To target inflation, or not to target: A conditional answer*

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Abstract

Does inflation targeting matter? We answer this question by examining, via a structural VAR, the conditional dynamics of inflation and output growth in response to markup shocks for 14 industrialized countries. Markup shocks create a trade-off between output gap and inflation stabilization purposes and the theory suggests that the conditional output growth relative to inflation variability increases after the adoption of an inflation target. The data suggest a substantial increase in the estimated ratio for both targeters and non-targeters. No other structural change can explain this pattern except changes in the conduct of monetary policy. The main conclusion is unchanged when we condition on other supply shocks, or monetary policy shocks: inflation targeting seems to matter, but it is difficult to reconcile this with the fact that some countries have announced it.

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1 Introduction

The issue of whether inflation targeting (henceforth, IT) improves economic performance has attracted a lot of attention in the beginning of the 1990s, since following the example of New Zealand, many industrial and emerging-economy countries have adopted explicitly an IT regime. The shift of focus towards IT has stimulated a vast empirical literature documenting its economic impact and since the evidence is controversial, a lively debate on the issue ensued.

The current state of the debate is well summarized in Mishkin and Schmidt-Hebbel (2007): depending on the samples, the estimation techniques and the measures of economic performance, one can find evidence in favor, or against IT. Among the most prominent advocates of IT are Bernarke et al. (1999), Neumann and von Hagen (2002), Corbo et al. (2002), Cohen et al. (2003), Levin et al. (2004) and Mishkin and Schmidt-Hebbel (2007); Ball and Sheridan (2005) are its most famous opponents. Bernanke et al. (1999) provide loose evidence on the importance of IT and Neumann and von Hagen (2002) report that adopting IT produces reductions in inflation levels and reductions in the volatility of inflation and of the interest rate. Corbo et al. (2002) find that IT leads to a fall in the sacrifice ratio, defined as the cumulative output loss arising from a permanent reduction in inflation, while Cohen et al. (2003) suggest that IT might cause the nominal exchange rate to act as a shock absorber for the real economy. Levin et al. (2004) find evidence that IT plays a role in anchoring long-run inflation expectations and in reducing the intrinsic persistence of inflation. On the other hand, Ball and Sheridan (2005) comparing seven OECD countries that adopted IT to thirteen that did not, find that differences in performance between targeters and non-targeters are explained by the fact that targeters performed worse than non-targeters before the early 90s, and there is regression to the mean.

Most of the above mentioned studies use unconditional estimates of inflation, output, and interest rates to draw their conclusions. An exception is Mishkin and Schmidt-Hebbel (2007), where differences in the dynamic responses of inflation to oil price and exchange rate shocks and of domestic interest rate to international interest rate shocks across groups are examined. In this paper we take this analysis a step further and analyze the conditional dynamics of output, inflation and the interest rate to markup shocks. These shocks represent shifts in the degree of the distortion in the economy's production process and are a standard feature of models used to analyze monetary policy (see, for example, Clarida, Gali, and Gertler (2002), Steinsson (2003), Ball, Mankiw, and Reis (2005)).

We consider markup shocks for several reasons. First, markup shocks have been estimated to be the most important source of variability in inflation in the short and medium term in the US and the Euro area (see, e.g., Smets and Wouters (2003, 2007) and Ireland (2004)). Second, since markup shocks do not affect the efficient level of output, we do not need to take a stance on the definition of the output gap in our empirical analysis. That is, the conditional dynamics of output in response to markup shocks are analogous to the dynamics of the output gap. Third, and most importantly, markup shocks induce a trade-off between stabilizing inflation and stabilizing the output gap since increases in the markup increase prices and reduce output, generating a negative output gap. John Taylor has characterized this short run trade off as the *new policy trade off*. For other business cycles shocks the new policy trade-off does not arise unless wages are sticky in the economy. Blanchard (1997) and Erceg et al. (1998) show that, any shock, such as productivity, or preference shocks, that creates a wedge between the actual and the efficient level of the real wage induces a trade-off between output gap and inflation variability. However, the latter shocks move both actual and potential output and the output gap measure is not well defined if we condition on these shocks. Finally, changes in the *new policy trade off* reveal changes in the central bank's preferences. When the central bank targets inflation, output variability induced by markup shocks should be higher relatively to the conditional output variability in response to the same shock in a non-inflation targeting regime (henceforth, NIT). In what follows we study the evolution of the *new policy trade off* in IT and NIT economies to assess whether the change in the monetary policy regime brought costs in terms of increased output variability in inflation targeting countries.

To identify markup shocks we use robust restrictions derived from a DSGE model with sticky prices. The theoretical framework we employ is a variant of Ireland's (2004) model. Using a structural VAR for log changes in GDP, CPI inflation, real wage, interest rates and labor productivity, we identify markup shocks using sign restrictions. Markup shocks robustly increase output growth and real wages and reduce the short-term interest rate and inflation contemporaneously. Since markup shocks may be confused with total factor productivity shocks in flexible price environments, we also impose the restriction that the median contemporaneous reaction of real wages to these shocks is always higher than the median response of labor productivity. In Gambetti and Pappa (2007) we show that these restrictions are not model specific and hold for more general DSGE models with additional real and nominal frictions.

We divide the countries into two groups, targeters and non targeters, and examine the conditional dynamics of output, inflation and the nominal interest rate for the two groups and the two sample periods: before and after the adoption of IT. To assess, whether IT makes a difference, we construct the "trade off ratio" defined as the ratio of conditional output growth to inflation variability induced by markup shocks for each country in our sample in the two periods. This ratio measures changes in the *new policy trade off. In theory,* as the weight placed on inflation variability rises in inflation targeting countries, conditional output variability should increase more relative to inflation variability. The data suggests no differences in the ratio across countries and significant increases of this ratio for all countries across time. Since other structural changes could have affected this ratio in NITers differently from ITers, we construct a second ratio that captures changes in the monetary policy stance, the "policy ratio." The latter ratio is defined as the ratio of the conditional nominal interest rate to inflation volatility induced by markup shocks. This ratio captures the strength with which central banks react to inflationary pressures stemming from price shocks and theory suggests that it should be higher in inflation targeting regimes. The data indicate similar increases in this ratio for both ITers and NITers in the last decades.

Our findings can be summarized as follows. First, inflation targeting should be harmful for relative output variability in the presence of shocks that create a trade-off between output gap and inflation stabilization. We find that overtime countries that have adopted an IT regime have witnessed decreases in inflation relative to output variability conditional on price shocks. However, we also find that the increase in the trade-off ratio is not different for ITers than NITers. Since no other changes in the structure of the economies of the NITers can explain this pattern, except for Japan, and since the policy ratios behave similarly in the two groups of countries, one must deduce that the industrial countries we consider as NITers are actually "covert inflation targeters" (See, Gambetti and Pappa (2007) for evidence for the US). In other words, there has been a change in the relative weight of inflation stabilization in the objective function of the central banks of all the countries in our sample. The fact that some of them has announced it does not seem to matter.

How can this be true? One reason is that our estimated markup shocks explain a small fraction of inflation and output variability in both groups and in both samples. As a result, policymakers in NIT regimes might not be very concerned for correcting deviations of output from potential when setting monetary policy, mimicking the behavior of inflation targeters. However, when we condition on shocks of greater magnitude such as supply shocks, defined as shocks that move output and inflation in the opposite direction, we also fail to detect differences in the new policy trade off between ITers and NITers. To check further the validity of our conclusions on the irrelevance of announcing an IT regime, we study the size of inflation and output growth variability in response to monetary policy shocks before and after the adoption of IT for the two groups of countries. Again, although these variabilities have decreased substantially after the adoption of IT, as theory suggests, they have been reduced similarly for ITers and NITers.

Finally, as Cecchetti and Erhman (2001) highlight, another reason for why it is hard to find strong empirical evidence in favor of IT policies might be due to the fact that the adoption of the IT regimes coincides with a globally more stable economic environment. Indeed, we document a significant reduction of the conditional variance of both inflation and output to markup shocks. In the absence of such reduction we should only observe movements in the southeast in the inflation and output variability space. However, this reduction implies an inward shift in the location of this trade off which points to a common and significant structural change. Given that this shift is common in all countries it is hard to believe that the adoption of an inflation targeting framework could have acted as a commitment mechanism that anchored expectations and induced such a shift. Thus, our conditional analysis confirms Cecchetti and Ehrmann's (2001) claim that IT may have done little to improve monetary policy outcomes over what any reasonable policy could have achieved in a benevolent environment.

2 The sample

For the choice of the countries in our sample and the IT and NIT periods we follow Ball and Sheridan (2005). We consider all OECD members as of 1990 and exclude countries that lacked independent currency before the Euro (i.e., Luxemburg), or have experienced high inflation rates (i.e., Greece, Iceland, and Turkey). This would have left us with twenty countries. However, our empirical specification requires time series for real wages and these series are not available for Denmark, Portugal and Switzerland. Also the German unification makes the use of German data problematic. Finally, Ireland and Norway are excluded due to the lack of continuous data series for interest rates and wages, respectively. As a result, we are left with 14 countries in our sample. Table 1 lists the countries included in our sample and summarizes the sample periods considered. The appendix describes data sources.

2.1 Targeters and non-targeters

Six countries in the sample are ITers and the other eight are not. For the targeters we examine periods of constant inflation targeting, where the target is unchanged, or varies within a specific range. We have also split the sample defining the targeting period as the first full quarter in which a specific inflation target, or range that was earlier announced was in effect. Since this produces insignificant changes in results, we opted for presenting results where the transitional targeting periods are not included in the IT regime definition[1]. The targeting period lasts through 2007 for all ITers, except Finland since the introduction of the Euro has changed the monetary policy regime.

As in Ball and Sheridan (2005) for the NITers we define the post-IT period as starting at the mean of the start dates for targeters, which is 1994:1. Our post targeting period ends in 2007:1 for both European and non-European countries, whereas Ball and Sheridan end the post targeting period for European countries in 1998. Since the sample between 1994 and 1998 is short for European countries, we follow Canova and Pappa (2007) and take a Bayesian approach and estimate responses for the 1994-1998 period using information for the whole 1994-2007 sample. In particular, we run our experiments in the 1994-2007 sample for these countries and then use the obtained estimates to calibrate the prior for the shorter dataset. In doing so, *a priori* we expect some similarities in the responses of the macro variables in the two datasets[2]. Clearly, if data in the sample 1994-1998 are informative, the posterior distribution of the estimated structural responses may deviate from the assumed prior. Thus, by stochastically combining datasets with potentially different charateristics, we are able to increase our information set.

[1] For that reason Spain is not included in the group of ITers since its target fell throughout its targeting period (between 1994:1 and 1998:4)

[2] Since the ECB reacts to an average of inflation and output of the European countries and since there are inflation and output growth differentials across European countries (See, e.g. Benalal et al. (2006) and Weber and Beck (2005)) one cannot claim that any of the individual European countries operates under an IT regime after 1998.

Table 1: The regimes

Country	*pre-IT sample*	*post-IT sample*
IT		
Australia	1970:1-1994:3	1994:4-2007:1
Canada	1970:1-1993:4	1994:1-2007:1
Finland	1970:1-1993:4	1994:1-1998:4
New Zealand	1970:1-1992:4	1993:1-2007:1
Sweden	1970:1-1994:4	1995:1-2007:1
UK	1970:1-1992:4	1993:1-2007:1
NIT		
Austria	1970:1-1993:4	1994:1-2007:1
Belgium	1980:1-1993:4	1994:1-2007:1
France	1970:1-1993:4	1994:1-2007:1
Italy	1971:1-1993:4	1994:1-2007:1
Japan	1970:1-1993:4	1994:1-2007:1
Netherlands	1970:1-1993:4	1994:1-2007:1
Spain	1977:1-1993:4	1994:1-2007:1
US	1970:1-1993:4	1994:1-2007:1

2.2 Unconditional statistics

We first examine some unconditional statistics for CPI inflation and output growth volatility for the 14 countries in our sample. In Figure 1 we plot the relationship between CPI inflation and output growth volatility for the two groups of countries before (blue marks) and after (green marks) the adoption of IT. ITers appear in squares and NITers in diamonds.

The picture summarizes previous findings in the literature that have used unconditional statistics to access the importance of the adoption of an IT regime. First, inflation targeting has reduced inflation volatility and output volatility has not worsened and, if anything, has improved after the adoption of the IT regime (See, e.g., Corbo et al. (2002)). However, the variability of inflation and output has been reduced substantially in both groups of countries in the second sample (See, e.g., Cecchetti and Erhman (2001)). In the pre IT period, and with the exception of US and Italy, all NITers experienced smaller output variabilities than the ITers and for that reason average output growth variability was relatively higher in the IT countries. This does not hold for inflation variability in the pre IT period, nor for any of the two variabilities in the post IT period - estimated variances for ITers and NITers are similar. Thus, controlling for regression to the mean, the unconditional statistics fail to show any clear advantage for IT regimes, as Ball and Sheridan (2005) have originally claimed.

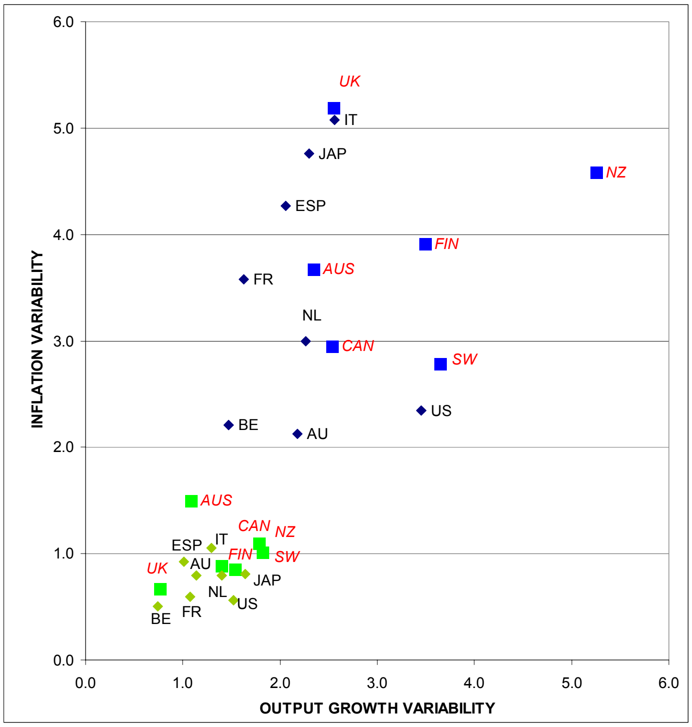


Figure 1: Inflation and output volatility pre and post IT.

If welfare depends negatively on output and inflation variability, as is usually the case in micro founded DSGE models with nominal rigidities, Figure 1 shows that all the countries in the sample have experienced better economic conditions. But, how much of this improvement can be attributed to monetary policy? Looking at unconditional moments cannot help answer this question since the outcome of Figure 1 can be attributed to different factors, such as economic structure, policy regimes and shocks' configurations. To isolate the role of a change in the monetary policy regime, in what follows, we perform a conditional analysis and examine the conditional statistics of output, inflation and the interest rate to markup shocks.

The choice of markup shocks is not accidental. Unlike demand shocks, markup shocks create a trade-off between output gap and inflation stabilization. Other supply shocks, such as technology or labor supply shocks, may also generate a trade off between output gap and inflation stabilization in the presence of sticky wages (See, Blanchard (1997) and Erceg et al.

(2000)). However, the latter shocks move both actual and potential output, whereas markup shocks leave potential output unaffected and, as a result, the conditional dynamics of output in response to markup shocks reflect the dynamics of the output gap, whereas this is not the case for the other disturbances. If it is true that policymakers react to deviations of output from potential it is more adequate to condition the analysis on markup shocks, since the conditional output gap measure for the latter is well defined. If we think of policymakers as choosing a point on an output-inflation variability trade-off, then a move to inflation targeting would be expected to result in a move along this frontier where inflation variability conditional on markup shocks will be lower and conditional output variability higher than it otherwise would have been. In other words, for markup shocks the *new policy trade off* is well defined and we can study the differences in its evolution in IT and NIT economies in the two different eras to assess whether the change in the monetary policy regime brought costs in terms of increased output variability in inflation targeting countries.

3 Extracting markup shocks: The methodology

In order to extract markup shocks from the data we use the methodology of Gambetti and Pappa (2007). The exercise consists of four steps:

1. We employ a general theoretical framework to study the macroeconomic effects of markups shocks.
2. We search for robust implications characterizing the dynamics induced by markup shocks in various specifications of the theoretical model. We mainly focus on the sign of the responses of macrovariables after a markup disturbance in the impact period, as these are usually independent of the parameterization.
3. We establish that the restrictions used to identify markup shocks cannot hold for other shocks.
4. We use a subset of these restrictions to extract markup shocks in the data.

Step 1: The New Keynesian model

We employ a simple version of the New Keynesian model with sticky prices and markup shocks (See also Ireland (2004)). We study four additional disturbances: total factor productivity, labor supply, preference and monetary policy shocks. The model economy consists of a representative household, a representative final good producer, a continum of intermediate good producers indexed by $i \in [0,1]$, and a central bank.

A. The representative household

The representative household derives utility from private consumption, C_t, and leisure, $1-N_t$. Preferences are defined by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\varepsilon_t^b \left[C_t^{\phi} (1-\varepsilon_t^n N_t)^{1-\phi} \right]^{1-\sigma} - 1}{1-\sigma} \tag{3.1}$$

where $0 < \phi < 1$, and $\sigma > 0$ are preference parameters, $0 < \beta < 1$ is the subjective discount factor and ε_t^n is a labor supply shock, and ε_t^b denotes a preference shock that affects the intertemporal substitution of households and ther logarithms follow an AR(1) process.

The household has access to a complete set of nominal state-contingent claims and maximizes (3.1) subject to an intertemporal budget constraint that is given by:

$$P_t C_t + B_t Q_t \leq P_t w_t N_t + B_{t-1} + D_t + A_t \tag{3.2}$$

The households income consists of nominal labor income, $P_t w_t N_t$; ; the net cash inflow from participating in state contingent securities at time t, denoted by A_t; income from bonds maturing at t, B_{t-1} and the dividends derived from the imperfect competitive intermediate good firms D_t. With the disposable income the household purchases consumption goods, C_t, and new bonds B_t at price Q_t.

B. The representative final good firm

In the production sector, a competitive firm aggregates intermediate goods into a final good using the following constant-returns-to-scale technology:

$$Y_t \leq \left[\int_0^1 y_t^{i \frac{1}{1+\lambda_{pt}}} di \right]^{1+\lambda_{pt}} \tag{3.3}$$

The variable λ_{pt} measures the time varying elasticity of demand for each intermediate good and represents a shock to the markup, or a cost-push shock. We assume that the logarithm of this shock follows an autoregressive process. The final good firm maximizes its profits by choosing: $y_t^i = \left(\frac{P_t^i}{P_t}\right)^{-\frac{1+\lambda_{pt}}{\lambda_{pt}}} Y_t$. Since competition implies zero profits for this firm, the price index, P_t, is determined by: $P_t = \left[\int_0^1 P_t^{i-\frac{1}{\lambda_{pt}}} di\right]^{-\lambda_{pt}}$.

C. Intermediate good firms

Each intermediate firm i hires N_t^i units of labor from the representative household to produce output, y_t^i, according to:

$$y_t^i = Z_t N_t^{i1-\alpha}$$

The logarithm of the aggregate technology shock, Z_t, follows a random walk with positive drift.

Intermediate firms are price takers in the input market and monopolistic competitors in the product markets. They stagger their pricing decisions in the spirit of Calvo (1983). Specifically, in each period of time, each firm receives an i.i.d. random signal that determines whether or not it can set a new price. The probability that a firm can adjust its price is $1-\gamma$. Thus, by the law of large numbers, a fraction $1-\gamma$ of all intermediate firms can adjust prices, while the rest of the firms cannot. If a firm who produces type-i intermediate good can set a new price, it chooses P_t^i to maximize its expected present value of profits

$$\mathrm{E}_t \sum_{\tau=t}^{\infty} \gamma^{\tau-t} Q_{t,\tau}[P_t^i - (1+\lambda_{p\tau})V_{N\tau}]y_\tau^{id}, \tag{3.4}$$

where V_{Nt} is the unit cost, which is identical across firms since all firms face the same input market, and y_t^{id} is the demand schedule for type i intermediate good originating from the final good producer. Regardless of whether a firm can adjust its price, it has to solve a cost-minimizing problem, the solution of which yields the unit cost function: $V_{Nt} = \frac{1}{1-\alpha}\frac{w_t}{Z_t}N_t^{\alpha}$ and a conditional factor demand function: $N_t = \left(\frac{Y_t}{Z_t}\right)^{\frac{1}{1-\alpha}} \int_0^1 \left(\frac{P_t^i}{P_t}\right)^{-\frac{1+\lambda_{pt}}{\lambda_{pt}(1-\alpha)}} di$.

D. Equilibrium

Market clearing in the goods market requires: $Y_t = C_t$. In the bonds market it must also hold that $B_t = 0$.

F. The linearized model

We log-linearize all variables around a steady state balance growth path, where output, $y_t = Y_t/Z_t$, and consumption, $c_t = C_t/Z_t$ are stationary. For any variable, S_t, lower case letters with hats, $\widehat{s}_t = \ln(s_t/s)$, denote percentage deviations of this variables from its steady state level, s. The log-linearized version of the model is briefly summarized below. *Aggregate demand* is characterized by:

$$\widehat{x}_t = E_t\widehat{x}_{t+1} + \frac{1}{\omega\xi}(\widehat{r}_t - E_t\widehat{\pi}_{t+1}) - \frac{1}{\omega\xi}(1-\rho_b)\widehat{\varepsilon}_t^b + (1-\rho_n)\Theta_n\widehat{\varepsilon}_t^n \tag{3.5}$$

where $\omega = (1-\sigma)\phi - 1 < 0$, $\xi = 1 - \frac{N(1-\phi)(1-\sigma)}{1-N}$ and $\Theta_n = \frac{1-\xi}{\xi} + \frac{N(1-\alpha)}{1-\alpha+\alpha N}$.

Equation (3.5) is the so called dynamic IS curve which results from the loglinearization of the Euler equation. The variable $\widehat{x}_t$ is the output gap defined as the deviation of the sticky price level of output from its efficient level. We define the efficient level of output as the level of output that would prevail under flexible prices and in the absence of markup shocks. In equilibrium the output gap is equal to: $x_t = y_t + \frac{N(1-\alpha)}{1-\alpha+\alpha N}\varepsilon_t^n$.

The *supply side* of the economy is described by:

$$\widehat{\pi}_t = \beta E_t\widehat{\pi}_{t+1} + \kappa\widehat{mc}_t + \widehat{\eta}_t^p \tag{3.6}$$

$$\widehat{g}_{yt} = \widehat{y}_t - \widehat{y}_{t-1} + \widehat{z}_t \tag{3.7}$$

$$\widehat{lp}_t = -\frac{\alpha}{1-\alpha}\widehat{x}_t + \frac{\alpha N}{1-\alpha-\alpha N}\widehat{\varepsilon}_t^n \tag{3.8}$$

Equation (3.6) is the AS equation that describes inflation as a function of marginal costs, $\widehat{mc}_t = \widehat{w}_t + \frac{\alpha}{1-\alpha}\widehat{y}_t$. The parameter $\kappa = \frac{(1-\alpha)\lambda_p}{\alpha+\lambda_p}\kappa_p$, where $\kappa_p = \frac{(1-\beta\gamma)(1-\gamma)}{\gamma}$, is the slope of the New Keynesian Phillips curve and depends crucially on γ, the probability that firms face for not being able to change their price. The variable $\widehat{\eta}_t^p = \kappa_p\widehat{\lambda}_{pt}$ is the markup shock that in the steady state equals λ_p. Notice that in the absence of the markup shock the IS and the AS equations imply that the central bank can replicate the efficient allocation by targeting inflation, however, the presence of the markup shock confronts the central bank with a trade-off between inflation and the output gap stabilization as competing goals of monetary policy. Equations (3.7) and (3.8) define the growth rate of output and labor productivity, respectively.

G. Monetary policy

The model is closed with the monetary policy rule which is represented by a generalized Taylor (1993) rule. Monetary policy is assumed to react to current inflation, output gap and output growth fluctuations and have preferences for interest rate smoothing represented by the parameter, ρ_R.

$$\widehat{r}_t = \rho_R \widehat{r}_{t-1} + (1 - \rho_R)(\rho_\pi \widehat{\pi}_t + \rho_{gy} \widehat{g}_{yt} + \rho_x \widehat{x}_t) + \widehat{\varepsilon}_t^R \tag{3.9}$$

where $\widehat{\varepsilon}_t^R$ is a zero mean, serialy uncorrelated monetary policy shock.

Equations (3.5)-(3.9) form a system involving seven equations in seven unknowns, $\widehat{\pi}_t, \widehat{g}_{yt}, \widehat{w}_t, \widehat{lp}_t, \widehat{r}_t$ are observable, while $\widehat{x}_t$ and $\widehat{y}_t$ are unobservable. The model features five exogenous processes: total factor productivity, $\hat{z}_t$, labor supply , $\widehat{\varepsilon}_t^n$, preference, $\widehat{\varepsilon}_t^b$, monetary policy, $\hat{\varepsilon}_t^R$, and the price markup shock, $\hat{\lambda}_{pt}$. The vector of the shocks, $\hat{s}_t = [\hat{z}_t, \widehat{\varepsilon}_t^n, \hat{\varepsilon}_t^b, \widehat{\epsilon}_t^R, \widehat{\lambda}_{pt}]'$, is parametrized as:

$$\hat{s}_t = \boldsymbol{\varrho} \hat{s}_{t-1} + V_t \tag{3.10}$$

where V is a (5x1) vector of innovations and $\boldsymbol{\varrho}$ is a (5x5) diagonal matrix. The innovation vector V is generated from a stationary, zero-mean, white noise process and the roots of $\boldsymbol{\varrho}$ are assumed to be less than one in modulus. For the productivity disturbance, $\hat{z}_t$, $\boldsymbol{\varrho}(\mathbf{1}, \mathbf{1})$ is set to zero.

Step 2: Robust restrictions

The second step of our procedure is designed to confront the uncertainty involved in calibration exercises. An implication is called robust if it holds independently of parameterization and of the functional forms for the primitives used. For example, if the responses of, say, output to TFP shocks have the same sign for a wide range of parameterizations, we call this implication robust. Robustness is not generic since many dynamic properties are sensitive to the exact parameterization employed and to specific features added, or subtracted to the model. For example, the sign of the response of hours to total factor productivity shocks may depend on the degree of price stickiness. Our method aims at identifying disturbances which produce dynamics which are qualitatively similar in the model and in the data. Obviously, such disturbances may not exist if some restrictions implied by the model are false. Also, some shocks may share the same restrictions. For example, output increases and inflation falls in response to TFP and markup shocks both in sticky and in flexible price environments. For that reason it is important to establish that none of the alternative shocks considered can generate the same sign restrictions as the ones we use to identify the markup shocks.

Formally speaking, let $h(y_t(\theta|x_t)))$ be a $J \times 1$ vector of functions of the data y_t produced by the model, when the $N \times 1$ vector of structural parameters θ is employed, conditional on shock the x_t. We let θ be uniformly distributed over Θ, where $\Theta = \prod_i \Theta_i$ is the set of admissible parameter values and Θ_i is an interval for each parameter i. We draw $\theta_i^l, i = 1, \ldots, N$ from each Θ_i, construct $h(y_t(\theta^l|x_t))$ for each draw $l = 1, \ldots, 1000$ and order them increasingly. Then $h_j(y_t(\theta|x_t))$, $j = 1, \ldots J$ is robust if $sgn[(h_j^U(y_t(\theta|x_t))] = sgn[h_j^L(y_t(\theta|x_t))]$ and where h^U and h^L are the 84 and 16 percentiles of the simulated distribution of $h(y_t(\theta|x_t))$.

Since we restrict the range of Θ_i on the basis of theoretical and practical considerations and draw uniformly from these ranges, our approach is intermediate between calibrating the parameters (to a point) and assuming informative subjective priors. Our approach also formalizes, via Monte Carlo methods, standard sensitivity analysis conducted in many calibration exercises.

The model period is one quarter. We split the parameter vector $\theta = (\beta, \theta_2)$, where β, the discount factor, is kept fixed so that the annual real interest rate equals 4%, while θ_2 are the parameters which are allowed to vary. Appendix B gives the ranges for the parameters in θ_2.

We summarize the qualitative responses of the variables of interest to the five shocks of the model in the impact period in Table 2. Appendix C plots the impulse responses bands for the variables in table 2 and the five shocks considered.

Table 2: Identification Restrictions

shocks\variables	$\widehat{g}_{yt}$	$\hat{\pi}_t$	$\widehat{r}_t$	$\widehat{w}_t$	$\widehat{w}_t, \widehat{lp}_t$	$\widehat{y}_t$	$\hat{x}_t$
markup	>0	<0	<0	>0	$\widehat{w}_t > \widehat{lp}_t$	>0	>0
productivity	$>\mathbf{0}$	$<\mathbf{0}$	>0 *NK* <0 *RBC*	<0 *NK* >0 *RBC*	$\widehat{w}_t < \widehat{lp}_t$ *NK* $\widehat{w}_t \leq \widehat{lp}_t$ *RBC*	>0	<0
labor supply	$>\mathbf{0}$	$<\mathbf{0}$	$<\mathbf{0}$	$<\mathbf{0}$	$\widehat{w}_t \simeq \widehat{lp}_t$	>0	<0
preference	$>\mathbf{0}$	$>\mathbf{0}$	>0	>0	$\widehat{w}_t > \widehat{lp}_t$	>0	>0
monetary policy	$>\mathbf{0}$	$>\mathbf{0}$	<0	>0	$\widehat{w}_t > \widehat{lp}_t$	>0	>0

We denote by NK the model presented in equations (3.5) to (3.9) and RBC the model under flexible prices. To ease comparisons we have normalized responses so that all the shocks considered increase output growth. The sign restrictions for the responses to markup shocks are reported in the first row of the table. The model produces a set of robust restrictions in response to markup shocks: a positive contemporaneous correlation between output, output growth, output gap and real wages with the shock and a negative contemporaneous correlation with the nominal interest rate and inflation. It remains to establish that the rest of the disturbances considered do not generate the same restrictions. We do so in the next step.

Step 3: Excluding other shock candidates

In order to ensure that the shock we seek to identify is not potentially a combination of the other shocks present in the economy, we examine the responses of the five variables of interest to the other shocks considered. As it is apparent in Table 2, none of the other shocks can satisfy jointly the restrictions described in the first row of the table. In particular, the sign restrictions on the impact effect of all the exogenous disturbances on the real wage, the nominal interest rate and inflation are sufficient to differentiate the dynamic responses of markup shocks from those of other disturbances in the NK model. The qualitative restriction on the size of the response of the real wage relative to labor productivity is crucial for differencing the effects of TFP shocks in the RBC model and markup shocks in New Keynesian environments. Since wages in the NK model are defined as the sum of labor productivity and marginal costs, real wages tend to increase more in reaction to a negative markup shock than labor productivity. The conditional responses of the output gap can also diferentiate the two shocks, but since the output gap is unobservable, the qualitative restriction on the real wage and labor productivity is the only plausible option we are left with for identification.

Step 4: Sign restrictions for markup shocks

The subset of the restrictions we use to identify markup shocks in the data are as follows: Markup shocks should increase output growth, the real wage and decrease interest rates and inflation on impact and the median response of real wages to such shocks should be higher than the median response of labor productivity. The probability that at least one of these sign restrictions is violated in the impact period of the shock is only 10%. Moreover, in Gambetti and Pappa (2007), we show that the restrictions we use to identify markup shocks hold in more general environments with capital accumulation and rigidities in both the wage and the price setting, and additional frictions, such as habit in consumption, investment adjustment costs, variable capacity utilization and wage and price indexation.

After having recovered robust theoretical predictions to identify the markup shocks, we proceed by presenting the econometric framework used to extract them from the data.

4 The Econometric framework

For each country in our sample we consider a vector, Y_t consisting of the quarterly growth rate of real GDP, the short term nominal interest rate, the log of real CPI wage, the log of labor productivity, measured as output per worker, and the CPI inflation rate and assume that it admits the following VAR representation

$$A(L)Y_t = \epsilon_t$$

where $A(L) = I - A_1 L - ... - A_p L^p$, L is the lag operator and ϵ_t is a Gaussian white noise process with variance covariance matrix Σ. Let P the Cholesky factor of Σ, the unique lower triangular matrix such that $PP' = \Sigma$. The markup shock is obtained as $e_t^m = H'P^{-1}\varepsilon_t$, where H is a unity vector such that the implied impulse response functions $A(L)^{-1}PH$ satisfy the identification restrictions presented in Table 2. We restrict the responses in the impact period of the shock.

To estimate the model, following Uhlig (2005), we assume a diffuse prior for (A, Σ, H), $A = [A_1, ..., A_p]$. Given that the likelihood for the posterior density for A, Σ, H is Normal-Wishart multiplied by an indicator function which assumes the value of one if the restrictions are satisfied and zero otherwise, to compute the impulse response functions we take a draw for (A, Σ) from the Normal-Wishart and a draw for H from a uniform distribution over the unit-sphere. If the restrictions are satisfied we retain the impulse response functions otherwise we go to the next draw. We repeat the procedure until 1000 draws are obtained.

5 Theoretical predictions

In what follows we present two empirical measures that capture the changes in the monetary policy regime. The trade-off ratio measures the movements along the trade off curve, while the policy ratio portrays the extent to which policymaking was shifted towards inflation stabilization. The "trade-off" ratio is calculated as the ratio between the standard deviation of output growth to the standard deviation of inflation conditional on markup shocks, while the "policy" ratio is defined similarly as the ratio of the standard deviation of the nominal interest rate to the standard deviation of inflation conditional on markup shocks.

Before going to the empirical analysis it is worth investigating theoretically how structural changes affect the two ratios in the model. In order to do that we need to analyze which structural parameters affect the conditional volatility of output, inflation and the interest rate to markup shocks. However, the effect of any parameter change in the size of the trade off and the policy ratio is not independent of the parameterization of the rest of the model. As a result, it is hard to say with certainty the effect of a single parameter change in the two ratios, as this might be positive or negative depending on the values employed for the rest of the parameters in the model. For example, consider equations (3.5), (3.6) and (3.9) when all disturbances but the markup shock are zero and assume that $\rho_R = \rho_{gy} = 0$. Then, substituting for the nominal interest rate in (3.5), we can represent the equilibrium conditions under (3.9) by means of the system:

$$\begin{bmatrix} 1-\frac{\rho_x}{\omega\xi} & -\frac{\rho_\pi}{\omega\xi} \\ -\kappa_x & 1 \end{bmatrix} \begin{bmatrix} \widehat{x}_t \\ \widehat{\pi}_t \end{bmatrix} = \begin{bmatrix} 1 & -\frac{1}{\omega\xi} \\ 0 & \beta \end{bmatrix} \begin{bmatrix} E_t\widehat{x}_{t+1} \\ E_t\widehat{\pi}_{t+1} \end{bmatrix} + \begin{bmatrix} 0 \\ \widehat{\eta}_t^p \end{bmatrix}$$

Using the method of undetermined coefficients, we can show that the solution to the above system is given by:

$$\widehat{x}_t = a_1\widehat{\eta}_t^p + a_2$$
$$\widehat{\pi}_t = b_1\widehat{\eta}_t^p + b_2$$

where, confirming the nature of the new policy trade off:

$$a_1 = -\frac{\kappa_p\rho_\pi}{\rho_x - \rho_\pi\kappa_x - \omega\xi} < 0 \text{ and } b_1 = \frac{\kappa_p\left(\rho_x - \omega\xi\right)}{\rho_x - \rho_\pi\kappa_x - \omega\xi} > 0$$

We write the trade off ratio as:

$$TOR = \frac{\sqrt{Var(\widehat{g}_{xt})}}{\sqrt{Var(\widehat{\pi}_t)}} = \frac{\sqrt{2\left(\frac{a_1}{1-\rho_\eta}\right)^2 Var(\widehat{v}_t^p)}}{\sqrt{\left(\frac{b_1}{1-\rho_\eta}\right)^2 Var(\widehat{v}_t^p)}} = \sqrt{2}\frac{\rho_\pi}{\rho_x - \omega\xi}$$

where ρ_η and $Var(\widehat{v}_t^p)$ is the persistence and the variance of the markup shock, respectively. Similarly using the above solution and (3.9), we can show that for the nominal interest rate: $\widehat{r}_t = (\rho_\pi b_1 + \rho_x a_1)\widehat{\eta}_t^p + \rho_\pi b_2 + \rho_x a_2$. As a result, we can write the policy ratio as:

$$PR = \frac{\sqrt{Var(\widehat{r}_t)}}{\sqrt{Var(\widehat{\pi}_t)}} = \frac{\sqrt{\left(\frac{\rho_\pi b_1+\rho_x a_1}{1-\rho_\eta}\right)^2 Var(\widehat{v}_t^p)}}{\sqrt{\left(\frac{b_1}{1-\rho_\eta}\right)^2 Var(\widehat{v}_t^p)}} = \rho_\pi + \frac{\rho_x\rho_\pi}{\rho_x - \omega\xi}$$

Clearly, in this case, $\frac{\partial TOR}{\partial\rho_\pi} > 0$ and $\frac{\partial PR}{\partial\rho_\pi} > 0$, $\frac{\partial TOR}{\partial\rho_x} < 0$ and $\frac{\partial PR}{\partial\rho_x} < 0$, and also using the definitions of ω and ξ $\frac{\partial TOR}{\partial\sigma} < 0$ and $\frac{\partial PR}{\partial\sigma} < 0$. But if we look at the effect of changes in ϕ in the two ratios, results are not so clear cut, since $\frac{\partial\omega\xi}{\partial\phi}$ is bigger, or smaller than zero depending on the values of σ, and the steady state level of employment. Moreover, parameters such as

γ, the degree of price stickiness, do not seem to affect directly the trade off and policy ratio, while in theory they should.

Hence, in order to robustly check the effect of one parameter change in the trade off and policy ratios, we calculate the probabilities that increases in this specific parameter generate increases in each of the two ratios. In other words, if we want to study the effect of increases in γ in the trade off and policy ratios, we draw parameter values for the remaining $(i-1)$ parameters of the model from the set of admissible parameter values 10000 times and study the bahavior of the trade off and the policy ratios when γ increases in the [0.4,0.9] interval, in each draw . If the trade off ratio is increasing in 5400 cases out of the 10000 and the policy ratio increases 5200 out of the 10000, the probality that the trade off ratio increases with increases in γ is 54% and the respective probability for the policy ratio is 52%. Table 3 reports these probabilities for all the parameters that might affect the behavior of the two ratios conditioning on markup shocks.

Table 3: Parameter changes and the evolution of TOR and PR

parameters	ranges	prob($\uparrow TOR$)	prob($\uparrow PR$)
γ	[0.4,0.9]	54%	52%
σ	[1,4]	*28%*	*80%*
ϕ	[0.6,0.8]	52%	48%
α	[0.2,0.4]	50%	50%
ρ_{π}	[1,5]	*81%*	*85%*
ρ_{x}	[0,1]	40%	40%
ρ_{gy}	[0,1]	*21%*	*25%*
ρ_{η}	[0,0.95]	40%	40%

If we assume that inflation targeting involves an increase in the weight that inflation stabilization receives in the central banks' objective, we can represent the change in the policy stance by an increase in ρ_{π}, or a reduction in ρ_{x}, or ρ_{gy}. Table 3 indicates that for the majority of parameter choices such a change should increase the trade off and the policy ratio more extensively for countries that adopted an IT regime. Yet, the table indicates that a reduction in the persistence of the shock might be also responsible for the simultaneous increases in the two ratios. On the other hand, the table suggests that changes in risk aversion, σ, could not have induced similar movements in the two ratios, while for some parameterizations increases in the degree of price stickiness could have produced similar changes in the trade off and policy ratios as changes in the policy stance. Finally, the magnitude of changes that parameters α and ϕ induce in the two ratios is small, suggesting that these last two parameters do not affect significantly the two ratios.

Next we examine the behavior of the trade off and policy ratios in the data and try to access whether changes in monetary policy, or other structural changes can explain the data pattern.

6 Does inflation targeting matter? The evidence

The trade off ratio

The first two columns of Table 4 report the trade off ratios for the two sample periods for both ITers and NITers. The new policy trade off is present in all IT countries but Sweden and with the exception of Australia, the other IT countries have experienced significant increases in the trade off ratio. However, this ratio has increased also for the countries operating under NIT. The increase in the trade-off ratio was drastic for Japan and France, while for the US and Belgium the magnitude of the changes is comparable with those of the IT economies. As a result, on average the changes in the trade off ratio are actually higher for NITers than for ITers, however, these differences are not statistically significant.

6.1 The policy ratio

The estimates of Table 4 do not conform with theoretical predictions: we document comparable increases in the trade-off ratio for both ITers and NITers. To examine whether other changes in the structure of the economy could be responsible for the increase in the trade off ratio for NITers we look at the behavior of the "policy ratio." The joint behavior of the two ratios helps us exclude some of the alternative explanations for the absence of evidence in favor of IT.

According to Table 3, increases in the coefficient of relative risk aversion, σ, tend to raise the policy ratio. However, they move the trade-off and the policy ratio in opposite directions. This is because increases in the relative risk aversion affect the responsiveness of output to changes in the interest rate and, in general, tend to decrease output variability, generating a fall in the trade-off ratio. At the same time, they restrain the effects of markup shocks on demand and, hence, on inflation, increasing the policy ratio. Thus, if we observe reductions in the policy ratio in NITers, we can, in principal, attribute the increase in the trade off ratio in

NITers to changes in preferences. Instead, it is more difficult to explain the similarities across groups if the policy ratio increases for both groups of countries.

Table 4: Trade-off, policy ratios and CPI persistence								
Country	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	v
IT	**trade-off ratio**		**policy ratio**		**persistence** π		**persistence** r	
Australia	0.32	0.34	1.05	0.18	0.93	0.89	0.91	0.91
Canada	0.64	4.10	0.94	2.31	0.97	0.72	0.94	0.87
Finland	0.83	4.32	0.39	1.06	0.97	0.82	0.90	0.91
New Zealand	0.50	1.50	0.60	1.33	0.92	0.87	0.89	0.86
Sweden	1.83	1.21	0.73	1.25	0.89	0.88	0.74	0.95
UK	0.26	0.71	0.24	1.21	0.92	0.75	0.86	0.94
	pre-IT	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*
NIT	**trade-off ratio**		**policy ratio**		**persistence** π		**persistence** r	
Austria	1.05	1.28	0.85	1.02	0.95	0.90	0.91	0.95
Belgium	0.35	2.42	0.85	1.18	0.95	0.78	0.92	0.91
France	0.15	2.36	0.47	2.03	0.98	0.89	0.94	0.91
Italy	0.41	1.10	0.58	4.15	0.94	0.94	0.88	0.97
Japan	0.23	4.78	0.32	0.23	0.93	0.76	0.89	0.89
Netherlands	1.00	2.65	1.93	1.23	0.97	0.91	0.90	0.94
Spain	0.73	0.86	1.29	2.23	0.96	0.87	0.79	0.96
US	2.14	9.21	2.27	6.85	0.97	0.93	0.88	0.96

The middle columns of Table 4 report the values of the policy ratio in the two periods for the two groups. According to our estimates, this ratio has increased significantly for all countries in the sample, except Australia, Japan and the Netherlands. The case of Japan is special since the zero bound restriction on the interest rate held back the variability of the policy instrument. In the Netherlands, the empirical pattern can be reconciled theoretically by changes in the relative risk aversion, whereas the case of Australia is hard to explain, since the change in the regime should have undoubtfully increased the policy ratio.

The main message conveyed in Table 4 is that there are no significant differences in the changes in the policy ratios across group of countries. Differences in the nominal rigidities, or the nature of the shock between ITers and NITers could also explain this pattern. In Table 3, reductions in the degree of price stickiness, γ, or the persistence of the markup shock, ρ_η, can potentially increase the two ratios with a relatively high probability. If the trade-off and policy ratios are high for NITers although there has been no change in the monetary policy regime this could be due to the fact that either price stickiness, or the persistence of markup shocks has fallen in the last decades in NIT economies more than in IT ones. We can entertain both hypotheses by looking at the CPI inflation and nominal interest rate persistence conditional on markup shocks in the two groups of countries for the two sample periods. Reductions in either price stickiness, or the persistence of the shock should generate reductions in both the conditional persistence of inflation and interest rate series. In particular, a fall in γ decreases inflation and interest rate persistence with probability 70% and a fall in the persistence of the shock reduces persistence in both series almost always (the probability here is 97% for inflation and 99% for the interest rate)[3]. The last columns of Table 4 report the autocorrelation coefficient for CPI inflation and interest rate conditional on markup shocks in the two groups of countries for the two sample periods. Price inflation persistence has fallen for all countries and with no significant differences between ITers and NITers suggesting the rejection of the hypothesis that price stickiness, or shock's persistence can account for increases in the trade-off and policy ratios in NITers. The pattern of the persistence of nominal interest rates conditional on markup shocks conforms this result. The persistence of the conditional interest rate series has remained almost unchanged in four countries (Australia, and Finland from the group of ITers and Belgium and Japan from the group of NITers) it has increased in seven countries (UK and Sweden from ITers and US, Spain, the Netherlands, Austria and Italy from NITers) and it has fallen for the remaining three countries. Overall, interest rate persistence has increased more in NITers than in ITers, this is clearly against the hypothesis of a relatively higher reduction in the shock persistence, or in the degree of nominal rigidities in NITers.

The message of the analysis is clear: in the majority of the industrialized countries there is a change in the relative weight that output gap and inflation stabilization receive in the objective function of central banks. Therefore, inflation targeting seems to matter, but it is difficult to reconcile this with the fact that some countries have announced an IT regime and

[3] Probabilities are calculated as in Section 5.

other countries have not. To conclude, one possibility is simply that announcing an inflation target does not matter, i.e., actions speak by themselves without words.

7 Why inflation targeting does not seem to matter?

In this section we search for possible explanations for the seeming irrelevance for the choice of monetary regime. We start by investigating the importance of markup shocks in explaining output and inflation fluctuations.

7.1 The importance of markup shocks

If markup shocks have a small predictive power for inflation and output variability this could explain why there are no differences in the macroeconomic performance of ITers and NITers. When the shocks that create a trade-off between inflation and output gap variability have little impact on output variability, policymakers in NIT regimes may not be very concerned for correcting for deviations of output from potential when setting monetary policy and their actions may be directly comparable to the actions of policymakers that operate under an IT regime. Existing evidence (See, e.g., Ireland (2004) and Smets and Wouters (2003, 2007)) suggest that markup shocks explain a significant fraction of the short-run forecast variance in inflation (between 50 and 70% of inflation variability at short horizons) in Euro area and the US. Since the methodology we used to estimate the shocks differs from that of the latter studies, we report in Table 4 the explanatory power of our identified markup shocks at long horizons (45 quarters).

The first two columns of Table 5 report the forecast error variance decomposition of output and inflation due to markup shocks for the pre IT period and the second two columns for the post IT period. Contrary to Ireland (2004) and Smets and Wouters (2003, 2007), we find that the relative contribution of markup shocks to output growth and inflation volatility in both samples and both groups of countries is quite moderate: it varies between 10% and 20%, with the exception of Canada for output and Sweden for inflation in the post 1990 era.

In addition, notice that the importance of markup shocks for output and inflation volatility in the pre 1990 sample does not seem to be different for the two groups of countries; hence the choice of the IT regime does not appear to be endogenous to the structure of the economy. That is, policymakers did not opt for an IT regime because the importance of markup shocks in their economies was smaller than in other economies. Perhaps, more importantly, the relevance of markup shocks for inflation and output growth variability does not seem to have changed dramatically in the two periods. The importance of markup shocks for inflation fluctuations increased in the post IT period for all countries except Austria and Finland. Their importance for output growth fluctuations increased substantially for Canada and for the US and Japan, while it has fallen significantly for Italy.

Since markup shocks are not the principle cause of business cycle fluctuation in NIT countries, it could very well be that central banks in NIT economies are not very concerned for correcting for deviations of output from potential when setting monetary policy. Consequently, they behave as inflation targeters and differences across the two groups of countries are likely to be small.

Table 5: Forecast error var decomposition

Country	*pre-IT sample*		*post-IT sample*	
IT	$var(y)$	$var(\pi)$	$var(y)$	$var(\pi)$
Australia	11.4	13.6	15.2	21.5
Canada	18.8	18.2	33.3	19.0
Finland	18.3	16.9	18.2	14.0
New Zealand	12.6	13.2	20.1	22.6
Sweden	11.7	16.7	13.2	32.4
UK	13.1	10.5	12.6	20.6
NIT	$var(y)$	$var(\pi)$	$var(y)$	$var(\pi)$
Austria	19.1	21.2	13.9	22.5
Belgium	14.2	14.9	11.3	15.8
France	14.5	15.0	13.9	16.2
Italy	20.4	13.1	10.0	20.2
Japan	13.4	16.1	21.5	21.3
Netherlands	16.9	10.9	12.5	14.9
Spain	17.9	20.4	18.1	25.0
US	9.5	8.4	18.1	13.6

7.2 The shift in the trade-off curve

Another possibility for why the adoption of IT does not seem to matter might be that it coincided with other changes that altered in more significant manner the structure of the economies. For example, Ceccheti and Ehrmann (2000) suggest that the environment of the 1990s was generally benevolent and that the choice of monetary policy strategy within a class of reasonable strategies might have been irrelevant. Ceccheti and Ehrmann' conjecture is confirmed in the unconditional statistics presented in Figure 2. However, our analysis can take us a step further since we can compute conditional variabilities to markup shocks for the two groups of countries. Figure 2 depicts the trade-off curve for ITers and NITers, conditional on markup shocks. The picture looks like a carbon copy of Figure 2. It shows a large reduction in conditional output and inflation volatility in the second sample for all countries. This reduction seems to have been more significant for ITers. However, controlling for initial performance, makes the differences between the two groups of countries statistically insignificant.

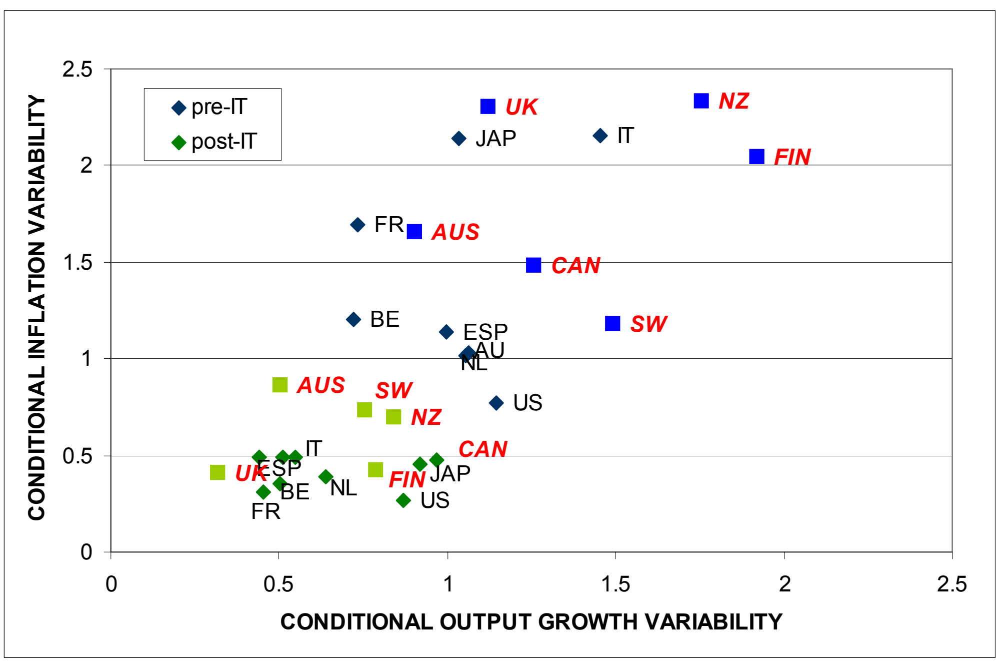


Figure 2: Inflation and output volatility conditional to markup shocks pre and post IT.

Since the figure undoubtedly suggests a remarkable shift of the trade-off curve in the last decade, there maybe another reason for why it is hard to find evidence in favor of IT: movements along the trade-off curve are small relative to the shift of this curve. The common and significant change appears to be far more important than the change in the monetary policy regime. Explaining this shift is far beyond the purpose of this exercise. Our analysis has excluded some candidates which could have been responsible for such shift such as changes in preferences (risk aversion and labor supply elasticity) and changes in the degree of nominal rigidities. Apart from the obvious explanation of a change in the variance of the markup shock, it is difficult to find a common explanation for this pattern.

7.3 Output versus output gap stabilization

In the analysis so far we have implicitly assumed that the objective function of the policymakers depends on variations of the output gap and inflation. However, it might well be that policymakers react to changes in output rather than the output gap. In this case, productivity and labor supply shocks also induce a trade off between output and inflation stabilization (see Table 2). Moreover, Erceg et al (2000) demonstrate that these shocks induce a variance trade off between inflation and the output gap in the presence of both price and nominal wage rigidities. Thus, the fact that inflation targeting does not make a difference between ITers and NITers for markup shocks, might be due to the fact that these shocks have relatively little predictive power compared with the other two supply shocks.

In this section, we identify a supply shock that moves output growth and inflation in opposite directions on impact and examine whether the behavior of the trade off ratio, defined as the ratio of the conditional output growth to inflation variability in response to a supply shock, is different between ITers and NITers in the two subsample periods. We present the estimated trade off ratios in Table 6.

Table 6 contains the same qualitative message with Table 4: both the trade off and the policy ratios conditional on supply shocks have increased similarly for both ITers and NITers in the post inflation targeting period. These shocks explain on average a higher percentage of output fluctuations, hence, the absence of differences between ITers and NITers is even more striking for these shocks.

Table 6: Trade-off and policy ratios / supply shock				
Country	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*
IT	**trade-off ratio**		**policy ratio**	
Australia	0.46	0.58	1.28	0.28
Canada	0.94	3.85	1.11	4.36
Finland	1.11	6.55	0.44	2.49
New Zealand	1.03	2.58	0.83	1.80
Sweden	2.31	2.81	0.91	1.77
UK	0.34	1.06	0.26	1.74
	pre-IT	*post-IT*	*pre-IT*	*post-IT*
NIT	**trade-off ratio**		**policy ratio**	
Austria	1.38	2.67	1.23	1.57
Belgium	0.42	4.18	0.83	1.80
France	0.28	2.79	0.58	4.31
Italy	4.35	7.35	1.35	8.37
Japan	0.29	6.58	0.33	0.35
Netherlands	1.89	3.66	1.69	1.25
Spain	0.68	1.06	0.81	4.00
US	3.37	8.04	2.25	10.2

7.4 Non trade off shocks

Before concluding, we investigate a last theoretical possibility: Although inflation targeting might not make a difference for shocks that create a variance trade off between output gap (or output) and inflation, it might be important for shocks that do not create such a trade off. In particular, adopting an inflation target might help reduce the volatility of monetary policy shocks, or improve the central banks control of inflation in response to demand shocks through anchoring inflation expectations.

To analyze such possibility we identify monetary policy shocks in our model as shocks that move output growth and inflation in the same direction and the nominal interest rate in the opposite direction on impact. Notice that since under flexible prices output does not react to such shocks, the conditional variance of the output gap is equal to the variance of output and proportional to the variance of the exogenous disturbance. Figure 3 plots the conditional inflation and output growth variability before (blue marks) and after (green marks) the adoption of IT in NIT (squares) and IT (diamonds) countries. If IT matters for monetary policy shocks, the conditional variability of inflation and output growth in response to these shocks should have reduced by much more in the post IT regime for ITers than for NITers.

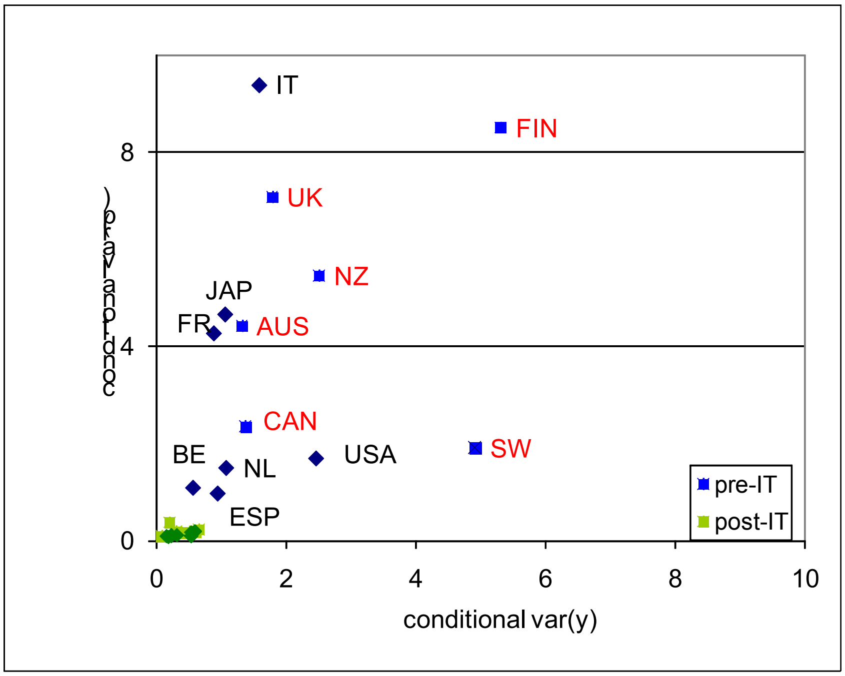


Figure 3: Inflation and output volatility conditional to monetary policy shocks pre and post IT.

Again the data suggest a substantial fall in these two variabilities, but no substantial differences between IT and NIT economies. Conditional inflation variability has fallen similarly and around 93% on average for the two groups of countries, while conditional output growth variability has fallen by 85% on average in IT economies and slightly less, 71% on average, in NIT countries. However, controlling for initial conditions, differences in performance due to the inflation targeting adoption are not significant for neither inflation, nor output growth. Thus, we are lead to conclude that announcing an inflation target does not result to any significant additional benefits either.

8 Conclusions

The paper examines the effects of the adoption of an IT regime conditioning on a particular shock that generates a trade off between inflation and output stabilization. The theory provides clear cut predictions that can be tested in the data. For any DSGE model with nominal rigidities a change in the relative weight that output and inflation stabilization have in the objective function of central banks implies movements along the output-inflation variability trade off curve towards points where inflation is less and output is more variable than it would otherwise have been. A movement of this type is present in the data but its size does not differ for IT and NIT economies. We show that this is not due to any change in consumer prefernces in NIT countries. In fact, our measure for the change in the policy stance, the policy ratio, defined as the ratio of conditional interest rate to inflation variability detects no differences between NIT and IT economies. We also show that the absence of strong evidence in favor of IT is not due to picking the wrong shock, i.e., markup shocks vs. other business cycle shocks, nor due to picking up the wrong criterion for monetary policy, i.e., output gap vs. output variability, since when we condition on supply shocks that create a trade off between output and inflation variability the trade off ratios for ITer and NITers increase again similarly in the post IT period. Since IT does not seem to invlove additional costs in face of shocks that create a trade off between output, or output gap and inflation variability, we finally examine, whether it involves additional benefits for demand shocks, that is shocks that move output and inflation in the same direction. Again, we fail to detect differences between IT and NIT economies when we condition our analysis on monetray policy shocks.

This analysis leads us to conclude that announcing an IT regime does not matter, while its adoption does actually bring about the predictive outcomes. We also show that the choice of regime might not seem to matter because the adoption of the IT regime has coincided with a considerable shift in the location of the trade off between output and inflation variability for all industrialized countries. Apart from discarding some obvious candidates for this shift, we leave this subject for future research.

Extensive recent research is focused on the sources of the so called "Great Moderation," the considerable fall in output and inflation variability after the 1980s in many industrilized countries. This literature has tried to address whether the change in unconditional variabilities was due to "good luck", or structural changes. Our analysis is related with this issue. Although in our exercise we compare the period before and after the 1990s and we condition on markup shocks. We find evidence in favor of a change in the relative weight that monetary policy gives to inflation fluctuations in the last two decades for most countries in our sample. Nevertheless, this change cannot explain the remarkable decrease of both inflation and output variability conditional on markup shocks. Thus, since no other change in the structure of the economy can explain this pattern, "good luck" (i.e., a reduction in the size of markup shocks for all countries) is the only alternative left to explain the empirical pattern.

Appendix A

The appendix presents provides a brief description of the data used for each of the countries considered in the sample.

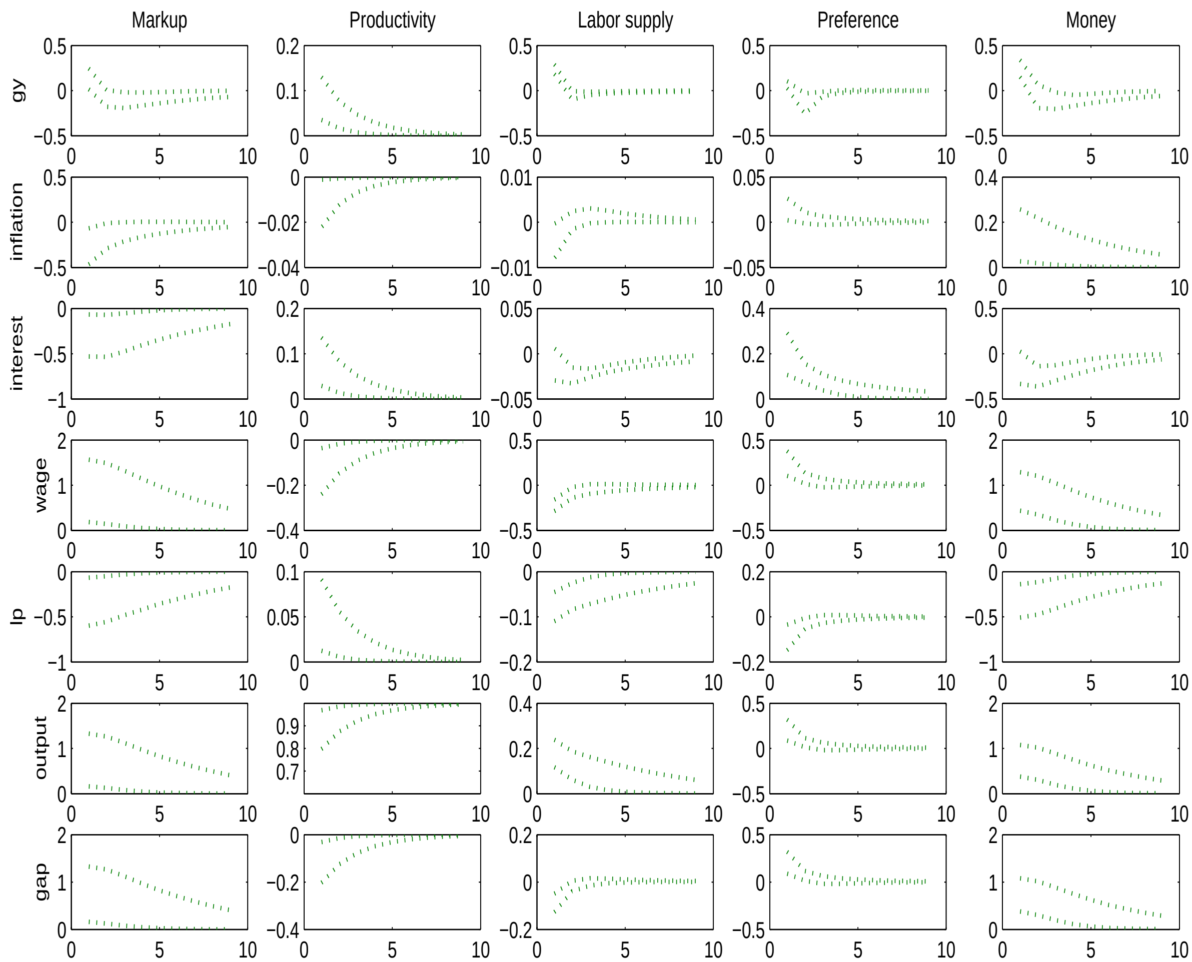
Variable	Source	Definition
RGDP	OECD	Real Gross Domestic Product
HOURS	OECD/IFS	Total Hours Worked per employee in the Business Sector
TOTEMP	OECD/IFS	Total employment
WAGES	OECD/IFS	Wages and Salaries of employees (net wage + social security contributions)
COMP	OECD	net wage + social security contributions paid by employees and employers
INT	IFS	short term nominal (money market) rate
CPI	IFS/OECD	consumer price index

Appendix B

	Parameter ranges	
β	discount factor	$1.04^{-1/4}$
σ	risk aversion coefficient	[1,4]
ϕ	steady state level of hours	[0.6,0.8]
$1-\alpha$	labor share	[0.6,0.8]
z	steady state growth rate	[1.004,1.0055]
λ_p	steady state markup	[0.0,0.25]
γ	degree of price stickiness	[0.4,0.9]
ρ_R	lagged interest rate coefficient	[0.2,0.9]
ρ_π	inflation coefficient on interest rate rule	[1.1,5.0]
ρ_x	output gap coefficient on interest rate rule	[0.0,1.0]
ρ_{gy}	output growth coefficient on interest rate rule	[0.0,1.0]
ϱ	persistence of shocks	[0,0.97]

Appendix C

The figure below presents 68-percent confidence bands for the responses of the variables in Table 2 after a markup (first column), a productivity (second column), a labor supply (third column), a preference (forth column) and a monetary policy shock (last column).



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