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To Target Inflation or Not to Target: A Conditional Answer

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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 the conditional dynamics of inflation and output growth in response to markup shocks for 14 industrialized countries. Markup shocks create a tradeoff between output gap and inflation stabilization purposes and, in theory, conditional output growth variability should increase relative to inflation variability after the adoption of an inflation target. The data suggests a substantial increase for both countries that adopted an inflation target and countries that did not. No structural change can explain this pattern, except for changes in the conduct of monetary policy of both groups. The conclusion remains when we condition on other shocks.

JEL classification: E31, E42, E58

Keywords: inflation targeting, markup shocks, new policy tradeoff, tradeoff ratio, policy ratio, conditional moments.

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1 Introduction

The issue of whether inflation targeting (henceforth, IT) improves economic performance or not has attracted a lot of attention in the early 1990s when, following the example of New Zealand, many industrial and emerging-economy countries have explicitly adopted an IT regime. The shift of policy focus towards IT has stimulated a vast empirical literature and, since the evidence is controversial, a lively debate on the issue ensued.

Earlier contributions advocating IT are numerous. For IT countries, Bernanke et al. (1999) find no increases in the size of output fluctuations relative to a pre-IT regime, while Neumann and von Hagen (2002) report reductions in the level and the volatility of inflation and of the interest rate; Corbo et al. (2002) document a fall in the "sacrifice ratio", the cumulative output loss arising from a permanent reduction in inflation; and Levin et al. (2004) find that long-run inflation expectations are better anchored and inflation persistence reduced. Ball and Sheridan (2003), on the other hand, comparing seven OECD countries that adopted IT to thirteen that did not, find that differences in performance are explained by the fact that targeters performed worse than non-targeters in the 1980s, and that there is regression toward the mean. Overall, the current state of the debate is well summarized in Mishkin and Schmidt-Hebbel (2007): depending on the sample, the estimation techniques and the measures of economic performance one uses, it is possible to find evidence in favor, or against IT.

With the exception of Mishkin and Schmidt-Hebbel (2007), all the above mentioned studies use unconditional estimates of the volatility of inflation, output, and interest rates to draw conclusions. However, unconditional analyses may not be the best vehicle to evaluate macroeconomic performance since many shocks need not create a tradeoff between stabilizing output and stabilizing inflation. Furthermore, since many factors have changed over the last 20 years, unconditional analyses cannot pin down the sources of changes.

In this paper we analyze the performance of IT vs. non-IT countries by looking at the dynamics of output, inflation and the interest rate, conditional on markup shocks. Markup shocks capture shifts in the degree of the distortion of the production process and are a standard feature of models used in policy discussions (see, for example, Clarida, Gali, and Gertler (2002), Steinsson (2003), Ball, Mankiw, and Reis (2005)). We focus on markup shocks for several reasons. First, markup shocks induce a tradeoff between stabilizing inflation and stabilizing the output gap since increases in the markup increase prices and reduce output, decreasing the output gap. John Taylor has characterized this short run tradeoff as the *new policy tradeoff*.

Other important cyclical shocks, such as technology or investment-specific shocks, do not produce such a tradeoff, unless wages are assumed to be sticky (see Blanchard (1997) and Erceg et al. (1998)). Second, markup shocks are apparently very important in explaining the short and medium term variability in inflation in the US and the Euro area (see, e.g., Smets and Wouters (2003, 2007) and Ireland (2004)). Therefore, they may be not only qualitatively but also quantitatively important to separate the two set of countries. Third, since markup shocks do not affect the efficient level of output, the analysis can be conducted without resorting to controversial output gap measures. Finally, markup shocks can help us to understand how changes in the central bank's preferences affect the *new policy tradeoff*. When the central bank targets inflation the ratio of output variability to inflation variability, induced by markup shocks, should be higher in IT than in non-IT countries.

To identify markup shocks in the data we follow Canova and Paustian (2008) and impose robust (sign) restrictions obtained from a standard New Keynesian model on a VAR composed of the growth rate of GDP, CPI inflation, real wage, interest rates and labor productivity. It turns out that in the theory, negative markup shocks robustly increase output growth and real wages and robustly reduce the short-term interest rate and inflation, at least contemporaneously. Since total factor productivity shocks in environments with flexible prices could also produce a similar pattern, we impose the additional restriction that the median contemporaneous reaction of real wages exceeds the median response of labor productivity. Gambetti and Pappa (2007) showed that these identifying restrictions are not model specific and hold for more general setups with additional real and nominal frictions.

We divide the countries we consider into two groups, examine the conditional dynamics of output, inflation and the nominal interest rate for targeters and non-targeters in two sample periods - before and after the adoption of IT - and evaluate macroeconomic performance using the "tradeoff ratio", i.e. the ratio of conditional volatility of output growth to the conditional volatility of inflation induced by markup shocks for each country and in the two sub periods. We complement this evidence using the "policy ratio", i.e. the ratio of the conditional volatility of the nominal interest rate to the volatility of inflation, which captures the strength with which central banks react to inflationary pressures stemming from markup shocks.

In theory, the tradeoff ratio and the policy ratio should be larger for IT countries. In the data, we find that after the adoption of an IT regime IT countries have experienced an increase in the tradeoff ratio. However, the increase is shared both by IT and non-IT countries and is similar in magnitude. Since the policy ratio also increased, on average, in the two groups of countries and joint increases in the two ratios are hard to generate by other structural changes, we conclude that non-inflation targeters are in reality "covert inflation targeters", i.e. inflation stabilization matters more in the objective function of the central banks of *all* the countries. The fact that some of them has announced it and some of them did not, does not seem to matter.

We examine alternative explanations of the evidence. In particular, we examine whether similarities across groups of countries could be due to the fact that our shocks explain little of the variability of output and inflation; whether concerns about output growth rather the output gap matter; and whether there are indirect gains from IT which our empirical analysis has not quantified. We find that none of these explanations seem to change the basic result: the macro performance of IT and non-IT industrialized countries is similar.

Our analysis is related to those conducted in the context of the Great Moderation (see, McConnell and Perez Quiroz, (2000), Cogley and Sargent (2001, 2005), Sims and Zha (2006), Stock y Watson (2003), and Gambetti, et.al. (2005), among others). As in that literature we are interested in quantifying the impact of structural changes on the dynamics of output and inflation variability. Relative to that literature, we find considerable evidence of changes in the responsiveness of interest rates to inflation across countries. However, we also stress that a more benign macroeconomic environment (good luck) may have considerably reduced the potential gains of an IT regime.

The rest of the paper is organized as follows. Section 2 describes the countries, samples and presents unconditional statistics. Section 3 describes the methodology for extracting markup shocks; section 4 presents theoretical predictions and section 5 the empirical findings. Section 6 examines alternative explanations for the evidence and section 7 concludes. Various appendices describe the data, the parameter ranges used in the numerical exercise, simulation results and estimation details.

2 The choice of regime and some preliminary evidence

For the choice of the countries in the sample and the selection of IT and non-IT periods, we follow Ball and Sheridan (2003). We consider all OECD members as of 1990 and exclude countries that i) lacked independent currency before the Euro (i.e., Luxemburg), ii) have experienced high inflation rates (i.e., Greece, Iceland, and Turkey), iii) do not have real wage data (Denmark, Portugal and Switzerland) or discontinuous data series (Ireland and Norway).

We also exclude Germany, as the German unification makes the experience problematic. As a result, we are left with 14 countries, six adopted an IT and the other eight did not.

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
Non IT		
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

For targeters we examine only periods of constant inflation targeting, i.e. where the target is unchanged, or varies within a specific range. The targeting period starts at the first full quarter where a specific inflation target or target range was implemented. We chose to exclude transitional targeting periods to make the comparison sharper but none of the results we present depend on including or excluding them [1]. The targeting period lasts through 2007 for all IT countries, except Finland which ends in 1998.

As in Ball and Sheridan (2003), we start the post-IT period for non-IT countries at the mean of the start dates for targeters, 1994:1. Our post targeting period ends in 2007:1 for both

[1] For that reason Spain is not classified as IT, since its target fell throughout 1994:1 and 1998:4.

European and non-European countries[2]. Table 1 compactly presents this information. Data sources are in the appendix.

Unconditional statistics

We first examine the unconditional volatility of CPI inflation and output growth for the 14 countries in our sample. In Figure 1 we plot the relationship between CPI inflation volatility and output growth volatility for the two groups of countries before (blue marks) and after (green marks) the adoption of IT. Countries that adopted an IT appear as squares and non-IT countries as diamonds.

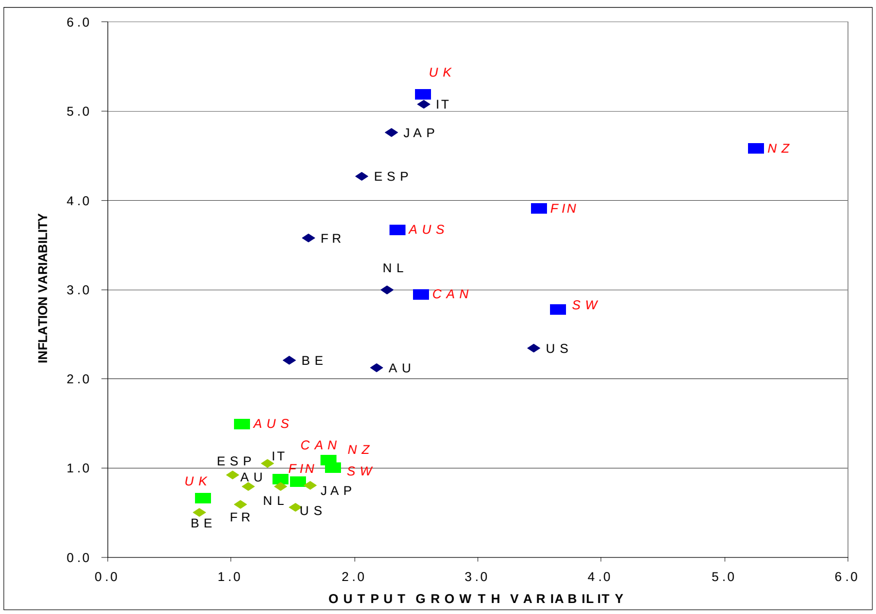


Figure 1: Unconditional inflation and output variability, pre and post IT.

The picture confirms previous findings. First, inflation targeting has reduced inflation volatility while output volatility has not worsened - if anything, it has improved after the adoption of the IT regime. Second, the variability of inflation and output has been reduced in both groups of countries in the second sample. Third, in the pre IT period, and with the exception of US and Italy, all non-IT countries experienced smaller output variability than IT

[2] Ball and Sheridan's sample stops at 1998 for European countries. Since there are no qualitative differences in the pattern of estimates between 1994-98 and 1994-2007 and since there is little evidence that the introduction of the Euro produced a structural break in the European economies (See, Canova, Cicarelli and Otrega (2006)), we have decided to base our analysis on the longer sample.

countries. The estimated variabilities for targeters and non-targeters are roughly similar in the post IT period. Thus, controlling for regression to the mean, Figure 1 fails to show any advantage for targeters.

If welfare depends negatively on output and inflation variability, as is usually the case in micro founded DSGE models with nominal rigidities, one must conclude that all the countries in the sample have experienced welfare gains. But, how much of this improvement can be attributed to monetary policy? Figure 1 cannot help in answering this question since changes in economic structure and in shocks' configuration could have also induced the observed changes. To isolate the role that the choice of the monetary regime has, one needs to examine the volatility of output, inflation and the interest rate in response to shocks which induce a relevant tradeoff and isolate changes in policy from other changes.

As we have mentioned, and unlike demand shocks, markup shocks do create a tradeoff between output gap and inflation stabilization. Other supply shocks, such as technology, or labor supply shocks, may also generate such a tradeoff but only in the presence of sticky wages (see, e.g. Blanchard (1997) and Erceg et al. (2000)). However, while markup shocks leave potential output unaffected, the latter shocks move both actual and potential output, making imperative to use controversial measures of the output gap in the analysis. Furthermore, if we think of policymakers as choosing a point on an output-inflation variability tradeoff, and we represent inflation targeting as a movement along this frontier, where conditional inflation variability is lower and conditional output variability higher than it otherwise would have been, the new policy tradeoff is well defined for markup shocks, making a comparison between IT and non-IT countries possible.

3 Extracting markup shocks: The methodology

In order to extract markup shocks from the data we use the methodology of Canova and Paustian (2008). The exercise consists of four steps:

1. We employ a general framework to study the theoretical effects of markup 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 are unique.

4. We use a subset of these restrictions to extract markup shocks in the data.

Step 1: The New Keynesian model

We employ a version of the New Keynesian model with sticky prices and markup shocks used by Ireland (2004). We study five disturbances: markup shocks, total factor productivity, labor supply, preference and monetary policy shocks. The model economy consists of a representative household, a representative final good producer, a continuum 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.

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:

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

λ_{pt} measures the time varying elasticity of demand for each intermediate good and represents a shock to the markup. Profits are maximized by choosing: $y_t^{id} = \left(\frac{P_t^i}{P_t}\right)^{-\frac{1+\lambda_{pt}}{\lambda_{pt}}} Y_t$. The zero profits condition implies that the price index is : $P_t = \left[\int_0^1 P_t^{i-\frac{1}{\lambda_{pt}}} di \right]^{-\lambda_{pt}}$.

C. Intermediate good firms

Each intermediate firm i hires N_t^i units of labor and produces output, y_t^i, according to:

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

The logarithm of the 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. Profit maximization implies:

$$\mathrm{E}_t \sum_{\tau=t}^{\infty} \gamma^{\tau-t} Q_{t,\tau} y_\tau^{id} [P_t^i - (1-\lambda_{p\tau}) V_{N\tau}] = 0, \tag{3.4}$$

where V_{Nt} is the unit labor cost 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. Its solution 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: $N_t^i = \left(\frac{Y_t}{Z_t}\right)^{\frac{1}{1-\alpha}} \int_0^1 \left(\frac{P_t^i}{P_t}\right)^{-\frac{1+\lambda_{pt}}{\lambda_{pt}(1-\alpha)}} di.$

D. Equilibrium

Market clearing in the goods and bonds market requires: $Y_t = C_t$ and $B_t = 0$.

E. 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. Let lower case letters with hats, denote percentage deviations of this variables from its steady state level. The log-linearized version of the model is briefly summarized below. The *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 $\Theta_n = \frac{1-\xi}{\xi} + \frac{N(1-\alpha)}{1-\alpha+\alpha N}$.

The variable $\widehat{x}_t$ is the output gap defined as the deviation of the sticky price level of output from its efficient level, i.e., as the level that would prevail under flexible prices and in the absence of markup shocks. In equilibrium the output gap is equal to: $\widehat{x}_t = \widehat{y}_t + \frac{N(1-\alpha)}{1-\alpha+\alpha N}\widehat{\varepsilon}_t^n$. The *supply side* is described by:

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

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

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

Equation (3.6) links inflation to the marginal costs, $\widehat{mc}_t = \widehat{w}_t + \frac{\alpha}{1-\alpha}\widehat{y}_t$. The slope parameter $\kappa = \frac{(1-\alpha)\lambda_p}{\alpha+\lambda_p}\kappa_p$, where $\kappa_p = \frac{(1-\beta\gamma)(1-\gamma)}{\gamma}$, depends on γ, the probability that firms face for not being able to change their price. The shock, $\widehat{\eta}_t^p = \kappa_p(\lambda_{pt} - \lambda_p)$ is the markup shock and in its absence, (3.5) and (3.6) imply that the central bank can replicate the efficient allocation by targeting inflation. Variations in the markup generate a tradeoff for the monetary authority, since they make it impossible to attain simultaneously inflation and output gap stabilization. Equations (3.7) and (3.8) define the growth rate of output and labor productivity, respectively.

F. Monetary policy

The monetary policy rule is represented by a generalized Taylor (1993) rule. Monetary policy is assumed to react to current inflation, output gap and output growth fluctuations:

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

where $\widehat{\varepsilon}_t^R$ is a monetary policy shock and ρ_R is a smoothing parameter.

G. Shocks

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. V is stationary, zero-mean, white noise vector and the roots of $\boldsymbol{\varrho}$ are assumed to be less than one in modulus (with $\boldsymbol{\varrho}(\mathbf{1},\mathbf{1}) = \mathbf{1}$).

Step 2: Robust restrictions

The second step of our procedure is designed to take into consideration the uncertainty involved in calibration exercises. An implication is called robust if it holds independently of parameterization used. For example, if inflation falls and the output gap increases in response to markup shocks, regardless of the parameter values, we call this implication robust. Robustness is not generic since many dynamic properties are sensitive to the exact parameterization and to specific features added, or subtracted to the model. For example, the sign of the response of wages to TFP shocks may depend on the degree of price stickiness. Our method seeks robust dynamic implication in response to the shocks which can then be used as identifying device to extract them from the data. Obviously, there may be disturbances which do not generate robust implications. Also, some shocks may share the same implications. For example, output increases and inflation falls in response to both TFP and markup shocks. For that reason it is important to establish that none of the other shocks in the model can generate the same restrictions we use to identify 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 i. We draw $\theta_i^l, i = 1, \ldots, N$ from Θ_i, construct $h(y_t(\theta^l|x_t))$ for each draw $l = 1, \ldots, L$ and order them. 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 let $\theta = (\beta, \theta_2)$, 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.

Table 2: Identification Restrictions

shocks\variables	$\widehat{g}_{yt}$	$\widehat{\pi}_t$	$\widehat{r}_t$	$\widehat{w}_t$	$\widehat{w}_t, \widehat{lp}_t$	$\widehat{y}_t$	$\widehat{x}_t$
markup	>0	<0	<0	>0	$\widehat{w}_t > \widehat{lp}_t$	>0	>0
TFP	$> \mathbf{0}$	$< \mathbf{0}$	>0 NK <0 FP	<0 NK >0 FP	$\widehat{w}_t < \widehat{lp}_t$ NK $\widehat{w}_t \leq \widehat{lp}_t$ FP	>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 summarize the qualitative features of the responses of the variables of interest to the five shocks in the impact period in Table 2. Appendix C plots pointwise 68-percent probability bands for the responses of these variables to the five shocks.

We denote by NK the model presented in equations (3.5) to (3.9) and FP the model under flexible prices. To ease comparisons we have normalized responses so that all the shocks increase output growth on impact. Markup shocks (see first row of Table 2) produce robust positive contemporaneous comovements with output, output growth, output gap and real wages and negative contemporaneous comovements with the nominal interest rate and inflation.

Step 3: Excluding other shock candidates

In order to ensure that the shock we seek to identify is not a combination of the other shocks, we examine the responses of the five variables of interest to the other shocks. As it is apparent from the remaining rows of Table 2, no other shocks can produce the set of restrictions markup shocks produce. In particular, the sign of the impact effect of the real wage, the nominal interest rate and inflation to the exogenous disturbances is 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 FP model and markup shocks in the NK model. 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 be used to differentiate the two shocks, but since the output gap is unobservable, the restrictions on the real wage and labor productivity are the only plausible options left for identification purposes.

Thus, the subset of the restrictions we use to identify markup shocks 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 in the model is about 10%. Moreover, Gambetti and Pappa (2007) show that these restrictions hold in more general environments with capital accumulation, 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.

Step 4: Implementing the restrictions in a VAR

For each country we let, Y_t include 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 the representation:

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

where $A(L) = I - A_1L - ... - A_pL^p$, L is the lag operator, $p = 2$ for all countries and ϵ_t is a Gaussian white noise process with covariance matrix Σ. Let P be 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 unit vector such that the implied response functions $A(L)^{-1}PH$ satisfy the identification restrictions of Table 2. We restrict the responses only in the impact period.

To estimate the structural model, we assume a diffuse prior for (A, Σ, H), $A = [A_1, ..., A_p]$ as in Uhlig (2005). Given that the posterior density for A, Σ, H is Normal-Wishart multiplied by an indicator function, taking the value of one if the restrictions are satisfied and zero otherwise, we compute responses drawing (A, Σ) from the Normal-Wishart and H from a uniform distribution over the unit-sphere. When the restrictions are satisfied, we retain the responses and calculate the statistics of interest. We draw until 1000 candidates are retained.

We consider two measures able to capture changes in the monetary policy regime: the tradeoff ratio, which measures the movements along the tradeoff curve, and the policy ratio, which portrays the extent to which policy preferences were shifted towards inflation stabilization. The "tradeoff" ratio is calculated as the ratio between the standard deviation of output growth to the standard deviation of inflation; the "policy" ratio as the ratio of the standard deviation of the nominal interest rate to the standard deviation of inflation, both conditional on markup shocks.

4 Theoretical predictions

To have a way to interpret the empirical results, it is worth investigating how structural changes in the theoretical economy affect the two ratios we consider. To do this we need to analyze which structural parameters affect conditional volatilities in response to markup shocks. Unfortunately, the effect of parameter changes on the magnitude of the tradeoff and the policy ratio is not independent of the parameterization of the model. For example, consider equations (3.5), (3.6) and (3.9) when all disturbances but the markup shock are set to zero and assume that $\rho_R = \rho_{gy} = 0$. Then, the equilibrium conditions under (3.9) are:

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

Using the method of undetermined coefficients, we can write the solution as:

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

where

$$\begin{aligned} a_1 &= -\frac{\rho_\pi - \rho_\eta}{(\rho_\pi - \rho_\eta)\kappa_x - ((1-\rho_\eta)\omega\xi - \rho_x)(1-\beta\rho_\eta)} < 0 \\ \text{and } b_1 &= \frac{\rho_x - (1-\rho_\eta)\omega\xi}{(\rho_\pi - \rho_\eta)\kappa_x - ((1-\rho_\eta)\omega\xi - \rho_x)(1-\beta\rho_\eta)} > 0 \end{aligned}$$

The tradeoff ratio is:

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

where ρ_η and $Var(\widehat{v}_t^p)$ are the persistence and the variance of the markup shock, respectively. Using the solution and (3.9), it follows that $\widehat{r}_t = (\rho_\pi b_1 + \rho_x a_1)\widehat{\eta}_t^p + \rho_\pi b_2 + \rho_x a_2$. As a result, the policy ratio is:

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

Clearly, $\frac{\partial TOR}{\partial \rho_\pi} > 0$, $\frac{\partial PR}{\partial \rho_\pi} > 0$ and $\frac{\partial TOR}{\partial \rho_x} < 0$, but the sign of $\frac{\partial PR}{\partial \rho_x}$, or $\frac{\partial TOR}{\partial \rho_\eta}$ and $\frac{\partial PR}{\partial \rho_\eta}$ is, in general, ambiguous.

To robustly check the effect of structural changes in the tradeoff and policy ratios, we calculate the probability that increases in one parameter jointly increase these ratios by drawing values for the remaining $(i-1)$ parameters of the model from an admissible range (see table 3) 10000 times and checking the sign of the derivative of the two ratios with respect to the parameter of interest in each draw. Table 3 reports these probabilities for all the parameters entering the two ratios.

Table 3: Parameter changes and probabilities of ↑ TOR and ↑ PR

parameters	ranges	prob(↑ TOR & ↑ PR)
γ	[0.4,0.9]	52%
σ	[1,4]	*29%*
ϕ	[0.6,0.8]	52%
α	[0.2,0.4]	51%
ρ_π	[1,5]	*90%*
ρ_{gy}	[0,1]	40%
ρ_x	[0,1]	*14%*
ρ_η	[0,0.95]	34%

If inflation targeting involves an increase in the weight that inflation variability receives in the central banks' objective, such a policy change can be represented by an increase in ρ_π, or a reduction in ρ_x, or in ρ_{gy}. Table 3 indicates that the tradeoff and the policy ratio are more likely to increase for countries that adopted an IT regime if this change involved increases in ρ_π, and that changes in risk aversion, σ, for example, due to financial market integration, or deregulation, could not have induced similar movements in the two ratios. While other factors could have also increased both ratios, the probability of such a joint event is low and never larger than the probability of flipping a coin. Hence, at least probabilistically, the theory implies that only changes in the responsiveness of interest rates to inflation fluctuations could have simultaneously increased the two ratios for a wide range of parameterization of the model.

5 Does inflation targeting matter? The evidence

The first two columns of Table 4 report the tradeoff ratios for the two sample periods for the two groups of countries. The emergence of a new policy tradeoff is evident in all IT countries but Sweden and, with the exception of Australia, IT countries have experienced significant increases in this ratio. However, the increase is also shared by non-IT countries. The tradeoff ratio drastically increases for Japan and France, while for the US and Belgium the magnitude of the changes is comparable with those of the IT countries. As a result, the changes in the tradeoff ratio are actually higher, on average, for non-IT than for IT countries. Differences across groups are, however, statistically insignificant.

To see whether changes in policy go hand in hand with changes in the tradeoff ratio, the third and fourth columns of Table 4 report the values of the "policy" ratio in the two sub periods for the two groups. The ratio has increased significantly for all countries in the sample, except Australia, Japan and the Netherlands and the difference in the changes between IT and non-IT economies is insignificant. Japan is special, since the zero bound restriction on the interest rate held back the variability of the policy instrument, whereas the case of Australia is hard to explain, since the policy ratio falls rather than increase. Overall, the policy ratio has changed also in non-IT countries .

What can account for this pattern? In theory, increases in the coefficient of relative risk aversion, σ, increase the policy ratio but make the tradeoff and the policy ratio move in opposite directions. This is because increases in the relative risk aversion coefficient reduce the responsiveness of output to changes in the interest rate, therefore decreasing output variability and the tradeoff ratio. At the same time, since they limit the effects of markup shocks on demand and, hence, on inflation, the policy ratio must increase. Thus, changes in the preferences of the agents in non-IT countries, could be responsible for the similarities between non-IT and IT if increases in the tradeoff ratio are accompanied by decreases in the policy ratio. As table 4 suggest, this is the case only for the Netherlands.

Table 4: tradeoff, policy ratios and persistence								
Country	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*
IT	**tradeoff 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
IT average	0.73 (0.6)	2.03 (1.7)	0.65 (0.3)	1.22 (0.7)	0.93 (0.03)	0.82 (0.07)	0.87 (0.07)	0.91 (0.04)
	pre-IT	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*
non-IT	**tradeoff 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
non-IT average	0.76 (0.7)	3.08 (2.8)	1.07 (0.7)	2.36 (2.2)	0.96 (0.02)	0.87 (0.07)	0.89 (0.04)	0.94 (0.03)

Standard deviations are in parenthesis

Differences in nominal rigidities or in the nature of the shock across inflation and non-inflation targeters could also matter. Theoretically, reductions in the degree of price stickiness, γ, or the persistence of the markup shock, ρ_η, can increase the two ratios with a relatively high probability. They also induce reductions in the conditional persistence of inflation and the interest rate: in the model a fall in γ decreases inflation and interest rate persistence with 70% probability and a fall in the persistence of the shock always reduces persistence in both series (the probability of a reduction is 97% for inflation and 99% for the interest rate). Could differential changes in these two parameters across the two groups of countries be responsible for the fact that the performance of IT and non-IT countries is similar? The last four columns of Table 4 report the conditional AR(1) coefficients of CPI inflation and interest rate in the two groups of countries for the two sub periods. Inflation persistence dropped in all countries in the second subsample. Targeters experienced a larger decrease in inflation persistence relative to non-targeters, but difference-in-differences estimates (see Appendix D, Panel I) are imprecise and indicate that differences are insignificant. Changes in the conditional persistence of nominal interest rates are more heterogeneous - persistence has remained almost unchanged in Australia, and Finland (which are ITs) and Belgium and Japan (which are non-IT) it has increased in seven countries (UK and Sweden from IT and US, Spain, the Netherlands, Austria and Italy from non-IT) and it has fallen for the remaining three countries - but, overall inconsistent with the idea that non-IT economies experienced a relatively larger reduction in the shock persistence or in the degree of nominal rigidities.

Hence, in the majority of the countries, the relative weight that output gap and inflation variability receive in the objective function of central banks must have changed. This conclusion, however, is hard to reconcile with the fact that some countries have announced an IT regime and other countries have not, unless actions speak by themselves and announcing an inflation target does not matter.

6 Why inflation targeting does not seem to matter?

We examine three potential explanations for why IT may not matter for the sample of countries we consider.

6.1 The importance of markup shocks and policy objectives

If markup shocks explain a small fraction of the variability of inflation and output variability, little differences in the macroeconomic performance of ITers and non-ITers should be recorded. In this situation, in fact, policymakers in non-IT countries may not be very concerned for correcting for deviations of output from potential, making the policy outcome similar to the one of IT countries. Existing evidence suggest that markup shocks maybe important in the Euro area and the US (see, e.g., Ireland (2004) and Smets and Wouters (2003, 2007)). But is this the case for the countries in our sample? Table 5 reports the explanatory power of our identified markup shocks for these two variables at long horizons (45 quarters) for the two groups of countries.

Table 5: Forecast error variance 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
IT average	14.3 (0.03)	14.8 (0.03)	18.7 (0.08)	21.7 (0.06)
non-IT	$var(y)$	$var(\pi)$	$var(y)$	$var(\pi)$
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
non-IT average	15.7 (0.04)	14.9 (0.04)	14.9 (0.04)	18.7 (0.04)

Standard deviations are in parenthesis

The table makes it clear that the relative contribution of markup shocks to output growth and inflation variability in both samples and both groups of countries is moderate and varies between 10% and 20%. Exceptions are Canada for output, and Sweden for inflation in the post 1990 era. Perhaps more importantly, the importance of markup shocks for inflation and output growth variability does not seem to have changed across sub periods. Markup shocks matter more for inflation fluctuations in the post IT period for all countries, except Austria and Finland; their importance for output growth fluctuations increased for Canada, the US and Japan, and fell significantly for Italy.

Interestingly, since the importance of markup shocks for output and inflation volatility in the pre 1990 sample is similar in the two groups of countries, the choice of the IT regime does not appear to be endogenous to the structure of the economy. In other words, policymakers did not choose an IT regime because markup shocks were less important in their economies.

The evidence of table 5 does not allow us to exclude the possibility that central banks in non-IT economies may not have been very concerned for correcting for deviations of output from potential. However, we can gather additional evidence on the issue if we are willing to assume that output growth matters for policy decisions (rather than the output gap). In this case, in fact, TFP and labor supply shocks may also induce a tradeoff between output and inflation stabilization (see Table 2). Therefore, by examining how the ratios behave in response to these shocks, one can draw firmer conclusions one way, or another.

Rather than separately identifying TPF and labor supply shocks, which is hard to do in the context of the model, since the implications they produce are not necessarily robust, we identify a generic supply shock, imposing the restriction that it moves output growth and inflation in opposite directions on impact, and examine whether the conclusions we have reached change, conditional on this generic shock.

Table 6, which contains the estimated tradeoff and policy ratios, has the same qualitative message as Table 4: both the tradeoff and the policy ratios conditional on supply shocks have increased across sub periods, and the increase is similar for both IT and non-IT economies. Given that these generic supply shocks explain a higher percentage of output and inflation fluctuations (on average 40% of output and 30% of inflation fluctuations), failure to find any difference between ITers and non-ITers is even more striking in this case.

Table 6: tradeoff and policy ratios / supply shock				
Country	*pre-IT*	*post-IT*	*pre-IT*	*post-IT*
IT	**tradeoff 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
IT average	1.03 (0.7)	2.9 (2.15)	0.8 (0.4)	2.07 (1.3)
	pre-IT	*post-IT*	*pre-IT*	*post-IT*
non-IT	**tradeoff 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
non-IT average	1.58 (1.5)	4.54 (2.5)	1.14 (0.6)	3.98 (3.6)

Standard deviations are in parenthesis

6.2 Other gains from IT

Many advocates of inflation targeting argue that inflation targeting can actually make it easier to reduce output fluctuations since an effective nominal anchor enables a central bank to be more aggressive in responding to negative demand shocks. Similarly, adopting an inflation target might help reduce the volatility of monetary policy shocks (See, e.g., Mishkin (2004)). As a result, although inflation targeting might not make a difference for shocks that create a new policy tradeoff, it might be important for responding to shocks that do not create such a tradeoff.

To analyze such possibility we identify monetary policy shocks as the disturbances that move output growth and inflation in the same direction and the nominal interest rate in the opposite direction on impact. Figure 2 plots the conditional variability of inflation and output growth before (blue marks) and after (green marks) the adoption of IT for non-IT (squares) and for IT (diamonds) countries. If IT matters, the conditional variability of inflation and output growth in response to monetary policy shocks must fall relatively more for targeters in the post IT regime.

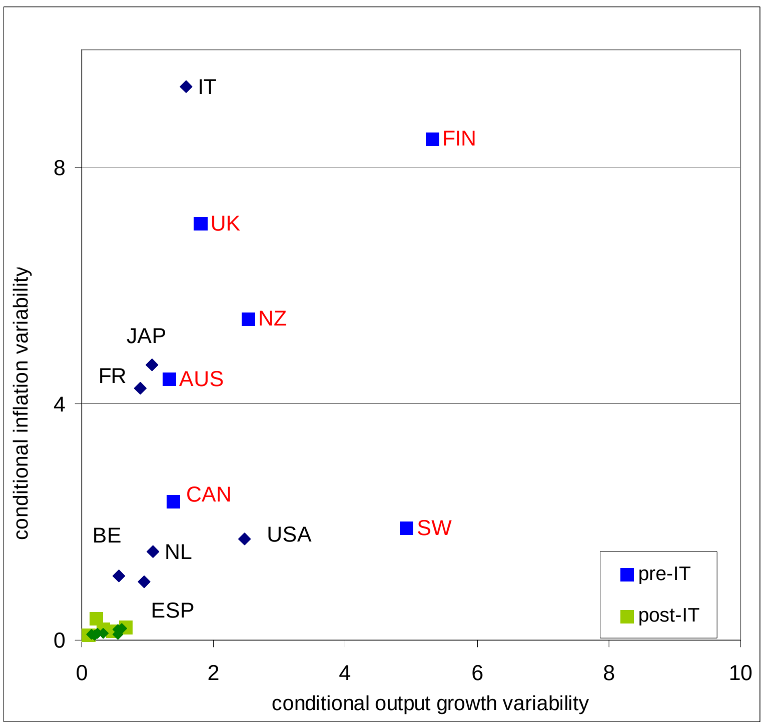


Figure 2: Inflation and output variability conditional to monetary policy shocks, pre and post IT.

Both variabilities clearly fall, but we detect no statistical differences between IT and non-IT countries. The fall in inflation variability is around 93% on average for both groups of countries, while output growth variability has fallen by 85% on average in IT countries and 71% on average in non-IT countries. DID estimates (See Panel IV of Appendix D) suggest that inflation targeting raises significantly the standard deviation of inflation conditional on monetary policy shocks. This result could be spurious, given that the number of regressions we run might produce some type I errors, i.e., observing a statistical difference when in truth there is none . In general, inflation targeting does not result in measureable benefits when monetary policy shocks hit the economy.

6.3 Shifts in the tradeoff curve

Another possibility for why the adoption of IT does not seem to matter is that it coincided with other changes that more significantly altered 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. Their conjecture is confirmed by the unconditional analysis of Figure 1. But is it true also for a conditional analysis? Figure 3, which depicts the tradeoff curve for ITers and non-ITers, conditional on markup shocks, closely replicates Figure 1: there is a large reduction in the conditional variability of output and inflation in the second sample for all countries. DID estimates suggest negligible gains in terms of output variability reduction and, if anything, a negative effect of IT in conditional inflation variability reduction.

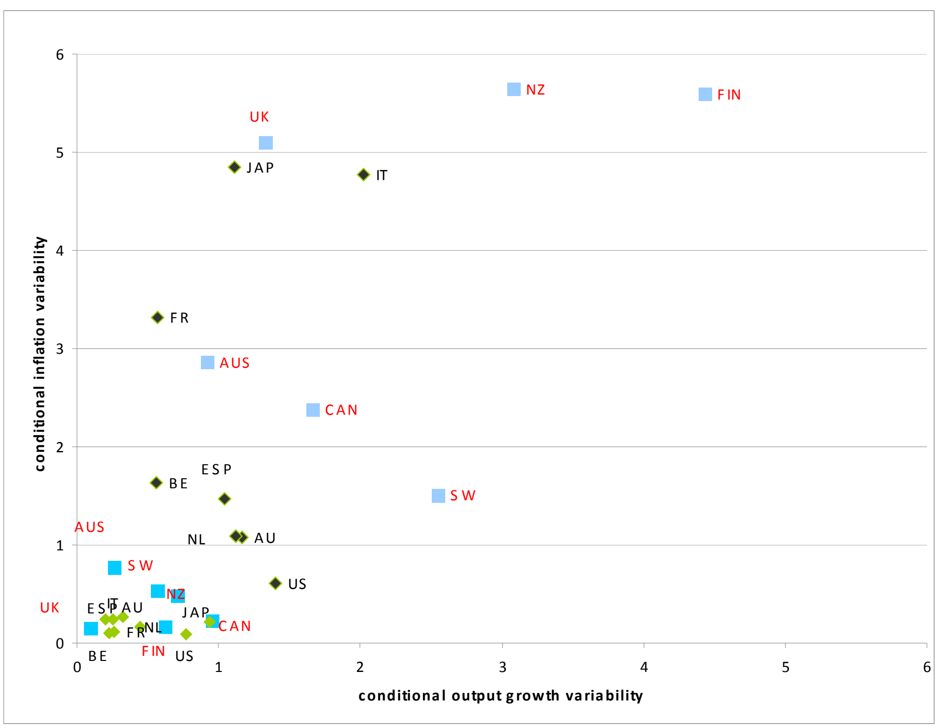


Figure 3: Inflation and output variability conditional to markup shocks, pre and post IT.

Since the figure suggests a remarkable shift of the tradeoff curve in the last decade, there maybe another reason for why the economic performance of IT and non-IT countries looks similar: movements along the tradeoff curve are small relative to the shift of this curve. But could monetary policy have induced this shift? Since the shift is common to both groups of countries, the choice of monetary regime may not be the explanation. However, if policy credibility has improved, in general, a shift of the tradeoff curve could be obtained. Quantifying improved credibility is difficult, but we know that, if it has increased, we should have observed a lower correlation between long term and short term rates in the IT period, conditional on markup shocks. This is because the sensitivity of long bond rates to markup shocks should fall, therefore reducing the correlation between the policy instrument and long term rates.

To examine such a possibility we repeated our exercise adding long term rates to our VAR. Studying a system with the long rate also shields us from the possibility that the results we have obtained are spurious and due to omission of inflation expectation proxies. There are two main conclusions that our analysis reaches. First, the magnitude of the changes in the tradeoff and policy ratios in the two groups of countries is unaffected by the addition of long term rates. Hence, even controlling for changes in inflation expectations, the macroeconomic performance of ITers and non-ITers is similar. Second, the conditional correlation between short and long term rates is significantly reduced in 4 countries (Australia, Canada, Belgium and Japan) and increased in Sweden, indicating that improved credibility cannot serve as a common explanation for the shift in the policy frontier.

7 Conclusions

The paper examines whether the adoption of an IT regime affects macroeconomic performance, when we condition the analysis on a shock that generates a tradeoff between inflation and output stabilization purposes. The theory provides clear cut predictions that can be tested in the data. In fact, in any DSGE model with nominal rigidities, a change in the relative weight that output and inflation variability have in the objective function of central banks implies movements along the output-inflation variability tradeoff curve towards a region 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 non-IT countries. We show that this change cannot be accounted for by changes in the structure of non-IT countries. Instead our measure of the policy stance, reveals similar changes in the behavior of non-IT and IT countries. We also show that the similarities in performance are not due to the fact that markup shock explain little of the volatility of output and inflation - generic supply shocks generate similar pictures; that potential addition benefits from inflation targeting do not seem to materialize; and that while shifts in the location of the output-inflation variability tradeoff are present, changes in inflation expectations induced by a generalized improvement of credibility cannot account for them.

Our analysis leads us to conclude that announcing an IT regime does not matter - agents seem to care more about facts than announcements - and that the benevolent situation of the last 15 years has contributed to make macroeconomic outcomes similar.

It is useful to relate our findings to those of the so called "Great Moderation" debate, since a leading explanation for the considerable fall in output and inflation variability in the 1980 in many industrialized countries is a change in monetary policy. Many papers have tried to examine whether the fall was due to "good luck" or structural changes. Our analysis is clearly related to this, even though, we compare the periods before and after the 1990s and conduct our analysis primarily conditional on markup shocks. Furthermore, while with the exception of Gambetti, et. al. (2005) and Canova et. al. (2007) most of the VAR literature finds evidence in favor of the good luck hypothesis, we do find evidence supporting the idea that the relative weight that monetary policy gives to inflation fluctuations in the last fifteen years has increased for most countries in our sample. Nevertheless, this change alone cannot explain the remarkable decrease of both inflation and output variability, conditional on markup shocks. Since no other reasonable change in the economic structure can account for this pattern, one must conclude a generic reduction of markup shock volatility across countries (i.e. "good luck") must be the main reason for the shift in the tradeoff frontier.

Appendix A

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

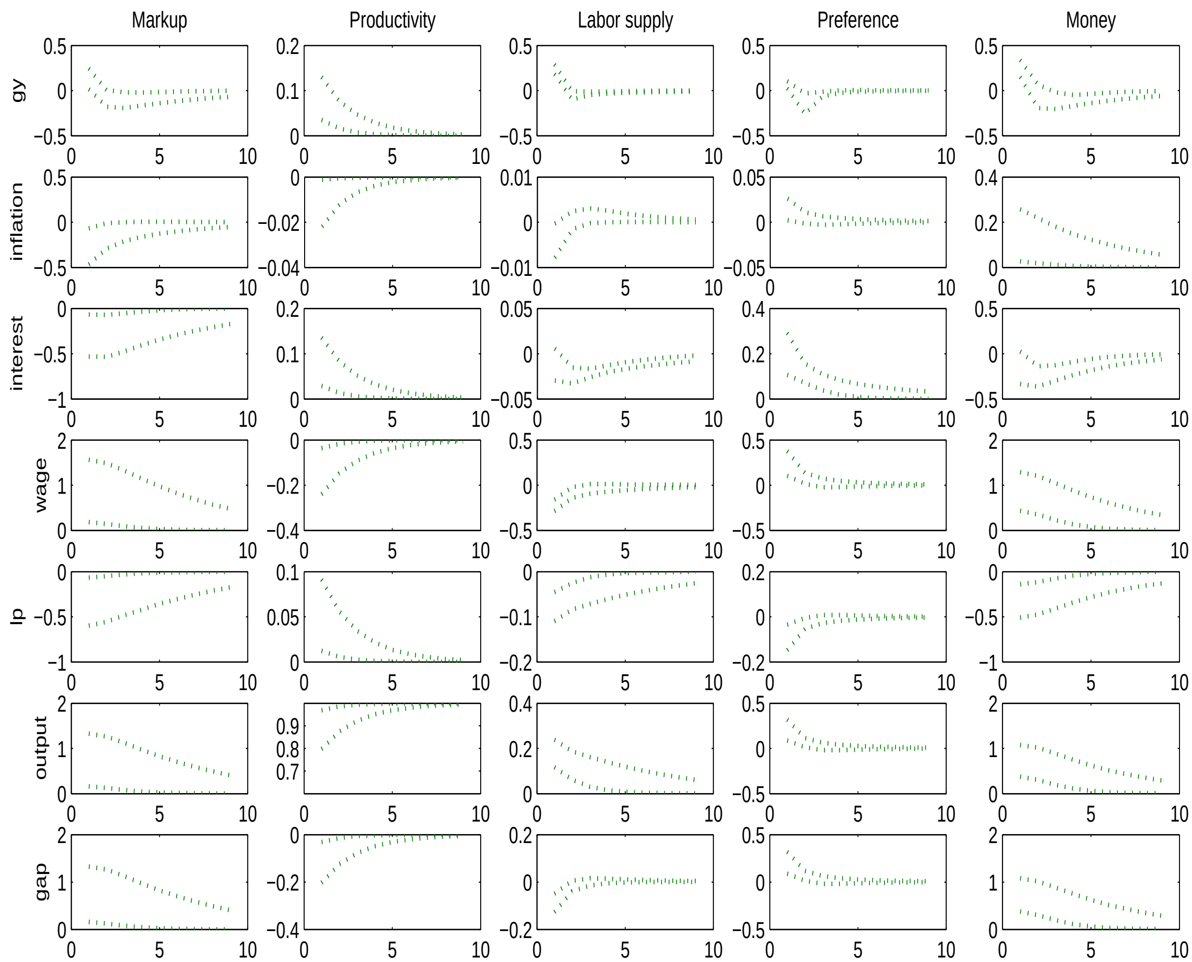
Variable	Source	Definition
RGDP	OECD	Real Gross Domestic Product
HOURS	OECD/IFS	Total Hours Worked per employee in the Business Sector
TOTEMP	OECD/IFS	Total employment
WAGES	OECD/IFS	Wages and Salaries of employees (net wage + social security contributions)
COMP	OECD	net wage + social security contributions paid by employees and employers
INT	IFS	short term nominal (money market) rate
CPI	IFS/OECD	consumer price index
LONG_INT	IFS/OECD	yield 10-year government bond

Appendix B

	Parameter ranges	
β	discount factor	$1.04^{-1/4}$
σ	risk aversion coefficient	[1,4]
ϕ	determines 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]
$\boldsymbol{\varrho}$	persistence of shocks	[0,0.97]

Appendix C

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



Appendix D

Difference-in-differences regressions $X_{post} - X_{pre} = a_0 + a_1 D + a_2 X_{pre} + e$				
X_{post} : a country's statistic X in the post-IT period X_{pre} : a country's statistic X in the pre-IT period D : dummy variable which is one if a country adopted IT				
X measures/ coefficients	a_0	a_1	a_2	Adj. R^2
PANEL I: Conditional on markup shocks, basic VAR				
Tradeoff ratio	1.62 (1.08)	-0.99 (1.17)	0.92 (1.00)	-0.03
Policy ratio	0.79 (0.99)	-0.53 (0.89)	0.46 (0.77)	-0.07
Persistence π	1.41 (0.86)	-0.06 (0.04)	-1.57 (0.90)	0.10
Persistence r	1.26 (0.12)	-0.04 (0.015)	-1.36 (0.13)	0.88
$var(y)$	0.31 (0.14)	-0.01 (0.19)	-0.89 (0.09)	0.92
$var(\pi)$	0.23 (0.09)	0.24 (0.1)	-1.02 (0.03)	0.99
PANEL II: Conditional on markup shocks, VAR with long term rates				
Tradeoff ratio	1.68 (0.83)	-1.06 (0.96)	0.43 (0.70)	-0.03
Policy ratio	0.57 (1.08)	-0.45 (0.95)	0.61 (0.85)	0.10
$cor(r^{long}, r^{short})$	0.91 (0.27)	-0.13 (0.08)	-1.19 (0.33)	0.49
PANEL III: Conditional on supply shocks, basic VAR				
Tradeoff ratio	2.87 (1.03)	-1.05 (1.13)	0.06 (0.46)	-0.08
Policy ratio	0.96 (1.81)	-1.02 (1.46)	1.65 (1.37)	0.05
PANEL IV: Conditional on monetary policy shocks, basic VAR				
$var(y)$	0.21 (0.07)	-0.08 (0.10)	-0.91 (0.04)	0.99
$var(\pi)$	0.13 (0.03)	0.10 (0.04)	-1.00 (0.01)	0.999

Standard errors are in parenthesis

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