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ABSTRACT

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Abstract

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1 Introduction

Inflation targeting (IT) continues to be debated among academics and policy makers.[1] The quest for an appropriate monetary policy strategy has persistently drawn the attention of economists and politicians alike. The main reason for this emphasis on the optimal monetary framework is both the belief and experience regarding the high costs of inflation as well as the welfare benefits of adequate monetary policies. In 1990, New-Zealand became the first country to formally adopt a novel monetary policy strategy, IT. Under this new monetary scheme, inflation became the nominal anchor for the monetary authority. The present paper tries to evaluate quantitatively the contribution of IT to the dynamics of inflation in several European countries.

The performance of IT is of special relevance for Western European countries. Most of these countries now form part of the European Monetary Union (EMU) and therefore, the European Central Bank monetary actions affect all of these countries. As a result, the formulation of the European Central Bank (ECB) monetary policy strategy is a highly debated topic in Europe today. The ECB first practiced monetary targeting, following the tradition of the anchor country of the European Monetary System, Germany. Since May 2003, the ECB explicitly tracks a broader set of indicators, a practice which is seen as closer to an IT regime.[2] In order to assess the validity of IT as a potential strategy for Europe, we analyze the performance of three European countries which adopted IT and compare it with the experiences of other European countries which did not adopt IT.

This paper makes two main contributions to the analysis of the performance of inflation in IT countries. First, it combines reduced-form and structural analysis to make

[1] "The Inflation-Targeting Debate" is precisely the title of one of the most recent books on IT: Bernanke and Woodford (2005).

[2] See the ECB (May 8, 2003) press release.

a clear connection between the influence of IT and inflation dynamics. All previous approaches had focused on estimating the reduced-form impact of IT, so that the evidence of the actual influence on inflation of the new monetary policy strategy was only suggestive. While the impact of IT should show in the reduced-form dynamics, even if the propagation of the economy changed under an IT regime, a case has to be made that the structure of the economy changed because monetary policy changed. As pointed out by Mishkin (2002), producing such evidence requires a structural model in order to link behavioral relations with inflation outcomes.

Second, our study highlights the differences in dynamics between monthly and quarterly inflation on the one hand and quarterly and annual moving average (trend) inflation on the other hand. Previous studies had also examined both high and low-frequency inflation dynamics (Ball and Sheridan (2003)), but their analysis did not reveal significant differences between inflation at different frequencies. Our study shows that IT may affect trend inflation but not monthly or quarterly inflation. This result is consistent with the fact that IT strategies are more focused on year-to-year inflation than on high-frequency fluctuations.

We study the performance of six European OECD countries: three inflation targeters - United Kingdom (UK), Spain and Finland - and three control non-targeters - France, Italy and Norway - respectively.[3] In this way, we can assess the differences among monetary policy strategies. Our results show that while IT was not responsible for most of the decline of high frequency (monthly and quarterly) inflation volatility in any of the IT countries, it was key in reducing low-frequency (annual-trend) inflation volatility in the UK. The control countries behaved similarly in terms of high-frequency inflation volatility. We also find that the decline in low-frequency Norwegian inflation variance

[3]Norway did adopt IT in 2000. However, since we will compare Finland and Norway up to 1998, Norway will be considered a non-IT country.

was mostly driven by a more forward-looking price setting behavior.

Several papers have compared the statistical moments of inflation before and after the establishment of IT. Two examples are King (2002) and Benati (2004) for the case of the UK. These papers show the different patterns of inflation after the adoption of IT, but they fall short of making a clear connection between IT and the improvements observed in UK inflation dynamics during the 90s. A different set of studies has examined changes in the reduced-form dynamics after IT was in place (Bernanke, Laubach, Mishkin, and Posen (1999), Kutner and Posen (1999), Levin, Natalucci, and Piger (2004)). While the evidence in these studies hints at the positive influence of IT on several countries, it does not elucidate whether the explicit shifts in monetary policy behavior were actually responsible for changes in either the volatility or the persistence of inflation. In a related paper, Neumann and von Hagen (2002) estimate both reduced-form systems and Taylor rules. They find that central banks fought against inflation more aggressively under IT regimes, but in the absence of a structural model, they cannot identify additional structural factors which could have also affected the behavior of inflation. Benati and Mumtaz (2005) conduct a careful statistical analysis of inflation in the UK. They conclude that its current inflation stability is mostly due to the smaller shocks of recent times. We complement their analysis in two directions. First, we show that in the case of trend inflation, reduced-form evidence points to a key improvement in the propagation of the UK economy. Second, our structural analysis reveals that monetary policy was instrumental for such improvement.

Cecchetti and Ehrmann (1999) is perhaps the closest work in terms of methodology. They estimate an increase in the aversion to inflation of several IT (and non-IT) countries and its impact on the output-inflation tradeoff. In the context of a very stylized macro model, they derive closed-form solutions relating the degree of inflation aversion to the volatility of inflation. However, given the simplicity of their model, they extract structural parameters from reduced-form models, instead of estimating a full structural model, as we do. Corbo, Landerretche, and Schmidt-Hebbel (2002) also estimate the IT countries aversion to inflation before and after the adoption date, and conclude that it did not change for industrialized countries. They find that inflation expectations became more forward-looking under IT frameworks. Our structural also reveals that this was the case in the UK.

Finally, Ball and Sheridan (2003) perform a set of reduced-form regressions and find that once they control for mean reversion, IT countries have not done better than non-IT countries prior to the adoption of IT. They also find that IT countries such as the UK had experienced higher and more volatile rates of inflation than control non-IT countries. While we also identify that the UK had performed worse than other European countries previously to the adoption of IT, our structural model allows us to detect how and why it stabilized inflation: Through the more aggressive stance against inflation of the IT regime.

Our framework is not without limitations. One is the fact that while a structural approach allows for interpretation, structural models are only first order approximations to the complex real world macro dynamics. In other words, we face the well-known tradeoff between interpretation and data-fit. However, our macro model, while interpretable, belongs to the family of New-Keynesian models, which are able to capture some important moments of the inflation dynamics. A second limitation has to do with the nature of our counterfactual exercises. Throughout the article, we analyze alternative macroeconomic scenarios which would have arisen under shocks and parameters of different periods. If a behavioral change in any of the agents is identified, this has to occur instantaneously at a given point in time; that is, there is no-learning and the speed of adjustment is immediate. However, our approach can be seen as an approximation to what happened in reality, where agents assign probabilities to parameter changes. We also check for the robustness of our results performing a sensitivity analysis for a set of structural parameter values.

The paper proceeds as follows. Section 2 lays out our first empirical framework. Section 3 discusses the data used, the subsamples chosen and the estimation procedure. In section 4 we present our reduced-form results for monthly, quarterly and trend inflation. Section 5 provides a structural interpretation for the change of low-frequency inflation dynamics in the UK and Norway in terms of a behavioral macroeconomic model. Section 6 concludes.

2 Empirical Framework

Macroeconomic dynamics are jointly driven by the size of the structural shocks and the way in which these shocks percolate throughout the economy (propagation). If IT has had any effect on the dynamics of inflation, it must have been through a change in the propagation of the economy, since structural shocks are completely exogenous to macro systems. In this section we describe our methodology, intended to capture a potential change in the propagation mechanism of the economy.

In order to assess a potential change in the structure of the economy induced by the advent of IT, we follow the counterfactual VAR approach laid out in Boivin and Giannoni (2003). We first split the full sample period in two subsamples, separated by the time of the introduction of inflation targeting. We assume that, for each subsample i, the joint distribution of a relevant set of macroeconomic variables including inflation, $X_{t,i}$, can be captured by a structural vector autoregressive (VAR) system, so that:

$$A_i X_{t,i} = c_i + \sum_{j=1}^{k} B_{i,j} X_{t-j,i} + \varepsilon_{t,i} \quad i = 1, 2 \tag{1}$$

where A_i and $B_{i,j}$ are square matrices, c_i is a vector of constants and $\varepsilon_{t,i}$ is a vector of the i-th subsample structural shocks which are independently and identically distributed with diagonal covariance matrix D_i. The lag-length of the VAR (k) is determined on the basis of the Schwarz Bayesian Information Criterion (BIC) and the structural errors are recovered through a recursive scheme (see Christiano, Eichenbaum, and Evans (1999)), where not all variables cause each other contemporaneously. As a result, A_i will be lower triangular. In the data section, we describe the exact recursive ordering.

Once we obtain estimates for the matrices of propagation $(A_i, B_{i,j})$ and shock standard deviations (D_i), we can compute the counterfactual standard deviations of inflation implied by the propagation of one period and the shocks of a different period. In this way, we can compare the actual performance of inflation on a given subsample with the counterfactual volatility implied by a change in either propagation or shocks. For instance, we can compare the inflation volatility implied by the first period's shocks and propagation $(A_1, B_{1,j}, D_1)$ with the inflation volatility implied by the shocks of the first period and the propagation of the second period $(A_2, B_{2,j}, D_1)$. If this second volatility is smaller, then the change in propagation did contribute to an overall smaller inflation volatility after the introduction of IT. In the (realistic) scenario of having both propagation and shocks contributing to lower inflation, we can also assess which one is more important, by simply comparing the volatilities associated with the shocks and the propagation of different periods.

We also conduct cross-country counterfactual exercises. Within a given subsample, we compute the inflation volatility implied by the shocks of an IT (control) country and the propagation of the control (non-IT) country. In this way, we can determine whether the structure of a foreign economy would prolong or mitigate the fluctuations induced by the shocks which affect the home country. Below we describe both types of counterfactual exercises in more detail.

3 Data, Subsample Selection and Estimation

We collect data from the 2003 IMF International Financial Statistics database. Our analysis comprises six countries: Three inflation targeters (United Kingdom, Spain and Finland) and three control non-inflation targeters (France, Italy and Norway), respectively. The vector of macroeconomic variables (X_t) includes a measure of consumer price inflation, industrial production growth, real money growth and a short-term interest rate. The first three variables are seasonally adjusted. The data is expressed in annualized percentages. The Appendix documents the exact data series employed. We used both the interest rate and money growth because there is evidence that monetary policy affects the real economy and inflation through both channels (Leeper and Roush (2003)). We also performed the analysis without money growth and the results did not change. The results are also robust to the use of alternative variables such as GDP growth for output at a quarterly frequency.

We perform the analysis at different frequencies. First, we perform the analysis with monthly and quarterly data. Monthly inflation is computed as the annualized log difference of the CPI between two consecutive months. Quarterly inflation is constructed analogously, for quarters. Second, we obtain three and twelve month-moving averages of all the variables and we perform the analysis with the trend variables. The reason is that the evolution of trend inflation is an important object of our study, since inflation targeters try to stabilize low-frequency inflation. As we show below, this difference turns out to be important.

Our analysis requires estimating the VAR systems for two subsamples in a given country. Since our goal is to identify changes induced by IT on the structure of the economy, we split the full sample based on the date of introduction of the inflation targeting scheme. Table 1 lists the periods included in all the subsamples and countries.[4] Note that for all estimations, we avoid any data overlapping across subsamples.

With regard to the identification of the structural shocks, we chose a recursive scheme similar to that of Christiano, Eichenbaum, and Evans (1999). The following VAR ordering is chosen: Inflation, real activity, interest rate and money growth. That is, inflation affects all the variables contemporaneously, but it is not affected by any of them contemporaneously. Our rationale for this ordering is the existence of price rigidities, so that it takes at least one period for the rest of the shocks to have an effect on inflation. Analogously, real activity does only react contemporaneously to current inflation and the interest rate reacts on impact to inflation and output shocks. Finally, the money growth rate reacts on impact to all the shocks. While it is known that impulse response functions usually differ when the recursive order changes, our counterfactual analysis below is robust to different orderings. We estimate the VAR system by OLS and recover the structural shocks through a standard Cholesky decomposition.

[4]We start all of the first subsamples in 1985 to balance the number of observations in the pre-IT and post-IT subsamples. We end the second subsamples in 1998, coinciding with the integration of several (IT and non-IT) countries of our study in the new monetary policy strategy designed by the ECB. Both Spain and Finland ended their IT experience on May, 1998. In the case of the UK and France, we finish our second subsample on December 1998, since France changed its monetary policy strategy starting in 1999, with the advent of the ECB. Even though the UK continued with its IT strategy, in the structural analysis we show that its results do not change whether we finish the second subsample in 1998 or in 2003.

4 Reduced-Form Analysis

4.1 A First Look at the Data

Table 2 presents descriptive statistics (mean, standard deviation and first order autocorrelation) of monthly and quarterly inflation for all our countries, subsamples and frequencies. They are computed through a generalized method of moments (GMM) procedure which yields the associated standard deviation for each statistic. Using this information, Table 2 also shows Wald statistics testing parameter equality across sample periods and countries. To organize the discussion, we pair each IT country and its control counterpart.

The table shows that UK inflation improved significantly after the adoption of IT for all statistics and frequencies. The improvement in France is however limited to the mean. While the UK has converged with France in terms of monthly and quarterly inflation volatility and persistence, it did not do it in terms of mean, where French inflation was still significantly smaller than that of the UK in the second subsample.

For our sample period, Spain and Italy only improved significantly in terms of mean. They actually worsened, although not statistically significantly, in standard deviation and autocorrelation. In terms of cross-country comparison, the adoption of IT by Spain seems to have decreased the relative Spanish inflation variance with respect to Italy (significantly in the quarterly case), but the remaining comparisons stay the same before and after IT.

Finland and Norway improved significantly most of their inflation moments at both inflation frequencies. The improvement was larger in the case of mean inflation for Finland, whose mean was significantly smaller after the adoption of IT. As for the remaining moments, they were not statistically different across countries for each sample period.

Overall, the inflation variance improved after IT for all countries, although significantly only for a subset of them. In our econometric exercise, we will try to elucidate what are the causes of this decline of inflation volatility for all countries. We will also analyze how IT countries performed relative to non-IT countries. To do so, we will employ a vector autoregressive framework which will enable us to distinguish alternative sources of declining inflation volatility.

4.2 Monthly and Quarterly Inflation

A relevant issue in our exercise is the choice of the lag-length for our state space. We select the VAR order based on the Schwarz BIC for all our subsamples. The Schwarz criterion chooses the best parsimonious model in terms of data fit. Panel A of Table 3 shows that a VAR(1) is preferred by the data for all countries and subsamples using monthly and quarterly data.

Panel A of Table 4 shows the results of our counterfactual exercise for monthly inflation. In order to interpret the results of our counterfactual exercises shown in the table, we first introduce some notation:

1. σ_1: historical standard deviation of inflation in the pre-IT period.
2. σ_2: historical standard deviation of inflation in the IT period.
3. Σ_{11}: implied standard deviation of inflation by the VAR in the pre-IT period.
4. Σ_{12}: implied standard deviation of inflation by the propagation of the pre-IT period and the shocks of the IT period.

5. Σ_{21}: implied standard deviation of inflation by the propagation of the IT period and the shocks of the pre-IT period.

6. Σ_{22}: implied standard deviation of inflation in the IT period.

Our parsimonious VAR models capture the volatility of inflation present in the data quite accurately for all the countries and sample periods, as Σ_{11} and Σ_{22} are quite similar to σ_1 and σ_2, respectively. In all four cases where inflation volatility actually went down, the VARs reproduce the decline in inflation volatility.

Our statistics show that the shocks in the second period contributed to the smaller inflation volatility of the 90s. This is found by noting that $\Sigma_{11} > \Sigma_{12}$ and $\Sigma_{21} < \Sigma_{22}$. This result is common to inflation and non-inflation-targeting countries. An "improved" propagation mechanism also contributed to lower inflation volatility in the second period for two inflation targeters (UK and Spain) and two non-targeters (France and Norway), given that $\Sigma_{11} > \Sigma_{21}$ and $\Sigma_{12} < \Sigma_{22}$. It did not however contribute to the smaller volatility of either Italy or Finland.

We now address the important question of quantifying the relative importance of shocks and propagation in the decline of inflation volatility. This is the case for all the countries in our dataset, except for Italy, where inflation volatility rose up slightly. In the case of Finland, the smaller shocks drive the decline of inflation and its volatility, given that, as shown above, propagation actually increased the volatility of inflation. In the remaining four cases, we need to compare the relative importance of each factor in the decrease of inflation volatility. In order to do that, we compare Σ_{12} with Σ_{21}. In all cases $\Sigma_{12} < \Sigma_{21}$, implying that the smaller shocks were more important in lowering inflation volatility than the change in the propagation of the economy. Since the establishment of IT would only affect the propagation mechanism, we can conclude that it was not the main factor behind the decline of monthly inflation volatility.

An exclusive examination of monthly inflation volatility may give an incomplete picture of the overall behavior of inflation under an IT regime. The different monetary authorities may be more concerned with stabilizing inflation at lower frequencies, given that monthly CPI inflation typically displays random events which may hinder the overall effect of a given policy on inflation.[5] As a result, we performed an analogous exercise with quarterly inflation, a more standard business cycle frequency. Panel B of Table 4 displays the results of our counterfactual exercise using quarterly data on inflation, output, interest rates and money supply. Except for the case of Norway - a non-targerter -, the results are essentially the same than in the monthly inflation case. That is to say, inflation volatility decreased at quarterly frequencies due mostly to the more benign macroeconomic conditions. Our results therefore hint at a common component of inflation, unexplained by our four macro variables, which made high-frequency inflation volatility decline in Europe during the 90s.

Table 5 shows the results of the cross-country counterfactual exercise. The goal of this exercise is to measure the positive or negative contribution which the propagation of a control (IT) country would have had on the inflation volatility of an IT (control) country on a given subsample.[6] To do so, we compute, for a given subsample i, the inflation volatility implied by the shocks of the home country and the foreign propagation (Σ_{ii}^{*}). Then, we substract Σ_{ii}^{*} from Σ_{ii}, the volatility implied by the shocks and the propagation of the home country. If this difference is positive (negative), the foreign country propagation would have decreased (increased) the inflation variance in the home country. In the case of France and the UK, the cross-country counterfactual shows that,

[5]This point is also made by Galí (2004).

[6]Some degree of caution should be exercised in interpreting the results of our cross-country counterfactuals, given that the construction of analogous variables can differ across countries.

in the first subperiod, the French propagation contributed to stabilize inflation relative to that in the UK. However, in the post-IT era, the UK propagation experienced an improvement which made it converge with the French one at the monthly frequency and be even more stabilizing than the French at the quarterly frequency. The case of Finland and Norway is analogous to that of UK and France, except that it is now the propagation of Norway, the non-IT country, is the one that seems to have converged with that of the IT country, Finland. The implications for the change in propagation of Spain and Italy are less clear, since they differ across frequencies: At the monthly frequency, the Spanish propagation improved relative to the Italian, whereas the opposite is true at the quarterly frequency.

4.3 Trend Inflation

In this subsection, we turn to the analysis of trend inflation for all our six European countries. As pointed out by Ball and Sheridan (2003), IT schemes are usually focused in stabilizing low-frequency inflation measures instead of their higher frequency counterparts. The rationale may be two-fold. On the one hand, it may be difficult in practice to smooth out high-frequency shocks, given its random and unpredictable nature. Even if one follows the correct policies, isolated shocks may be driving up inflation volatility temporarily. On the other hand, investors may track more closely moving averages of inflation, rather than monthly or quarterly inflation, because lower frequencies may reflect more accurately the actual commitment of the monetary authority fighting inflation. If these averages are low and stable, investors and economic agents in general may trust the central bank's policies and act accordingly, anchoring inflation expectations at low and stable levels.

We study trend inflation by computing moving averages of the CPI inflation measures across countries. We perform two alternative analysis with trend inflation measures: 3-month and 12-month moving averages of inflation. In order to keep up with the data frequency, the remaining variables are also expressed in moving average form in the VARs. One advantage of working with overlapping annual trend inflation data is that we can overcome the short length the of non-overlapping annual data and still draw conclusions on annual inflation dynamics.

Table 6 shows the descriptive statistics with quarterly and yearly trend inflation together with the associated Wald tests of parameter equality across periods and countries. The UK improved significantly in mean and standard deviation for both inflation frequencies. France also improved significantly in mean, but not in standard deviation or first order autocorrelation. Interestingly, after the adoption of IT, the UK has converged with France in inflation standard deviation. Spain and Italy improved significantly only in trend inflation mean. Their inflation moments were similar to each other for both subperiods. Finally, while Norway and Finland improved significantly in most moments, the Finnish inflation mean was significantly smaller than its Norwegian counterpart after IT. However, the improvement of Norwegian trend inflation volatility and autocorrelation was larger, so that Norway converged in both moments with Finland after the adoption of IT by Finland.

Analogously to the case of monthly and quarterly inflation, Panel B of Table 3 shows the VAR lag-lengths chosen by the BIC in the case of trend variables. The BIC criterion points at a VAR(2) as sufficient for capturing most of the dynamics of the systems expressed in moving-average form. It should be noted that if the BIC chooses a VAR(1) for monthly data, it would strictly imply a VARMA(1,n) for an n period moving average transformation. However, in order to avoid systems with an overly large number of parameters, we abstract from the MA terms. As a result, we restrict our attention to optimally selected VARs, since our main goal is to work with reduced-form systems which capture the essential dynamics of a macro system. Notice that in some cases, the VAR order chosen for a given country differs across subperiods. In terms of the cross-country counterfactual exercise reported below, there are also differences in VAR order, for a given subperiod, across an IT country and its control counterpart. In those cases, we choose the longer lag-length for both subperiods or countries in order to compute the associated counterfactual volatilities appropriately.

Table 7 displays the results of the counterfactual exercises with quarterly and yearly trend variables. It shows that the VARs are again able to capture the inflation volatilities across countries and subsamples with the exception of annual trend data of Spain and Italy. This is probably due to the fact that in their second subsample there is a small number of observations relative to the number of parameters being estimated. Panel A in Table 7 shows the results for our counterfactual exercise with quarterly trend inflation. The results are similar to those under actual quarterly inflation, but with one exception: Now propagation is the most important factor behind the decline in the UKs inflation volatility, since $\Sigma_{12} > \Sigma_{21}$. Panel B presents the results under yearly trend inflation. The finding that the UKs propagation mechanism mattered greatly for the reduction of inflation volatility is reinforced. Norway also displays the same pattern, but only with 12-month moving average inflation.

Table 5 shows the results of the cross-country counterfactual exercise for trend inflation volatility. The results are similar to the case of high-frequency inflation. That is to say, the propagation of the UK and Norway improved in the second subsample relative to that of France and Finland, respectively. In the case of Spain and Italy, the Spanish propagation seemed to have improved with respect to the Italian at the quarterly trend frequency, while both propagations remained similar at the annual trend frequency.

As a result, the decline of both the inflation standard deviations in both the UK and Norway cannot be simply attributed to good luck, because the structure of the economy changed, as reflected by the reduced-form parameters of our vector autoregressions. Additionally, the cross-country counterfactual exercise showed that the structure of their economies improved with respect to their control countries in terms of stabilizing inflation volatility. In this setting, the question which naturally arises is the following: What was the structural force behind the change in the propagation of the economy for these two countries? It could be that the behavior of their monetary authorities was responsible for it, but it could also be that the private sector, through alternative mechanisms in the economy, changed. Whatever the answer to this question is, we need a structural model in order to disentangle the different factors behind the structural change of both economies. We turn now to address this important question.

5 Structural Analysis

In the previous section, we saw that, unlike in the case of monthly and quarterly inflation, the volatility of trend inflation in the UK -one of our IT countries- and Norway -a non-targeter- improved significantly after the adoption of IT due to the change in the structure of the economy. In order to provide a structural explanation to this phenomenon, we will now introduce a macroeconomic model which will be the basis for our analysis.

The following three-variable, three-equation structural New-Keynesian model has been proposed to analyze the joint co-movement of inflation (π_t), output growth (y_t)

and the short-term interest rate (r_t).[7] The model is expressed as:

$$\pi_t = \delta E_t\pi_{t+1} + (1-\delta)\pi_{t-1} + \lambda y_t + \epsilon_{AS,t} \tag{2}$$

$$y_t = \mu E_t y_{t+1} + (1-\mu)y_{t-1} - \phi(r_t - E_t\pi_{t+1}) + \epsilon_{IS,t} \tag{3}$$

$$r_t = \rho r_{t-1} + (1-\rho)\left[\beta E_t\left(\pi_{t+1} - \bar{\pi}\right) + \gamma y_t\right] + \epsilon_{MP,t} \tag{4}$$

E_t is the Rational Expectations operator conditional on the information set at time t, which comprises π_t, y_t, r_t and all the lags of these variables. The three structural errors are the supply ($\epsilon_{AS,t}$), demand ($\epsilon_{IS,t}$) and monetary policy shock ($\epsilon_{MP,t}$). They describe the exogenous side of the economy and are assumed to be normally distributed with variances σ_{AS}, σ_{IS} and σ_{MP} respectively. The first equation is a standard aggregate supply or Phillips curve equation, where inflation depends on its own past, inflation expectations and output growth. The second equation is the demand equation, and output growth depends on its own past, output growth expectations and the ex-ante real interest rate. Finally, the third equation is the monetary policy rule. The interest rate depends on its own past on deviations of inflation expectations from its target and on output growth. As a result, all the equations exhibit endogenous persistence, necessary to capture macro dynamics, and a forward-looking part, in order to address the Lucas' Critique.

The structural parameters of the model govern the internal dynamics of this economy and capture the propagation side of the economy. The parameters ρ, β and γ describe the behavior of the monetary authority. For instance, an increase in β reflects a stronger

[7] Different versions of the New-Keynesian model can be found in Rotemberg and Woodford (1998) and Clarida, Galí, and Gertler (1999). In most instances, the New-Keynesian model is defined in terms of the output gap instead of output growth. In order to be consistent with the previous analysis, we use output growth. Neither the previous counterfactual results nor the results in this section change qualitatively using an output gap measure. Galí and Rabanal (2004) also estimate a New-Keynesian model with output growth and obtain similar estimates to those obtained under an output gap measure.

commitment of the monetary authority to stave off inflation pressures, lowering the inflation volatility, as shown in Cho and Moreno (2005). The remaining parameters in the AS and IS equations can be classified as private sector parameters.

In order to capture the relative importance of the change in the monetary authority stance and the private sector behavior on the decline of inflation volatility in the UK and Norway, we proceed as follows: We first estimate the structural model before and after the adoption of IT as a monetary policy strategy. As a result, we obtain two sets of parameters for both the monetary authority and the private sector. With these two sets of parameters, we compute the counterfactual inflation volatilities which would have arisen under the pre-IT private sector and post-IT monetary policy (Υ_{12}) and also under post-IT private sector and pre-IT monetary policy (Υ_{21}). If monetary policy was more important, then the standard deviation associated with the post-IT monetary policy stance should be smaller.

We estimate the model with annual trend data using the Full Information Maximum Likelihood (FIML) procedure employed in Moreno (2004). In the estimation, we fix the Phillips curve parameter λ and the elasticity of output to the real interest rate ϕ across sample periods. Our motivation for fixing these two parameters is two-fold. First, we aim at providing a meaningful characterization to changes in the private sector parameters. If we fix λ and ϕ, changes in the private sector will be triggered by a different degree of forward-looking behavior in the private sector (δ and μ), which is a competing explanation for changes in inflation volatility. Second, different estimation approaches yield different results for λ and ϕ, and estimation techniques such as GMM or MLE typically yield values statistically non-different from zero in the three-equation-three-variable New-Keynesian model. As a result, we chose a value of 0.0075 for λ and 0.01 for ϕ, which is in line with alternative estimation exercises in the literature (see, for instance, Fuhrer and Moore

(1995), Galí and Gertler (1999), Smets and Wouters (2003) or Bekaert, Cho, and Moreno (2005)). As we show below, we performed a sensitivity analysis under different values for λ and ϕ, but the results did not change qualitatively.

Table 8 presents the parameter estimates across sample periods for both the UK and Norway. We first discuss the results for the UK. A unique solution arose in both estimations. The results show that the stance of the Bank of England against inflation became significantly more aggressive during the IT regime in economic terms. Interestingly, the stance of the monetary authority against output growth fluctuations became more accommodative, hinting that IT does not necessarily imply a strong action against output growth. The interest rate smoothing parameter did not change significantly across sample periods. In terms of the private sector parameters, δ and μ increased, reflecting a more forward-looking behavior by the private sector. Finally, consistent with our earlier reduced-form VAR analysis, the standard deviations of the three shocks declined significantly in the 90s. Table 8 also displays the parameter estimates for an alternative post-IT subsample, including data up to August 2003. It shows that the results are very similar whether one looks at a post-IT subsample finishing at the end of 1998 or in the second semester of 2003.

The results for Norway, a non-IT country in our study, are substantially different from those of the UK. On the one hand, Norway's monetary authority became more focused on stabilizing output after 1993, since γ, the interest response to output fluctuations increased greatly in the second subsample. On the other hand, its response to expected inflation only increased minimally, not even reaching the level of 1. As a result, the Taylor principle did not hold and multiple equilibria obtained. We selected the solution associated with the three smallest eigenvalues, following the practice of Blanchard and Kahn (1980). The results also show that the forward-looking parameter of the IS equation declined in the second subperiod. Finally, and in a similar fashion to the UK, the private sector became significantly more forward-looking in the second period in the AS equation. As we show below, this change in the private sector behavior is the key factor behind the decline in Norwegian the inflation volatility.

Table 9 compares the inflation standard deviations implied by the model with the historical inflation volatilities for both countries. The structural model's standard deviations are easy to compute given that this is nested in a VAR(1). The results show that, despite of the highly non-linear restrictions imposed by the structural model, this is able to match quite closely the historical inflation volatility across countries and sample periods, since Σ_{11} and Σ_{22} are similar to σ_{11} and σ_{22}, respectively, for both the UK and Norway.

Table 10 shows the results of the aforementioned counterfactual exercise with our structural model. To control for the average shocks across sample periods, the standard deviations of the structural shocks are fixed at their two period averages. However, the results do not change when we worked with the standard errors of either of the two periods. Both the private sector and the monetary authority's behavior contributed to the smaller inflation volatility in the two countries. In the case of the UK, for alternative parameter values of ϕ and λ, we find that $\Upsilon_{12} < \Upsilon_{21}$, so that the more aggressive stance of the Bank of England against inflation turns out to be the most important factor behind the decline of inflation volatility. The opposite is true for Norway, where the private sector became more forward-looking in the AS equation but less forward-looking in the IS equation. Higher degrees of forward-looking behavior in the AS and IS equation decrease inflation volatilities, since they make inflation and output less persistent. It is therefore the more forward-looking behavior of the private sector in the AS equation what explains most of the decline in annual trend Norwegian inflation volatility.

5.1 The Drop in Output Volatility

As a by-product of our analysis, we investigate the extent to which IT has had an effect on the output growth volatility during the 90s. If IT gets to smooth the variations of inflation, it "de facto" creates conditions for growth stability, as the inflation risk would be lower.

A host of studies has shown, starting with McConnell and Quirós (2000), that output growth volatility declined in industrialized countries since the mid-80s. Panels A and B in Table 11 show that this is also the case for all of the countries in our dataset for both quarterly and 12-month moving average output growth, respectively.[8] To investigate the sources of this positive macroeconomic development, we perform a reduced-form counterfactual exercise analogous to the one of inflation. For all countries and data frequencies (including monthly and 3-month moving average not reported in the table), the smaller shocks of the 90s were responsible for the lower output growth volatility. Therefore, the "good luck" hypothesis of more benign macroeconomic conditions during the 90s, and not the adoption of IT, seems to be behind the decline of output growth volatility across western European countries.

[8]The same is true for monthly and 3-month moving average output growth.

6 Conclusions

The UK was the first European country to adopt an IT strategy in October of 1992 and its overall success in controlling inflation has been widely recognized. The contribution of this paper is to show where and why IT was indeed influential: The Bank of England fought more aggressively against trend inflation fluctuations once IT was in place.

IT practices differ among IT countries. Despite not having become fully independent until 1997, IT in the UK has been practiced with transparency -an example of which is its famous *Inflation Report*-, and accountability, as the Bank of England is required to provide a formal explanation to the government if the inflation target is not reached. Additionally, since 1997, the inflation target is an inflation rate, instead of the more standard inflation interval. To the extent that the UK has been very successful in controlling inflation, it can become a model for other countries pursuing IT strategies. Although the ECB and other central banks share some of the features of the Bank of England's modus operandi, much can be learned from the English experience.

This paper has shown that lower shocks were very important for the lower high-frequency inflation volatilities in several European countries. It could be that our set of macroeconomic variables does not reflect all of the key factors in these economies, such as international aspects or exchange rates. In particular, the countries which joined the EMU had a nominal anchor in the requirements of the Maastricht treaty. It could also be that an increased international interdependence makes inflation more stable, a factor which would not be captured by our macroeconomic system. Whatever the answer is, this question remains open for future work.

In future research, we also intend to study the performance of IT in emerging economies. We think that they should be studied separately, due to the substantial differences which they present with respect to more developed countries. For instance, their starting inflation rates at the beginning of their respective IT periods were larger and more volatile. However, the performance of inflation in countries such as Peru, Poland, Colombia or the Czech Republic has improved greatly under IT. As a result, it would be most interesting to provide a structural interpretation to these encouraging macroeconomic outcomes.

References

Andrews, Donald W. K., and Ray C. Fair, 1988, Inference in Nonlinear Econometric Models with Structural Change, *Review of Economic Studies* 55, 615–639.

Ball, Lawrence, and Niamh Sheridan, 2003, Does Inflation Targeting Matter? in Ben S. Bernanke and Michael Woodford, Ed., *The Inflation Targeting Debate* Chicago: University of Chicago Press, pp. 57–119.

Bekaert, Geert, Seonghoon Cho, and Antonio Moreno, 2005, New-Keynesian Macroeconomics and the Term Structure, *NBER Working Paper No 11340.*

Benati, Luca, and Haroon Mumtaz, 2005, The Great Stability in the U.K.: Good Policy or Good Luck?, *Bank of England, Working Paper.*

Benati, Luca, 2004, Evolving Post-World II U.K. Economic Performance, *Journal of Money, Credit and Banking* 36, 691–717.

Bernanke, Ben S., and Michael Woodford, 2005, *The Inflation Targeting Debate.* (The University of Chicago Press Chicago, IL).

Bernanke, B.S., T. Laubach, F.S. Mishkin, and A.S. Posen, 1999, *Inflation Targeting: Lessons from the International Experience.* (Princeton University Press Princeton, N.J.).

Blanchard, Olivier J., and C.M. Kahn, 1980, The Solution of Linear Difference Models Under Rational Expectations, *Econometrica* 48, 1305–1311.

Boivin, Jean, and Marc Giannoni, 2003, Has Monetary Policy Become More Effective?, *NBER Working Paper No 9459.*

Cecchetti, Stephen G., and Michael Ehrmann, 1999, Does Inflation Targeting Increase Output Volatility? An International Comparison of Policymakers Preferences and Outcomes, *NBER Working Paper No 7426.*

Cho, Seonghoon, and Antonio Moreno, 2005, A Small-Sample Analysis of the New-Keynesian Macro Model, *Journal of Money Credit and Banking, Forthcoming.*

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans, 1999, Monetary Policy Shocks: What have we learned and to what end? in John B. Taylor and Michael Woodford, Eds., *Handbook of Macroeconomics,* vol. 1A, Amsterdam: North Holland, pp. 65–148.

Clarida, Richard H., Jordi Galí, and Mark Gertler, 1999, The Science of Monetary Policy: A New Keynesian Perspective, *Journal of Economic Literature* 37, 1661–707.

Corbo, Vittorio, Oscar Landerretche, and Klaus Schmidt-Hebbel, 2002, Does Inflation Targeting Make a Difference? In Inflation Targeting: Design, Performance, Challenges, ed. Norman Loayza and Raimundo Saito. Central Bank of Chile., .

ECB, May 8, 2003, Press Release, *http://www.ecb.int/mopo/strategy.*

Fuhrer, Jeffrey C., and George Moore, 1995, Inflation Persistence, *Quarterly Journal of Economics* 440, 127–59.

Galí, Jordi, and Mark Gertler, 1999, Inflation Dynamics, *Journal of Monetary Economics* 44, 195–222.

Galí, Jordi, and Pau Rabanal, 2004, Technology Shocks and Aggregate Fluctuations: How Well Does the RBC Model Fit Postwar U.S. Data?, *NBER Macroeconomics Anual.*

Galí, Jordi, 2004, Has the Inflation Process Changed? A Comment, *Third BIS Annual Conference, Brunnen.*

King, Mervyn, 2002, The Inflation Targeting Ten Years On, *Speech delivered to the London School of Economics. 19 November.*

Kutner, Kenneth N., and Adam S. Posen, 1999, Does Talk Matter After All? Inflation Targeting and Central Bank Behavior, *Federal Reserve Bank of New York, Staff Report No. 88.*

Leeper, Eric M., and Jennifer E. Roush, 2003, Putting M Back In Monetary Policy, *Journal of Money, Credit and Banking* 35, 1217–1256.

Levin, Andrew T., Fabio M. Natalucci, and Jeremy M. Piger, 2004, The Macroeconomic Effects of Inflation Targeting, *Federal Reserve Bank of St. Louis v86* pp. 51–80.

McConnell, Margaret, and Gabriel Pérez Quirós, 2000, Output Fluctuations in the United States: What has changed since the early 1980s, *American Economic Review* 90, 1464–1476.

Mishkin, Frederic S., 2002, Does Inflation Targeting Matter?, *Commentary. Federal Reserve Bank of St. Louis v84* pp. 149–153.

Moreno, Antonio, 2004, Reaching Inflation Stability, *Journal of Money, Credit and Banking* 36, 801–825.

Neumann, Manfred J.M., and Jurgen von Hagen, 2002, Does Inflation Targeting Matter?, *Federal Reserve Bank of St. Louis v84* pp. 127–148.

Rotemberg, Julio J., and Michael Woodford, 1998, An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy: Expanded Version, *NBER Working Paper No T0233.*

Smets, Frank, and Raf Wouters, 2003, An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area, *Journal of the European Economic Association* 1, 1123–1175.

Appendix

We present below the data documentation of all the series for our countries of study. The data was collected from the International Financial Statistics Database.

- **UK**
  - Inflation: Consumer Price Index
  - Output: Industrial Production
  - Interest Rate: Money Market Rate
  - Money Aggregate: M4
- **France**
  - Inflation: Consumer Price Index
  - Output: Industrial Production
  - Interest Rate: Money Market Rate
  - Money Aggregate: M2
- **Spain**
  - Inflation: Consumer Price Index
  - Output: Industrial Production
  - Interest Rate: Money Market Rate
  - Money Aggregate: M2
- **Italy**
  - Inflation: Consumer Price Index
  - Output: Industrial Production
  - Interest Rate: Money Market Rate
  - Money Aggregate: M2
- **Finland**
  - Inflation: Consumer Price Index
  - Output: Industrial Production
  - Interest Rate: Money Market Rate
  - Money Aggregate: M2
- **Norway**
  - Inflation: Consumer Price Index
  - Output: Industrial Production
  - Interest Rate: Three Month Interbank Rate
  - Money Aggregate: M2

Table 1: **Subsamples**

	1st P.	*2nd P.*
UK and France	1985:2-1992:9	1992:10-1998:12
Spain and Italy	1985:2-1994:10	1994:11-1998:5
Finland and Norway	1985:2-1993:1	1993:2-1998:5

Note: This Table shows the subsample periods selected for the econometric analysis in each of the countries. $1stP.$ stands for first period and $2ndP.$ stands for second period.

Table 2: **Summary Statistics**

Panel A: Monthly Inflation

	$\bar{\pi}_1$	$\bar{\pi}_2$	$\bar{\pi}_1 = \bar{\pi}_2$	$\sigma_{\pi,1}$	$\sigma_{\pi,2}$	$\sigma_{\pi,1} = \sigma_{\pi,2}$	$\rho_{\pi,1}$	$\rho_{\pi,2}$	$\rho_{\pi,1} = \rho_{\pi,2}$
UK	5.42	2.66		4.17	2.58		0.33	0.08	
	(0.60)	(0.31)	(0.000)	(0.57)	(0.36)	(0.018)	(0.07)	(0.12)	(0.072)
France	3.02	1.48		2.14	1.79		0.29	-0.02	
	(0.25)	(0.22)	(0.000)	(0.21)	(0.16)	(0.185)	(0.11)	(0.10)	(0.037)
$\theta_{UK} = \theta_F$	(0.000)	(0.002)		(0.001)	(0.045)		(0.759)	(0.522)	
Spain	5.75	2.95		3.88	3.41		0.06	0.25	
	(0.38)	(0.63)	(0.000)	(0.49)	(0.27)	(0.401)	(0.05)	(0.12)	(0.144)
Italy	5.28	3.25		2.00	2.21		0.23	0.59	
	(0.24)	(0.57)	(0.001)	(0.22)	(0.36)	(0.619)	(0.14)	(0.13)	(0.059)
$\theta_S = \theta_I$	(0.296)	(0.724)		(0.001)	(0.008)		(0.253)	(0.055)	
Finland	4.37	1.00		3.01	2.69		0.08	0.01	
	(0.36)	(0.35)	(0.000)	(0.25)	(0.34)	(0.448)	(0.09)	(0.10)	(0.603)
Norway	4.98	1.95		3.54	2.49		0.40	-0.02	
	(0.53)	(0.32)	(0.000)	(0.47)	(0.36)	(0.076)	(0.08)	(0.09)	(0.001)
$\theta_F = \theta_N$	(0.341)	(0.045)		(0.319)	(0.686)		(0.008)	(0.823)	

Panel B: Quarterly Inflation

	$\bar{\pi}_1$	$\bar{\pi}_2$	$\bar{\pi}_1 = \bar{\pi}_2$	$\sigma_{\pi,1}$	$\sigma_{\pi,2}$	$\sigma_{\pi,1} = \sigma_{\pi,2}$	$\rho_{\pi,1}$	$\rho_{\pi,2}$	$\rho_{\pi,1} = \rho_{\pi,2}$
UK	5.32	2.73		2.73	1.33		0.59	-0.01	
	(0.84)	(0.30)	(0.004)	(0.53)	(0.28)	(0.019)	(0.12)	(0.10)	(0.000)
France	2.89	1.46		1.00	1.12		0.14	0.13	
	(0.20)	(0.26)	(0.000)	(0.14)	(0.18)	(0.599)	(0.07)	(0.19)	(0.964)
$\theta_{UK} = \theta_F$	(0.005)	(0.001)		(0.002)	(0.528)		(0.001)	(0.515)	
Spain	5.68	2.74		2.09	1.78		0.10	0.42	
	(0.41)	(0.60)	(0.000)	(0.45)	(0.42)	(0.614)	(0.15)	(0.08)	(0.060)
Italy	5.21	3.00		1.12	1.85		0.45	0.72	
	(0.29)	(0.78)	(0.008)	(0.11)	(0.40)	(0.079)	(0.10)	(0.16)	(0.152)
$\theta_S = \theta_I$	(0.349)	(0.791)		(0.036)	(0.903)		(0.052)	(0.094)	
Finland	4.23	0.95		1.62	1.36		0.61	0.06	
	(0.51)	(0.28)	(0.000)	(0.25)	(0.15)	(0.373)	(0.09)	(0.12)	(0.000)
Norway	4.91	1.88		2.57	1.30		0.61	0.02	
	(0.80)	(0.30)	(0.000)	(0.49)	(0.15)	(0.013)	(0.09)	(0.11)	(0.000)
$\theta_F = \theta_N$	(0.473)	(0.023)		(0.084)	(0.777)		(1.000)	(0.807)	

Note: This Table shows the descriptive statistics of monthly and quarterly CPI inflation for all countries and subsamples. $\bar{\pi}$ stands for the average, σ_π is the standard deviation and ρ_π is the first order autocorrelation. These statistics and their respective standard errors (in parentheses) were computed using generalized method of moments (GMM) estimation. The Table also displays the p-values of the Wald tests for equality of parameters across subsamples in a given country ($\bar{\pi}_1 = \bar{\pi}_2, \sigma_{\pi,1} = \sigma_{\pi,2}, \rho_{\pi,1} = \rho_{\pi,2}$) and across countries in a given subsample $\theta_i = \theta_j$, where i and j are IT and non-IT countries, respectively. The Wald statistic used is: $W = (\theta_1 - \theta_2)'(V_1 + V_2)^{-1}(\theta_1 - \theta_2)$. It is distributed as a chi-square with p degrees of freedom under the null of parameter stability (Andrews and Fair (1988)), where θ_i is a given parameter estimate and V_i its associated variance.

Table 3: **Optimal VAR length**

	Monthly		*Quarterly*		*Trend Quarterly*		*Trend Annual*	
	1st P.	*2nd P.*	*1st P.*	*2nd P.*	*1st P.*	*2nd P.*	*1st P.*	*2nd P.*
UK	1	1	1	1	1	1	2	1
France	1	1	1	1	1	1	2	2
Spain	1	1	1	1	2	2	2	2
Italy	1	1	1	1	2	1	2	1
Finland	1	1	1	1	2	2	2	2
Norway	1	1	1	1	1	1	2	2

This Table lists the optimal VAR order for each country, sample period and inflation frequency selected by the Bayes Information Criterion (BIC). All the VAR systems include inflation, output growth, the short-term interest rate and money growth.

Table 4: **Counterfactual Analysis**

Panel A: Monthly Inflation

	σ_{11}	Σ_{11}	Σ_{12}	Σ_{21}	Σ_{22}	σ_{22}
UK	4.18	4.21	2.97	3.89	2.60	2.60
France	2.16	2.15	1.80	2.10	1.77	1.80
Spain	3.91	3.90	3.32	3.55	3.32	3.44
Italy	2.14	2.00	1.79	5.36	3.80	2.21
Finland	3.02	3.03	2.62	3.17	2.70	2.70
Norway	3.55	3.60	2.62	3.20	2.51	2.49

Panel B: Quarterly Inflation

	σ_{11}	Σ_{11}	Σ_{12}	Σ_{21}	Σ_{22}	σ_{22}
UK	2.83	2.88	1.95	2.23	1.36	1.34
France	1.28	1.04	0.94	1.14	1.12	1.12
Spain	2.22	2.19	1.55	3.88	2.42	1.79
Italy	1.35	1.05	1.40	2.43	1.98	1.88
Finland	1.69	1.64	1.45	1.46	1.29	1.38
Norway	2.58	2.79	1.93	1.87	1.34	1.37

This Table lists the reduced-form counterfactual analysis for monthly and quarterly inflation. Σ_{ij} stands for the implied inflation volatility under the $i-th$ period VAR propagation coefficients and the $j-th$ period shocks. σ_{ii} stands for the historical inflation volatility in the $i-th$ period.

Table 5: **Cross-Country Counterfactual Analysis**

	Monthly		*Quarterly*		*Trend Quarterly*		*Trend Annual*	
	Λ_1	Λ_2	Λ_1	Λ_2	Λ_1	Λ_2	Λ_1	Λ_2
UK	0.33	0.06	0.65	-0.24	0.73	0.08	1.62	-0.01
France	-0.44	-0.22	-0.36	0.04	-0.69	-0.13	-1.33	0.01
Spain	-0.06	-2.79	0.02	0.17	1.18	-1.61	-0.21	-0.05
Italy	0.00	2.16	-0.18	-0.06	-2.41	0.26	-0.07	0.00
Finland	-0.65	0.02	-0.68	0.03	-2.23	0.07	-0.75	0.16
Norway	0.90	-0.04	0.64	-0.07	0.22	-0.10	0.75	-0.18

This Table shows the results of a cross-country counterfactual exercise for the first and second period inflation volatilities of each of the countries across inflation frequencies. $\Lambda_i = \Sigma_{ii} - \Sigma^*_{ii}$ where i stands for a given subsample. Σ_{ii} is the inflation volatility implied by the $i-th$ subsample shocks and propagation of the home country whereas Σ^*_{ii} is the inflation volatility implied by the $i-th$ period shocks of the home country and the $i-th$ period propagation of the foreign -control- country. For instance, in the case of monthly UK data, $\Lambda_2 = 0.06$ means that the UK would have experimented a decline in its second period inflation volatility under its own shocks and the French propagation.

Table 6: **Summary Statistics: Trend Inflation**

Panel A: 3-Month Moving Average Inflation

	$\bar{\pi}_1$	$\bar{\pi}_2$	$\bar{\pi}_1 = \bar{\pi}_2$	$\sigma_{\pi,1}$	$\sigma_{\pi,2}$	$\sigma_{\pi,1} = \sigma_{\pi,2}$	$\rho_{\pi,1}$	$\rho_{\pi,2}$	$\rho_{\pi,1} = \rho_{\pi,2}$
UK	5.39	2.73		2.97	1.50		0.85	0.67	
	(0.56)	(0.25)	(0.000)	(0.42)	(0.25)	(0.003)	(0.06)	(0.07)	(0.051)
France	2.99	1.46		1.34	1.02		0.72	0.73	
	(0.21)	(0.20)	(0.000)	(0.18)	(0.12)	(0.139)	(0.07)	(0.07)	(0.920)
$\theta_{UK} = \theta_F$	(0.000)	(0.000)		(0.000)	(0.084)		(0.159)	(0.545)	
Spain	5.74	2.83		2.28	2.28		0.69	0.72	
	(0.33)	(0.56)	(0.000)	(0.32)	(0.31)	(1.000)	(0.06)	(0.10)	(0.797)
Italy	5.26	3.22		1.38	1.87		0.75	0.93	
	(0.22)	(0.57)	(0.001)	(0.12)	(0.38)	(0.219)	(0.05)	(0.08)	(0.056)
$\theta_S = \theta_I$	(0.226)	(0.626)		(0.009)	(0.403)		(0.442)	(0.101)	
Finland	4.33	1.00		1.87	1.59		0.78	0.66	
	(0.34)	(0.32)	(0.000)	(0.19)	(0.23)	(0.348)	(0.06)	(0.09)	(0.267)
Norway	4.99	1.93		2.70	1.40		0.86	0.67	
	(0.51)	(0.28)	(0.000)	(0.39)	(0.23)	(0.004)	(0.05)	(0.10)	(0.089)
$\theta_F = \theta_N$	(0.282)	(0.029)		(0.056)	(0.559)		(0.306)	(0.938)	

Panel B: 12-Month Moving Average Inflation

	$\bar{\pi}_1$	$\bar{\pi}_2$	$\bar{\pi}_1 = \bar{\pi}_2$	$\sigma_{\pi,1}$	$\sigma_{\pi,2}$	$\sigma_{\pi,1} = \sigma_{\pi,2}$	$\rho_{\pi,1}$	$\rho_{\pi,2}$	$\rho_{\pi,1} = \rho_{\pi,2}$
UK	5.54	2.87		2.19	0.60		0.98	0.89	
	(0.49)	(0.14)	(0.000)	(0.24)	(0.07)	(0.000)	(0.03)	(0.05)	(0.123)
France	2.98	1.48		0.48	0.53		0.85	0.95	
	(0.10)	(0.13)	(0.000)	(0.05)	(0.07)	(0.561)	(0.07)	(0.05)	(0.245)
$\theta_{UK} = \theta_F$	(0.000)	(0.000)		(0.000)	(0.480)		(0.088)	(0.396)	
Spain	5.77	2.69		1.25	0.90		0.93	0.94	
	(0.23)	(0.32)	(0.000)	(0.16)	(0.09)	(0.057)	(0.04)	(0.04)	(0.860)
Italy	5.23	2.96		0.86	1.25		0.94	0.95	
	(0.16)	(0.44)	(0.000)	(0.07)	(0.24)	(0.119)	(0.04)	(0.03)	(0.842)
$\theta_S = \theta_I$	(0.054)	(0.620)		(0.026)	(0.172)		(0.860)	(0.842)	
Finland	4.38	1.05		1.39	0.62		0.98	0.90	
	(0.30)	(0.16)	(0.000)	(0.14)	(0.05)	(0.000)	(0.02)	(0.05)	(0.137)
Norway	5.10	1.94		2.14	0.65		1.00	0.87	
	(0.47)	(0.17)	(0.000)	(0.25)	(0.07)	(0.000)	(0.03)	(0.04)	(0.009)
$\theta_F = \theta_N$	(0.197)	(0.000)		(0.009)	(0.727)		(0.579)	(0.639)	

Note: This Table shows the descriptive statistics of the 3-month and 12-month moving averages of CPI inflation for all countries and subsamples. $\bar{\pi}$ stands for the average, σ_π is the standard deviation and ρ_π is the first order autocorrelation. These statistics and their respective standard errors (in parentheses) were computed using generalized method of moments (GMM) estimation. The Table also displays the p-values of the Wald tests for equality of parameters across subsamples in a given country ($\bar{\pi}_1 = \bar{\pi}_2, \sigma_{\pi,1} = \sigma_{\pi,2}, \rho_{\pi,1} = \rho_{\pi,2}$) and across countries in a given subsample $\theta_i = \theta_j$, where i and j are IT and non-IT countries, respectively. The Wald statistic used is: $W = (\theta_1 - \theta_2)'(V_1 + V_2)^{-1}(\theta_1 - \theta_2)$. It is distributed as a chi-square with p degrees of freedom under the null of parameter stability (Andrews and Fair (1988)), where θ_i is a given parameter estimate and V_i its associated variance.

Table 7: **Counterfactual Analysis: Trend Inflation**

Panel A: 3-Month Moving Average Inflation

	σ_{11}	Σ_{11}	Σ_{12}	Σ_{21}	Σ_{22}	σ_{22}
UK	3.03	3.04	2.39	2.17	1.48	1.52
France	1.40	1.39	1.17	1.19	0.95	1.02
Spain	2.33	4.59	2.50	4.34	2.43	2.32
Italy	1.48	1.31	0.91	4.00	2.35	1.88
Finland	1.88	1.80	1.68	1.92	1.58	1.59
Norway	2.70	2.80	1.86	1.97	1.39	1.42

Panel B: 12-Month Moving Average Inflation

	σ_{11}	Σ_{11}	Σ_{12}	Σ_{21}	Σ_{22}	σ_{22}
UK	2.19	2.44	1.70	0.94	0.55	0.61
France	0.49	0.50	0.47	0.65	0.63	0.54
Spain	1.28	1.29	0.55	1.10	0.41	0.94
Italy	0.90	0.83	0.53	0.66	0.40	1.33
Finland	1.39	1.69	0.82	1.10	0.62	0.63
Norway	2.14	2.45	2.29	0.77	0.62	0.65

This Table lists the counterfactual analysis for the 3-month and 12-month moving averages of inflation. Σ_{ij} stands for the implied inflation volatility under the $i-th$ period VAR propagation coefficients and the $j-th$ period shocks. σ_{ii} stands for the historical inflation volatility in the $i-th$ period.

Table 8: **FIML Estimates of the Structural Model**

	UK			*Norway*	
Parameters	*(1)*	*(2)*	*(3)*	*(1)*	*(2)*
δ	0.4630	0.4930	0.4929	0.4944	0.5490
	(0.0220)	(0.0132)	(0.0107)	(0.0157)	(0.0179)
μ	0.5947	0.6304	0.4828	0.8815	0.6154
	(0.0250)	(0.0270)	(0.0094)	(0.0818)	(0.1424)
ρ	0.9475	0.9621	0.9615	0.8999	0.9479
	(0.0186)	(0.0132)	(0.0065)	(0.0246)	(0.0215)
β	1.7655	3.6259	3.6448	0.7682	0.9411
	(0.4892)	(1.4492)	(0.7231)	(0.0732)	(0.7704)
γ	1.2557	-1.5816	-0.2158	-0.0905	2.3473
	(0.8978)	(0.4429)	(0.2051)	(0.2253)	(1.2198)
σ_{AS}	0.2374	0.1309	0.1451	0.1752	0.1700
	(0.0199)	(0.0118)	(0.0091)	(0.0138)	(0.0179)
σ_{IS}	0.3231	0.1842	0.2334	0.5408	0.2124
	(0.0270)	(0.0197)	(0.0135)	(0.0662)	(0.0436)
σ_{MP}	0.1320	0.0566	0.0673	0.1289	0.0991
	(0.0103)	(0.0054)	(0.0041)	(0.0099)	(0.0104)

Note: This Table shows the FIML parameter estimates of the structural macro model for the UK and Norway with the 12-month moving averages of inflation, output growth and the interest rate. *(1)* and *(2)* stand for the pre-IT and post-IT periods documented in Table 1, respectively. *(3)* stands for an additional post-IT period (1993:9M-2003:8M) in the case of the UK. The model's equations in demeaned form are:

$$\begin{aligned}
\pi_t &= \delta E_t \pi_{t+1} + (1-\delta)\pi_{t-1} + \lambda y_t + \epsilon_{AS_t} \\
y_t &= \mu E_t y_{t+1} + (1-\mu) y_{t-1} - \phi(r_t - E_t \pi_{t+1}) + \epsilon_{IS,t} \\
r_t &= \rho r_{t-1} + (1-\rho)\left[\beta E_t \pi_{t+1} + \gamma y_t\right] + \epsilon_{MP_t}
\end{aligned}$$

ϕ and λ are fixed at 0.01 and 0.0075 respectively.

Table 9: **Matching the Inflation Volatility Across Periods**

	UK				*Norway*			
	$\sigma_{\pi,1}$	$\hat{\sigma}_{\pi,1}$	$\hat{\sigma}_{\pi,2}$	$\sigma_{\pi,2}$	$\sigma_{\pi,1}$	$\hat{\sigma}_{\pi,1}$	$\hat{\sigma}_{\pi,2}$	$\sigma_{\pi,2}$
(1)	2.19	1.61	0.51	0.61	2.14	1.80	0.52	0.65
(2)	2.19	1.47	0.56	0.61	2.14	1.81	0.58	0.65
(3)	2.19	1.71	0.50	0.61	2.14	1.92	0.53	0.65

Note: This Table shows the implied inflation volatilities of the estimated structural models for the UK and Norway across sample periods ($\hat{\sigma}_{\pi,1}$ and $\hat{\sigma}_{\pi,2}$) together with their counterparts in the data ($\sigma_{\pi,1}$ and $\sigma_{\pi,2}$). The analysis is performed across sample periods for different values of λ and ϕ. (1): $\phi = 0.01$, $\lambda = 0.0075$, (2): $\phi = 0.0075, \lambda = 0.01$ and (3): $\phi = 0.01, \lambda = 0.005$.

Table 10: **Structural Counterfactual Analysis**

	UK		*Norway*	
	Υ_{12}	Υ_{21}	Υ_{12}	Υ_{21}
(1)	0.81	0.84	1.23	0.54
(2)	0.84	0.88	0.96	0.61
(3)	0.79	0.81	1.66	0.54

Note: This Table shows the counterfactual UK inflation volatilities obtained combining first period structural parameters and second period monetary policy parameters (Υ_{12}) and vice versa (Υ_{21}). The structural errors standard deviations were fixed at their 2 period average. The analysis is performed for different values of λ and ϕ. (1): $\phi = 0.01$, $\lambda = 0.0075$, (2): $\phi = 0.0075, \lambda = 0.01$ and (3): $\phi = 0.01, \lambda = 0.005$.

Table 11: **Counterfactual Analysis: Output Growth**

Panel A: Quarterly Output Growth

	σ_{11}	Σ_{11}	Σ_{12}	Σ_{21}	Σ_{22}	σ_{22}
UK	1.21	1.04	0.77	0.87	0.64	0.61
France	0.92	1.05	1.32	1.03	1.21	1.32
Spain	1.58	1.60	0.61	3.43	1.32	1.07
Italy	1.69	1.71	1.46	1.90	1.40	1.32
Finland	1.81	1.84	1.50	1.80	1.52	1.49
Norway	3.98	4.03	2.22	3.78	2.05	1.97

Panel B: 12-Month Moving Average Output Growth

	σ_{11}	Σ_{11}	Σ_{12}	Σ_{21}	Σ_{22}	σ_{22}
UK	0.25	0.26	0.17	0.25	0.14	1.15
France	0.20	0.10	0.09	0.25	0.25	0.27
Spain	0.37	0.51	0.29	0.40	0.17	0.34
Italy	0.31	0.31	0.21	0.37	0.23	0.31
Finland	0.43	0.46	0.30	0.63	0.35	0.35
Norway	0.63	0.64	0.31	0.66	0.28	0.30

This Table lists the reduced-form counterfactual analysis for quarterly and 12-month moving average output growth. Σ_{ij} stands for the implied output growth volatility under the $i-th$ period VAR propagation coefficients and the $j-th$ period shocks. σ_{ii} stands for the historical output growth volatility in the $i-th$ period.