an increase in exchange rate volatility due to exchange rate crisis of 1992-93, first an increase then a decrease in interest rate volatility, a decrease in money growth volatility and an increase in production growth volatility. After the adoption of inflation targeting, inflation volatility decreases, exchange rate volatility decreases twice, interest rate volatility and production growth volatility decrease while money growth volatility does not change.

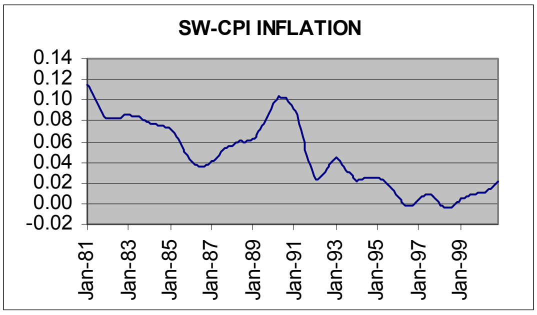


Figure 10.a.1 CPI inflation

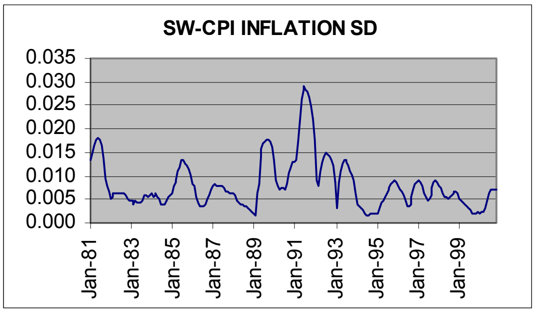


Figure 10.a.2 CPI inflation std. dev.

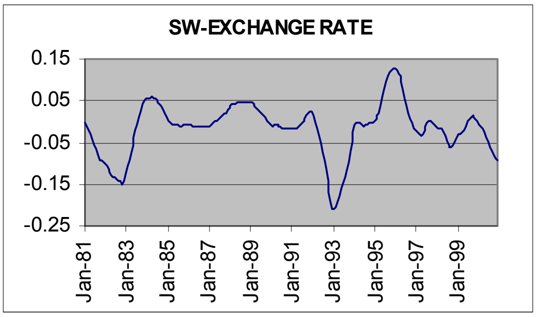


Figure 10.b.1 Exchange rate

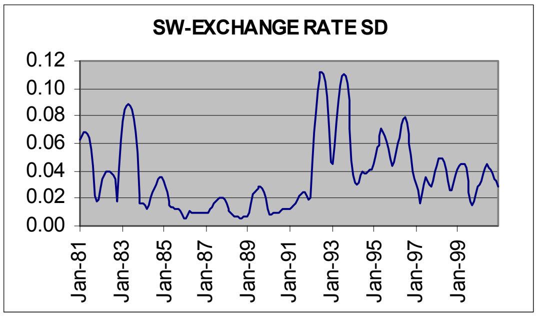
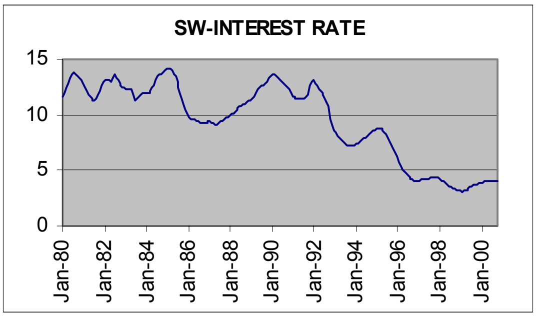


Figure 10.b.2 Exchange rate std. dev.



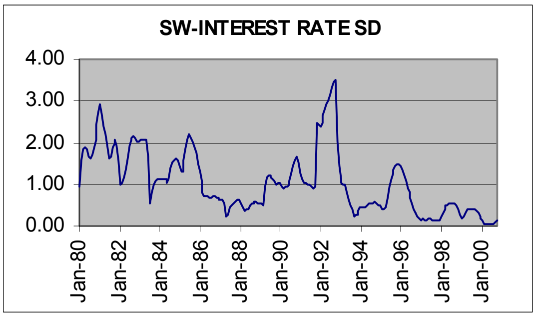
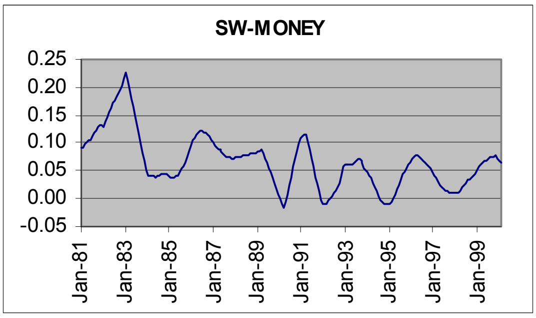


Figure 10.c.1 Interest rate **Figure 10.c.2 Interest rate std. dev.**



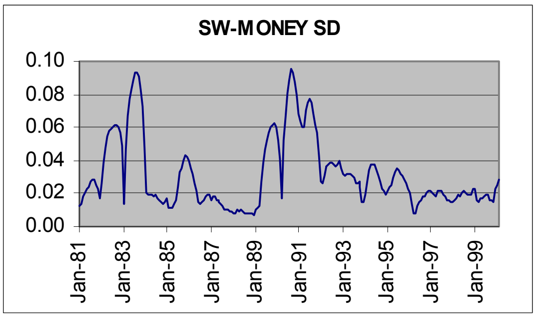
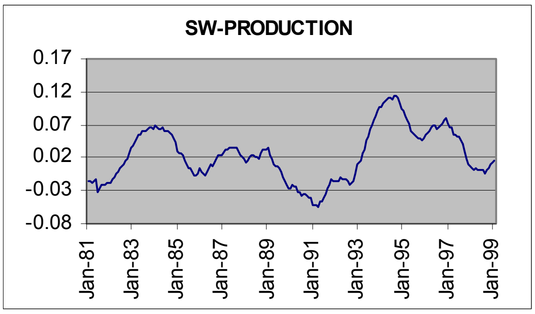


Figure 10.d.1 Money growth **Figure 10.d.2 Money growth std. dev.**



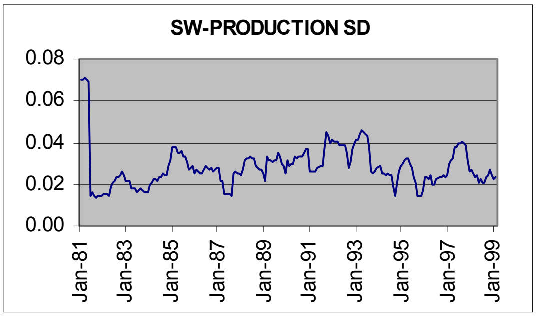


Figure 10.e.1 Production growth **Figure 10.e.2 Prod. growth std. dev.**

4.11 Denmark

There are structural breaks for all of the monetary aggregates. The results are listed in Table 11. The comparisons with Sweden are listed through the Figures 18-19. For CPI inflation, all breaks are before 1990. We can see from the coefficients of the volatility between break dates that inflation volatility is very low in Denmark.

The lowest volatility of the twenty years is achieved after the break at 1990. We can also see from the figures that there is a very smooth disinflation period that ends approximately at 1990 and then inflation swings around 2 percent. Denmark is similar to Sweden in terms of inflation volatility except the period between 1990 and 1991 when VAT is increased in Sweden that in turn triggered inflation. However, volatility of inflation in Sweden is greater than in Denmark before and after Sweden introduced inflation targeting. This is because Denmark stabilised its inflation at 2 percent but Sweden let inflation to fluctuate in the 0-2 percent band.

For exchange rate in Denmark, there are five breaks. After a period of low volatility between November 1987 and January 1989, there is a significant increase in volatility that is persevered until mid 1994. Between May 1994 and May 1997 there is a decrease, which is followed by an increase that lasts in mid 1999. When we compare the volatilities of Denmark and Sweden, we can see that Sweden has a larger exchange rate volatility after the introduction of inflation targeting.

For interest rate there are four breaks. There is an era of low volatility between 1982 and 1991, which is followed by an increase until the end of 1992. Afterwards volatility declines sharply attaining its minimum with a value of 0.47. We can also see from the figures that interest rates fall gradually since 1980 with the exception of the increase in 1992. When we compare Sweden and Denmark, we can conclude that after the consequences of the ERM crisis in 1993 are overcome; in general, Sweden managed to have a lower volatility of interest rates than Denmark.

There aren't any breaks for money growth. When we look at the figures we can see that money growth rate gradually declined over time and there is a significant increase in 1994 in the volatility of money growth. Comparing Denmark and

Sweden, we can say that since Sweden introduced inflation targeting, money is less volatile in Sweden than in Denmark.

There are five breaks for production growth; the first two are at 1984 and 1986. The minimum volatility of the period analyzed is reached between 1986 and 1992. Between the end of 1992 and the end of 1993 the volatility doubles compared to the previous period and decreases afterwards. When we compare Sweden and Denmark, we see that production is less volatile in Sweden at all times after the introduction of inflation targeting with a higher average production growth until 1997.

To sum up, inflation is lower in Sweden than in Denmark with a higher volatility after the adoption of inflation targeting in Sweden. Exchange rate is significantly more volatile in Sweden after the regime shift. Interest rates and money growth rate are less volatile in Sweden after the adoption of inflation targeting but this cannot be confidently attributed to the regime change. Sweden manages to have a high production growth with a less volatile production growth than Denmark after the regime change.

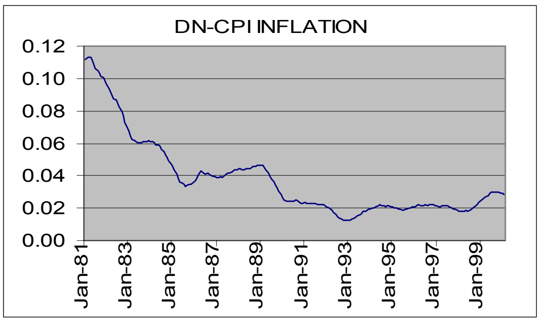


Figure 11.a.1 CPI inflation

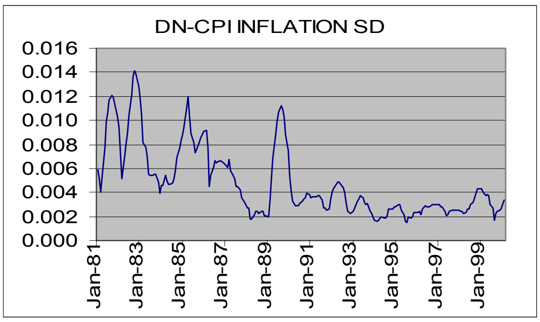


Figure 11.a.2 CPI inflation std. dev.

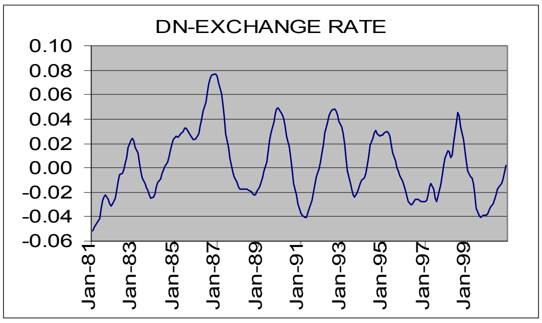


Figure 11.b.1 Exchange rate

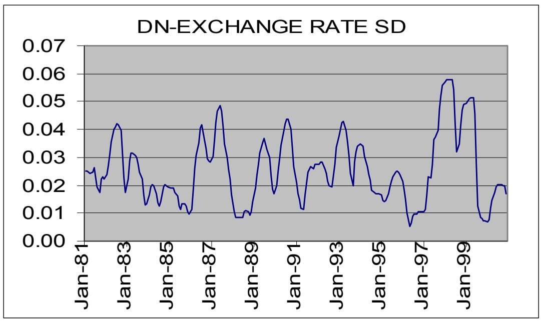


Figure 11.b.2 Exchange rate std. dev.

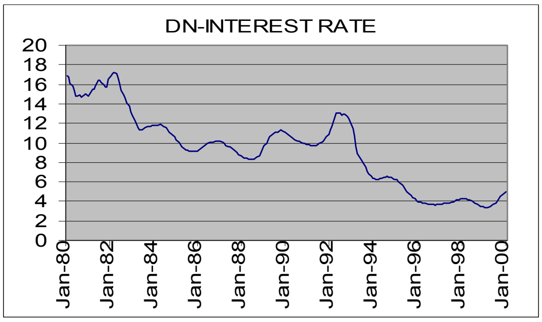


Figure 11.c.1 Interest rate

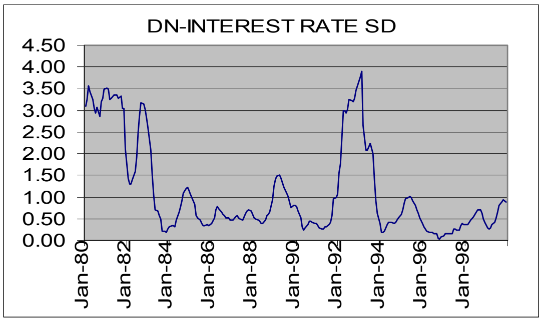


Figure 11.c.2 Interest rate std. dev.

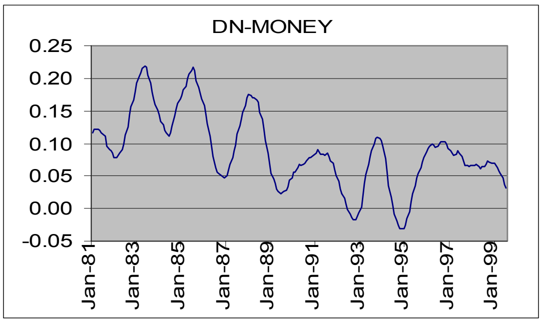


Figure 11.d.1 Money growth

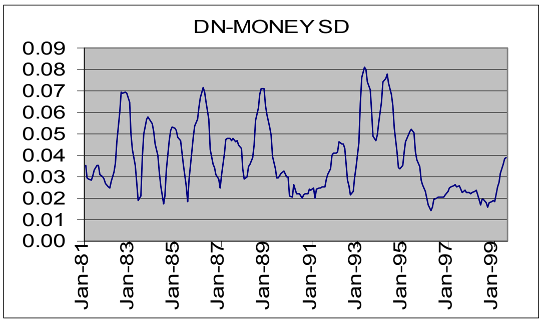


Figure 11.d.2 Money growth std. dev.

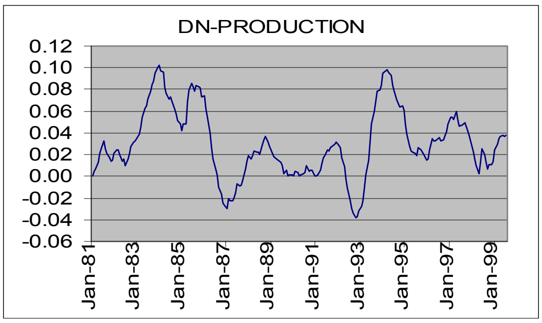


Figure 11.e.1 Production growth

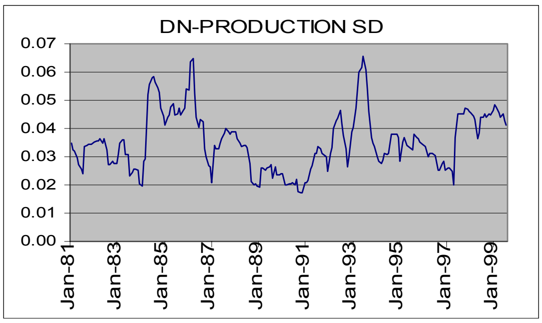


Figure 11.e.2 Prod. growth std. dev.

4.12 United Kingdom

U.K. shifts to inflation targeting at October 1992. The structural break results are listed in Table 12. For CPI inflation, there are five structural breaks and all breaks are before the introduction of inflation targeting. After March 1991 inflation volatility is stable with the volatility being 0.0021. We can see from Figure 12.a.1 that inflation is around 1 percent after 1993 and there are only minor movements in inflation rate.

First break for exchange rate is at 1985. An increase in exchange rate volatility follows up to 1987. Between 1987 and October 1991, volatility decreases. But after the currency crisis begins there is an increase that endures till the end of 1993. A decrease follows with standard deviation reaching its minimum level of the 1980s and 1990s. After August 1995 there is no break and exchange rate volatility is higher than its previous level.

For interest rate there are three breaks. Between May 1982 and August 1987 interest rate volatility is low, it slightly increases until October 1992 and achieves its minimum afterwards with a volatility of 0.35. Also, there is a gradual decline in interest rate levels from 1990 to 1994 and afterwards interest rates swing around 5.5 percent.

Money growth rate volatility is stable between 1983 and 1987 with a standard deviation of 0.3 percent. There is a slight increase between 1987 and September 1990 followed by a decrease to 0.3 percent level. After December 1998, there is an increase in money growth volatility for one year.

There are three breaks for production growth rate. The first two are at 1983 and 1985 that is caused by the minors’ strike in 1984. Between October 1984 and

December 1994 there are no breaks. Inspection of the production graph, Figure 12.e.1, shows the recession between 1990 and 1992, which is followed by a rapid growth that offsets the effects of recession. After 1995 there are no structural changes, production volatility is at its minimum with a 0.7 percent and production growth rate is around 1 percent.

For U.K., within the two years before inflation targeting is adopted; inflation volatility first increases then decreases, exchange rate volatility increases due to the exchange rate crisis of 1992-93, money growth volatility decreases, and interest rate and production growth volatilities do not change. After the adoption of inflation targeting, inflation volatility increases between 1997 and 1998 and then drops again, exchange rate volatility decreases from September 1993 to August 1995 and slightly increases thereafter, interest rate volatility decreases, money growth volatility increases between 1997 and 1998 and then decreases again and production volatility decreases.

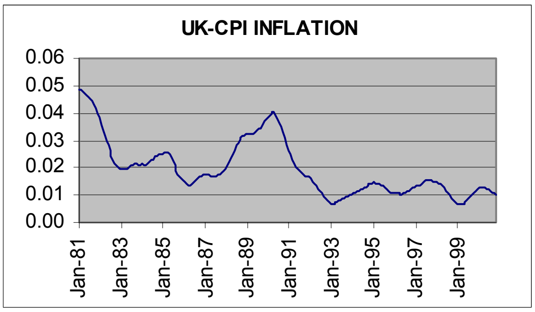


Figure 12.a.1 CPI inflation

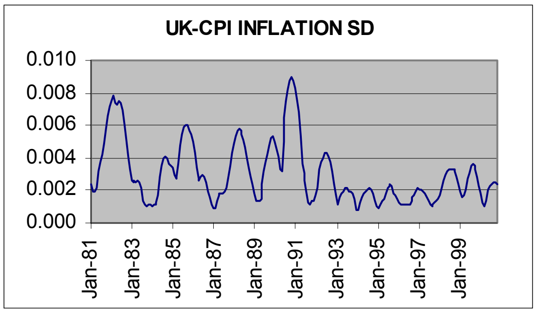


Figure 12.a.2 CPI inflation std. dev.

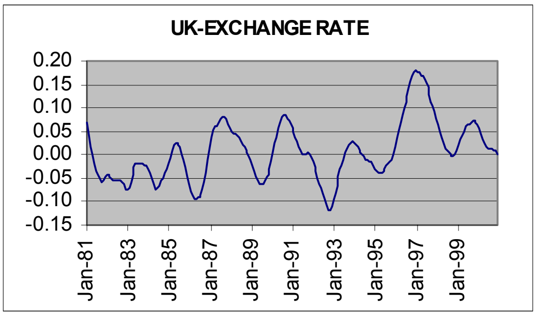


Figure 12.b.1 Exchange rate

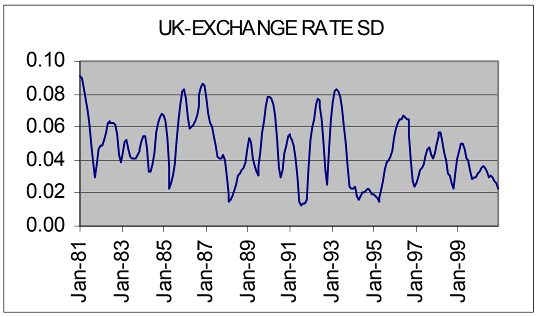


Figure 12.b.2 Exchange rate std. dev.

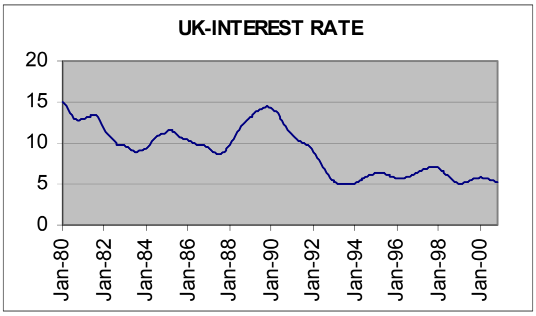


Figure 12.c.1 Interest rate

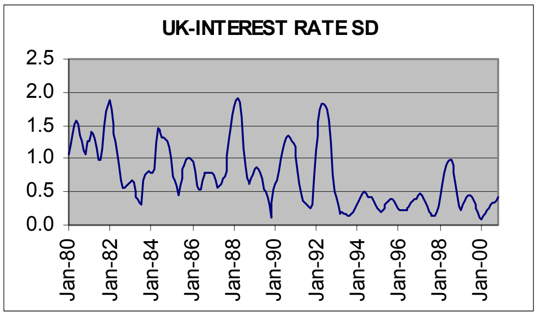


Figure 12.c.2 Interest rate std. dev.

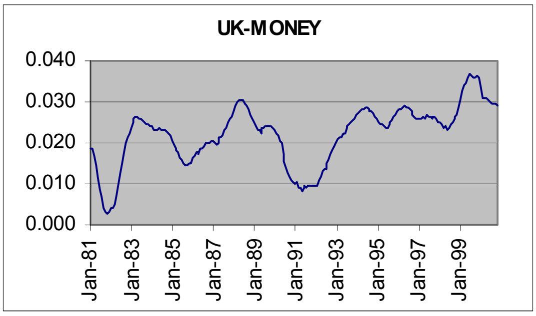


Figure 12.d.1 Money growth

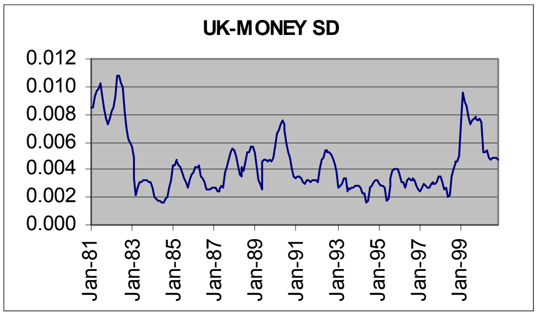


Figure 12.d.2 Money growth std. dev.

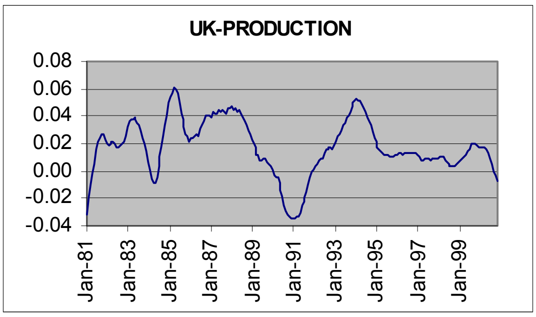


Figure 12.e.1 Production growth

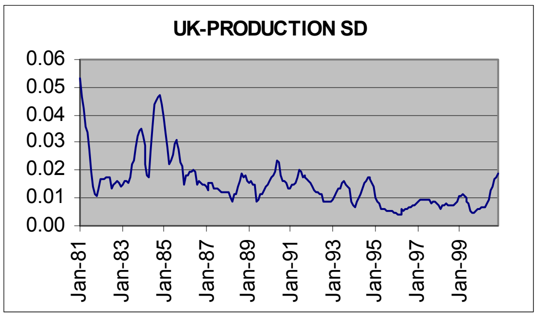


Figure 512.e.2 Prod. growth std. dev.

4.13 France

The structural break test results are listed in Table 13. Except money growth, there are structural breaks for France. The Figures 20-21 in the appendix are the comparison graphs of U.K. with France.

For CPI inflation there are five breaks all of which are before 1987. After 1987 disinflation is completed and a period with a low volatility of inflation emerges. We can see that the volatility coefficient is as low as 0.2 percent. When we compare U.K. with France we can see that except the period between October 1988 and May 1991, the volatility of inflation is most of the time lower in the U.K than in France and inflation is also almost always lower in the U.K. than in France before and after the introduction of inflation targeting in U.K.

For exchange rate there are four breaks. From February 1984 to April 1990 exchange rate volatility is decreasing. There is an increase that lasts until 1994 due to the ERM crisis. After mid-1994, exchange rate is less volatile compared to the previous periods with a volatility coefficient of 1.2 percent. The difference between the exchange rate volatilities in U.K. and France is almost always positive and does not change with the introduction of inflation targeting in U.K.

The tests do not suggest any breaks for interest rate. We can see that there is a decreasing trend in interest rates, which is in line with the disinflation period but takes longer than inflation. We can also see from the figures that at time of the ERM crisis, interest rate volatility increases and interest rates stay at a high level. We can see from the figures that there is a clear difference between U.K. and France before and after the introduction of inflation targeting in U.K. Between August 1981 and August 1992, interest rate volatility in U.K. is higher than in France almost always.

After August 1992 till June 1996, the volatility in U.K. is lower than in France at all times with one exception. This period matches with the time U.K. has a lower level of interest rate than France. But between June 1996 and June 1999 volatility in U.K. is again greater than in France because of the increasing level of the interest rate differences between these countries; while interest rate in the U.K. fluctuates around 5 percent, it is around 3 percent in France.

There are five breaks for money growth; three of them are between 1986 and 1990. Money growth volatility is higher between August 1989 and November 1993 compared to the previous period, it then decreases for one year and finally after December 1994, it stays at a higher level than the previous seven years. We can see from the figures that there is an increasing trend in average money growth after the last break at 1994, which in turn brings a higher volatility. We can see from the figures that regardless of the money growth rate differences, volatility of money is greater in France than in U.K. at all times.

There are four breaks in production growth. Three breaks are between 1993 and mid-1995. After June 1995, production volatility decreases and it further decreases after mid-1999. The breaks in 1993-95 are due to the sharp decline in production growth in 1993. We can see from the figures that between October 1991 and June 1996, U.K. production growth is higher than in France with the exception of eleven months in 1994. After June 1996, production growth is at all times lower in U.K. than in France. Starting from December 1991 production volatility is lower in U.K until May 2000. Whether the production level is higher or lower, U.K. managed to have lower production volatility than France after 1992.

To sum up, inflation is lower in the U.K. almost always and also inflation volatility is most of the time lower in the U.K. with the exception of the period between October 1988 and May 1991. Exchange rate volatility is always higher in the U.K. and money growth volatility is always higher in France. Both the level and the volatility of interest rates are higher in the U.K. at all times except the period of the ERM crisis that affected France more severely. After inflation targeting is introduced production volatility is lower in the U.K. but the production growth levels are also lower especially after mid-1996.

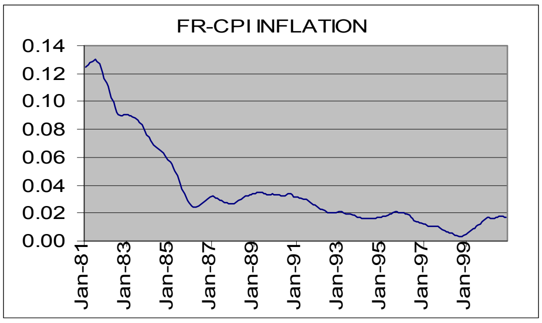


Figure 13.a.1 CPI inflation

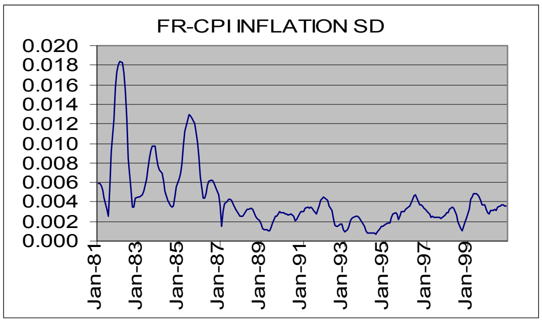


Figure 13.a.2 CPI inflation std. dev.

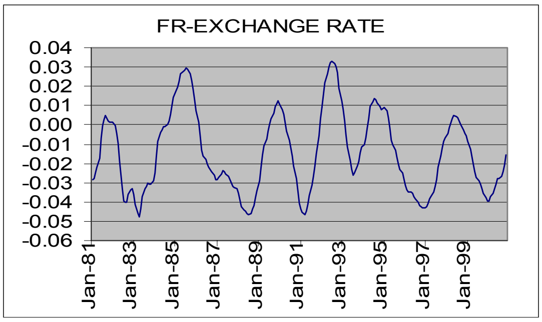


Figure 13.b.1 Exchange rate

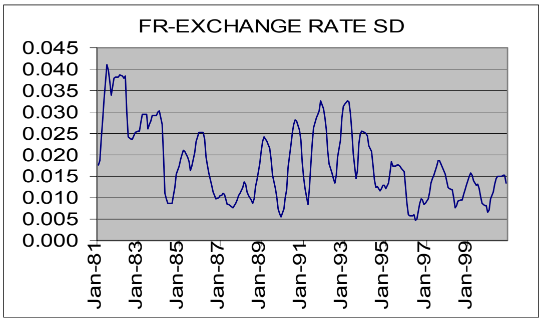
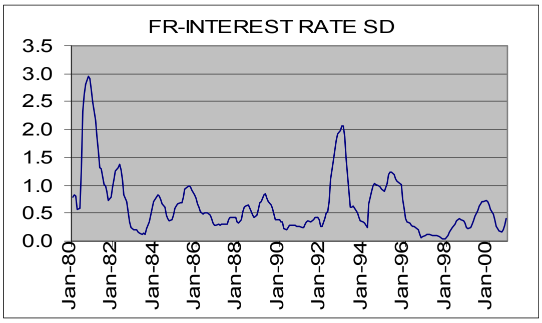


Figure 13.b.2 Exchange rate std. dev.



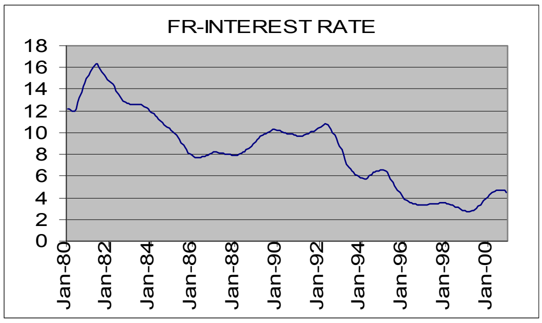
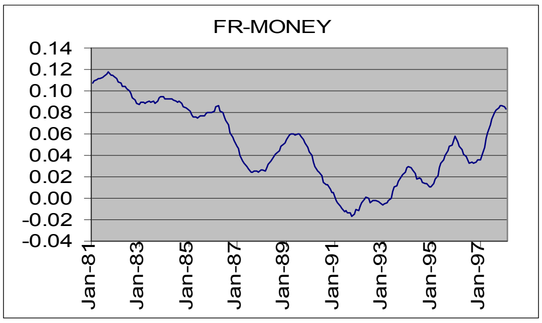


Figure 13.c.1 Interest rate

Figure 13.c.2 Interest rate std. dev.



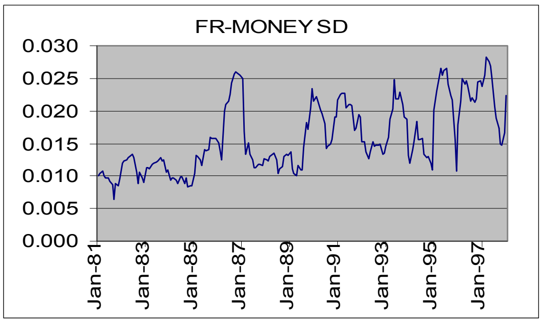
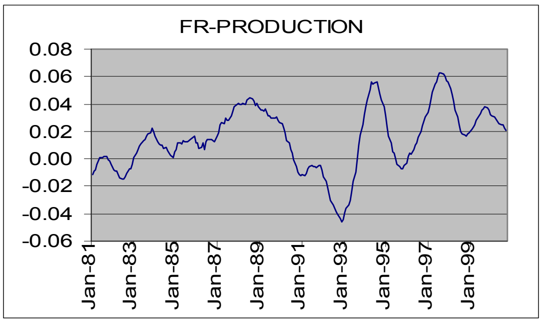


Figure 13.d.1 Money growth

Figure 13.d.2 Money growth std. dev.



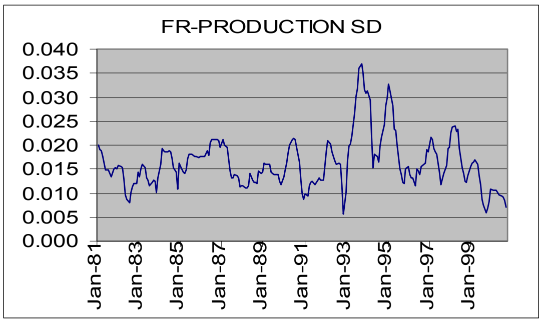


Figure 13.e.1 Production growth

Figure 13.e.2 Prod. growth std. dev.

CHAPTER 5

Conclusion

In this thesis we analyze nine countries that adopted inflation targeting between 1990 and 1995: Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden and United Kingdom. We try to investigate the impact of inflation targeting on the volatility of output growth, interest rate, exchange rate, inflation and money.

There are two particular differences of this thesis other than the works in the literature. First, different from the approaches used in the literature, we make structural break tests on the monetary aggregates. The results tell us whether there is a structural break in the monetary aggregate analysed as well as what the effect of the structural break is if there exists one. We also try to interpret these changes and try to figure out whether the changes in volatility are the results of the changes in the level or not. This is particularly important for output growth and inflation volatilities since it is desirable to have a high level of output growth with a low volatility and a low level of inflation with a low volatility. However, a decline in output volatility might be the consequence of a decline in output growth and a decline in the level of inflation not always implies a decline in the volatility of inflation. The second difference is, we not only look at the changes in inflation, output and interest rate variability, as is the case in the literature of inflation targeting, but also search for changes in exchange rate and money variability. The results provide important insights on whether inflation targeting central banks excessively use money and exchange rate to control inflation. We also compare the results of Canada with United States, United Kingdom with France, Sweden with Denmark and Finland with Norway.

The main finding is, inflation targeting countries well managed to improve their performance in terms of the volatilities of monetary aggregates. Despite the fact that there are upward movements in the volatilities of monetary aggregates at the time of the regime shift in inflation targeting countries, after the adoption of inflation targeting, in general, the volatilities declined. After the adoption of inflation targeting, the most notable declines are in the volatilities of exchange rates and interest rates. Interest rate volatility declines in Australia, Canada, Chile, Finland, Spain, Sweden and U.K. and remains unchanged in Israel and New Zealand. Exchange rate volatility decreases in Australia, Finland, Israel, New Zealand, Spain and Sweden. It remains unchanged in Canada and Chile and slightly increases after 1995 in the U.K. There aren't any notable increases in inflation volatility and production growth volatility in any of the countries analyzed and also there are decreases in inflation volatility in Canada, Chile, Finland and Sweden and decreases in production growth volatility in Chile, Israel, Spain, Sweden and U.K. Money growth volatility remains unchanged or decreases in all the countries but in the U.K. for a short period of time.

The above results suggest that producing decreased inflation and output volatility does not come with the cost of increased interest rate volatility or exchange rate volatility. Moreover, all inflation targeting countries managed stable low inflations and low interest rates except Israel where interest rates are notably higher than inflation at all times. However, not all of the inflation targeting countries managed to sustain high output growth levels. Canada, Finland, Israel and Sweden sustains high output growth levels after the introduction of inflation targeting but in Chile, Spain and the U.K. production growth is fluctuating making it hard to conclude whether it could have been better without inflation targeting or not. The results on the levels of exchange rates and money growth rates are far from being conclusive.

When we compare Canada with U.S., we see that Canada does not perform as well as U.S. in terms of volatilities before and after the introduction of inflation targeting except for exchange rate. After the introduction of inflation targeting Canada successfully achieves a lower CPI inflation than the U.S. and also the differences between the levels of interest rate and production growth in Canada and U.S. are either declining or negative which implies that the relative performance of Canada has been improving after the adoption of inflation targeting. For Finland there is a change in trend when compared to Norway after the introduction of inflation targeting. Production growth is bigger and interest rate and inflation levels are smaller when compared to Norway after the introduction of inflation targeting. Production growth volatility and interest rate volatility are smaller but inflation volatility and exchange rate volatility are usually higher than in Norway. When Sweden is compared to Denmark, it is seen that after Sweden introduced inflation targeting, Sweden has a lower inflation level than Denmark with a higher volatility. Moreover, Sweden manages to have a higher production growth with a lower volatility than Denmark however interest rates do not follow the decline in inflation.

After inflation targeting is implemented, Sweden has also lower volatility in interest rates and money growth but lower volatilities cannot be safely attributed to the regime change. Exchange rate is more volatile in Sweden especially after inflation targeting is introduced. When we compare U.K. with France, we find that the volatility and the level of inflation is almost always lower in the U.K. before and after inflation targeting, exchange rate is always more volatile in U.K., money growth is always more volatile in France. After the introduction of inflation targeting in U.K. there is a clear evidence of declining production and interest rate volatility, however production growth level is also lower in the U.K. especially after mid-1996 and the relative interest rate volatility increases after mid-1996.

So, the results clearly suggest that inflation targeting countries successfully lowered their inflation levels below the benchmark countries' inflation levels. However, except U.K. inflation volatilities are higher in inflation targeting countries. Sweden and Finland manage to sustain high production growth levels with low production growth volatilities compared to the benchmark countries but this is not the case for U.K. and Canada. Interest rate level differences are declining in Canada and Finland but not in the U.K. and Sweden. There is a relative improvement in interest rate volatilities after the regime change in all countries except Canada. Exchange rate is always more volatile in the inflation targeting countries. Money growth is less volatile in the U.K., Sweden and Finland but not in Canada. So there isn't any clear pattern of how inflation targeting countries perform relative to the benchmark countries and the relative success of the regime changes from one country to another.

To conclude, up to now, inflation targeting countries managed to perform well but the comparisons of the performance of the four benchmark countries suggest that it is far from conclusive how inflation targeting performs relative to other monetary regimes. But since inflation targeting is still a new regime, more time and experience with the new regime are needed to evaluate the performance of inflation targeting as a monetary policy.

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APPENDIX A

List of Tables

Table 1. Australia Structural Break Test Results

Shift Date: Sep.1994

		CPI	Exchange rate	Interest Rate	Money	Production
Type of Shift		Sudden	Sudden	Sudden and Gradual	No Break[1]	No Data
Number of Breaks		5	4	4		
Coefficients and Standard Errors of Variables	1	0.008154 (0.000437)	0.037331 (0.002060)	1.543665 (0.051228)		
	2	0.011466 (0.000580)	0.076040 (0.001647)	1.982234 (0.063960)		
	3	0.020498 (0.000729)	0.037697 (0.001661)	1.289783 (0.050288)		
	4	0.015703 (0.000580)	0.059276 (0.002682)	0.620894 (0.063039)		
	5	0.005285 (0.000624)	0.046894 (0.001751)	0.335506 (0.043354)		
	6	0.009655 (0.000590)				
Break Dates From Bai-Perron Test	1	May-85	Mar-84	May-84		
	2	Nov-87	Apr-89	Mar-87		
	3	Jun-89	Apr-94	Oct-91		
	4	Dec-91	Mar-96	Sep-94		
	5	Feb-94				

[1] Both 10 and 5 percent trimming do not reveal any breaks.

Table 2. Canada Structural Break Test Results

Shift Date: Feb 1991

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Sudden[2]	No Break[3]	Sudden	Sudden	Sudden
Number of Breaks		5		5	5	3
Coefficients and Standard Errors of Variables	1	0.005600 (0.000576)		2.379674 (0.051588)	0.022251 (0.000834)	0.056011 (0.001556)
	2	0.015212 (0.000622)		0.900472 (0.043802)	0.015583 (0.000834)	0.038216 (0.001505)
	3	0.003189 (0.000237)		0.661660 (0.041897)	0.020265 (0.000802)	0.02353 (0.00153)
	4	0.008074 (0.000650)		1.163102 (0.049260)	0.012603 (0.000411)	0.015755 (0.000691)
	5	0.015254 (0.000650)		0.884072 (0.043802)	0.007701 (0.000712)	
	6	0.004537 (0.000208)		0.368695 (0.039454)	0.031104 (0.000691)	
Break Dates From Bai-Perron Test	1	Feb-82		Jul-82	Dec-82	May-83
	2	Feb-83		Feb-86	Dec-84	Dec-85
	3	Jan-90		Jan-90	Feb-87	Jun-88
	4	Dec-90		Nov-92	May-95	
	5	Nov-91		Jun-96	Feb-98	

[2] 5 percent trimming result
[3] Both 10 and 5 percent trimming do not suggest break.

Table 3. U.S. Structural Break Test Results

		CPI	Exchange rate	Interest Rate	Money	Production
Type of Shift		Sudden	Sudden and Gradual	No Break	Gradual	Sudden
Number of Breaks		5	5		4	5
Coefficients and Standard Errors of Variables	1	0.012219 (0.000348)	0.038977 (0.001593)		0.993313 (0.018963)	0.030533 (0.001284)
	2	0.004462 (0.000282)	0.100663 (0.003257)		-0.000064 (0.000373)	0.050613 (0.001643)
	3	0.008851 (0.000348)	0.035735 (0.001021)		0.002288 (0.000595)	0.027147 (0.001407)
	4	0.003166 (0.000282)	0.050132 (0.003257)		-0.003040 (0.000744)	0.012386 (0.000581)
	5	0.007454 (0.000357)	0.020671 (0.002252)		0.000092 (0.000280)	0.008301 (0.000567)
	6	0.002489 (0.000151)	0.036962 (0.0018)		0.002271 (0.000606)	0.021637 (0.001643)
Break Dates From Bai-Perron Test	1	Sep-1982	Oct-1984		Oct-1985	Jun-1982
	2	May-1985	Sep-1985		Jan-1987	May-1983
	3	Feb-1987	Jan-1995		Dec-1987	Aug-1984
	4	Oct-1989	Dec-1995		Oct-1999	Dec-1991
	5	Jun-1991	Nov-1997			Oct-1999

Table 4. Chile Structural Break Test Results

Shift Date: Jan 1991

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Gradual and Sudden	Sudden	Sudden[4]	Gradual and Sudden	Sudden[4]
Number of Breaks		3	2	5	5	5
Coefficients and Standard Errors of Variables	1	0.054158 (0.001568)	0.132283 (0.004479)	7.018249 (0.531029)	0.110191 (0.002280)	0.103418 (0.002732)
	2	0.043322 (0.001189)	0.077547 (0.004337)	18.083997 (0.735177)	0.044512 (0.002633)	0.083117 (0.002732)
	3	0.020121 (0.000880)	0.036371 (0.001854)	5.703711 (0.735177)	0.026657 (0.002150)	0.047086 (0.001433)
	4	0.006540 (0.000741)		21.040924 (0.735177)	0.040795 (0.002317)	0.037122 (0.001211)
	5			8.436490 (0.245059)	0.181017 (0.002580)	0.052406 (0.001889)
Coefficients and Standard	6			3.062782 (0.277871)	0.028005 (0.001337)	0.033613 (0.000920)
Break Dates From Bai-Perron Test	1	Nov-82	Jun-83	Nov-81	Aug-83	Nov-81
	2	Mar-86	Feb-86	Nov-82	Aug-85	Oct-82
	3	Apr-92		Nov-83	Aug-88	Feb-86
	4			Nov-84	Mar-91	Oct-90
	5			Jan-95	Apr-93	Sep-92

[4] 5 percent trimming results

Table 5. Finland Structural Break Test Results

Shift Date: Feb 1993

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Sudden	Sudden	Sudden	Sudden	No Break
Number of Breaks		5	5	5	5	
Coefficients and Standard Errors of Variables	1	0.009081 (0.000373)	0.018090 (0.000941)	0.486317 (0.055446)	0.014358 (0.003352)	
	2	0.006577 (0.000251)	0.039495 (0.001843)	1.628567 (0.086194)	0.061989 (0.008823)	
	3	0.002154 (0.000395)	0.075015 (0.003044)	0.837883 (0.036753)	0.171199 (0.007204)	
	4	0.005444 (0.000167)	0.038040 (0.002800)	1.403277 (0.048437)	0.009811 (0.003864)	
	5	0.003042 (0.000243)	0.070994 (0.003044)	2.233378 (0.086194)	0.321807 (0.007038)	
	6	0.006371 (0.000364)	0.021477 (0.001314)	0.434800 (0.030797)	0.035921 (0.009953)	
Break Dates From Bai-Perron Test	1	Jul-82	Jul-90	May-82	Jan-89	
	2	Jan-86	Jan-93	May-83	Mar-90	
	3	Jun-87	Dec-93	Nov-88	Dec-91	
	4	May-95	Jan-95	Jan-92	Jan-98	
	5	Feb-99	Dec-95	Jan-93	Nov-99	

Table 6. Norway Structural Break Test Results

		CPI	Exchange rate	Interest Rate	Money	Production
Type of Shift		No Break	No Break	No Break	Sudden[5]	Sudden and Gradual
Number of Breaks					5	5
Coefficients and Standard Errors of Variables	1				0.023363 (0.001285)	0.051054 (0.001356)
	2				0.000000 (0.001803)	0.034398 (0.001864)
	3				0.030619 (0.001568)	0.098241 (0.002193)
	4				0.077445 (0.002140)	0.111561 (0.002384)
	5				0.020170 (0.001629)	0.049366 (0.000775)
	6				0.039648 (0.001514)	0.026198 (0.001086)
Break Dates From Bai-Perron Test	1				Jan-1986	Oct-1983
	2				Aug-1988	Apr-1984
	3				Jan-1992	May-1986
	4				Nov-1993	Apr-1987
	5				Jan-1997	Dec-1995

[5] The second break is due to missing data between Jan 1987 and Sep 1987.

Table 7. Israel Structural Break Test Results

Shift Date: Jan 1992

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Sudden[6]	Sudden[6]	No Break[7]	Gradual and Sudden	Sudden
Number of Breaks		5	5		3	5
Coefficients and Standard Errors of Variables	1	0.060801 (0.004444)	0.037212 (0.002421)		0.059432 (0.004433)	0.034634 (0.000848)
	2	0.233310 (0.006833)	0.079060 (0.003424)		0.184156 (0.003792)	0.042087 (0.001160)
	3	0.145196 (0.006833)	0.033876 (0.001171)		0.062230 (0.002381)	0.034099 (0.000940)
	4	0.308093 (0.005861)	0.043597 (0.002539)		0.034314 (0.003083)	0.046168 (0.000983)
	5	0.044128 (0.006833)	0.020004 (0.001531)			0.023410 (0.000642)
	6	0.014406 (0.001770)	0.055157 (0.001919)			0.034333 (0.001160)
Break Dates From Bai-Perron Test	1	Feb-83	Oct-82		Jun-83	Jul-84
	2	Jan-84	Sep-83		Nov-86	Jun-86
	3	Dec-84	Jul-91		Jul-95	May-89
	4	Mar-86	Mar-93			Jan-92
	5	Feb-87	Oct-97			Apr-98

[6] 5 percent trimming results
[7] There is one break at November 1985

Table 8. New Zealand Structural Break Test Results

Shift Date: March 1990

		Exchange rate	Interest Rate	Money
Type of Shift		Sudden	Sudden	Sudden[8]
Number of Breaks		5	3	5
Coefficients and Standard Errors of Variables	1	0.026529 (0.002972)	0.083619 (0.152479)	0.036889 (0.001027)
	2	0.097878 (0.002846)	2.654578 (0.165534)	0.058530 (0.002618)
	3	0.072827 (0.003560)	1.589560 (0.152479)	0.028345 (0.002268)
	4	0.038239 (0.002282)	0.797861 (0.069906)	0.063105 (0.001934)
	5	0.018729 (0.002666)		0.027362 (0.001034)
	6	0.046424 (0.002490)		0.047416 (0.001512)
Break Dates From Bai-Perron Test	1	Sep-83	Nov-83	Jun-87
	2	Sep-86	Mar-86	Jun-88
	3	Aug-88	Dec-88	Oct-89
	4	Apr-93		Aug-91
	5	Sep-96		Jan-98

[8] 5 percent trimming results

Table 9. Spain Structural Break Test Results

Shift Date: Nov 1994

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Sudden[9]	Sudden[9]	Sudden[9]	No Break[10]	Gradual[11]
Number of Breaks		5	5	5		2
Coefficients and Standard Errors of Variables	1	0.002329 (0.000209)	0.035658 (0.002235)	2.107796 (0.104002)		0.955924 (0.010832)
	2	0.003691 (0.000111)	0.071796 (0.001889)	3.191779 (0.080559)		0.000768 (0.000250)
	3	0.002655 (0.000209)	0.026533 (0.000879)	1.220214 (0.081937)		0.003476 (0.000525)
	4	0.005828 (0.000209)	0.044352 (0.001698)	2.757013 (0.107017)		0.000804 (0.000386)
	5	0.002630 (0.000145)	0.025159 (0.001698)	0.914720 (0.051293)		
	6	0.001577 (0.000058)	0.013054 (0.001178)	0.543030 (0.048433)		
Break Dates From Bai-Perron Test	1	Nov-81	Mar-82	Jun-81		Apr-90
	2	Feb-85	Dec-83	Dec-83		Jan-93
	3	Jan-86	Jan-92	Jul-87		
	4	Dec-86	Mar-94	Dec-88		
	5	Nov-88	May-96	Feb-95		

[9] 5 percent trimming results
[10] Both 10 and 5 percent did not reveal breaks
[11] Taken from 2 year moving average standard deviation 10 percent structural change test

Table 10. Sweden Structural Break Test Results

Shift Date: January 1993

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Sudden[12]	Gradual and Sudden	Gradual and Sudden	Gradual[12]	Sudden[13]
Number of Breaks		5	4	5	5	4
Coefficients and Standard Errors of Variables	1	0.013889 (0.000848)	0.053081 (0.002404)	1.888218 (0.067585)	0.767536 (0.026926)	0.042380 (0.002493)
	2	0.006120 (0.000300)	0.016048 (0.001381)	1.370807 (0.076501)	0.005463 (0.001829)	0.019545 (0.001373)
	3	0.012283 (0.000599)	0.089757 (0.002945)	0.720989 (0.058891)	0.016769 (0.002009)	0.028632 (0.000860)
	4	0.024571 (0.000848)	0.052780 (0.002335)	1.944933 (0.081783)	0.003438 (0.000883)	0.039870 (0.001577)
	5	0.011570 (0.000586)	0.036323 (0.002404)	0.752657 (0.065241)	0.011461 (0.002095)	0.025850 (0.000971)
	6	0.005232 (0.000309)		0.256129 (0.061201)	0.020120 (0.002389)	
	7				0.005551 (0.000898)	
Break Dates From Bai-Perron Test	1	Nov-81	Sep-83	May-83	Nov-81	Oct-81
	2	Mar-89	Jan-92	Jan-86	Sep-83	Jul-84
	3	Jan-91	Nov-93	Jul-90	Feb-89	Jul-91
	4	Dec-91	Oct-96	Nov-92	Feb-90	Aug-93
	5	Nov-93		Jul-96	Jun-91	

[12] 5 percent trimming results
[13] 10 percent trimming gives 2 breaks at July 1991and August 1993 with 0.0273, 0.0398 and 0.0258 coefficients respectively.

Table 11. Denmark Structural Break Test Results

		CPI	Exchange rate	Interest Rate	Money	Production
Type of Shift		Sudden	Sudden	Sudden and Gradual	No Break[14]	Sudden and Gradual
Number of Breaks		5	5	4		5
Coefficients and Standard Errors of Variables	1	0.009533 (0.000268)	0.025497 (0.000892)	3.247719 (0.078307)		0.030293 (0.000977)
	2	0.005172 (0.000344)	0.011058 (0.002171)	2.175021 (0.093887)		0.049689 (0.001133)
	3	0.007626 (0.00025)	0.028645 (0.001015)	0.635775 (0.036477)		0.029036 (0.000704)
	4	0.002904 (0.000309)	0.016528 (0.001354)	2.878211 (0.086157)		0.051318 (0.001839)
	5	0.008668 (0.000427)	0.04826 (0.001658)	0.474536 (0.042798)		0.031779 (0.00093)
	6	0.002889 (0.000124)	0.014805 (0.001915)			0.044502 (0.001196)
Break Dates From Bai-Perron Test	1	Apr-1983	Nov-1987	Nov-1981		Mar-1984
	2	Sep-1984	Jan-1989	May-1982		Aug-1986
	3	May-1987	May-1994	Mar-1991		Nov-1992
	4	Feb-1989	May-1997	Oct-1992		Oct-1993
	5	Jan-1990	May-1999			Feb-1997

[14] Both 10 and 5 percent trimming do not reveal any breaks

Table 12. United Kingdom Structural Break Test Results

Shift Date: October 1992

		CPI	Exchange rate	Interest Rate	Money	Industrial Production
Type of Shift		Sudden[15]	Sudden	Sudden	Sudden[15]	Sudden[16]
Number of Breaks		5	5	3	5	3
Coefficients and Standard Errors of Variables	1	0.003977 (0.00352)	0.051609 (0.001934)	1.351195 (0.059745)	0.008830 (0.000208)	0.020732 (0.000989)
	2	0.006822 (0.000352)	0.069295 (0.002991)	0.793498 (0.040535)	0.003182 (0.000129)	0.031655 (0.001059)
	3	0.001808 (0.000275)	0.040660 (0.001989)	0.999493 (0.040861)	0.005043 (0.000158)	0.014533 (0.000525)
	4	0.003490 (0.000138)	0.061623 (0.002991)	0.352607 (0.032837)	0.003267 (0.000098)	0.007691 (0.000658)
	5	0.007449 (0.000352)	0.021930 (0.002991)		0.007958 (0.000284)	
	6	0.002106 (0.000109)	0.041452 (0.001807)		0.005440 (0.000294)	
Break Dates From Bai-Perron Test	1	Nov-81	Jul-85	May-82	Oct-82	Jul-83
	2	Oct-82	Jun-87	Aug-87	Jul-87	Oct-85
	3	Apr-84	Oct-91	Oct-92	Sep-90	Dec-94
	4	Apr-90	Sep-93		Dec-98	
	5	Mar-91	Aug-95		Nov-99	

[15] 5 percent trimming results.
[16] 10 percent trimming results, 5 percent did not reveal any break.

Table 13. France Structural Break Test Results

		CPI	Exchange rate	Interest Rate	Money	Production
Type of Shift		Sudden	Sudden[17]	No Break	Sudden	Sudden and Gradual
Number of Breaks		5	4		5	4
Coefficients and Standard Errors of Variables	1	0.006880 (0.000574)	0.030369 (0.000832)		0.011246 (0.000356)	0.015198 (0.000291)
	2	0.012520 (0.000574)	0.017649 (0.000969)		0.023712 (0.000893)	0.031025 (0.001065)
	3	0.006050 (0.000366)	0.012382 (0.000756)		0.012395 (0.000507)	0.023232 (0.000883)
	4	0.011044 (0.000574)	0.023170 (0.000740)		0.018370 (0.000395)	0.016368 (0.000515)
	5	0.005477 (0.000574)	0.012419 (0.000577)		0.013991 (0.000783)	0.009104 (0.000883)
	6	0.002752 (0.000147)			0.022211 (0.000464)	
Break Dates From Bai-Perron Test	1	Nov-1981	Feb-84		Mar-1986	Mar-1993
	2	Oct-1982	Jun-86		Jan-1987	Feb-1994
	3	Jan-1985	Apr-90		Aug-1989	Jun-1995
	4	Dec-1985	Apr-94		Nov-1993	May-1999
	5	Nov-1986			Dec-1994	

[17] Taken from 10 percent trimming

Table 14. Data

		PRICES	EXCHANGE RATE	INTEREST RATE	MONEY	PRODUCTION
Australia	Description of Data	Prices: Manufacturing Output [No Monthly Data for CPI]	Reer Based on Rnulc	13 Weeks' Treasury Bills	Money	No data
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	
	Data Ends	June 97	Aug 2001	Oct 01	Sep 01	
Canada	Description of Data	Consumer Prices	Reer Based on Rnulc	Treasury Bill Rate	Monetary Base Seasonally Adjusted [Datastream]	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Sep 01	Sep 01	Oct 01	Jan 02	Aug 01
U.S.	Description of Data	Consumer Prices	Reer Based on Rnulc	Treasury Bill Rate	M1, Seasonally Adjusted	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Sep 01	Oct 01	Jan 01	Sep 01	Jan 01

Chile	Description of Data	Consumer Prices	Reer Based on Rnulc	Deposit Rate	Monetary Base Seasonally Adjusted [Datastream]	Manufacturing Production
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Oct 01	Aug 01	Oct 01	Jan 02	Sep 01
Finland	Description of Data	Consumer Prices	Reer Based on Rnulc	Average Cost of Central Bank Debt	Currency in Circulation plus Demand Deposits	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Sep 01	Oct 01	Oct 01	Oct 01	Sep 01
Norway	Description of Data	Consumer Prices	Reer Based on Rnulc	Government Bond Yield	Money, Seasonally Adjusted	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Oct 01	Jan 01	Jan 01	Jan 01	Apr 01
Israel	Description of Data	Prices: Industrial Products	Reer Based on Rnulc	Treasury Bill Rate	Money, Seasonally Adjusted	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	June 84	Jan 80	Jan 80
	Data Ends	Oct 01	Aug 01	Oct 99	Aug 01	Feb 01

New Zealand	Description of Data	No Data	Reer Based on Rnulc	New Issue Rate: 3 Months T Bills	M1 [Datastream]	No Data
	Data Starts		Jan 80	Jan 80	Jan 80	
	Data Ends		Aug 01	Oct 01 [Feb 85-April 86 exclusive]	Dec 01	
Spain	Description of Data	Consumer prices	Reer Based on Rnulc	Call Money Rate	M1	Industrial Production Seasonally ADJ
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Oct 01	Oct 01	Oct 01	Dec 98	Sep 01
Sweden	Description of Data	Consumer prices	Reer Based on Rnulc	3 Months Treasury Discount Notes	Money Plus Quasi-Money, Seasonally Adjusted	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Oct 01	Oct 01	Aug 01	Dec 00	Jan 00
Denmark	Description of Data	Consumer Prices	Reer Based on Rnulc	Call Money Rate	Money, Seasonally Adjusted	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Jan 01	Jan 01	Dec 00	June 00	June 00

United Kingdom	Description of Data	Consumer prices	Reer Based on Rnulc	Treasury bill rate	M0	Industrial Production Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Sep 01	Oct 01	Sep 01	Sep 01	Sep 01
France	Description of Data	Consumer Prices	Reer Based on Rnulc	Treasury Bills: 3 Months	M1, Seasonally Adjusted	Industrial Production, Seasonally Adjusted
	Data Starts	Jan 80	Jan 80	Jan 80	Jan 80	Jan 80
	Data Ends	Aug 01	Oct 01	Jan 01	Dec 98	Aug 01

APPENDIX B

Comparison Figures

Canada - U.S. Difference Figures:

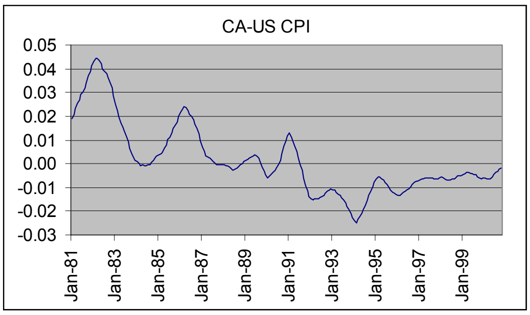

Figure 14.a.1 CPI inflation

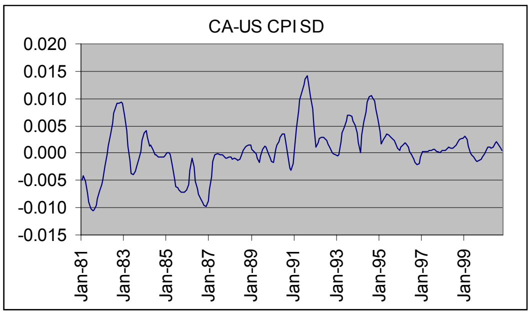

Figure 14.a.2 CPI inflation std. dev.

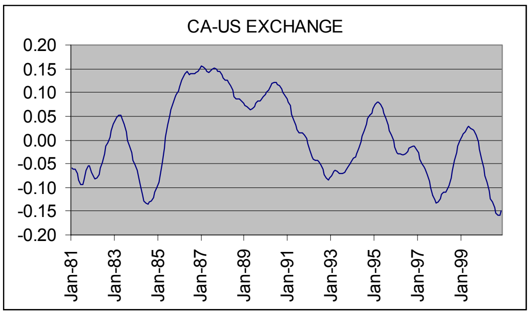

Figure 14.b.1 Exchange rate

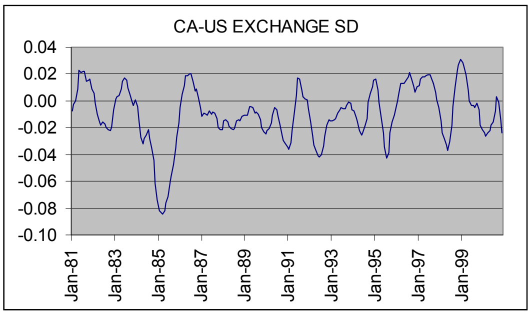

Figure 14.b.2 Exchange rate std. dev.

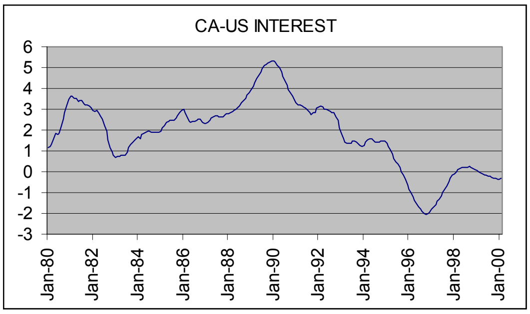

Figure 14.c.1 Interest rate

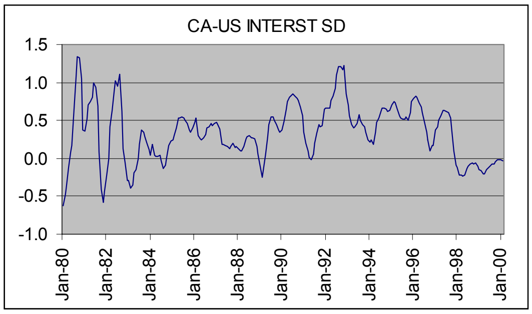

Figure 14.c.2 Interest rate std. dev.

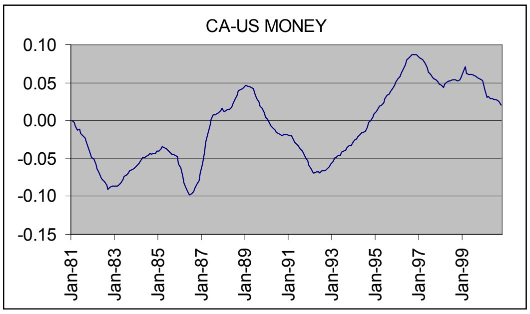

Figure 14.d.1 Money growth

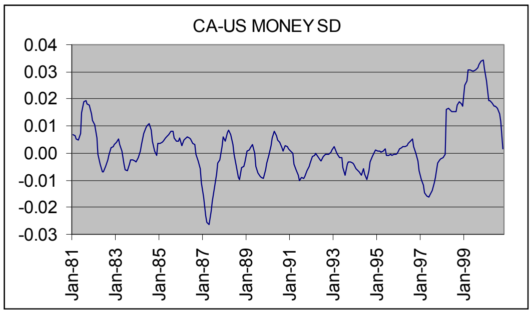

Figure 14.d.2 Money growth std. dev.

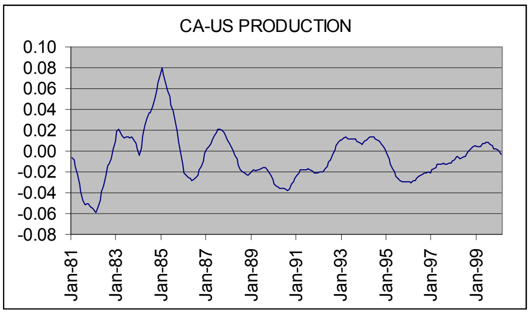

Figure 14.e.1 Production growth

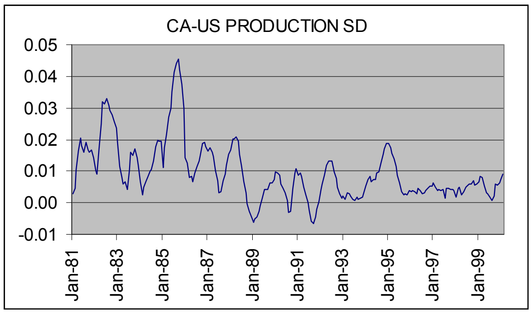

Figure 14.e.2 Prod. growth std. dev.

Canada - U.S. Ratio Figures:

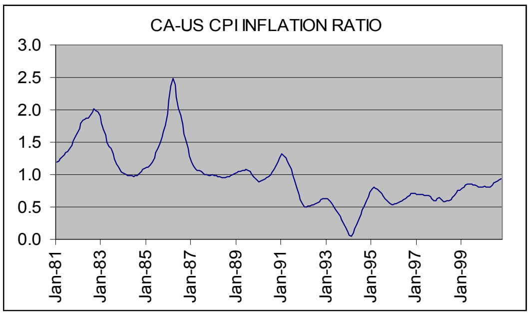

Figure 15.a.1 CPI inflation

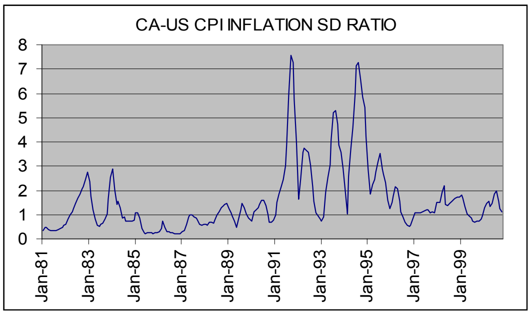

Figure 15.a.2 CPI inflation std. dev.

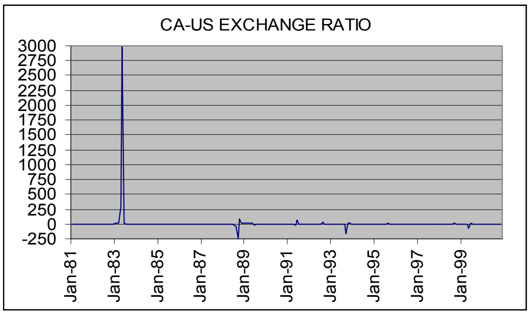

Figure 15.b.1 Exchange rate

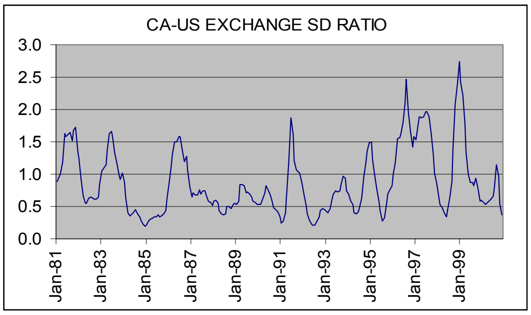

Figure 15.b.2 Exchange rate std. dev.

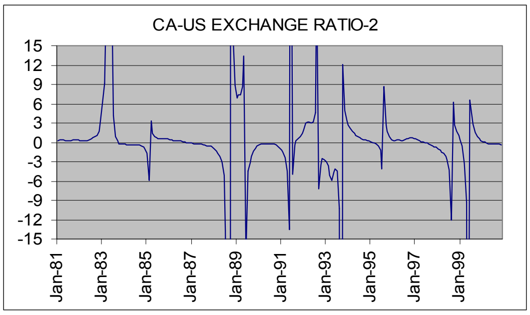

Figure 15.b.3 Exchange rate (rescaled)

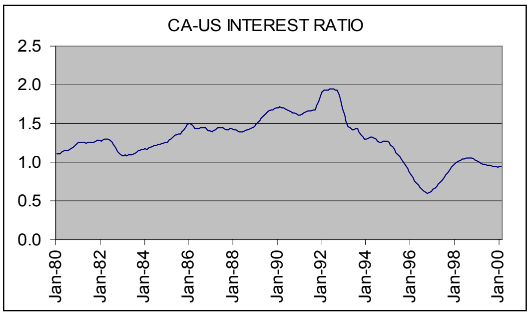

Figure 15.c.1 Interest rate

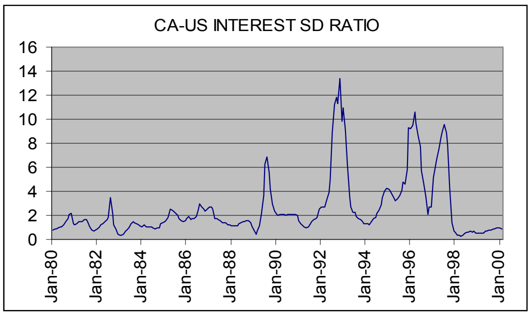

Figure 15.c.2 Interest rate std. dev.

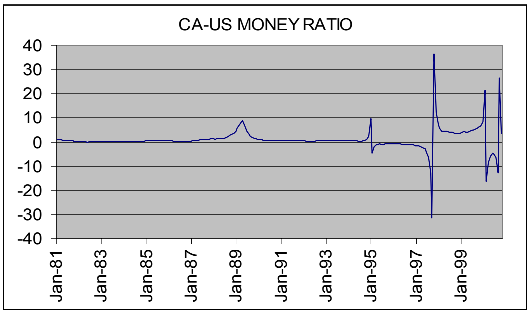

Figure 15.d.1 Money growth

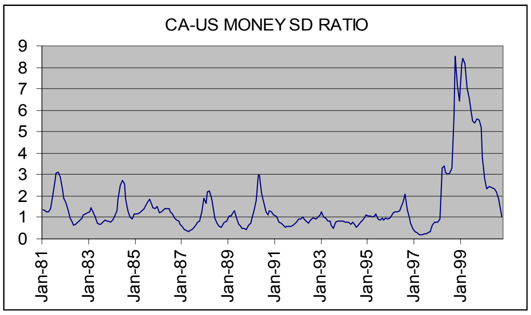

Figure 15.d.2 Money growth std. dev.

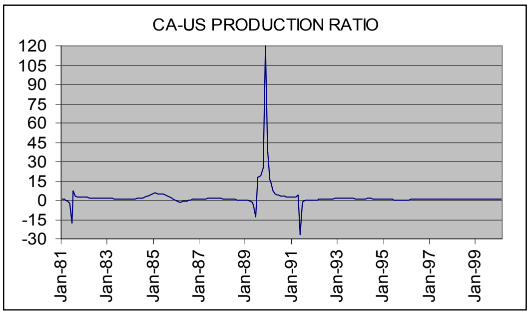

Figure 15.e.1 Production growth

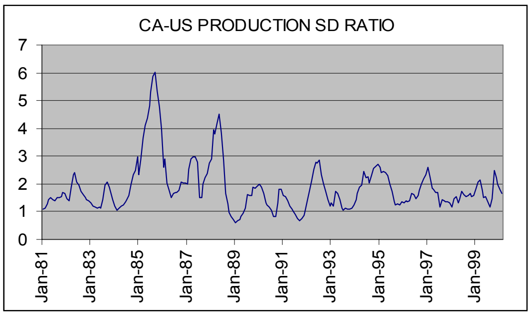

Figure 15.e.2 Prod. growth std. dev.

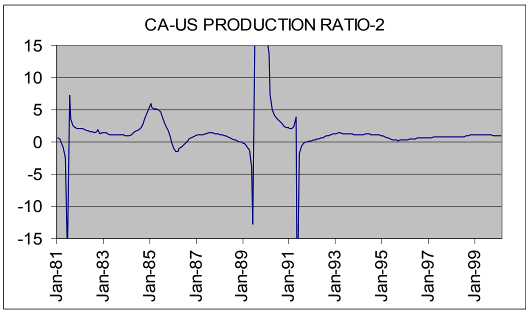

Figure 15.e.3 Production growth (rescaled)

Finland – Norway Difference Figures:

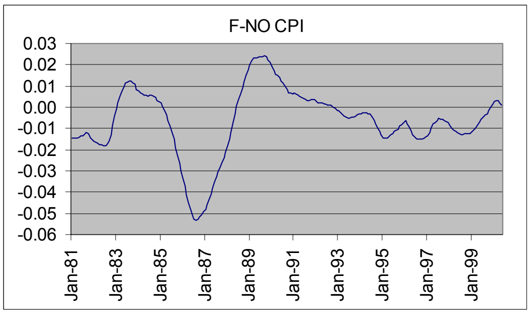

Figure 16.a.1 CPI inflation

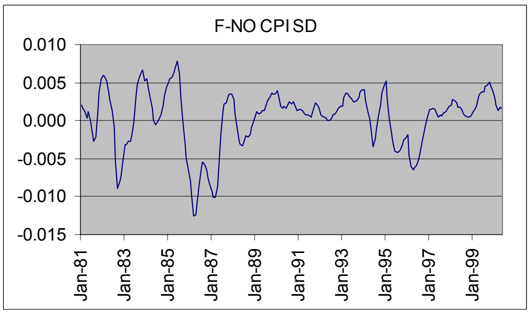

Figure 16.a.2 CPI inflation std. dev.

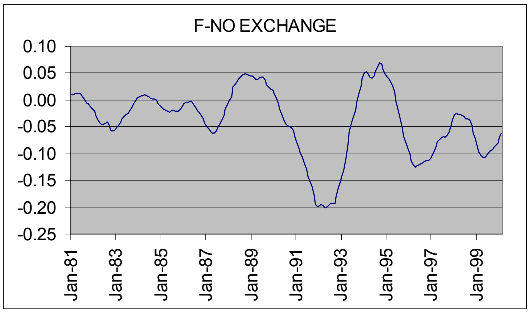

Figure 16.b.1 Exchange rate

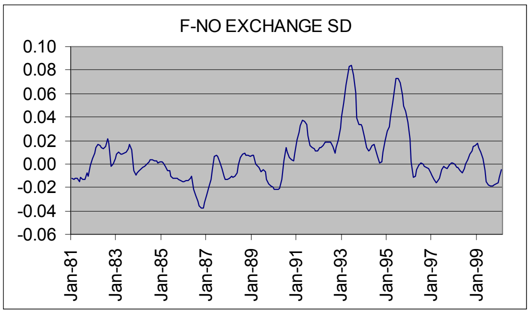

Figure 16.b.2 Exchange rate std. dev.

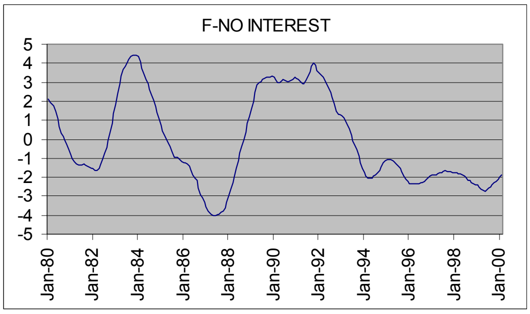

Figure 16.c.1 Interest rate

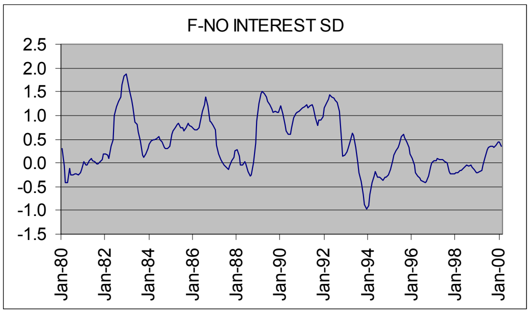

Figure 16.c.2 Interest rate std. dev.

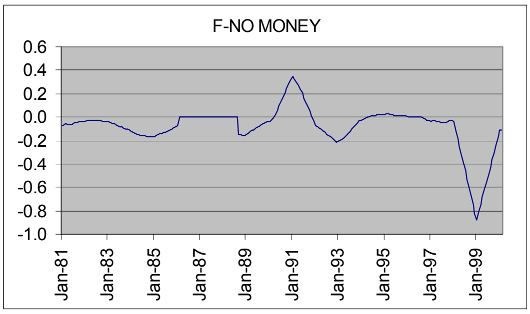

Figure 16.d.1 Money growth

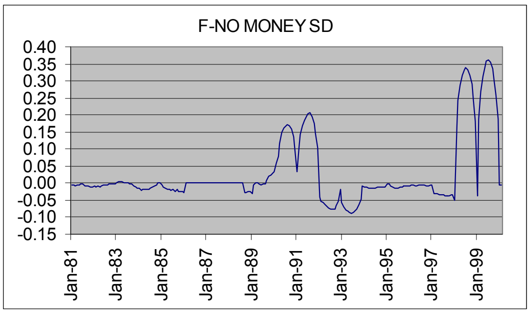

Figure 16.d.2 Money growth std. dev.

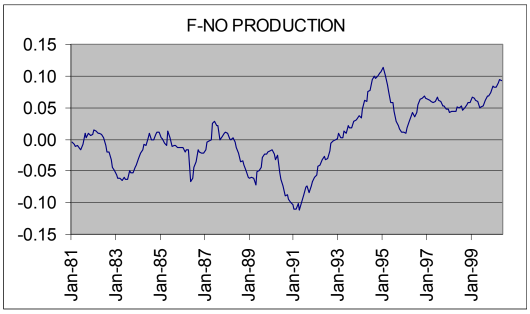

Figure 16.e.1 Production growth

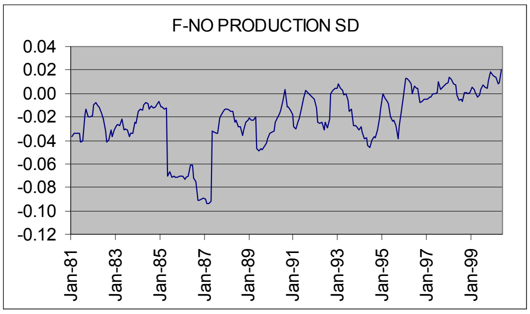

Figure 16.e.2 Prod. growth std. dev.

Finland – Norway Ratio Figures:

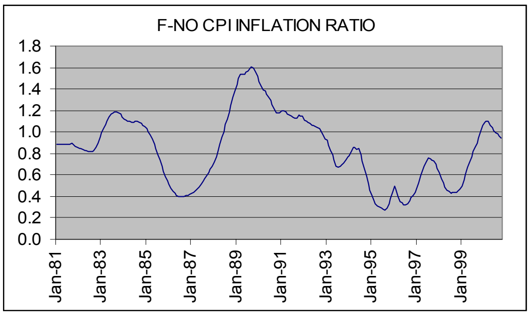

Figure 17.a.1 CPI inflation

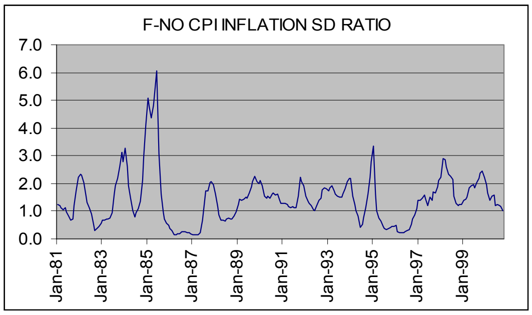

Figure 17.a.2 CPI inflation std. dev.

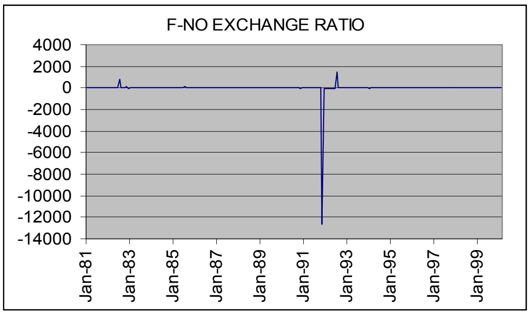

Figure 17.b.1 Exchange rate

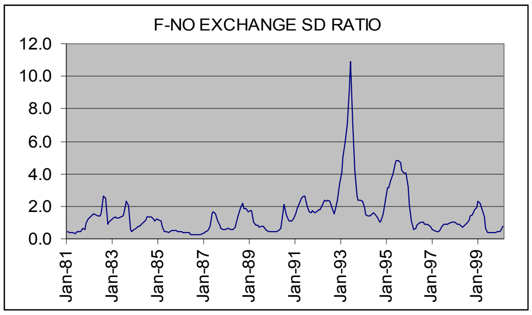

Figure 17.b.2 Exchange rate std. dev.

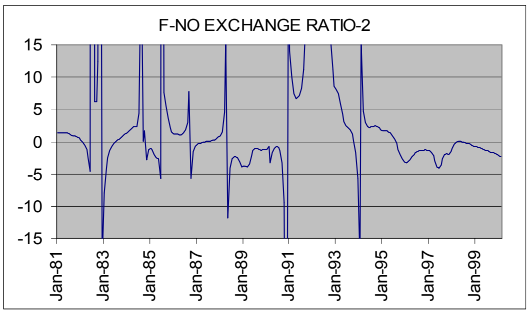

Figure 17.b.3 Exchange rate (rescaled)

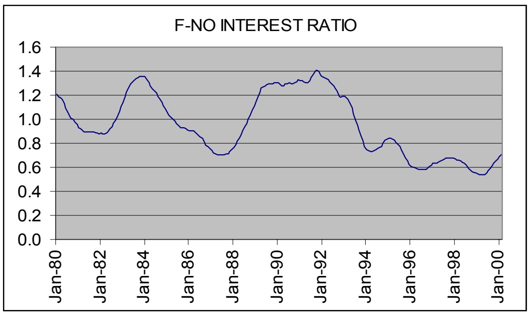

Figure 17.c.1 Interest rate

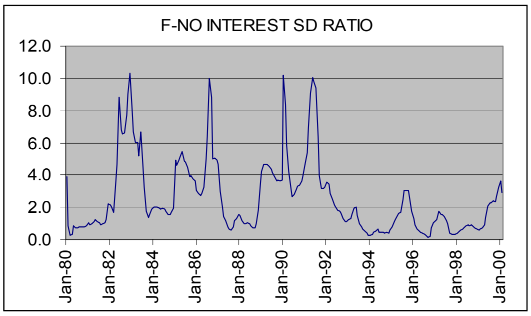

Figure 17.c.2 Interest rate std. dev.

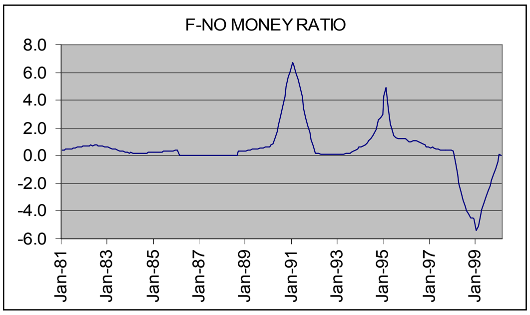

Figure 17.d.1 Money growth

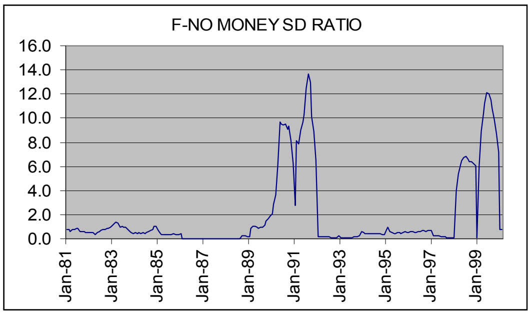

Figure 17.d.2 Money growth std. dev.

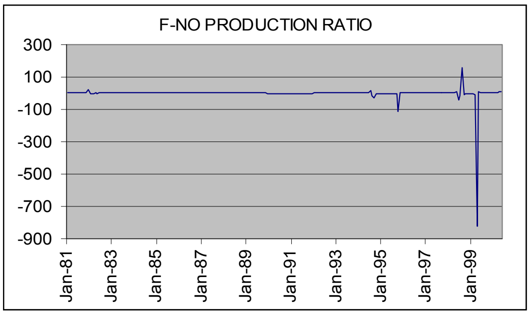

Figure 17.e.1 Production growth

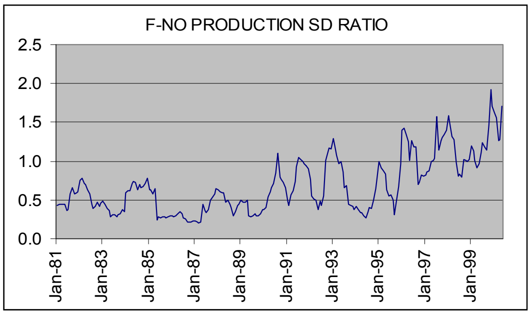

Figure 17.e.2 Prod. growth std. dev.

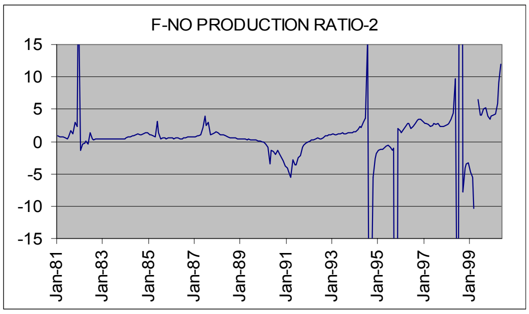

Figure 17.e.3 Production growth (rescaled)

Sweden – Denmark Difference Figures:

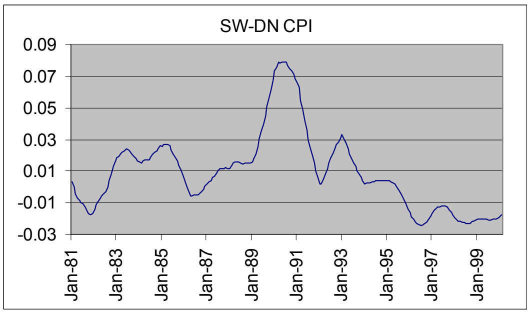

Figure 18.a.1 CPI inflation

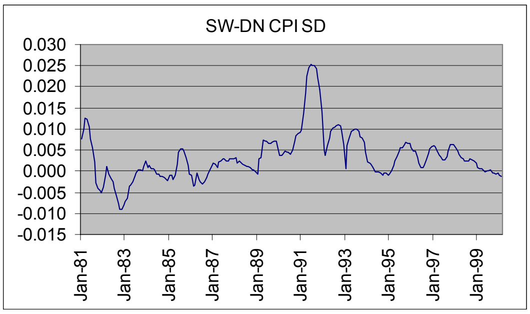

Figure 18.a.2 CPI inflation std. dev.

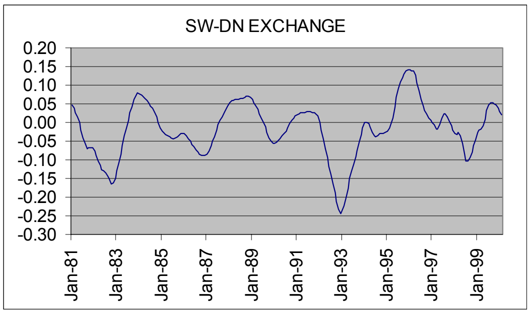

Figure 18.b.1 Exchange rate

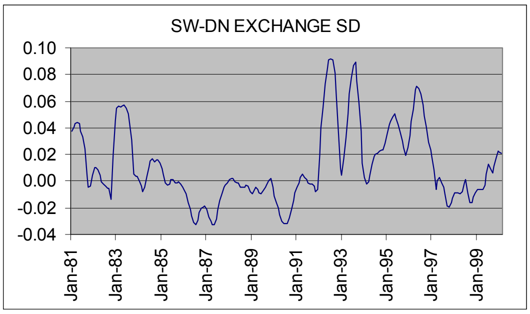

Figure 18.b.2 Exchange rate std. dev.

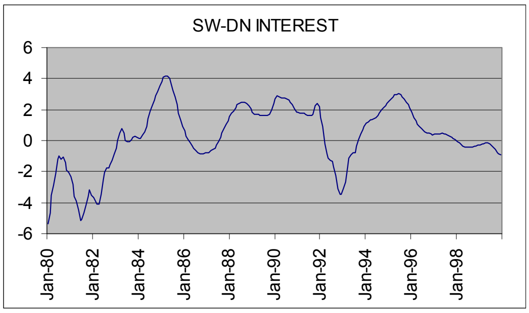

Figure 18.c.1 Interest rate

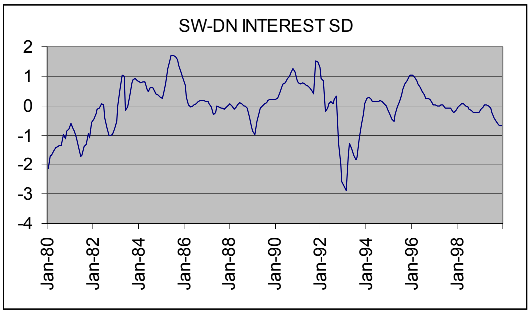

Figure 18.c.2 Interest rate std. dev.

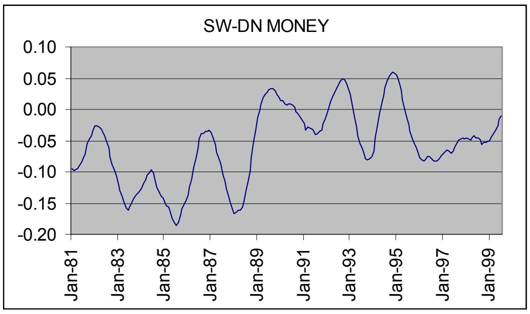

Figure 18.d.1 Money growth

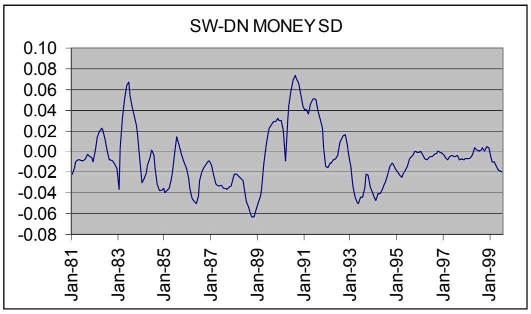

Figure 18.d.2 Money growth std. dev.

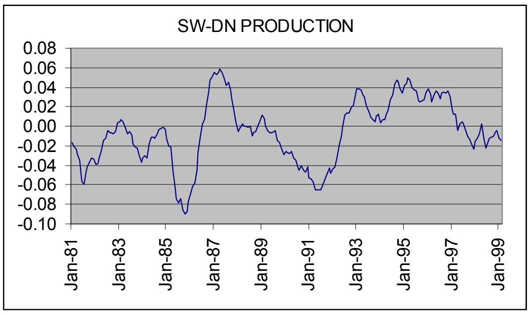

Figure 18.e.1 Production growth

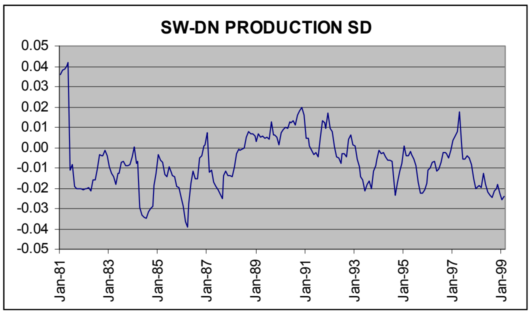

Figure 18.e.2 Prod. growth std. dev.

Sweden – Denmark Ratio Figures:

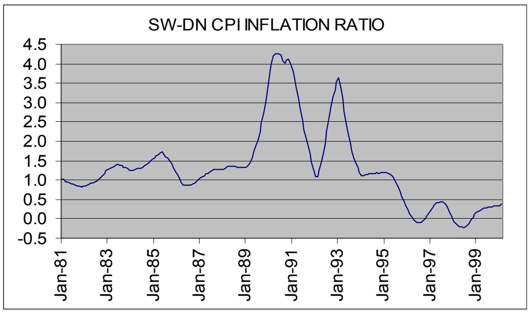

Figure 19.a.1 CPI inflation

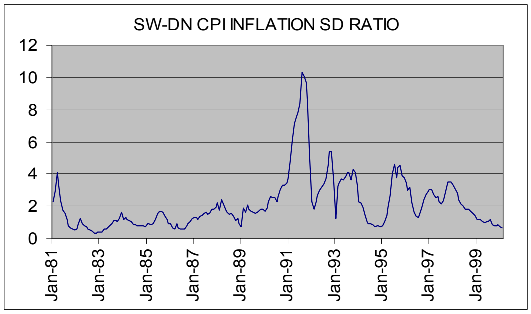

Figure 19.a.2 CPI inflation std. dev.

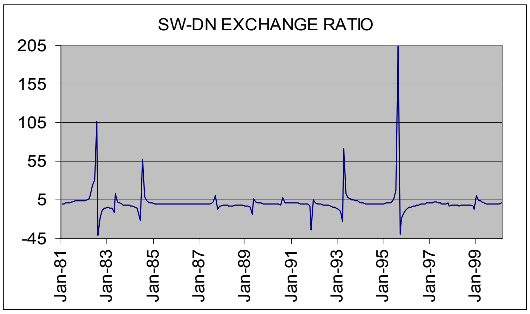

Figure 19.b.1 Exchange rate

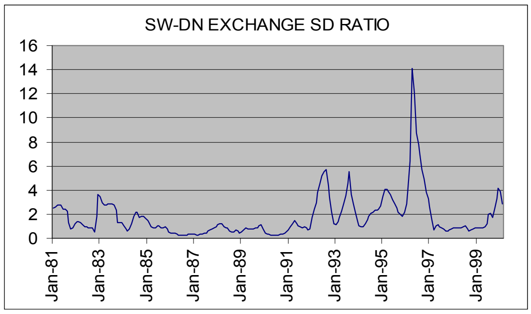

Figure 19.b.2 Exchange rate std. dev.

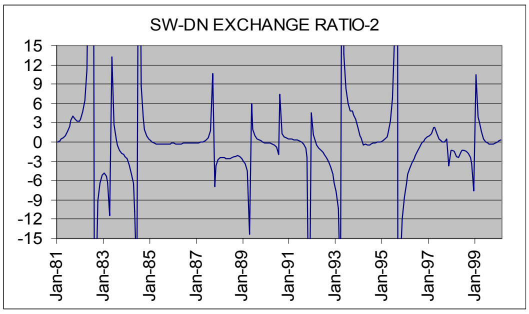

Figure 19.b.3 Exchange rate (rescaled)

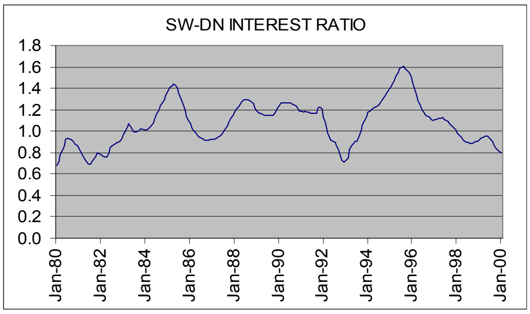

Figure 19.c.1 Interest rate

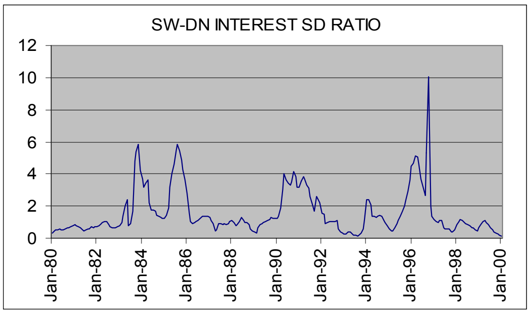

Figure 19.c.2 Interest rate std. dev.

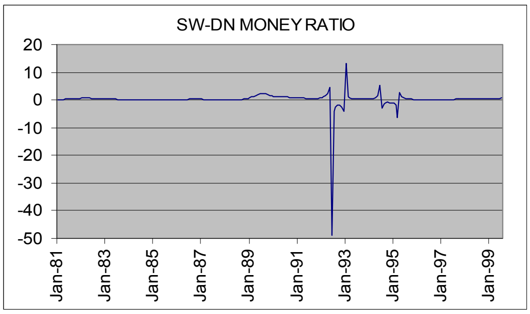

Figure 19.d.1 Money growth

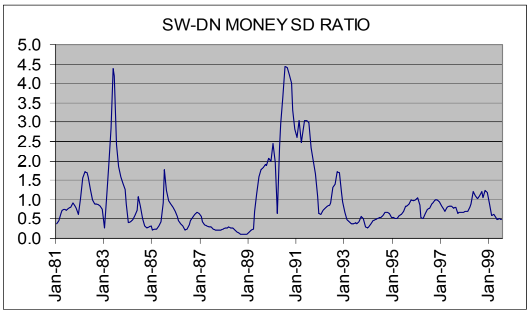

Figure 19.d.2 Money growth std. dev.

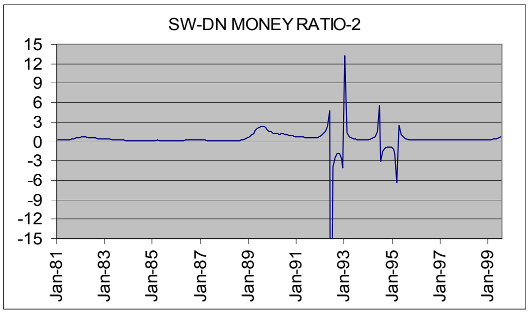

Figure 19.d.3 Money growth(rescaled)

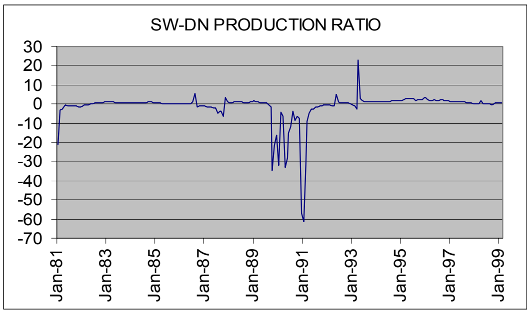

Figure 19.e.1 Production growth

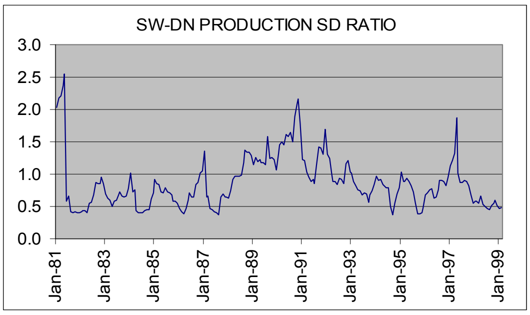

Figure 19.e.2 Prod. growth std. dev.

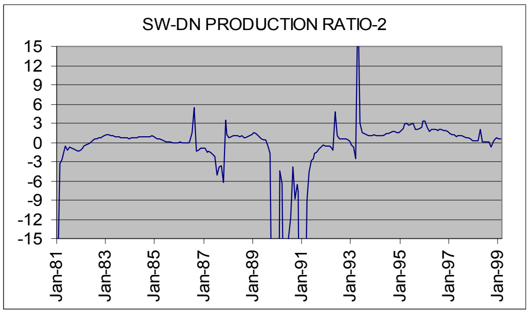

Figure 19.e.3 Production growth (rescaled)

U.K. – France Difference Figures:

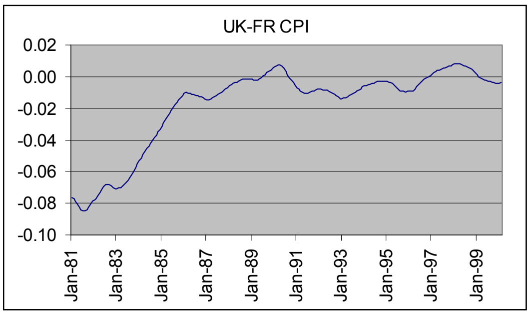

Figure 20.a.1 CPI inflation

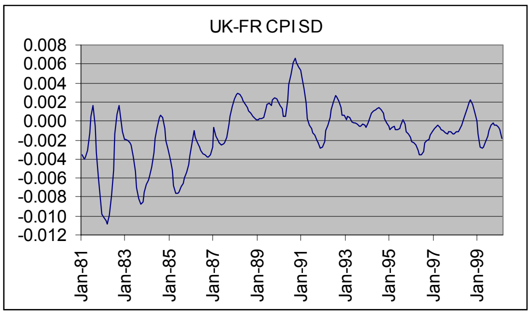

Figure 20.a.2 CPI inflation std. dev.

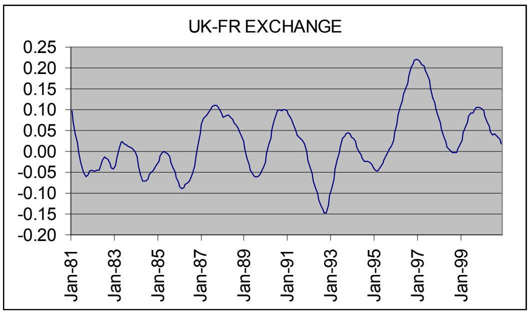

Figure 20.b.1 Exchange rate

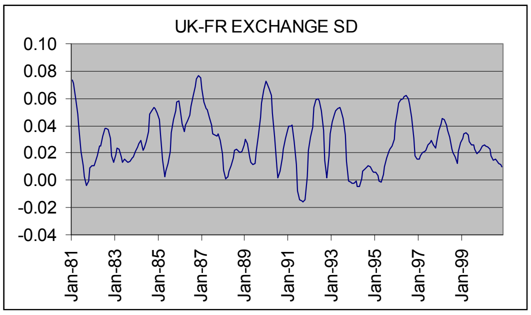

Figure 20.b.2 Exchange rate std. dev.

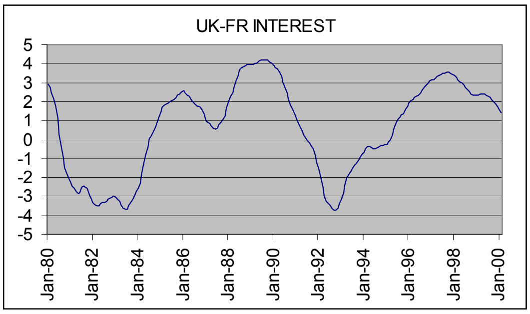

Figure 20.c.1 Interest rate

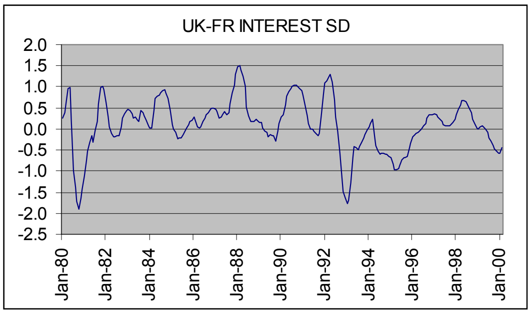

Figure 20.c.2 Interest rate std. dev.

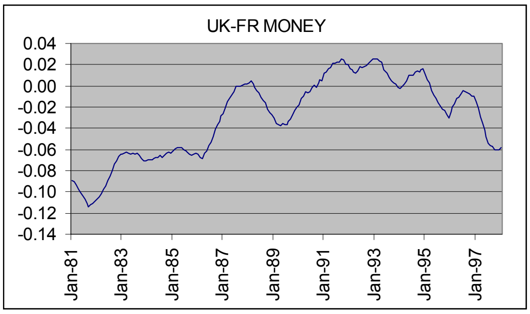

Figure 20.d.1 Money growth

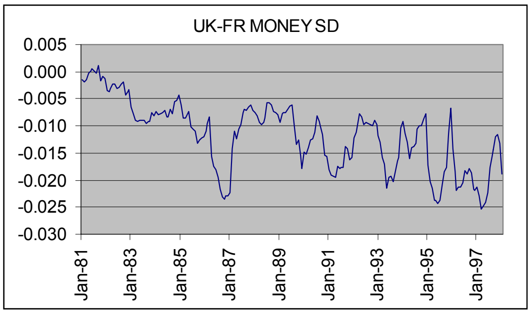

Figure 20.d.2 Money growth std. dev.

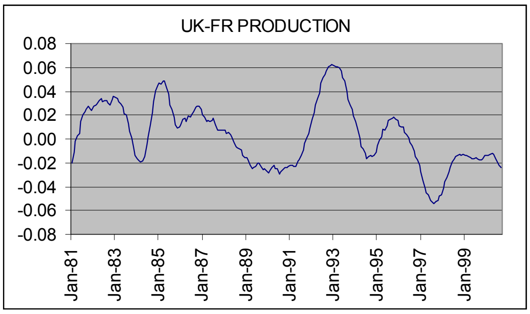

Figure 20.e.1 Production growth

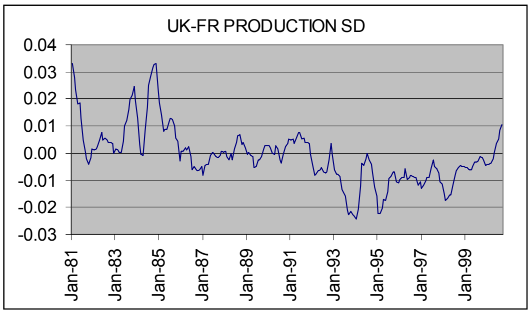

Figure 20.e.2 Prod. growth std. dev.

U.K. – France Ratio Figures:

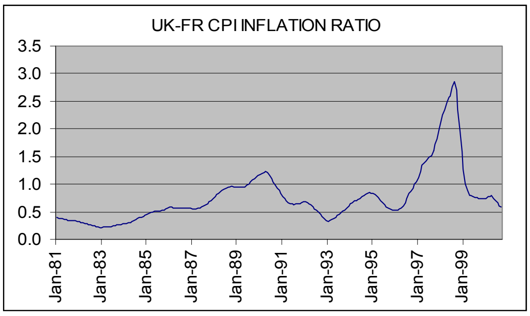

Figure 21.a.1 CPI inflation

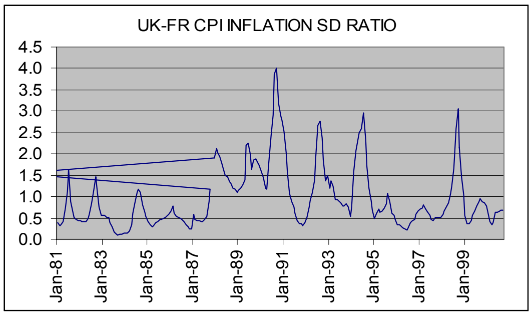

Figure 21.a.2 CPI inflation std. dev.

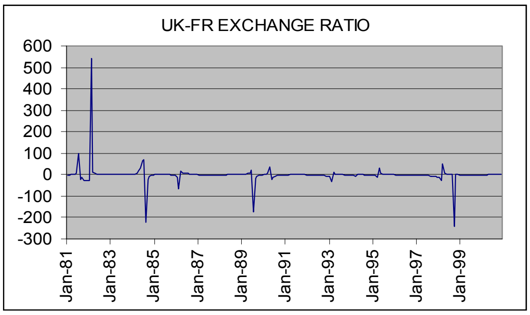

Figure 21.b.1 Exchange rate

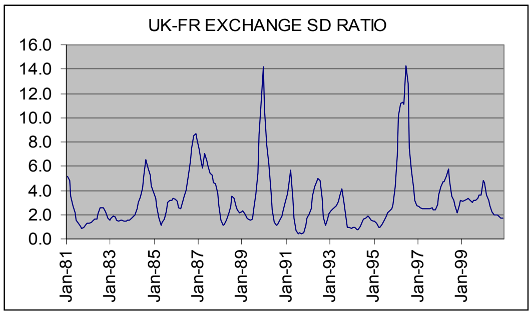

Figure 21.b.2 Exchange rate std. dev.

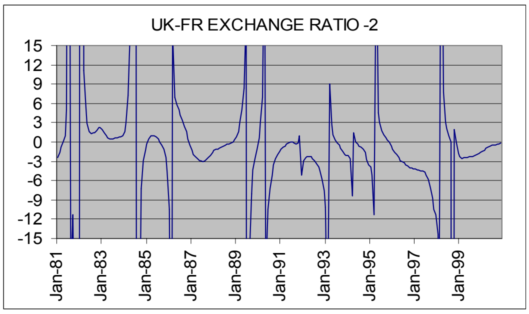

Figure 21.b.3 Exchange rate (rescaled)

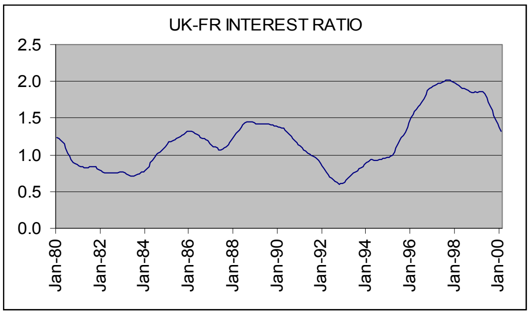

Figure 21.c.1 Interest rate

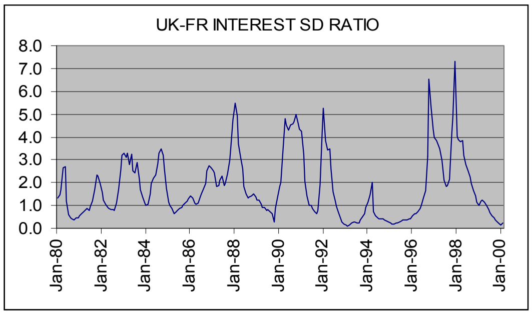

Figure 21.c.2 Interest rate std. dev.

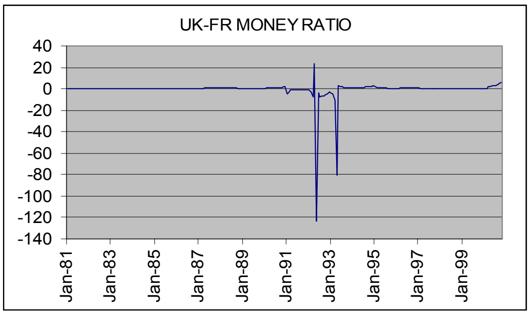

Figure 21.d.1 Money growth

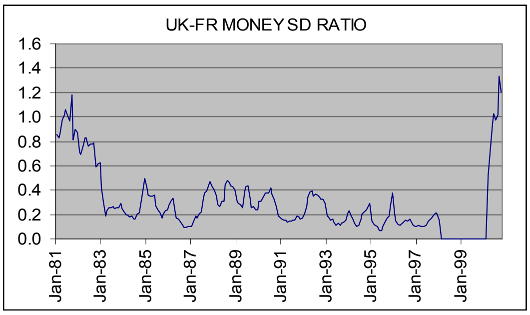

Figure 21.d.2 Money growth std. dev.

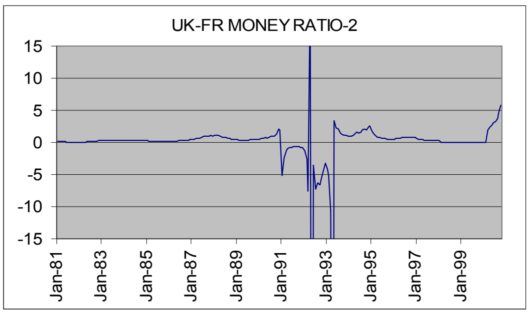

Figure 21.d.3 Money growth (rescaled)

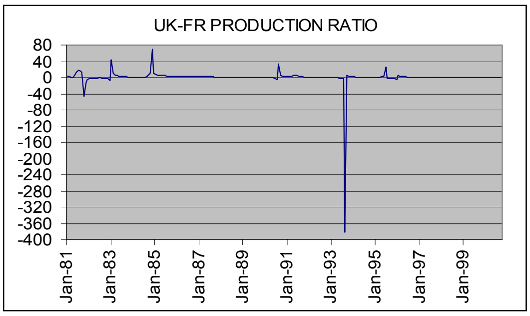

Figure 21.e.1 Production growth

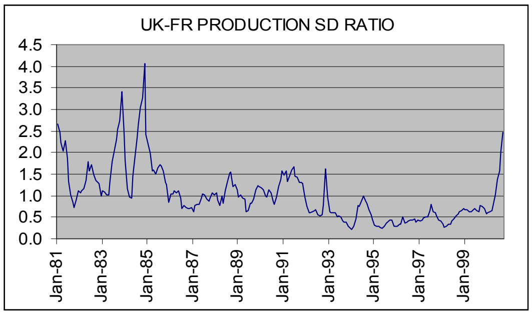

Figure 21.e.2 Prod. growth std. dev.

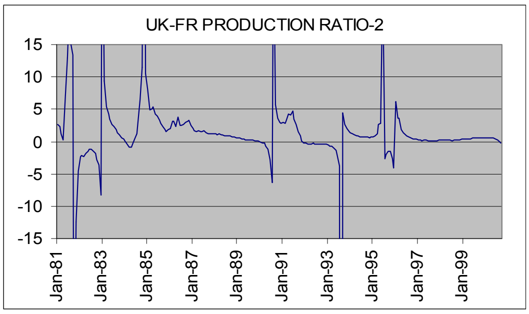

Figure 21.e.3 Production growth (rescaled)