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Verónica Cohen Sabbán
Banco Central de la República Argentina

Martín Gonzalez Rozada
Universidad Torcuato Di Tella

Andrew Powell
Universidad Torcuato Di Tella

Miñones 2177, C1428ATG Buenos Aires • Tel: 4784.0080 interno 181 y 4787.9394 • Web site: www.utdt.edu/departamentos/empresarial/cif/cif.htm

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Verónica Cohen Sabbán
Banco Central de la República Argentina

Martín Gonzalez Rozada
Universidad Torcuato Di Tella

Andrew Powell[1]
Universidad Torcuato Di Tella

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Abstract

We propose a new test, derived from a set of variance decompositions of a structural VAR, for the success of inflation targeting. In contrast to standard sacrifice ratios this test considers changes in the structure of real and nominal shocks; second moment effects. We find strong support for IT with 7 of the 9 countries in our sample having negative "sacrifices" and many countries with "benefits". However, we also find very different performances across IT countries. We find that "IT success" depends on the size of the real shocks suffered but controlling for this there are differences in country performance.

JEL Categories: E42, E52

Keywords: Inflation targeting, Structural Vector Auto-Regression (VAR)

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1. Introduction

Inflation targeting has become popular in both academic and policy-making circles. In this paper we consider 9 countries that have adopted IT regimes[2], ranging from pioneering New Zealand to other industrialised countries, including Australia, Canada, Sweden and the UK, to several more recent emerging country converts including Mexico and Brazil, the pioneer in Latin America, Chile, and finally Israel[3].

There is also a growing academic literature on IT[4]. Chapter 10 of Bernanke et al (1999) is devoted to a comparative analysis, considering largely a sample of industrialised countries. Three questions are posed; (1) does IT make disinflation less costly? (2) does IT reduce inflation expectations?, and (3) does IT change the behaviour of inflation? The preliminary conclusion is that, countries that have adopted IT have seen inflation levels and inflation expectations fall below what would be expected given extrapolations of past behaviour. However, this analysis finds no support for the view that disinflation is less costly under IT[5]. Still, the authors shy away from concluding whether this implies that IT fails to "create credibility" or whether

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[2] We also comment in the text on the case of Spain that adopted an IT regime before joining EMU. We do not include Spain in the empirical section due to the very short period of IT.

[3] It is also interesting that the two most largest currency areas by GDP, Euroland and the US, have not adopted IT regimes - see Bernanke et al 1999 for a discussion.

[4] Notable empirical contributions using cross-country samples include Bernanke et al (1999), Schmidt Hebbel and Werner (2002), Corbo, Landerretche and Schmidt Hebbel (2001) and Debelle (1997). For a more theoretical review see, for example, Svensson (1998). See Haldane (1999) for an attempt to draw out general lessons from the UK experience and Mishkin (2000) for a review of the issues from the standpoint of emerging countries.

[5] This result stems from comparing sacrifice ratios (normally defined as the output loss for each percentage point reduction in inflation) between IT and non-IT countries.

this reflects a confirmation of previous results that the structure of monetary policy has little impact on the output-inflation trade-off in the short run.

Schmidt Hebbel and Werner (2002) focus on the performance of emerging country inflation targeters in Latin America: namely Brazil, Chile and Mexico but also present comparative statistics against a wider control group of IT countries. While the post IT period has been associated with lower inflation, the sacrifice ratios presented by these authors show a slight deterioration for Brazil and Mexico and an improvement for Chile[6]. They also present a variety of empirical exercises to attempt to understand the effect of IT in these three countries.

One analysis, that they claim is standard, is to run a Vector Auto Regression including as endogenous variables the real interest policy rate, the inflation target, core inflation, output growth, money growth and the real exchange rate. There are at least two issues worth discussing with this methodology. One is that their sample periods cover pre and post-IT periods and hence they use an expected inflation proxy for the inflation target in the pre IT period[7]. Second, the inflation target is a step variable and given that it is a target set by the Central Bank, it is not clear how to interpret the error term in the equation for

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[6] Sacrifice ratios are again the output loss (GDP and industrial output) for each percentage point reduction in inflation.

[7] The analysis is conducted recursively and the authors discuss the difference in the impulse responses in the pre and post inflation-targeting period. While the results are suggestive, if the IT target is a better predictor of expected inflation than the proxy employed in the pre IT period, then that could explain why the effect of target changes becomes more significant after IT without that target having any real influence on actual inflation. It is also not clear what the policy interest rate variable corresponds to in the pre IT period.

that variable (treated as endogenous) nor what its statistical properties are. It is difficult to estimate how these issues affect the results presented[8].

IT regimes have in general developed as a way to move away from other nominal anchors and in particular from explicit or implicit exchange rate targets or bands towards greater exchange rate flexibility. One of the potential benefits of floating exchange rates is that these rates can then respond to real shocks and act as a type of shock absorber for the rest of the economy. At the same time, floating exchange rates may imply a sacrifice in that real exchange rates may become more volatile and PPP deviations more severe[9]. On the other hand, if IT regimes develop credibility and are successful then perhaps we would expect that floating with IT would result in only small and non-persistent nominal shocks on the real exchange rate and hence for real rates not to be unduly affected.

The current 'tests' regarding the 'success' of IT regimes as mentioned above stress the effect of IT on inflation expectations and outcome inflation levels. These might be thought of as first moment effects. However, a different way to consider the question of whether IT changes the behaviour of inflation and other variables is to consider how the adoption of IT affects the structure and the impact of nominal and real shocks – second moment effects. As discussed we might, on the one hand, expect that the nominal exchange rate would become more volatile and be driven more by real shocks as the exchange rate

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[8] The results claim a strong and significant effect of IT target changes on inflation in Chile and significant but quantitatively small effects of IT target changes in Mexico and Brazil.

[9] A previous literature focused on the "excess volatility" of nominal rates with rational models of over-shooting and bubbles as well as irrational panics and herd behavior potentially driving real rates away from equilibrium or fundamental values.

acts as a shock absorber. This may be thought of as the benefit of floating with IT. However, on the other hand if the real exchange rate becomes more volatile and driven more by nominal shocks, then this would constitute a sacrifice. Successful IT regimes should then have only a small (or no) sacrifice and significant benefits.

These arguments suggest a different 'test' regarding the 'success' of IT regimes. Namely an analysis of the structure of shocks between the real and the nominal exchange rate and this is indeed the approach taken in this paper. We are helped in this regard by Enders and Lee (1997) who consider the structure of nominal and real exchange rate shocks between G4 countries in the post Bretton Woods era. We follow their methodology here, which in turn employs the estimation of a structural VAR as suggested by Blanchard and Quah (1999). However our purpose is different. We estimate structural VARS for 9 countries splitting the sample between 'prior IT' and 'post IT' windows[10]. In some cases, where data permits, and notably the UK and Chile, we also split the 'post IT' sample into two to test whether there is evidence of changes as, perhaps, the IT regime has gained credibility over time.

Our results suggest that IT has indeed allowed the nominal exchange rate to react more to real shocks as nominal exchange rate regimes have become closer to pure floats. In other words the benefits have been positive. However, the results on sacrifices are surprising to say the least. We find that for a set of IT regimes, mainly in industrialised countries, there are no sacrifices.

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[10] Note that this methodology does not employ the inflation target directly within the VAR. It is then a more indirect test regarding changes in the relation between nominal and real shocks in the economy.

However, we also find considerable variation across countries as to how IT is performing.

The paper is organised as follows. In section 2, we briefly discuss the adoption of IT in the sample countries. Section 3 develops the empirical methodology while section 4 is devoted to a discussion of the data and the results. Section 5 concludes.

2. The Adoption of Inflation Targeting in a Sample of Industrialised and Developing Countries.

In this paper we conduct tests on 9 countries that have adopted IT regimes. To give some background, in this section we briefly contrast the developments in these economies as they adopted IT. While each country has its own particular context and monetary history, we attempt to delineate some common themes across the countries in this highly summarised account. We also discuss briefly the differences in the way in which IT has been implemented across the countries in our sample[11].

Adopting IT

In Table 1 we detail the countries in the sample and the dates at which IT was adopted[12,13]. As can be seen from the Table the first country to adopt IT was

[11] This section draws on Bernanke et al (1999), Schmidt Hebbel and Werrner (2000) and information from the websites of the relevant Central Banks.

[12] These dates are largely speaking the dates when the relevant Central Banks claim to have adopted IT.

[13] It is sometimes debatable exactly when IT was adopted as Central Banks do not always give specific dates and others appear to 'jump the gun' in claiming IT adoption. See for

New Zealand in 1990 although other countries followed rapidly. The latest IT country in our sample is Brazil and we use 1999 as the date for its adoption. Countries have adopted IT in quite different macroeconomic settings. Here we identify three main circumstances. First, several countries in our sample adopted IT after a period of poor economic performance, weak economic credibility and a desire to seek greater transparency in monetary operations and a belief that with greater transparency might come greater credibility and (hence) improved economic performance. Countries fitting this set of stylised facts include New Zealand, Canada, Australia and arguably Mexico. Second, countries have adopted IT as a way to obtain greater flexibility moving away from an exchange rate band after a significant deflation frequently obtained using the exchange rate band as nominal anchor[14]. Countries in this group include Israel, Chile and Spain[15]. The third group are countries that suffered an exchange rate crisis as an exchange rate band was forcibly abandoned and IT was then adopted in its aftermath, in part, as a way to attempt to regain credibility. Countries in this category include Brazil, Sweden and the UK[16].

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example Benanke et al (1999) for a discussion of the Australian case. The IT adoption date for Chile is in particular debatable with the Central Bank typically claiming 1991, but also note Schmidt Hebbel and Werner (2002) suggesting that only, "In 1999-2000 the Bank upgraded its monetary framework to full inflation targeting" pp36. This later date coincided with the disposal of the exchange rate band and development of the Central Bank's modeling and forecasting activities.

[14] This is not to say that there were not also significant deflations in other countries such as New Zealand but the countries included here used an exchange rate anchor during the deflation and the deflation was immediately prior to the adoption of IT.

[15] Spain adopted IT also within the context of explicitly seeking EMU membership and within the context of following the rules of ERM II - including making the Central Bank independent. Spain subsequently joined EMU. We do not consider Spain in the empirical analysis due to the short period in the post IT regime prior to EMU entry.

[16] Mexico also suffered an exchange rate crisis prior to adopting IT but the crisis was in early 1994 and the adoption of IT was much later and hence we include Mexico in the first group.

Table 1: Adopting IT

	Adoption of IT	Before IT	After IT	Frequency
New Zealand	1990	1980-1989	1990-2001	quarterly
Canada	1991	1980-1990	1991-2001	monthly
Chile	1991	1986-1990	1991-2001	monthly
Israel	1991	1986-1990	1991-2001	monthly
Australia	1993	1980-1992	1993-2001	quarterly
United Kingdom	1993	1980-1991	1993-2001	monthly
Sweden	1995	1985-1994	1995-2001	monthly
Brazil	1999	1994-1998	1999-2001	monthly
Mexico	1999	1996-1998	1999-2001	monthly

Prior to adopting IT, the countries in our sample had a variety of monetary regimes. These ranged from a non-transparent (or "just do it") style of monetary policy that characterised the prior IT regimes of Australia, Canada and New Zealand, and arguably Mexico, to the exchange rate targeting regimes of Spain, Sweden and the UK to the more explicit exchange rate bands of Brazil, Chile, Israel[17]. Each of the countries in the sample had some measure of nominal exchange rate flexibility in the prior IT regime. Perhaps the hardest 'fix' was the exchange rate band of the Brazilian real plan but even here the nominal exchange rate varied within band, the band crawled and the band was also adjusted a number of times.

Characteristics of IT regimes

There is considerable debate in the IT literature as to the appropriate way to conduct IT[18]. Here we focus on six particular characteristics to illustrate

[17] Chile maintained the exchange rate band after adopting IT. However, Schmidt Hebbel and Werner (2002) claim that the inflation target always had priority and the exchange rate band was adjusted several times.
[18] Svennson (1988) suggests that IT, as practiced in New Zealand, Canada, the UK, Sweden and Australia can be thought of as, " (1) an explicit quantitative inflation target, (2) an

some of the similarities and differences in IT regimes across the world. The characteristics are (i) if specific IT legislation has been enacted, (ii) if Central Banks are independent, (iii) how inflation is defined, (iv) the role of the exchange rate and whether an explicit and transparent monetary conditions index is used (v) the type of target adopted and (vi) the degree of flexibility that exists around that target[19].

Most industrialised countries have enacted specific legislation regarding IT - the exception being Canada. However, emerging countries have tended to lag behind this trend. Also, most IT countries have given formal independence (objective or goal) to their Central Bank but Brazil and Mexico to date have not. There is considerable debate in the IT literature as to what measure of inflation should be employed. Most countries use headline CPI inflation however New Zealand and Australia use an underlying inflation index that takes out certain volatile components.

Inflation targeting appears to have become particularly popular in small open economies – as evidenced by our 9-country sample. The role of the exchange rate is then a crucial variable in all of these IT regimes. Indeed, some countries have defined an explicit Monetary Conditions Index (MCI) or similar - most transparently in Canada, New Zealand and Israel - for the

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operating procedure can be described as inflation forecast targeting…. and (3) a high degree of transparency and accountability".

[19] Bernanke et al (1999) suggest ten operational and communication issues are paramount (which we have summarized in the 6 listed above); (1) which measure of inflation should be used?, (2) what numerical value should the target have? (3) a price level or an inflation target? (4) what horizons? (5) a point or a range? (6) what information should be used in policy making? (7) when should deviations from the target be allowed? (8) when is the best time to implement IT? (9) what should be communicated and in what forum? (10) to what degree should central banks be held accountable?

purposes of short term monetary control. In the case of Canada and New Zealand, for example, a change in the MCI is defined as the weighted sum of changes in 90 day commercial paper interest rate and the trade weighted exchange rate (with weights 3 to 1 for Canada and 2: 1 for New Zealand). In the case of New Zealand a 2% rise in the exchange rate is then estimated to have the same effect as a 1% point rise in interest rates. This ratio indicates particularly the importance of the exchange rate in the case of NZ. Since July 1997, the reserve bank has published a forecast of the MCI to indicate the path of monetary policy for the following three years if conditions remain unchanged.

Haldane (1999) contrasts the automatic use of an MCI index to govern monetary policy responses to exchange rate changes versus what he refers to as a “spot the shock” approach where the monetary policy response is conditioned on a view as to what caused the exchange rate to move. Schmidt-Hebbel and Werner (2002) also devote a section of their paper to the role of the exchange rate within the IT frameworks of Brazil, Chile and Mexico. Their focus is on the related issues of whether there is evidence of high pass-through from the exchange rate to interest rate behaviour and whether there has been a 'fear of floating' in these countries[20].

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[20] On the latter they conclude that considering the volatility of exchange rates and reserves, "fear of floating has declined substantially with the adoption of the floating regime, and it appears to be levelling off towards levels observed in the more mature floaters" (namely Australia, Canada and New Zealand). Regarding "pass through", they suggest that, controlling for inflation, exchange rate movements do not lead to significant changes in interest rates in the three countries analysed.

There are also differences as to how the target should be specified. The UK, Brazil, Chile Sweden and Australia have tended to adopt point targets whereas Canada, New Zealand and Israel have inflation ranges[21]. Finally regarding flexibility, New Zealand also has the most explicit rule-based system. The UK has a formal procedure if inflation is outside of the range involving a public letter from the Central Bank Governor to the Minister explaining the situation. Other countries have fewer rules and hence, arguably, greater flexibility. Flexibility is often related to whether the Central Bank only has the inflation target or other objectives such as output stabilization as well. Most Central Banks in our sample have other goals as well as simply the inflation target although with arguably with varying weights[22].

This brief description of some of the salient characteristics serves to highlight that while a variety of countries claim to have adopted Inflation Targeting there is still considerable debate as to what IT actually means and differences as to how it is implemented across the globe. We come back to this as we discuss the results.

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[21] See the discussion in Haldane (1999) regarding the alleged benefits of a specific target rather than a range.

[22] See Svensson (1997) for a discussion on strict versus flexible inflation targeting.

3. Econometric Methodology

In this section, we describe the methodology we use to analyse the performance of IT regimes. Our approach is to consider how the adoption of IT by a country affects the behaviour of the nominal and real exchange rate. One possible alternative to study this type of problem would be to consider a structural model of exchange rate determination. However, the empirical evidence, as reviewed in Enders and Lee (1997) (EL hereafter), suggests that these kinds of models do not explain well real and nominal exchange rate movements. Instead of using a structural specification, we follow EL and decompose the exchange rate movements into changes induced by real versus nominal factors[23]. By studying the structure of real and nominal shocks and their effects, before and after the adoption of IT, we can assess the performance of this new monetary regime.

The proposed decomposition is based on the technique developed by Blanchard and Quah (1989) (BQ hereafter). The basic idea behind this decomposition is the estimation of a reduced form vector autoregressive model (VAR) for both exchange rates, real and nominal, and then to decompose the exchange rate series into movements caused by real shocks and those caused by nominal shocks.

[23] Moreover EL shows that the decomposition is consistent with a number of theories regarding exchange rate determination.

We assume that the real shocks affect both real and nominal rates similarly while the nominal shocks affect both rates differently. In the latter case, consistent with the idea of long-run money-neutrality, the nominal shocks are assumed to have only a temporary, rather than permanent, effect on the real exchange rate. This is the key restriction that allows BQ to identify both type of shocks.

Before we can formulate the model, it is necessary to analyse the stochastic properties of both exchange rate series. If both series are stationary, an unrestricted stable VAR model in levels can be specified; if both series are characterised by unit root processes and they are co-integrated, then the correct model to be specified will be a restricted VAR for the variables in first-differences incorporating the co-integrating vector to represent the long run; finally, if both series are non-stationary but they are not co-integrated, then the corresponding model would be an unrestricted stable VAR for the variables in first-differences[24].

For ease of exposition, we consider the BQ decomposition technique for an unrestricted VAR model for both rates expressed in first-differences,

[24] In a set of preliminary results we find that in general the relevant series are I(1) but are not co-integrated. The exceptions are Mexico and Israel in the post-IT period where we find the series are I(1) and cointegrated. In these cases we incorporate the cointegrating vector into the relevant empirical model.

$$\Delta e_t = \sum_{s=0}^{S} \beta_{1(t-s)} \Delta e_{t-s} + \sum_{s=0}^{S} \gamma_{1(t-s)} \Delta r_{t-s} + \varepsilon_{1t}$$
$$\Delta r_t = \sum_{s=0}^{S} \beta_{2(t-s)} \Delta e_{t-s} + \sum_{s=0}^{S} \gamma_{2(t-s)} \Delta r_{t-s} + \varepsilon_{2t} \qquad (1)$$

where e_t and r_t are the nominal and real exchange rates, respectively; the *β's,* and *γ's* are the parameters of the model; $\varepsilon = [\varepsilon_1, \varepsilon_2]' = [\Delta e_t, \Delta r_t]' - E([\Delta e_t, \Delta r_t]' \mid [\Delta e_{t-s}, \Delta r_{t-s}]', s \geq 1)$, with $var(\varepsilon) = \Sigma$; and $\Delta = 1\text{-}L$, with L being the lag operator. In the empirical analysis below we use the nominal dollar exchange rate for almost all countries except for Sweden and United Kingdom for which we employ the German DM (and subsequently the Euro). We use the WPI to calculate the relevant real exchange rates.

Since the VAR model is stable it has a moving average representation given by,

$$\Delta e_t = \sum_{s=0}^{\infty} b_{11}(s) L^s u_{rt} + \sum_{s=0}^{\infty} b_{12}(s) L^s u_{nt}$$
$$\Delta r_t = \sum_{s=0}^{\infty} b_{21}(s) L^s u_{rt} + \sum_{s=0}^{\infty} b_{22}(s) L^s u_{nt} \qquad (2)$$

where, u_{rt} and u_{nt} are zero-mean mutually uncorrelated real and nominal shocks, respectively. BQ show that one can impose restrictions on any of the two models in order to identify real and nominal shocks in the system. In particular, the restriction that the nominal shocks have no long-run effect on the real exchange rate is represented by the restriction that in the moving average representation of the system.

$$\sum_{s=0}^{\infty} b_{22}(s) = 0$$

That is the cumulative effect of u_{nt} on Δr over time is zero. Similarly, because the sum of b_{12} from zero to infinity is the same, as the effect of u_n on r after an infinite number of periods, the nominal shock has only short run effects on the real exchange rate[25]. This restriction on the moving average representation can be equivalently expressed in terms of the VAR model by the following expression,

$$\left[1 - \sum_{s=0}^{\infty} \beta_{1(t-s)}\right] b_{22}(0) + \sum_{s=0}^{\infty} \beta_{2(t-s)} b_{12}(0) = 0 \qquad (4)$$

The coefficients of the structural model can then be represented as follows:

$$\begin{bmatrix} b_{11}(L) & b_{12}(L) \\ b_{21}(L) & b_{22}(L) \end{bmatrix} \quad \text{where} \sum_{s=0}^{\infty} b_{22}(s) = 0 \qquad (5)$$

This means that, as suggested by the theory, in the long run real shocks can cause permanent changes in the real exchange rate, but nominal shocks can cause only temporary movements in the real rate.

In our applied work we would like to know the response of one of the exchange rate to an exogenous impulse in another variable. That is, we would like to trace out what happens to the estimated system during subsequent periods after an exogenous shock has occurred. Specifically, we would like to separate the variation in an endogenous variable into the component shocks to the VAR. Therefore we employ variance decompositions. The variance decomposition provides information about the relative importance of each random innovation in affecting the first differences in the real and nominal

[25] See Blanchard and Quah (1989) or Enders and Lee (1997).

exchange rates. Using the variance decompositions we can then see whether IT has had any systematic effect on the relative importance of the component shocks driving the real and nominal exchange rate.

To assess the statistical significance of any changes in the variance decompositions we compute 90% bootstrapping confidence intervals[26]. These intervals are computed in the following way. First, we estimate the corresponding VAR system and obtain the estimated coefficients and residuals from both equations. Second, from the vector residuals we select randomly a new vector of residuals that we call the bootstrapping residuals vector. With this new residuals' vector and the estimated coefficients of step one, we reproduce the values of both dependent variables. Third, once we have the bootstrapping values of the dependent variables, we repeat the VAR estimation and produce the structural variance decomposition. Next, we go to the second step and repeat this procedure.

We perform this simulation 1000 times so that after the simulation process is complete we have for each forecasting period, 1000 replications of the variance decomposition. Then, for each forecasting period we construct a 90% empirical confidence interval for the variance decomposition.

To analyse the success of IT regimes, we propose a new sacrifice and a benefit ratio as a function of the variance decompositions. On the one hand, we expect the real exchange rate to be driven more by nominal shocks. Hence we propose a sacrifice ratio expressed as:

S = % of r explained by NS after IT - % of r explained by NS before IT

Where *r* is the real exchange rate and *NS* is a nominal shock..

A positive number for S represents a sacrifice in the sense that the real exchange rate is now affected more by nominal shocks after IT than before[27].

On the other hand, we may also expect the nominal exchange rate to become more volatile and be driven more by the real shocks. This in our view constitutes the 'benefit' - the fact that nominal exchange rates can act more as a shock absorber for real shocks. We then define a benefit ratio as:

B = % of e rate explained by RS after IT - % of e explained by RS before IT

Where *e* is the nominal exchange rate and *RS* is a real shock.

[26] Naturally, these confidence levels also serve to analyze whether the variance decompositions are statistically significant in them-selves and not just due to say sampling error.
[27] We note that the Blanchard and Quah (1989) identification procedure in the structural VAR imposes the constraint that in the long run the nominal shock does not affect the real exchange rate however this does not imply a restriction on the variance decompositions and does not therefore invalidate the above ratio.

In this case, a positive number for B represents a benefit. This is the case when an IT regime allows the nominal exchange rate to be affected more by the real shocks and hence act more as a type of 'shock absorber'.

In the case of the UK and Chile we also split the post-IT sample to analyse how the these sacrifice and benefit ratios change comparing the two post-IT periods against the period pre-IT. Our idea is that if we find that the benefit ratio becomes more positive and the sacrifice ratio more negative, then there is evidence that the IT regime has become more successful over time. The nominal exchange rate would then have become more affected by the real shocks and the real exchange rate less affected by the nominal shocks.

Finally, we analyse the results across countries in the post IT regime to consider how different IT regimes in different countries are functioning. In particular we seek to ascertain whether there are systemic differences in the structure of the shocks. We find strong and interesting country differences.

4. Empirical Results

In this section, we present the results of the empirical analysis in 9 countries that have adopted IT. In Table 2 below we first present the results for the structural model identified using the Blanchard and Quah technique for the 9 countries. The table for each country gives the long run coefficients for the structural model and standard errors. As can be seen many coefficients are significant at any standard significance level and they are all of the expected sign.

Table 2:

	Pre - IT		Post - IT	
Chile	0.000493	0.015967	0.016521	0.011588
	(0.002062)	***(0.001458)***	***(0.001460)***	***(0.000727)***
	0.023128	**0.000000**	0.016004	**0.000000**
	(0.002111)		***(0.001004)***	
Mexico	0.022129	0.012413	0.010352	0.006659
	(0.003832)	***(0.001918)***	***(0.002424)***	***(0.000940)***
	0.031578	**0.000000**	0.026757	**0.000000**
	0.002958		***(0.003273)***	
Brazil	0.004786	0.007688	0.037640	0.013203
	(0.001143)	***(0.000740)***	***(0.005615)***	***(0.001764)***
	0.020639	**0.000000**	0.047020	**0.000000**
	(0.001986)		***(0.006283)***	
United Kingdom	0.024728	0.004213	0.024678	0.007194
	(0.001526)	***(0.000253)***	***(0.001833)***	***(0.000494)***
	0.024118	**0.000000**	0.024965	**0.000000**
	(0.001447)		***(0.001715)***	
New Zealand	0.053542	0.025813	0.060371	0.009804
	(0.007637)	***(0.003042)***	***(0.006389)***	***(0.001011)***
	0.054790	**0.000000**	0.050060	**0.000000**
	(0.006457)		***(0.005163)***	
Australia	0.039608	0.013564	0.067315	0.011490
	(0.004401)	***(0.001356)***	***(0.008161)***	***(0.001354)***
	0.037491	**0.000000**	0.066130	**0.000000**
	(0.003749)		***(0.007793)***	
Sweden	0.020203	0.007760	0.023491	0.006142
	(0.001484)	***(0.000501)***	***(0.001956)***	***(0.00048)***
	0.021053	**0.000000**	0.022441	**0.000000**
	(0.001359)		***(0.001752)***	
Israel	0.015293	0.016285	0.002264	0.019043
	(0.002589)	***(0.001525)***	***(0.00167)***	***(0.001176)***
	0.024711	**0.000000**	0.014193	**0.000000**
	(0.002314)		***(0.000877)***	
Canada	0.009731	0.006103	0.011501	0.005913
	(0.000807)	***(0.000379)***	***(0.000875)***	***(0.000364)***
	0.012849	**0.000000**	0.012633	**0.000000**
	(0.000797)		***(0.000777)***	

Given the coefficients of the structural model, we then estimate the variance decompositions and confidence intervals as described in the previous section. In Table 3 below we detail the results for each country for the pre and post IT regimes with 90% confidence intervals for lags of 1, 5 and 10 periods. As can be seen the confidence intervals are relatively tight indicating that the variance decompositions are in general very well defined. More specifically, in only very few cases do we find that the confidence intervals overlap – in other words we find strong evidence for changes in the structure of shocks in the pre and post IT regimes.

Table 3: Variance Decompositions and 90% Confidence Intervals

	Nominal Exchange Rate				Real Exchange Rate			
	Nominal Shock		Real Shock		Nominal Shock		Real Shock	
	Pre IT	Post IT	Pre IT	Post IT	Pre IT	Post IT	Pre IT	Post IT
Chile								
Lag 1	84.70	41.14	15.30	58.86	7.05	10.10	**92.95***	**89.90***
	(83.77-86.06)	*(39.82-43.15)*	*(15.30-15.74)*	*(58.74-59.68)*	*(7.04-7.57)*	*(9.93-10.76)*	*(91.58-94.85)*	*(88.38-91.91)*
Lag 5	81.07	39.75	18.93	60.25	9.35	13.33	90.65	86.67
	(80.25-82.44)	*(38.80-41.31)*	*(18.89-19.53)*	*(59.63-61.50)*	*(9.35-9.94)*	*(13.08-13.94)*	*(89.29-92.59)*	*(85.02-88.69)*
Lag 10	81.06	39.74	18.94	60.26	9.36	13.35	90.64	86.65
	(80.25-82.43)	*(38.81-41.31)*	*(18.90-19.54)*	*(59.63-61.51)*	*(9.35-9.94)*	*(13.10-13.96)*	*(89.28-92.59)*	*(85.00-88.67)*
Mexico								
Lag 1	74.57	65.25	25.43	34.75	49.10	30.47	50.90	69.53
	(71.75-78.44)	*(64.40-67.35)*	*(25.42-26.48)*	*(34.70-36.06)*	*(47.96-52.59)*	*(30.25-31.71)*	*(50.56-53.60)*	*(68.41-71.67)*
Lag 5	70.41	65.94	29.59	34.06	50.30	33.91	49.70	66.09
	(68.59-73.79)	*(65.62-67.18)*	*(28.87-31.85)*	*(33.01-36.01)*	*(49.27-52.59)*	*(33.77-34.56)*	*(47.80-52.86)*	*(64.14-68.56)*
Lag 10	70.38	65.19	29.62	34.81	50.65	33.20	49.35	66.80
	(68.60-73.75)	*(64.88-66.37)*	*(28.87-31.85)*	*(33.70-36.81)*	*(49.63-52.95)*	*(33.08-33.87)*	*(47.42-52.56)*	*(64.82-69.32)*
Brazil								
Lag 1	99.81	67.07	0.19	32.93	25.35	34.97	74.65	65.03
	(99.40-100.73)	*(65.55-70.55)*	*(0.19-0.71)*	*(32.40-35.41)*	*(25.31-25.96)*	*(34.20-37.44)*	*(74.09-75.78)*	*(63.29-68.48)*
Lag 5	93.47	61.07	6.53	38.93	27.94	40.94	72.06	59.06
	(93.09-94.33)	*(60.78-62.15)*	*(6.44-7.12)*	*(35.40-43.24)*	*(27.88-28.37)*	*(40.78-41.75)*	*(71.11-73.38)*	*(54.87-63.90)*
Lag 10	93.44	61.08	6.56	38.92	27.94	40.95	72.06	59.05
	(93.07-94.31)	*(60.78-62.15)*	*(6.46-7.15)*	*(35.40-43.24)*	*(27.88-28.37)*	*(40.79-41.75)*	*(71.11-73.38)*	*(54.85-63.89)*
United Kingdom								
Lag 1	22.19	4.71	77.81	95.29	11.03	0.65	88.97	99.35
	(20.69-24.39)	*(3.36-6.97)*	*(77.36-78.96)*	*(95.28-96.19)*	*(10.43-12.20)*	*(0.65-1.41)*	*(87.45-91.06)*	*(97.80-101.65)*
Lag 5	28.87	7.72	71.13	92.28	18.71	4.69	81.29	95.31
	(28.66-29.36)	*(7.43-8.99)*	*(68.81-73.73)*	*(91.20-94.33)*	*(18.55-19.09)*	*(4.55-5.63)*	*(78.83-83.95)*	*(93.86-97.56)*
Lag 10	29.53	8.05	70.47	91.95	19.61	4.94	80.39	95.06
	(29.35-29.99)	*(7.77-9.31)*	*(68.07-73.13)*	*(90.86-94.02)*	*(19.47-19.95)*	*(4.80-5.89)*	*(77.86-83.11)*	*(93.62-97.32)*
New Zealand								
Lag 1	71.20	11.79	28.80	88.21	54.18	2.90	45.82	97.10
	(68.87-77.61)	*(9.81-15.95)*	*(28.07-33.61)*	*(88.16-90.42)*	*(53.01-58.69)*	*(2.82-4.94)*	*(43.44-51.55)*	*(95.07-101.11)*
Lag 2	70.65	14.80	29.35	85.20	56.01	9.91	43.99	90.09
	(69.57-74.95)	*(14.36-17.00)*	*(26.47-35.44)*	*(83.06-89.09)*	*(55.61-57.74)*	*(9.65-11.35)*	*(38.63-50.69)*	*(87.30-94.07)*
Lag 4	66.12	17.80	33.88	82.20	52.48	18.73	47.52	81.27
	(65.64-67.81)	*(17.40-20.17)*	*(28.14-40.81)*	*(79.96-86.40)*	*(52.24-53.35)*	*(18.53-20.79)*	*(41.04-54.63)*	*(78.70-85.68)*
Australia								
Lag 1	23.36	0.09	76.64	99.91	**8.87***	**9.16***	**91.13***	**90.84***
	(20.62-27.68)	*(0.09-0.51)*	*(75.88-78.99)*	*(95.75-104.48)*	*(8.11-11.07)*	*(5.46-14.06)*	*(88.20-95.52)*	*(90.84-92.05)*
Lag 2	25.60	0.51	74.40	99.49	15.09	9.40	84.91	90.60
	(24.38-28.25)	*(0.47-1.28)*	*(71.88-78.33)*	*(95.64-104.05)*	*(14.56-16.49)*	*(5.81-14.41)*	*(80.93-89.75)*	*(90.58-92.04)*
Lag 4	25.69	2.36	74.31	97.64	15.17	9.52	**84.83***	**90.48***
	(24.46-28.30)	*(2.00-3.86)*	*(71.73-78.28)*	*(94.10-102.32)*	*(14.62-16.59)*	*(7.85-13.45)*	*(80.83-89.69)*	*(88.74-94.48)*
Sweden								
Lag 1	30.48	16.27	69.52	83.73	12.35	3.22	87.65	96.78
	(29.41-32.26)	*(15.03-18.29)*	*(69.31-70.44)*	*(83.71-84.51)*	*(12.09-13.27)*	*(3.12-3.87)*	*(86.52-89.42)*	*(95.41-98.71)*
Lag 5	33.03	16.54	66.97	83.46	14.63	4.54	85.37	95.46
	(32.56-33.84)	*(15.81-18.09)*	*(65.72-68.57)*	*(82.93-84.80)*	*(14.43-15.06)*	*(4.35-4.98)*	*(83.71-87.25)*	*(93.83-97.35)*
Lag 10	34.98	16.59	65.02	83.41	16.13	4.62	83.87	95.38
	(34.60-35.70)	*(15.91-18.13)*	*(63.65-66.74)*	*(82.87-84.80)*	*(15.94-16.55)*	*(4.45-5.06)*	*(82.19-85.79)*	*(93.74-97.27)*
Israel								
Lag 1	74.03	99.57	25.97	0.43	23.35	1.09	76.65	98.91
	(72.81-76.07)	*(97.93-101.54)*	*(25.81-26.96)*	*(0.43-0.76)*	*(23.16-24.31)*	*(1.09-1.23)*	*(75.47-78.59)*	*(97.72-100.24)*
Lag 5	72.64	96.98	27.36	3.02	28.41	3.09	71.59	96.91
	(71.56-74.50)	*(95.41-98.96)*	*(26.98-28.51)*	*(3.00-3.46)*	*(28.24-29.07)*	*(3.08-3.31)*	*(69.96-73.69)*	*(95.77-98.28)*
Lag 10	72.64	96.97	27.36	3.03	28.41	3.09	71.59	96.91
	(71.56-74.50)	*(95.40-98.95)*	*(26.98-28.51)*	*(3.00-3.47)*	*(28.24-29.07)*	*(3.09-3.32)*	*(69.96-73.69)*	*(95.79-98.28)*
Canada								
Lag 1	46.29	43.33	53.71	56.67	13.80	4.86	86.20	95.14
	(45.51-47.42)	*(42.29-44.70)*	*(53.56-54.19)*	*(56.63-57.01)*	*(13.60-14.29)*	*(4.82-5.14)*	*(85.30-87.38)*	*(94.09-96.42)*
Lag 5	47.34	42.95	52.66	57.05	20.80	7.32	79.20	92.68
	(46.73-48.25)	*(42.21-44.08)*	*(52.30-53.34)*	*(56.72-57.76)*	*(20.62-21.17)*	*(7.24-7.64)*	*(78.13-80.47)*	*(91.62-93.97)*
Lag 10	47.34	42.95	52.66	57.05	20.80	7.32	79.20	92.68
	(46.73-48.25)	*(42.21-44.08)*	*(52.30-53.34)*	*(56.73-57.76)*	*(20.62-21.17)*	*(7.24-7.64)*	*(78.13-80.47)*	*(91.62-93.97)*

** indicates that the 90% two sided confidence intervals overlap. In all other cases we then find strong evidence of changes between pre and post IT regimes*

We are now in a position to consider the benefit and sacrifice ratios as defined above. The following table summarises the results obtained for both ratios and using a 1-period, 5-period and 10-period horizon in the variance decompositions[28]:

Table 4: Sacrifice and Benefit Ratios

	Lag 1		Lag 5		Lag 10	
	Sacrifice Ratio	Benefit Ratio	Sacrifice Ratio	Benefit Ratio	Sacrifice Ratio	Benefit Ratio
Chile	**3.05**	43.56	**3.98**	41.32	**3.99**	41.32
Mexico	-18.63	9.32	-16.39	4.47	-17.45	5.19
Brazil	**9.62**	32.74	**13.00**	32.40	**13.01**	32.36
New Zealand*	-51.28	59.40	-46.10	55.85	-33.75	48.32
Australia*	**0.29**	23.26	-5.69	25.09	-5.65	23.33
Canada	-8.94	2.96	-13.48	4.38	-13.48	4.39
Sweden	-9.14	14.21	-10.09	16.49	-11.51	18.38
United Kingdom	-10.38	17.47	-14.02	21.15	-14.67	21.49
Israel	-22.26	**-25.54**	-25.33	**-24.34**	-25.32	**-24.33**

The results regarding the sacrifice and benefit ratios are surprising. In particular it is notable that in 6 of the 9 countries there appears to be negative sacrifice ratios at the first lag and in 7 of the 9 countries at the tenth lag. This implies that with the adoption of inflation targeting, the real exchange rate is driven **more** by real shocks and **less** by nominal shocks. The two remaining countries where sacrifices are positive at a lag length of ten are Chile, where the sacrifice is relatively small (an additional 3% of real exchange rate movements are explained by nominal shocks post IT) and Brazil where the sacrifice is higher (some 13% at the tenth lag).

[28] For all countries a period refers to one month except Australia and New Zealand where we work with quarterly information. For these countries the lags are 1-period, 2-period and 4-periods.

Moreover, the benefit ratios appear to be in general large and positive implying that the nominal rate reflects much more the real shocks post inflation targeting. This is especially the case for New Zealand, Chile, Brazil, Australia and the UK. The benefit ratios for Mexico and Canada are small - although the sacrifice ratios are negative – and Israel is clearly a special case where the benefit ratio and the sacrifice ratio are both negative. This implies that in Israel after IT, the nominal exchange rate reflects more the nominal shocks (negative benefit) and the real exchange rate reflects more the real shocks (negative sacrifice). It is as if the nominal and the real economies have become more independent from each other.

For two countries – namely the Chile and the UK – where the data allows, we consider whether there has been any 'learning' or gain in credibility over the period of post IT. In both cases we split the sample in 1996. For the case of the UK this corresponds to when the Bank of England was granted greater independence and specifically "instrument independence" and in the case of Chile when, arguably, the Central Bank was applying a more pure inflation-targeting regime. The results are presented in Table 5.

Table 5:

	Lag 1		Lag 5		Lag 10	
	Sacrifice Ratio	Benefit Ratio	Sacrifice Ratio	Benefit Ratio	Sacrifice Ratio	Benefit Ratio
Chile						
1991-2001	3.05	43.56	3.98	41.32	3.99	41.32
1991-1996	1.39	32.51	1.34	30.00	1.32	29.99
1997-2001	6.40	47.55	12.91	39.74	13.67	40.46
United Kingdom						
1993-2001	-10.38	17.47	-14.02	21.15	-14.67	21.49
1993-1996	-7.46	8.90	-11.55	15.85	-12.35	16.37
1997-2001	-8.43	21.98	-13.70	25.37	-14.58	26.01

The results indicate that comparing the two post-IT periods with the pre-IT period, in the case of Chile the benefit ratio rises but so too does the sacrifice ratio. The nominal exchange rate was then allowed greater flexibility to reflect more the real shocks but at the cost that the real exchange rate reflected more the nominal shocks. In the case of the UK the benefit ratio in the second period is greater and the sacrifice ratio is more negative. Hence, the real exchange rate reflected more the real shocks and the nominal exchange rate also reflected more the nominal shocks. In the case of the UK, a case can be made then that over time there was an overall improvement in the functioning of the IT regime whereas in the case of Chile there was a tradeoff – more benefit but also a slightly higher sacrifice.

Table 4 gives quite strong support for inflation targeting, as in general there appears to be a significant benefit but with little or negative sacrifice. However, there may be quite different reasons why we are obtaining these results in different countries related to how IT is working across different countries. To investigate this further, in Table 6 we present a matrix of the decomposition of real and nominal exchange rate movements into the real and nominal shocks in the post IT periods for all the 9 countries.

Table 6:

	Shock / Exchange Rate	Pre - IT		Post - IT	
		Nominal	Real	Nominal	Real
Chile	Nominal	81.1	18.9	39.7	60.3
	Real	9.4	90.6	13.3	86.7
Mexico	Nominal	70.4	29.6	65.2	34.8
	Real	50.7	49.3	33.2	66.8
Brazil	Nominal	93.4	6.6	61.1	38.9
	Real	27.9	72.1	40.9	59.1
New Zealand*	Nominal	66.1	33.9	17.8	82.2
	Real	52.5	47.5	18.7	81.3
Australia*	Nominal	25.7	74.3	2.4	97.6
	Real	15.2	84.8	9.5	90.5
Canada	Nominal	47.3	52.7	42.9	57.1
	Real	20.8	79.2	7.3	92.7
Sweden	Nominal	35.0	65.0	16.6	83.4
	Real	16.1	83.9	4.6	95.4
United Kingdom	Nominal	29.5	70.5	8.0	92.0
	Real	19.6	80.4	4.9	95.1
Israel	Nominal	72.6	27.4	97.0	3.0
	Real	28.4	71.6	3.1	96.9

* For New Zealand and Australia we show lag 4, because they have quarterly data.

This Table is revealing in a number of ways. First it is extraordinary to note that in the case of the UK, 95% of real exchange rate movements reflect real shocks and some 92% of nominal exchange rate movements also reflect real shocks! A similar but not quite so extreme pattern is also found in the cases of Sweden (95% and 83% respectively) and Australia (90% and 97% respectively).

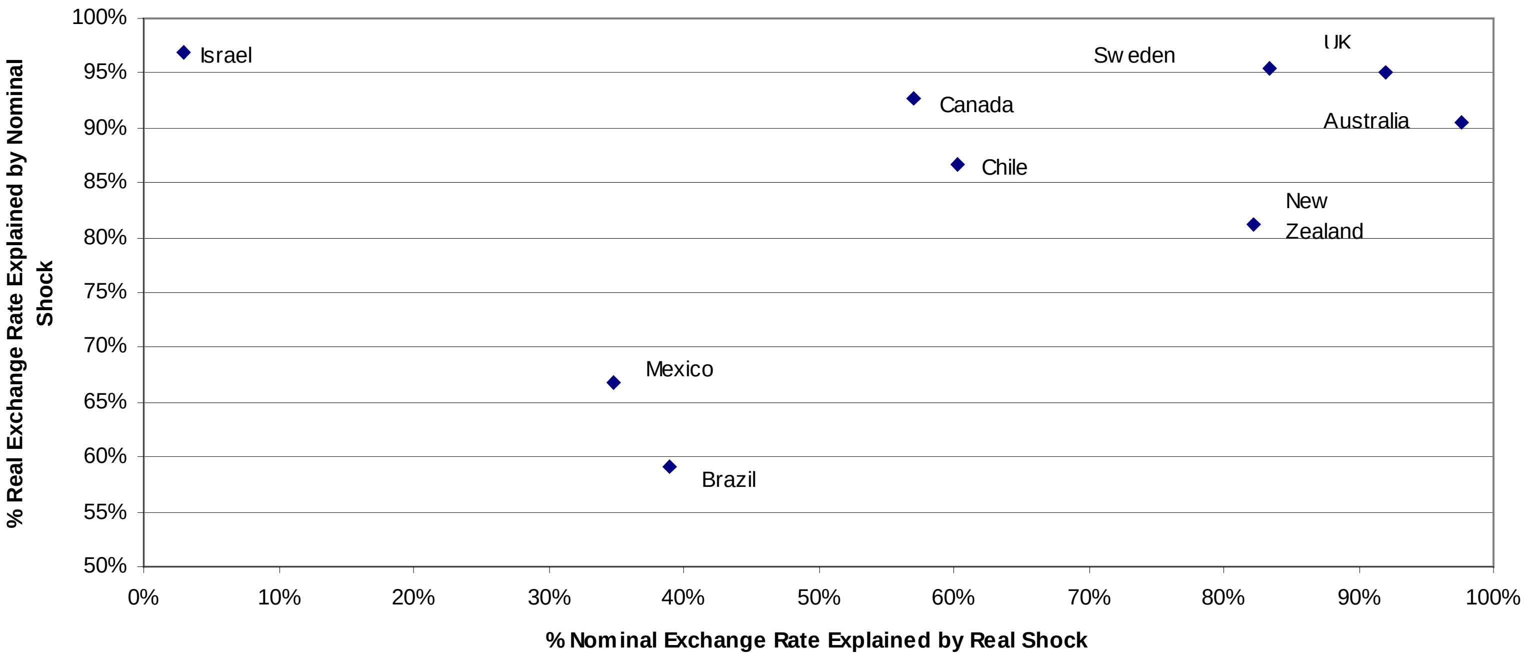
Canada, New Zealand and Chile represent more mixed cases where in the case of Canada the real exchange rate is driven 93% by real shocks but the nominal exchange rate only reflects the real shocks to the tune of 57% and for New Zealand the real exchange rate reflects 74% real shocks and the nominal exchange rate 79% real shocks. In the case of Chile the real exchange rate reflects the real shocks as much as 87% and the nominal exchange rate reflects the real shocks some 60%.

In the cases of Mexico and Brazil, the real and the nominal exchange rates are driven more by the nominal shocks. We might conclude that these are cases where the full potential benefits of a successful IT regime have yet to be reaped. Israel, as before, is a special case where 97% of the real exchange rate is driven by the real shocks and 97% of the nominal exchange rate is driven by the nominal shocks! It is as if the nominal and the real economy are virtually independent.

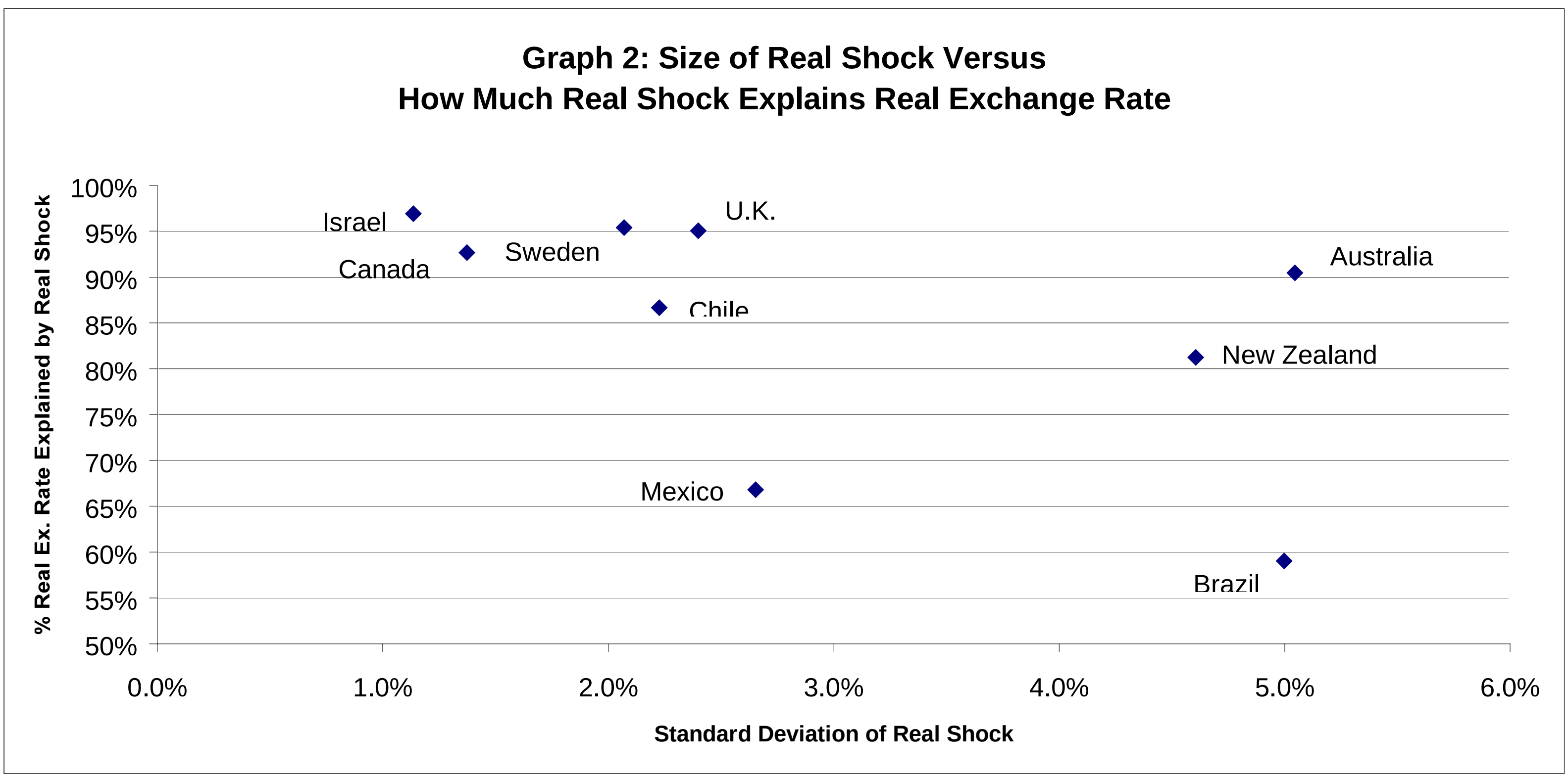
The above results can also be summarized in the form of a graph – namely an x-y plot, where each point represents a country – in the post IT regime – and where the axes represent the percentage of the real exchange rate explained by real shocks and the percentage of the nominal exchange rate explained by the reall shocks.

The graph shows the different country groups as identified above. In the top right corner we have as a first group the UK, Sweden and Australia illustrating that both the nominal and real exchange rates are very largely explained by real shocks in these countries. A mixed second group then comprises of Canada, New Zealand and Chile where either the nominal shocks explain a higher percentage of the real exchange rate (New Zealand) or the nominal exchange rate (Canada and Chile). We then have a third group of Mexico and Brazil where both the real and nominal exchange rate are driven much more by the nominal shocks and finally the special case of Israel where the real exchange rate is driven almost entirely by the real shocks and the nominal exchange rate by the nominal shocks.

Graph 1: Comparative IT Performance



Broadly speaking there are two theories that might explain these results across countries. The first is simply that the first group of countries has extremely high "credibility" in their monetary regimes and hence the influence of nominal shocks is limited, while the third group has yet to gain "full-credibility". The second group of countries is in an intermediary position. An alternative view however is that "credibility" is in fact in itself related to the size of the real shocks in that if a country suffers very high real volatility it is then extremely difficult to gain "full credibility". Rather than credibility being an independent asset to do say with institutions, this view suggests that it is itself endogenous to the size of the real shocks and countries, where the effect of the nominal shocks is large will also be those countries that suffer large real shocks.



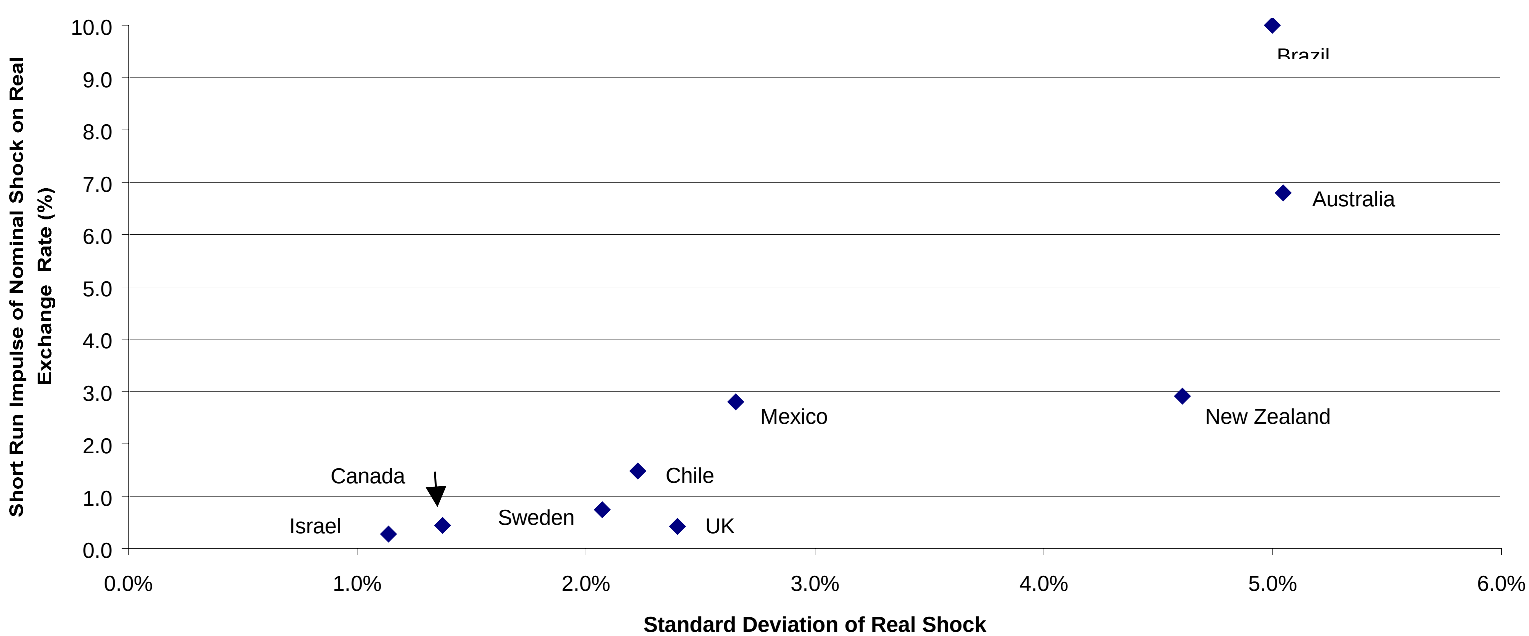
Our econometric methodology, by disentangling the real from the nominal shocks, allows us to investigate precisely this issue. In Graph 2, we plot the size of the real shock (or in other words the standard error of the equation for the real exchange rate) against the percentage of the movement of the real exchange rate explained by the real shocks (from the variance decomposition of the structural VAR). The Graph is not conclusive of any particular relationship. However, for those that claim a negative relationship, it is clear that controlling for the size of the negative shocks, Australia and New Zealand perform well relative to Brazil and Mexico. Australia in particular has suffered from very large real shocks during its IT regime and yet the real exchange rate has been affected very little by other factors apart from those real shocks.

A second way to consider the importance of the nominal shocks on the real exchange rate is not through the second moment (the variation of the real exchange rate is explained), but rather by the first moment or in the language of the structural VAR by the impulse response. In this case we want to know how important is the absolute response and hence we consider the standardized impulse response multiplied by the standard error of the nominal shock.. This then gives us a comparative measure of the importance of the immediate effect of the nominal shock on the real exchange rate.[29] In Graph 3 we then plot the size of the standard deviation of the real shock (standard error of the equation for the real exchange rate) against the first period absolute impulse response of the nominal shock on the real exchange rate.

[29] We find that the effect of the nominal shock as would be expected given the constraints on the structural Var die out reasonably quickly.

There is some evidence here of a positive relationship although, consistent with Graph 2, it is clear that controlling for the size of the real shock Australia does well compared to Brazil (i.e.: there is a lower effect of nominal shocks on the real exchange rate) and the effects of the nominal shock on the real exchange rate is about the same for New Zealand as Mexico even though New Zealand suffered much larger real shocks. Consistent with our previous results, the UK has surprisingly high real shocks but a lower effect of the nominal shocks on the real exchange rate compared to Chile and Sweden.

Graph 3: Effect of Nominal Shock vs Size of Real Shock



There is then mixed evidence with respect to the argument that the size of the real shocks matters in terms of how important nominal shocks are in explaining real exchange ate movements but that even taking into account a potential relation there remain differences across countries. In other words, to explain our results, admittedly based on the handful of country observations that are available to date, there also appears to be something else present. We posit that this something might well be related to institutional factors, reputation or credibility.

5. Conclusions

In this paper we have proposed a new test for the success of inflation targeting based on a set of variance decompositions stemming from a structural VAR estimation in countries that have adopted inflation targeting. We have presented results on a sample of 9 countries - 5 industrialised and 4 emerging.

Inflation targeting (IT) has frequently been adopted to replace some other kind of nominal anchor, typically an implicit or explicit exchange rate target or band and to allow for greater nominal exchange rate flexibility such that the nominal exchange rate can act as a type of shock absorber for the real economy. This suggests that it might be expected that under IT, nominal exchange rates might reflect more the real shocks but that the real exchange rate might reflect more nominal shocks that drive the nominal exchange rate away from some fundamental equilibrium value. The former we use as the basis of our proposed benefit ratio and the second the basis of our proposed sacrifice ratio.

Our results give quite strong support for inflation targeting. Indeed considering the 10 period horizon, 7 of the 9 countries display negative sacrifice ratios. And of the two that have a positive sacrifice it is relatively small in the case of Chile (4%) but a little higher for Brazil (13%). On the other hand, 6 of the 9 countries have a benefit ratio higher than 10%.

However, we also find strong differences across counties in terms of how IT is working. In the case of the UK, Sweden and Australia we find that real exchange rate and nominal exchange rate changes are almost exclusively explained by real shocks. More mixed cases are New Zealand, Canada and Chile. Brazil and Mexico have yet to fully reap the potential benefits of IT according to these measures and Israel appears as a special case where the nominal exchange rate is almost entirely driven the nominal shocks and the real exchange rate by real shocks.

Investigating these results more closely, we find that there is mixed evidence of a relationship between the size of the real shocks and the importance of the nominal shocks in explaining real exchange rate movements. However, even taking such a relationship into account there remains cross-country differences indicating for example, that given the size of the real shocks Australia and New Zealand have performed extremely well and Brazil and Mexico not so well. We conclude then that apart from this relationship there appears to be something else at work that may be related more to institutional factors, reputation and credibility. While IT is still young in these countries it is notable that the most important institutional difference of the IT regimes of these two countries and the more successful inflation targeters appears to be the degree of autonomy of the respective Central Banks.

As more data becomes available for more countries, it will be interesting to compare the results of this type of analysis against the characteristics of the IT regimes as discussed in the first section of this paper. New Zealand is recognised as having the most 'rule based' IT system and this has clearly led to significant benefits (and negative sacrifices) comparing the pre and post IT regimes and comparing performance across countries given the size of the real shocks suffered. However, at the same time the most successful IT regimes according to our measures have greater in-built flexibility (namely the UK, Sweden) and there is also evidence that the UK has improved performance over time perhaps as a result of learning, greater Bank of England autonomy or greater pure credibility[30]. Over time with more data to work with it might be possible to investigate whether certain IT regime characteristics are secrets for success or whether there really is no one size fits all and IT regime characteristics should be modelled to particular country situations.

[30] Chile has also been relatively successful according to our measures and increased the benefit over time but at the cost of a slightly higher sacrifice.

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