The impact of monetary policy on New Zealand business cycles and inflation variability

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Abstract

This paper uses the open economy structural VAR model developed in Buckle, Kim, Kirkham, McLellan and Sharma (2002) to evaluate the impact of monetary policy on New Zealand business cycles and inflation variability and the output/inflation variability trade-off. The model includes a forward-looking Taylor Rule to identify monetary policy and the impact of monetary policy is evaluated by deriving a monetary policy index using a procedure suggested by Dungey and Pagan (2000). Monetary policy has generally been counter-cyclical, thereby reducing business cycles and inflation variability. Exceptions are in 1994 and 1995 when monetary policy accentuated the business cycle upswing and in 1998 when monetary policy accentuated the recession, although its impact in 1998 was small relative to the impact of adverse climatic conditions. During the initial years of inflation targeting monetary policy tended to simultaneously reduce inflation and output variability. From 1996 to 2001 monetary policy was less effective in reducing inflation and output variability. This latter period included a brief experiment with a Monetary Conditions Index, the Asian crisis and a large adverse domestic climate shock.

JEL CLASSIFICATION C22 Time series models; E32 Business fluctuations, cycles; E52 Monetary policy; E58 Central banks and their policies; E65 Studies of particular policy episodes; F41 Open economy macroeconomics

KEYWORDS Monetary policy; inflation targeting, business cycles; open economy; structural VAR models; inflation, interest rates, exchange rates, climate; international linkages

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1 Introduction

New Zealand introduced formal inflation targeting to the world with the introduction of the Reserve Bank of New Zealand Act (1989).[1] At least 18 other central banks have since adopted inflation targeting and evidently more are considering adoption of this monetary framework (Mishkin and Schmidt-Hebbel, 2001). According to Walsh (2002) the New Zealand model nevertheless remains a good example of monetary reform designed to ensure the economy has a nominal anchor, to ensure policy transparency, and to promote accountability.

The outcome of the New Zealand inflation targeting experience has therefore attracted considerable international interest and debate. The purpose of this paper is to evaluate the impact of New Zealand monetary policy on real output and inflation variability since the introduction of formal inflation targeting. Its purpose is to try to answer three questions. First, has monetary policy during the period of inflation targeting accentuated or mitigated booms and recessions in New Zealand business cycles? That is, in the pursuit of low inflation has monetary policy been pro-cyclical or counter-cyclical in its impact on GDP? Second, has monetary policy accentuated or mitigated inflation variability around trend inflation. Third, what effect has monetary policy had on the output/inflation variability trade-off?

The approach in this paper is to answer these three questions using an open economy structural vector auto-regression (SVAR) model of the New Zealand business cycle. VAR models are designed to capture empirically the impulse propagation framework that has come to dominate the analysis of expansions and recessions that characterise the evolution of business cycles. This approach, well illustrated by Blanchard and Watson's (1986) analysis of US business cycles, conceives of fluctuations in economic activity as arising from impulses (shocks) that affect the economy through a complex dynamic propagation process. Therefore identification of shocks that precipitate expansions and recessions in economic growth, or business cycles, represents a major conceptual and statistical challenge. This complexity means that debates concerning the impact of monetary policy are difficult to resolve without the aid of techniques that control for the impact of other shocks. This is precisely the type of issue for which vector autoregression (VAR) models have been developed since they were first introduced by Sims (1980).

[1] The historical and theoretical background motivating the Reserve Bank of New Zealand Act 1989 has been extensively covered by Lloyd (1992), Dawe (1992), Hansen and Margaritis (1993), Grimes (1996, 2001), Evans, Grimes and Wilkinson with Teece (1996), and Brash (1999).

International and domestic debate concerning New Zealand's inflation targeting experience have tended to range over four major themes. These themes include policy coordination issues, whether the contract implicit in the New Zealand legislation is in some sense optimal, whether the policy implementation procedures applied by the Bank have been appropriate and, in light of these issues, whether in the pursuit of inflation targeting monetary policy has generated adverse outcomes for other macroeconomic variables such as interest rates, the exchange rate and the volatility of real output growth.

An impressive flow of research has emerged from debates on the first three issues.[2] Although there have been several papers comparing the behaviour of macroeconomic variables pre and post-inflation targeting (For example Orr and Rae, 1996; Mishkin and Posen, 1997; Reserve Bank of New Zealand, 2000a; Buckle, Haugh and Thomson, 2001), despite ongoing debate (see for example Harris, 1996 and Reserve Bank of New Zealand, 1998 and 1999) there has been little empirical research that has endeavoured to systematically isolate the impact of monetary policy on other macroeconomic variables. Exceptions are the papers by Fischer and Orr (1994) and Hutchison and Walsh (1998) identifying the impact of central bank reform on price uncertainty and monetary policy credibility. This paper is intended to fill that gap by providing an empirical contribution to the debate surrounding the impact of monetary policy on New Zealand's business cycles and inflation.

The paper is structured as follows. Section 2 explains the main features of the SVAR model used to incorporate and evaluate the impact of monetary policy on business cycles and the variability of output and inflation. The method used to identify monetary policy is discussed in Section 3. Section 4 briefly discusses the historical contribution of alternative shocks to New Zealand business cycles. Section 5 evaluates the impact of monetary policy on business cycles and inflation, while Section 6 evaluates the impact of monetary policy on the output/inflation variability trade-off. Section 7 provides concluding comments.

2 A structural VAR model of the business cycle

2.1 Basic features

The SVAR model we apply is the open economy structural VAR model developed by Buckle, Kim, Kirkham, McLellan and Sharma (2002). Compared to previous New Zealand VAR models, it includes an expanded set of international, financial and domestic variables with the object of capturing and identifying shocks emanating from key geographical and industrial characteristics of the New Zealand economy.

The model contains 13 variables and each variable is explained by a structural equation that has an error term associated with it. The error term for each equation is interpreted as representing a particular innovation or shock. These shocks are labelled according to the structural equation from which they derive. For example, the error term derived from the equation for domestic interest rates, which is specified to capture the central bank's reaction function in order to identify monetary policy, is given the name 'domestic interest rate shock'.

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[2] These papers are too numerous to cite here. Many are published in academic journals including *New Zealand Economic Papers*, *Journal of Money Credit and Banking, Journal of Monetary Economics* and in Reserve Bank of New Zealand publications and lectures presented by Victoria University Foundation/RBNZ Professorial Monetary Fellows.

The model focuses on the identification of shocks that lead to temporary deviations of economic activity from its long-run growth path. In other words, in line with the structural VAR models of Sims (1980), Bernanke and Blinder (1992) and Dungey and Pagan (2000), departures from trend are viewed as transient. To make this approach operational, all variables in the SVAR model are detrended using the Hodrick-Prescott filter (Hodrick and Prescott, 1997) with the exception of the climate variable, which was detrended by removing the long-run average for each quarter. This is consistent with understanding the dynamic impact of temporary shocks around a long-run growth path. Shocks may be persistent, but they are transient.

2.2 Structure and identification issues

Structural VAR models are derived from a system of reduced form equations relating each endogenous variable to lagged endogenous (predetermined) and exogenous variables. Since the model contains 13 variables, there are several challenges in recovering robust estimates of the parameters in the structural form equations from the estimated parameters in the reduced form equations.

The approach used is to assume the economy is described by a structural form equation, ignoring constant terms, given by

$$B(L)y_t = u_t \tag{1}$$

where $B(L)$ is a p^{th} order matrix polynomial in the lag operator L, such that $B(L) = B_0 - B_1L - B_2L^2 - ... - B_pL^p$. B_0 is a non-singular matrix normalised to have ones on the diagonal and summarises the contemporaneous relationships between the variables in the model contained in the vector y_t. y_t is a n vector of variables and u_t is a n vector of mean-zero serially uncorrelated structural disturbances. The variance of u_t is denoted by Λ, a diagonal matrix where elements are the variances of structural disturbances; therefore the structural disturbances are assumed to be mutually uncorrelated. Structural disturbances cannot be observed and must be inferred from the reduced form shocks.

Associated with this structural model is the reduced form VAR which is estimated

$$A(L)y_t = \varepsilon_t \tag{2}$$

where $A(L)$ is a matrix polynomial in the lag operator L; ε_t is a n vector of serially uncorrelated reduced form disturbances; and $\mathrm{var}(\varepsilon_t) = \Sigma$. The relationship between the components of equations (1) and (2) are as follows

$$A(L) = B_0^{-1}B(L) = I - A_1L - A_2L^2 - ... - A_pL^p \tag{3}$$

and

$$\varepsilon_t = B_0^{-1}u_t \tag{4}$$

Recovering the structural parameters of the VAR model specified by equation (1) from the estimated reduced form coefficients requires that the model is either exactly identified or over-identified. Exact identification requires the same number of parameters in B_0 and Λ as there are independent parameters in the covariance matrix (Σ) from the reduced form model.

Using equations (3) and (4), the parameters in the structural form equation and those in the reduced form equation are related by

$$A(L) = I - B_0^{-1}[B_1L - B_2L^2 - ... - B_pL^p] \quad (5)$$

and

$$\Sigma = B_0^{-1}\Lambda B_0^{-1'} \quad (6)$$

Maximum likelihood estimates of B_0 and Λ can be obtained only through sample estimates of Σ. The right-hand side of equation (6) has $n(n+1)$ free parameters to be estimated. Since Σ contains $n[(n+1)/2]$, we need at least $n[(n+1)/2]$ restrictions. By normalising each diagonal element of B_0 to 1, we need at least $n[(n-1)/2]$ restrictions on B_0 to achieve identification. This is a minimum requirement. In the structural VAR approach, B_0 can be any structure as long as it has sufficient restrictions.

There are several ways of specifying the restrictions to achieve identification of the structural parameters. One procedure is to use the restrictions implied by a fully specified macroeconomic model. An alternative procedure is to choose the set of variables and identification restrictions that are broadly consistent with the preferred theory and prior empirical research. This approach has been described by Leeper, Sims and Zha (1996) as an informal approach to applying more formal prior beliefs to econometric modelling and it is the approach applied in this paper.

The particular method we use to impose identifying restrictions is similar to that suggested by Cushman and Zha (1997) and Dungey and Pagan (2000) in their structural VAR models of Canada and Australia respectively.[3] This is a more flexible method than the Choleski decomposition procedure originally suggested by Sims (1980) while still giving restrictions on only contemporaneous structural parameters. It permits non-recursive structures and the specification of restrictions based on prior theoretical and empirical information about private sector behaviour and policy reaction functions.

The small open economy extension developed by Cushman and Zha (1997) and Dungey and Pagan (2000) is to impose two blocks of structural equations. One block represents the international economy. The other block of structural equations represents the domestic economy. Variables appearing in the domestic economy block are completely absent from equations in the international block. This follows naturally from the small open economy assumption.

There are several potential advantages to be gained from this block exogeneity approach for the small open economy. One advantage claimed by Cushman and Zha (1997), Kim and Roubini (2000) and Brischetto and Voss (1999) is that it helps identify the monetary policy reaction function for a small open economy. This approach enables monetary policy to react contemporaneously to a variety of domestic and international variables whose data are likely to be immediately available to the monetary authority.[4] Another advantage of this block exogeneity approach is that it enables a larger set of international variables to be included in the model, while reducing the number of parameters needed to

[3] Their method is an adaptation to small open economies of the procedure suggested by Blanchard and Watson (1986), Bernanke (1986) and Sims (1986).

[4] Kim and Roubini (2000), for example, included contemporaneous exchange rate and world price of oil (as a proxy for expected future inflation) variables in the domestic monetary policy reaction function. Cushman and Zha (1997) and Brischetto and Voss (1999) also included the contemporaneous US Federal Funds rate in their specification of the domestic monetary policy reaction function.

estimate the domestic block.[5] The lessons from these recent developments in open economy VAR modelling is that the inclusion of more foreign variables is likely to be important for correct specification, for better identification of contemporaneous interactions, and for a richer set of lagged responses.

2.3 Block structure and structural equations

This New Zealand economy structural VAR model is composed of an international economy block, an international trading prices block, a domestic economic block and a domestic climate block. The choice of four blocks is based on the reasonable assumptions that New Zealand is a small open economy and that climate is exogenous. Variables appearing in the two domestic blocks are absent from the international economy block and the trading prices block. Furthermore, variables appearing in the trading prices block are also absent from the international economy block. Variables appearing in the international economy and trading prices blocks may appear in the domestic economic block, but do not appear in the exogenous domestic climate block. Variables in the domestic climate block can appear in the domestic economic block, but not in the international economy block or the trading prices block.

Table 1 summarises the 13 structural equations. The rows show the dependent variable in each equation. The columns show which explanatory variables appear in each equation, as indicated by the shaded cells and asterisks. Shaded cells indicate the contemporaneous relationships. Asterisks indicate the lagged variables that appear in the equations for each dependent variable.

This model is intended to capture the key macroeconomic characteristics of the New Zealand economy since the early 1980s. Some of these characteristics are captured in the first structural VAR model of the New Zealand economy developed by Wells and Evans (1985). However, their model was estimated for the period 1961 to 1981. Subsequent wide-ranging economic reforms have changed some of those characteristics and the institutional settings for monetary policy.

International linkages are likely to have become more complex and more pervasive as a result of deregulation of New Zealand trade and financial markets since 1984 (as demonstrated for example by Conway, 1998). The international block therefore includes foreign real output, foreign interest rates and foreign real asset returns. The international block is a Wold recursive system in the contemporaneous variables. The contemporaneous causal ordering runs from foreign real output to foreign interest rates and real asset returns. Foreign real output (y^w) depends upon lags of foreign nominal interest rates (i^w) and foreign real asset returns (q^w).

Foreign nominal interest rates respond to contemporaneous and lagged movements in foreign real output and to lags in foreign interest rates. Foreign real asset returns (q^w) respond contemporaneously to foreign real output and foreign interest rates, and to lags in these variables and its own lags. The inclusion of q^w reflects growing integration of New Zealand financial markets with international markets since financial deregulation during the mid 1980s.

The international trading prices block reflects the Australian three-goods model of the dependent economy (developed by Salter, 1959 and Swan, 1963). This approach

[5] Cushman and Zha (1997) included four international variables in their model of the Canadian economy: United States (US) industrial production, US consumer prices, the US Federal Funds rate and world total commodity export prices. Dungey and Pagan (2000) included real US GDP, real US interest rates, the Australian terms of trade, and the Dow Jones Index deflated by the US consumer prices index. They also treated Australia's real exports as exogenous to the domestic economy, making a total of 5 variables in their international block.

emphasises the distinction between imports, exports and non-traded goods, and has exogenous terms of trade. The reason for adopting this three-good approach is New Zealand's industrial structure. A substantial proportion of New Zealand's imports are inputs to the production process and a significant proportion of its exported products are primary based with a low proportion of exportable production absorbed by home consumption.

Within the context of this type of commodity structure the effects of import and export price shocks on domestic real output and inflation therefore need not necessarily be mirror images of each other. This argument is supported by Wells and Evans (1985) who found that an increase in export prices raised private sector output and employment and had virtually no effect on output prices. An increase in import prices reduced private sector output and employment but also raised output prices, the classical stagflation effect.

Table 1 – Contemporaneous and lag structure of the SVAR model

Independent Variables

Dependent Variables

	y^w	i^w	q^w	px^w	pz^w	d	y	x	e	i	q	pc	c
y^w	*	*	*										
i^w	*	*											
q^w	*	*	*										
px^w	*			*									
pz^w	*				*								
d				*	*	*	*		*	*	*	*	
y	*			*	*	*	*	*	*				*
x				*				*	*			*	*
e	*	*	*	*	*	*	*	*	*	*	*	*	
i		*				*				*		*	
q	*		*	*	*	*	*		*	*	*		
pc				*	*	*			*			*	*
c													*

Note : y^w = foreign real output; i^w = foreign nominal interest rates; q^w = and foreign real asset returns; px^w = foreign currency price of New Zealand exports; pz^w = foreign currency price of New Zealand imports; d = aggregate real domestic demand; y = aggregate real domestic output; x = New Zealand supply of exports; e = the nominal exchange rate; i = domestic interest rates; q = real domestic equity returns; pc = domestic prices; c = domestic climatic conditions.

Consistent with the small open economy assumption, we model the foreign currency price of New Zealand exports (px^w) and the foreign currency price of New Zealand imports (pz^w) as responding to contemporaneous and lagged foreign real output and to their respective lagged values.

A domestic climate block is included to capture the importance of the agricultural sector as a source of final output and intermediate inputs to several manufacturing industries and the importance of hydro electricity as a source of energy in New Zealand. Earlier industry level studies suggest that variations in climatic conditions have the potential to influence the aggregate level of economic activity.[6] We use the soil moisture conditions variable derived by Porteous, Basher and Salinger (1994) and analysed by NIWA (2001) to capture the impact of climatic conditions on New Zealand real GDP and exports. The soil moisture variable is block exogenous. To capture the impact of climatic conditions we postulate that changes in soil moisture conditions have important contemporaneous and lagged effects on total New Zealand real GDP (y) and on New Zealand export supply (x).

There are two main components to the domestic economy block. Three variables represent aggregate real domestic output and aggregate real demand for domestic output (y, d, x). Four variables represent prices and real returns to wealth (e, i, q, pc). Since real gross national expenditure (GNE) includes spending on imports, the inclusion of real GDP and real GNE in the same model imply the model captures shocks to the balance of trade. This feature is also present in Dungey and Pagan's (2000) model for Australia.

Shocks to GNE are interpreted as aggregate demand shocks. Contemporaneous influences on domestic demand include shocks to aggregate demand and foreign prices for exports and imports (px^w and pz^w), the latter reflecting the terms of trade effect on the purchasing power of New Zealand output. Income and relative price effects arising from changes to domestic real GDP (y), the interest rate (i), the exchange rate (e), and domestic prices (pc), impact after a one-quarter lag. The introduction of a goods and services tax (GST) in 1986:4 and a further increase in 1989:3 was foreshadowed by increases in domestic demand in the quarters prior to each tax increase. These shocks have been absorbed into two GST dummy variables. The first takes the value 1 in 1986:3 and zero in all other quarters; the second takes the value 1 in 1989:2 and zero in all other quarters.

Contemporaneous shocks to aggregate real GDP arise from two sources of demand shocks, domestic GNE (d), and export demand (x), and two supply shocks, climate (c) and other unexplained supply shocks that are captured by the error term in the equation for real GDP. To allow for the possibility of spillover effects from world productivity shocks, lagged foreign output is included in the equation for domestic real GDP. Other influences include lagged expenditure-switching effects arising from shocks to the exchange rate, export prices and import prices.

New Zealand producers are assumed to face infinitely elastic demand on world markets. Contemporaneous influences on export supply include climatic and other export supply shocks. Real exchange rate effects arising from changes to world prices for exports, the exchange rate and domestic prices (px^w, e, pc) impact after a one-quarter lag.

The domestic price variable (pc) is the difference between the log of the domestic Consumers' Prices Index and its trend value. It is therefore a measure of the extent to which prices are growing faster or slower than trend growth. The equation for domestic prices can be interpreted as a reduced form equation capturing mark-up on cost pricing by domestic firms and the direct price effects of final tradeable goods that are consumed domestically, similar to that estimated by Hampton (2001).

[6] These studies include the pioneering research by Maunder (1966, 1968) and Maunder and Ausubel (1985) using agroclimatological models to predict the effect of rainfall, temperature and sunshine on butterfat production, and subsequent investigations of the impact of climate on livestock investment and slaughter rates (Tweedie and Spencer, 1981) and on farm profits (Wallace and Evans, 1985).

The production costs of domestic firms include prices of imported intermediate production inputs, labour costs and productivity. Labour costs are assumed to be determined by a Phillips curve that relates wage inflation to demand pressure and expected inflation. Demand pressure is proxied by the deviation of real GNE from trend (d). Expected inflation which is determined by a combination of current and lagged deviation of prices from trend (pc). Domestic currency prices of imported intermediate goods are captured by the world price of imports (pz^w) and the exchange rate (e), while the domestic currency prices of final tradeable goods consumed locally are captured by foreign prices for exports, imports and the exchange rate (px^w, pz^w, e).

Dummy variables are used to account for the effect on domestic prices of two goods and services taxation (GST) increases in 1986:4 and 1989:3. The first dummy variable takes the value 1 in 1986:4 and zero in all other quarters; the second takes the value 1 in 1989:3 and zero in all other quarters.

Real returns on domestic equities (q), represented by the NZSE40 gross return index and deflated by the New Zealand Consumers' Price Index, are specified as a function of contemporaneous foreign real output (y^w), foreign real asset returns (q^w) and the exchange rate (e) to reflect the globalisation of international asset markets. Real domestic equity returns are also specified as being influenced by variables considered likely to affect expectations of domestic real output growth (px^w, pz^w, y) and returns from alternative financial assets (i).

The equation for domestic interest rates (i) is intended to capture the monetary authority's reaction function. For reasons explained in Section 3, this reaction function is modelled as a forward-looking Taylor-rule. This specification appears to successfully identify monetary policy shocks.

2.4 Data and variables

The quarterly data series used to represent the 13 variables contained within the four blocks are as follow. Foreign real output is represented by the log of trade weighted world industrial production (y^w).[7] Foreign nominal interest rates (i^w) are represented by a weighted average of Australian, United States, United Kingdom, Japan and German 90 day interest rates, where the weights are determined by the ratio of country GDP to the sum of GDP for all these economies. Foreign real asset returns are represented by the log of the Morgan Stanley World Capital Index of gross equity returns (q^w) deflated by an index of United States consumer prices.

The foreign currency price of New Zealand exports is calculated by multiplying Statistics New Zealand's domestic currency export price index by the trade weighted exchange rate and expressed in logs (px^w). The foreign currency price of New Zealand imports is calculated by multiplying Statistics New Zealand's domestic currency import price index by the trade weighted exchange rate, and expressed in logs (pz^w). The domestic exchange rate is represented by the nominal trade weighted exchange rate for New Zealand, expressed in logs (e).

Domestic real aggregate output is represented by Statistics New Zealand's chained measure of production based quarterly real GDP that has been calibrated back to 1978 by Haugh (2001) and expressed in logs (y). Domestic real aggregate demand is

[7] Weighted by the two-year moving average of New Zealand's main export destinations (Australia, US, UK, Japan, Germany, Hong Kong, Taiwan and South Korea). The industrial production indices are from "Datastream".

represented by Statistics New Zealand's chain-linked measure of quarterly real GNE backdated to 1982:2, expressed in logs (d).[8] Domestic real exports are represented by Statistics New Zealand's System of National Accounts measure of real exports of goods and services, expressed in logs (x).[9]

Domestic prices are represented by Statistics New Zealand's Consumers' Price Index for New Zealand, expressed in logs (pc). The domestic interest rate is represented by the New Zealand 90-day interest rate (i). Real returns on domestic equities are represented by the NZSE40 gross return index available from Datastream, deflated by the New Zealand Consumers' Price Index and expressed in logs (q). Domestic climate is represented by the number of days of soil moisture deficit in each quarter estimated by the National Institute of Water and Atmospheric Research Limited (NIWA) (2001), and is denoted as (c). This soil moisture variable is calculated from the daily water balance. It measures the net impact of rainfall entering the pasture root zone in the soil and that which is lost from this zone as a result of evapotranspiration or use of water by the plants.

Each data series enters the structural VAR as a deviation from long-run trend, where the trend is estimated using the Hodrick-Prescott filter, with the smoothing parameter λ=1600.[10] An exception is the climate variable which is detrended by removing from each quarterly value the long-run average value for that quarter. This is done to measure climatic conditions that differ from the normal seasonal pattern to model the impact of climatic conditions above and below the norm on the New Zealand economy. The climate variable therefore represents the soil moisture deficit level above or below the normal seasonal level. The model is estimated using quarterly data from 1983:1 to 2002:1.

2.5 Estimation

The selection of lag length was restricted to between one and four because when we estimated the model using five lags the variance-covariance matrix was singular. On the basis of both the Akaike Information criterion (AIC) and the Bayesian Information Criterion (BIC), the sample evidence for the entire reduced form VAR system suggested a lag length of one. A series of sequential likelihood ratio tests for a shorter lag length versus a longer lag length, suggested a lag length of two. A lag length of one or two is quite short compared with other New Zealand VAR studies.

Given these considerations, the reduced form VAR was estimated with three lags using Seemingly Unrelated Regression (SUR). SUR estimators were used because the inclusion of zero restrictions on some lagged variables renders ordinary least squares estimators inefficient. The Durbin H statistic suggested the reduced form VAR with three lags was absent of serial correlation.

The contemporaneous matrix, B_0, was estimated using maximum likelihood. Initial starting values for B_0 were found using the genetic algorithm. The estimates from the genetic algorithm were then used as starting values to find the final parameter estimates for B_0 using the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm. As part of the sensitivity analysis, the model was estimated over sample sub-periods to test the

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[8] Backdated using the quarterly percentage changes from the System of National Accounts (1968) gross national expenditure series.

[9] Also backdated using the quarterly percentage changes from the System Of National Accounts (1968) total real exports of goods and services series.

[10] The value for λ is based on Kim, Buckle and Hall (1994) who used λ=1600 to analyse key features of New Zealand business cycles. Although, as Cogley and Nason (1995) point out, the Hodrick-Prescott filter can sometimes produce spurious cycles the use of alternatives such as linear trends and first differences are problematic for the New Zealand data over this period.

robustness of coefficient estimates. The estimation results from different sub-periods suggested the model was robust to changes in the sample period.[11]

3 Identifying monetary policy

The specification for domestic interest rates (i) implied by Table 1 is intended to incorporate the monetary authority's reaction function plus other shocks to domestic interest rates. Recent research suggests that for most of our sample period, the conduct of monetary policy in New Zealand approximates a Taylor-type (Taylor, 1993) reaction function (see Plantier and Scrimgeour, 2002; Huang, Margaritis and Mayes, 2001). The basic specification of the interest rate equation reflects this idea, but with several modifications.

The New Zealand monetary authority's behaviour is probably appropriately described by forward-looking behaviour. This model therefore embodies a variant of the Taylor Rule in which the monetary authority reacts to forecasts of inflation and demand three quarters in the future. The Taylor Rule takes the form reflected in Table 1, but with the independent variables replaced with three-quarter-ahead forecasts generated from the reduced form VAR. Stock and Watson (2001) compare the implications of backward and forward-looking Taylor Rules in a three variable model of U.S. inflation. They found the choice of specification affected interest rate impulse response functions. Alternative specifications of the monetary authority's reaction function applied in this New Zealand SVAR model revealed that the choice of a forward-looking specification produced different and more sensible reactions to interest rate shocks. Clarida, Gali and Gertler (1998) have also applied forward-looking Taylor Rules in an empirical context.

Over the sample period for this study there were several changes in the operation of monetary policy in New Zealand. Alternative specifications for the interest rate equation that included intercept and interactive dummy variables were tested to capture these changes. For example, a dummy variable that interacted with the exchange rate, and which took on a value of one between 1997:2 and 1999:4 and zero elsewhere, was used to capture the operation of monetary policy when monetary policy decisions were based on a monetary conditions index (MCI) (see Reserve Bank of New Zealand, 1996).[12] This alternative specification for the interest rate equation had little discernable effect on the impulse response functions used to identify monetary policy.[13]

Although the Official Cash Rate (OCR) is the current monetary policy instrument in New Zealand, this variable is unavailable for the full sample period. We have therefore used the 90-day rate as a proxy variable. The 90-day rate is not strictly controlled by the monetary authority and can be influenced by private expectations and shifts in portfolio decisions. We therefore include the world interest rate as a direct contemporaneous and lagged influence on the domestic interest rate.

The interest rate equation therefore takes the following form:

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[11] Details of estimation results are available from the authors on request.

[12] The MCI was developed by the Bank of Canada in the late 1980s as a linear combination of changes in a summary measure of the exchange rate and a benchmark interest rate from a base period value. Although published by a variety of organisations, the central banks of Canada and New Zealand are evidently the only central banks to have used MCIs as an operational target for monetary policy (see Engelbrecht and Loomes, 2002). Reserve Bank of New Zealand (1997) discusses the introduction of an MCI in New Zealand. Freedman (1995) explains the concept and role of a monetary conditions index in the operation of monetary policy.

[13] Although we found no evidence that the reaction function was unstable, there could nevertheless be changes in the relative importance of the transmission channels. Some stability testing was undertaken by reestimating the model after dropping the first three years and the last three years of observations. The impulse response functions were however very similar to those estimated using data for the full sample period.

$$i_t = \sum_{i=1}^{n=3} \alpha_i i_{t-i} + \sum_{i=0}^{n=3} \chi_i i^w_{t-i} + \beta \hat{d}_{t+3} + \delta \hat{p}c_{t+3} + \varepsilon_t \qquad (7)$$

where $\hat{d}_{t+3}$ and $\hat{p}c_{t+3}$ are the three-quarter ahead reduced form model forecasts for the deviations from trend of log real domestic demand and log domestic prices.

Structural VAR models have typically been used to identify dynamic responses of an economy to particular shocks. This serves two purposes. It provides a means of analysing an estimated structural VAR and it reveals information about the dynamic properties of the economy investigated. The results can be used to inform policy makers and economic forecasters how economic variables such as real output and prices respond over time to changes in policy or other events.

As with all empirical work, the information value of dynamic simulations depends on the validity of the structure of the simulated empirical model. Because the focus of this paper is to measure the effect of monetary policy on New Zealand business cycles, of particular importance is that the model satisfactorily captures the dynamic impact of interest rates on the economy.

Impulse response functions have traditionally been used as a means of analysing an estimated structural VAR model (Hamilton, 1994). They represent the dynamic response of a variable in the model to an error term (referred to as a shock or innovation) in one of the structural equations. The transmission of the shock will depend on the form of the structural equations. Using Table 1, a shock to the domestic interest rate (i) will have a contemporaneous impact on the domestic exchange rate (e) and domestic asset returns (q), and an impact on these and other variables one period into the future, two periods into the future,…, etc. These reactions represent the impulse responses.

Each variable in the model can be expressed as a combination of current and all past errors in the structural equations. That is, from equations (2) and (4), the SVAR can be written in moving average representation as follows:

$$y_t = A(L)^{-1} B_0^{-1} u_t \qquad = \Theta(L) u_t \qquad (8)$$

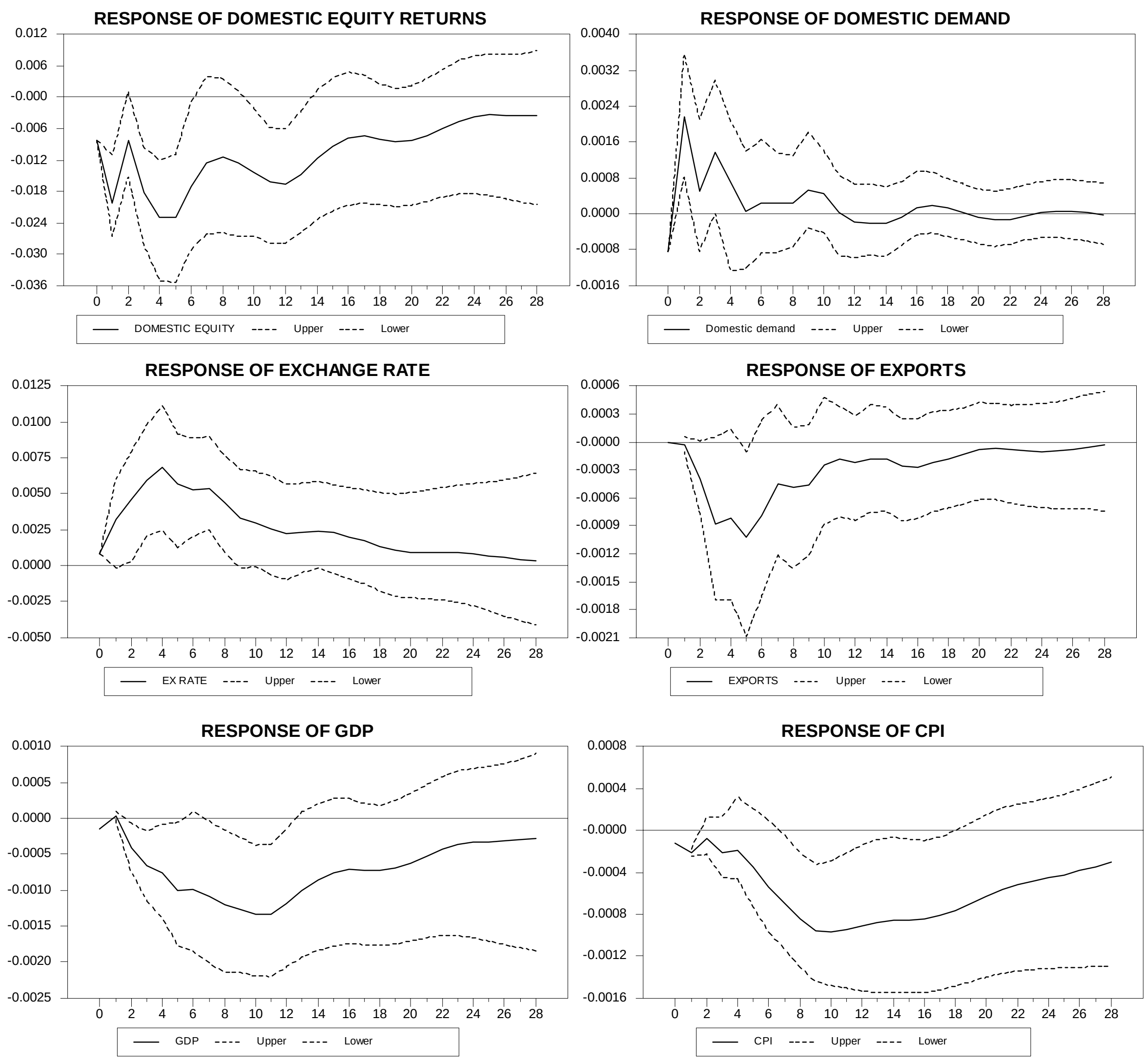
where $\Theta(L)$ contains the dynamic multipliers used to map out the impulse response functions following innovations to the structural error terms. The impulse response function represents the dynamic path for y_t from the *i*th equation following an innovation to the structural error term u_t from the *j*th equation, holding all other structural error terms constant.

A range of impulse response functions derived from this open economy SVAR model were used to evaluate the dynamic properties of the model and are illustrated in Buckle, Kim, Kirkham, McLellan, and Sharma (2002, Section 4, pages 19-27). The focus of this paper is the impact of monetary policy and therefore Figure 1 provides a selection of the impulse response functions from an interest rate shock.

Figure 1 shows the responses of several macroeconomic variables to an increase in the domestic interest rate. The size of the shock is an increase in the domestic interest rate of approximately 120 basis points above trend, which is equivalent to one standard deviation of the structural error term from the domestic interest rate equation. As is commonplace in the VAR literature, sixty-eight percent confidence bands have been estimated for the impulse response functions using the Monte Carlo bootstrapping approach of Runkle (1987). Both the impulse response functions and the sixty-eight percent confidence bands have been normalised by dividing by the size of the shock.

Monetary policy is expected to affect macroeconomic variables through a number of transmission channels. An increase in the domestic nominal interest rate will lead to an appreciation in the nominal exchanges rate, all else held constant. This appreciation in the nominal exchange rate results in a decrease in the domestic currency price of tradeable goods. When exporters are pricing goods in foreign currency terms, an increase in the nominal exchange rate results in a reduction in the domestic currency price of export goods. Likewise, an appreciation in the nominal exchange rate results in a decrease in the domestic currency price of imported goods. Changes in the domestic currency price of tradeable goods that are also consumed domestically, or that are used as an input in the production of goods that are consumed domestically, may take some time to be reflected in the domestic price of these goods. The magnitude and speed of exchange rate passthrough to the price of domestic consumption goods is dependent on a number of factors, including the level of domestic competition and fixed costs associated with altering domestic prices.

Figure 1 – Responses to domestic interest rate shock



Note: The solid lines represent the impulse response functions and the dotted lines represent the 68% confidence bands estimated using the Monte Carlo bootstrapping approach of Runkle (1987).

In the presence of short-run nominal rigidities, an increase in the nominal domestic interest rate results in an increase in the real domestic interest rate and an appreciation in the real exchange rate. A higher real exchange rate makes exporting and importing competing goods less competitive, resulting in lower aggregate demand. A higher real domestic interest rate reduces aggregate demand via a dampening effect on household consumption and firm investment.

Monetary policy may also affect aggregate demand and domestic prices via the credit channel. This channel arises from the impact of changes in the short-term interest rate on household balance sheets and bank lending decisions. For example, a higher domestic interest rate that results in a reduction in household equity may lead to lower housing investment, resulting in lower aggregate demand.[14] These effects are not identified in this model.

Figure 1 illustrates that an increase in the domestic interest rate (i) results in an immediate decline in domestic equity returns (q) as equities are substituted for bonds. Although equity returns (q) decline there appears to be little impact on domestic demand (d) (with the impulse response function not being significantly different from zero apart from the first quarter after the shock). The structural VAR model therefore suggests a weak transmission channel from domestic interest rates to domestic demand either indirectly through a reduction in equity returns or directly through a dampening effect on household consumption and firm investment.

The exchange rate (e) appreciates in response to the domestic interest rate (i) increase. The strongest reaction is after four quarters. The exchange rate (e) appreciation is likely to reflect the impact of an increase in the interest rate differential between domestic and foreign interest (i^w) rates. An appreciation of the exchange rate (e) results in a fall in export volumes (x), a decline in domestic output (y) and a fall in domestic consumer prices (pc). While domestic prices start to fall almost immediately, the trough occurs over eighteen months after the shock. This is consistent with the presence of nominal price rigidities and slow exchange rate pass through (IMF, 2001). These impulses suggest the tradeables sector plays an important role in transmitting interest rate changes to domestic prices.

A number of VAR studies have encountered difficulties in detecting the impact of monetary policy actions on other macroeconomic variables. Kim and Roubini (2000) outlined several empirical "puzzles" that have been associated with attempts to identify monetary policy in both open and closed economies. One attractive feature of this New Zealand SVAR model is that it does not encounter two of the puzzles discussed by Kim and Roubini (2000), namely the price puzzle (where the price level rises in response to a positive interest rate shock) and the exchange rate puzzle (where the exchange rate depreciates following a positive interest rate shock). Monetary policy appears to have been successfully identified, without the need to include non-monetary policy variables that several other VAR studies have had to resort to in order to identify monetary policy (see for example Brischetto and Voss, 1999 and Kim and Roubini, 2000).

4 Contributions to New Zealand growth cycles

The purpose of this section is to use the structural VAR model to identify the relative importance of domestic financial (domestic interest rate, exchange rate and equity) shocks compared to international, domestic economic, and domestic climate shocks in contributing to business cycle fluctuations. The sample period includes the 1991 to 1993 recession, the boom during the mid 1990s, the 1998 recession and subsequent growth recovery.

The business cycle represented here is the percentage deviation of real GDP from its trend level, which is also known as the growth cycle. Therefore, this part of the paper concentrates on contributions to detrended domestic GDP (y). Following equation (8),

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[14] Claus and Smith (1999) and Grimes (2001) provide more detailed discussion of the credit channel and how it relates to monetary policy in New Zealand.

the structural VAR can be written in moving average representation to explain the impact of shocks to detrended GDP as follows:

$$y_t = \textit{initial conditions} + \sum_{i=0}^{t-1} \sum_{j=1}^{13} \theta_{ij} u_{j,t-i} \tag{9}$$

where θ_{ij} is the ith impulse response associated with the jth shock, with 13 shocks in our system.

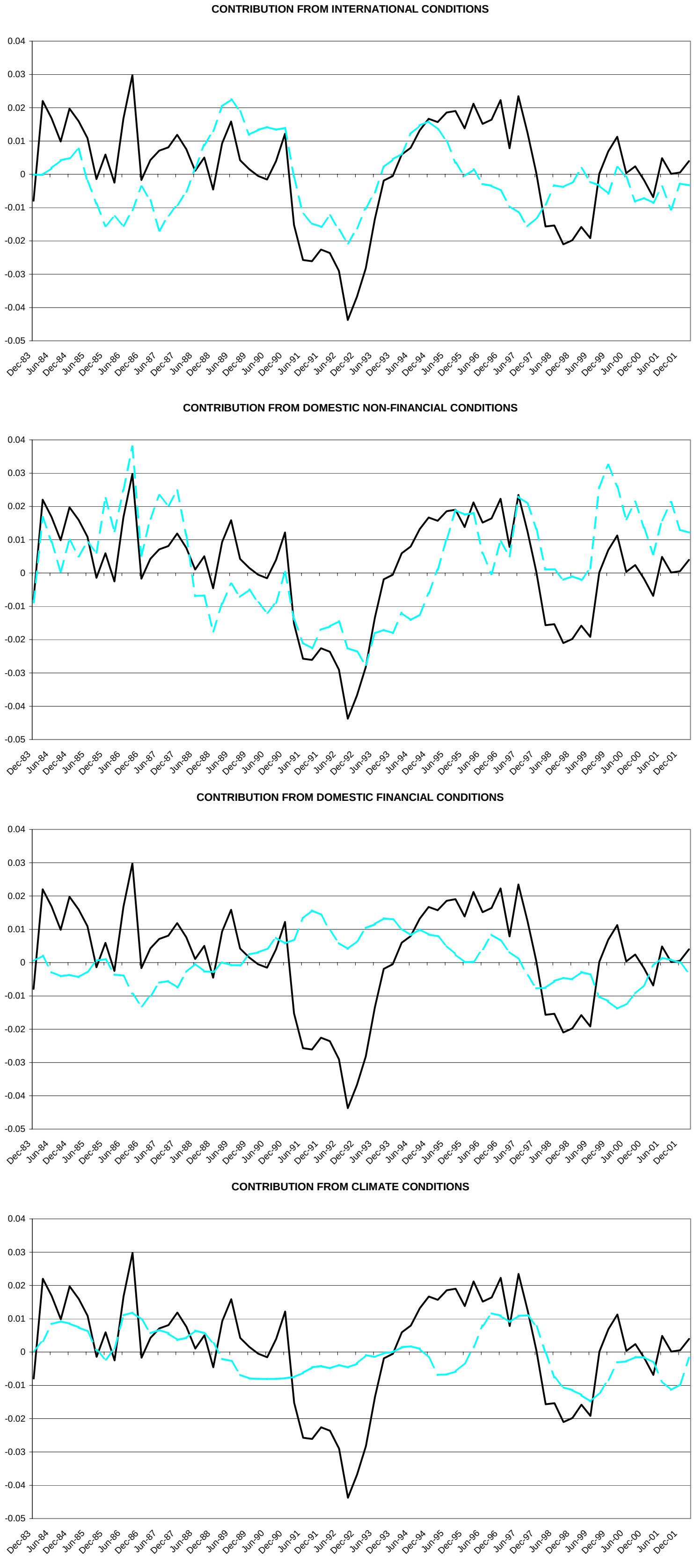
At the beginning of the sample period, initial conditions will contribute a substantial proportion to deviations of real GDP from trend. But over time the contributions from initial conditions converge toward zero. The relative contribution of domestic financial shocks compared to international, domestic economic (which includes the effect of initial conditions) and domestic climate shocks can be seen in Figure 2.

In general, the main reasons for New Zealand business cycle fluctuations are international shocks, domestic climate shocks and domestic economic (non-financial) shocks that have tended to be pro-cyclical. The contributions from domestic climate shocks were particularly marked during the mid to late 1990s. The contribution of domestic financial shocks, which includes the summation of the effects of domestic interest rate, exchange rate and equity shocks, have been relatively moderate and generally counter-cyclical, thereby dampening the impact of other shocks to the business cycle.

A comparison of the two recessions illustrates how the contributions of these shocks can vary across time. International and domestic economic shocks were the main explanations for the recession that commenced in 1991. Climate contributed moderately to that recession. Contributions from domestic financial conditions tended to offset these forces and moderated the depth of the recession.

In contrast, deteriorating climatic conditions were the main reason for the recession in 1998. International and domestic economic factors were relatively neutral. In contrast to previous periods, domestic financial shocks tended to accentuate the recession, although their contribution was smaller than the impact of climate shocks. During the subsequent recovery, however, domestic financial contributions reverted to a counter-cyclical role again.

Figure 2 – Contributions to New Zealand growth cycles



Note: The solid black line is detrended domestic GDP (*y*). The dotted line represents the contribution of the respective components to detrended domestic GDP (*y*). International conditions include foreign real output (y^w), foreign interest rates (i^w), foreign asset returns (q^w) and foreign currency prices for exports and imports (px^w and pz^w); domestic non-financial conditions include domestic demand (*d*), New Zealand supply of exports (*x*), domestic prices (*pc*) and initial conditions; and domestic financial conditions include the exchange rate (*e*), the domestic interest rate (*i*) and domestic equity returns (*q*). Climate conditions are captured by the domestic climate conditions (*c*) variable.

5 The impact of monetary policy on the growth cycle and inflation

Section 4 showed that changes in domestic financial conditions, including interest rates, have sometimes moderated the magnitude of the growth cycle; at other times they have accentuated the magnitude of the cycle. The purpose of this section is to isolate the impact of monetary policy on the growth cycle and deviations of inflation from trend.

The impact of domestic interest rate shocks included in the contribution of domestic financial shocks to detrended GDP, and presented in Figure 2, do not fully capture the impact of monetary policy. This is because in addition to the direct (non-systematic) impact of interest rate shocks on detrended GDP, there is also an induced (systematic) impact. The direct impact of interest rate shocks are captured by structural shocks to the interest rate equation that can arise from random shifts in interest rates including changes in preferences of the central bank and exogenous changes in portfolio preferences. The induced impact arises when the monetary authority changes interest rates in response to changes in the domestic economic environment. For example, in response to a rise in import prices that is expected to induce a recession, the central bank will lower interest rates to offset the anticipated fall in domestic demand. This induced impact of monetary policy is captured by the reaction function. Therefore, to gauge the impact of monetary policy on detrended GDP (*y*), both the direct and induced effects need to be measured. The methodology outlined in this section follows Dungey and Pagan (2000, pages 335-336).

The reaction function is derived on the basis that the monetary authority responds to forecasts of deviations in domestic demand and the domestic price level from trend. Hence to isolate the policy-induced impact of changes in the interest rate, the decomposition for detrended domestic GDP is computed when the monetary authority's reaction function is suppressed. That is, the historical decomposition for detrended GDP (*y*) is computed where the coefficients on forecast inflation and GNE in the domestic interest rate equation are set equal to zero and all other coefficients in the model remain the same. This idea is represented by equation (10).

$$y_t^* = \textit{initial conditions} + \sum_{i=0}^{t-1}\sum_{j=1}^{13}\theta_{ij}^* u_{j,t-i} \qquad (10)$$

where θ^* are the impulse response functions and y_t^* is detrended GDP when the monetary authority's reaction function has been suppressed.

The total effect of monetary policy is then found by subtracting equation (10) from equation (9), and then adding back the direct effect of interest rate shocks (that is, the second term in equation (10) corresponding to $u_{10,t-i}$) to gain the monetary policy index (MPI):

$$MPI_t = \sum_{i=0}^{t-1}\theta_{t,10}^* u_{10,t-i} + \sum_{i=0}^{t-1}\sum_{j=1}^{13}(\theta_{ij} - \theta_{ij}^*)u_{j,t-i} \qquad (11)$$

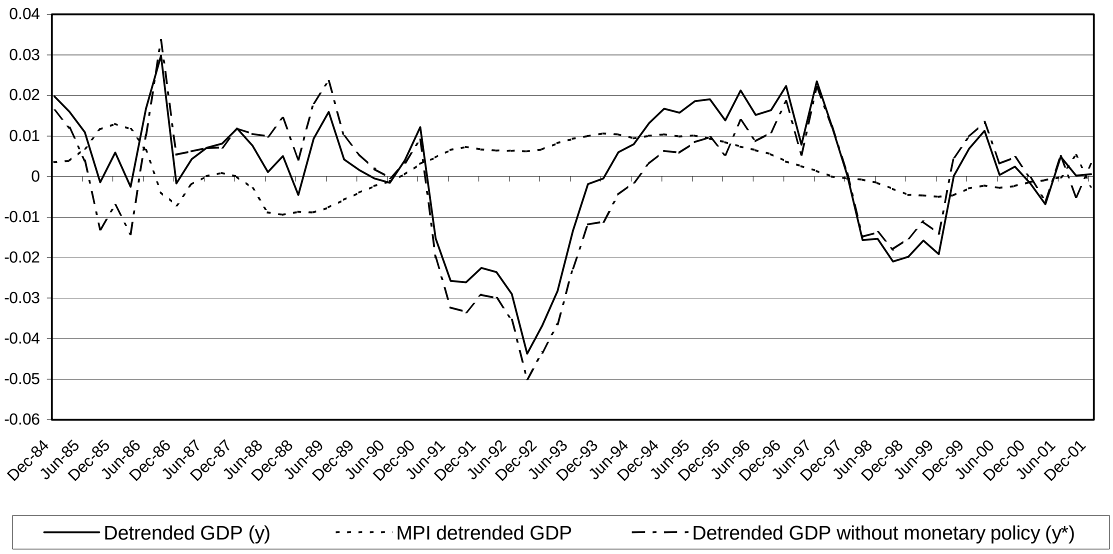
The MPI, represented by equation (11), measures how much monetary policy is adding or subtracting to detrended GDP at each point in time. The first component of equation (11) captures the non-systematic reaction of monetary policy and the second component captures the systematic reaction of monetary policy to shocks (such as an import price shock). The profile for detrended GDP in the absence of a monetary policy response is calculated by subtracting the MPI from detrended GDP (*y*).[15]

Figure 3 shows detrended GDP (*y*), the monetary policy index (MPI) and detrended GDP without the impact of monetary policy (*y**). When the MPI is above zero, monetary policy is acting to raise detrended GDP. When the MPI is below zero it indicates that monetary policy is depressing detrended GDP (*y*).

One way to evaluate the impact of monetary policy on the growth cycle is to gauge the degree to which monetary policy has been 'countercyclical'. There are two dimensions to this. One is to see how closely in time the MPI and detrended GDP without monetary policy (*y**) cut the horizontal axis with opposite slope. Ideally the MPI would move above zero when detrended GDP without the influence of monetary policy (*y**) moves below zero and vice-versa.

The second dimension is the magnitude to which the MPI moves above zero when detrended GDP without monetary policy (*y**) is below zero and vice-versa. If monetary policy had been perfectly countercyclical, the amplitude and frequency of the MPI and detrended GDP without monetary policy (*y**) cycles would have been the same but opposite in sign. In this case, detrended GDP (*y)* would have been at zero (that is, monetary policy would have kept GDP at its trend level). Clearly, this is a stringent criterion by which to evaluate the effectiveness of monetary policy in stabilising GDP (*y*).

Figure 3 – Monetary policy impact on the growth cycle



From Figure 3 it is apparent there have been periods when monetary policy has been countercyclical and periods when it has been procyclical. Until late 1993 the MPI was generally positive when detrended GDP without monetary policy (*y**) was negative and vice-versa, although at times the MPI and detrended GDP without monetary policy (*y**) cut the horizontal axis at different points in time. For instance, during the 1991 to 1993 recession monetary policy moderated the depth of the recession. Moreover, at times these offsetting effects are quite large. In 1988 and in 1993 these offsetting effects of monetary policy on the deviation of real GDP from trend were as large as 1 percent per quarter.

However, there are also times during the mid and late 1990s when monetary policy was pro-cyclical. From late 1993 until 1997 monetary policy raised detrended GDP (*y*), even

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[15] This procedure necessarily assumes that the non-policy parameters of the system would remain the same irrespective of the operation of monetary policy. As Lucas (1976) has pointed out, this assumption does not hold if behaviour is influenced by the policy regime.

though y^* was positive. This pro-cyclical impact became smaller after 1995 but the impact of monetary policy was not reversed sufficiently quickly to offset the other shocks to GDP between 1993 and 1999. For example, in 1998 the economy was experiencing a growth recession and monetary policy was accentuating the below trend decline in real GDP. This was the period during which the Reserve Bank of New Zealand adopted the Monetary Conditions Index (MCI) as an operating procedure for monetary policy. It was also the period when New Zealand was impacted by a severe drought. However, the impact of monetary policy on detrended GDP during the 1998 growth recession was small compared to that arising from the droughts.

This analysis is an *ex post* assessment of the impact of monetary policy on the business cycle. It is not an evaluation of the optimality of monetary policy which would require a comparison of the consequences of the monetary policy implementation procedures used by the Reserve Bank with the consequences of using alternative procedures based on 'real time' data and judged against the monetary authority's loss function. The results nevertheless provide support for both the Reserve Bank of New Zealand's (2000b) and Svensson's (2001) assessment that monetary policy was "a little slow to recognise the pace of acceleration in 1992/93, and a little slow to recognise the joint impact of the Asian crisis and the first drought through late 1997 and early 1998" (Svensson, p.26). The outcome in 1998 may also reflect problems associated with operating monetary policy using the monetary conditions index that have been raised by Stevens (1998), Guender (2001), Guender and Matheson (2002) and Engelbrecht and Loomes (2002).

Although the structural VAR model captures the deviation of the log of output and the log of the price level from trend, with some modifications the same procedure can be applied to derive the impact of monetary policy on deviations of inflation from trend.[16] The impact of monetary policy on deviations of the domestic price level from trend can be obtained by deriving equation (11) for the domestic price level. The impact of monetary policy on deviations in domestic inflation from trend can also be isolated by recognising the following relationship:

$$\pi_t^a = pc_t^a - pc_{t-4}^a = pc_t^T - pc_{t-4}^T + pc_t^D - pc_{t-4}^D \qquad (12)$$

where π_t^a is actual annual inflation in the year to quarter *t*, pc_t^a is the log of the actual price level, pc_t^T is the log of the trend value of the log of price level and pc_t^D is the deviation of the log of the price level from its trend value.

Recognising that the deviations from trend component pc_t^D comprises two parts, one part generated by monetary policy, denoted pc_t^M, and the other part generated by all other influences, denoted pc_t^O, equation (12) can be rearranged as

$$\left(pc_t^a - pc_{t-4}^a\right) - \left(pc_t^T - pc_{t-4}^T\right) = \left(pc_t^M - pc_{t-4}^M\right) + \left(pc_t^O - pc_{t-4}^O\right) \qquad (13)$$

$$\Rightarrow \qquad \pi_t^a - \pi_t^T = \pi_t^M + \pi_t^O \qquad (14)$$

The left hand side of equation (14) is the deviation of actual from trend inflation (where π_t^T is trend inflation), and the right hand side is the sum of the deviation from trend

[16] Section 8 of the Reserve Bank of New Zealand Act states that the primary objective of the Bank is to maintain price stability. This has been made operational by Policy Targets Agreements (PTA) that have specified inflation targets. The particular inflation target for the Bank has changed somewhat over the sample period. Between December 1990 and December 1996 the PTA instructed the RBNZ to maintain inflation within a 0 to 2% target band. However, even before the introduction of the Reserve Bank Act (1989), the RBNZ was seeking to reduce inflation in the New Zealand economy during the late 1980s. From 1996 to 2002 the PTA instructed the RBNZ to maintain inflation within a 0 to 3% target band. Since September 2002 the target band has been 1 to 3%.

inflation generated by monetary policy, π_t^M, and by all other influences in the year to quarter *t*, π_t^O.

From equation (11) corresponding to the impact of monetary policy on deviations of the domestic price level from trend,

$$\pi_t^M = MPI_t - MPI_{t-4} \qquad (15)$$

Accordingly, the model generates estimates for the impact of monetary policy on the deviations of actual inflation from trend (π_t^M) and the deviations of inflation from trend generated by all other influences (π_t^O).

Figure 4 shows the time series plots for the three components of equation (14): the deviation of inflation from its trend rate $(\pi_t^a - \pi_t^T)$, the component arising from the effect of monetary policy (π_t^M), and the component arising from all other shocks (π_t^O). The interpretation is similar to Figure 3. When the observations for π_t^M and π_t^O are on the same side of the horizontal zero line the interpretation is that monetary policy accentuates inflation variability around trend. When the observations for π_t^M and π_t^O are on the opposite sides of the horizontal zero line the interpretation is that monetary policy reduces inflation variability around trend.

Figure 4 – Monetary policy impact on inflation deviations from trend

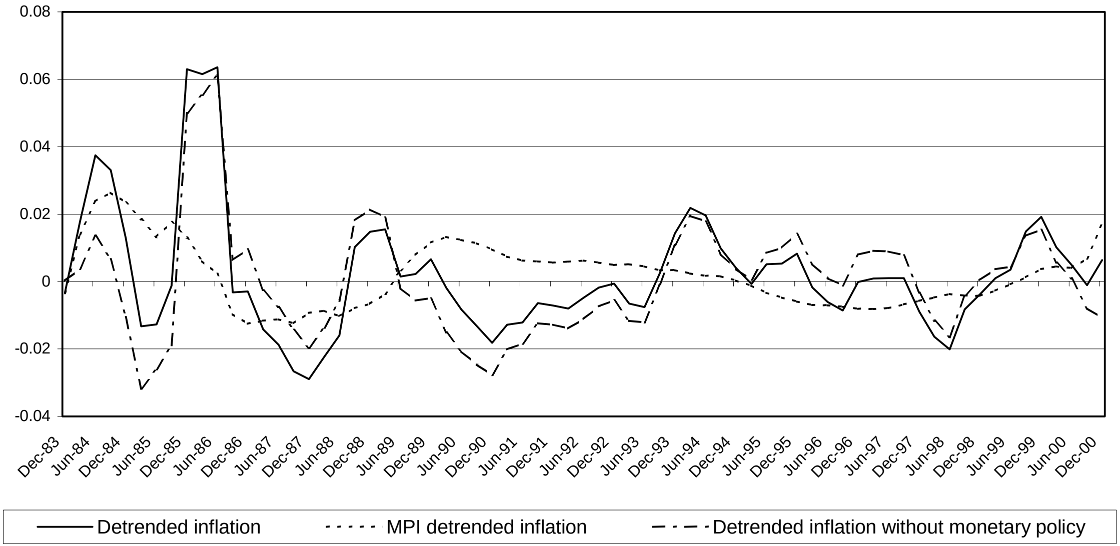


Figure 4 shows that prior to the introduction of formal inflation targeting there are periods when monetary policy was adding to inflation variability arising from other shocks (for instance during 1984, most of 1987 and 1988). There are also periods when monetary policy was reducing the impact of other shocks on inflation variability (for instance from 1985 to late 1986). The pattern appears to change after the introduction of the 1989 Act until the late 1990s. From 1990 until 1999 the predominant impact of monetary policy was to reduce the impact on inflation variability arising from other shocks. Exceptions were from December 1993 to late 1994, in late 1996, and during the 1998 recession. These periods closely correspond to the periods when monetary policy was also adding to output variability and, in the case of 1998, when the Reserve Bank was using the Monetary Conditions Index as an operating procedure.

6 Inflation targeting and the output/inflation variability trade-off

This section examines how monetary policy has affected the relationship between output variability and inflation variability before and during inflation targeting. Evaluations of monetary policy reaction functions using theoretical and calibrated model simulations typically assume the central bank's objective is to minimise a weighted sum of the squared deviations of inflation and real output from their target values. The target for real output is typically the natural rate while the target for the rate of inflation is typically assumed to be zero. The relative weights assigned to the inflation and output targets vary according to central bank preferences and characteristics of the economy. Expression (16) is an example of the type of central bank objective function typically assumed in the literature.

$$E_t\left\{\sum_{t=0}^{\infty}\beta^t\left(\alpha y_t^2+\pi_t^2\right)\right\} \quad (16)$$

The object of monetary policy is assumed to be the minimisation of the loss function represented by expression (16). The parameter α is the relative weight on output deviations. The target variables are assumed to be potential output (so that y is the deviation of output from trend) and zero trend inflation (so that π is actual inflation).

Clarida, Gali and Gertler (1999) discuss the theoretical implications and Hunt and Orr (1998) and Drew and Orr (1999) provide examples of calibrated model simulation based derivations of optimal monetary policy rules using this type of objective function. In the context of dynamic general equilibrium models with money and temporary nominal rigidities, the policy problem is to choose a time path for the nominal interest rate to influence time paths for the target variables that maximise the objective function subject to the constraints of the private sector and behavioural functions of other policy institutions. These target variables depend not only on current policy but also on expectations about future policy. Therefore credibility of future policy intentions can influence the cost of lower inflation in terms of foregone output during the transition to low inflation. In this framework, an important result to emerge is that, to the extent cost-push inflation is present, there exists a short-run trade-off between inflation and output variability around the target values (Taylor, 1979).

The importance of this trade-off rests on the assumption that the objective function is maximized by minimising the deviations of actual from potential output and actual inflation from target inflation. Some formal justification for this is provided by Rotemberg and Woodford (1999). Inflation distorts intertemporal decisions with respect to labour supply and consumption. In the presence of nominal rigidities, shocks can force output to vary from the optimal or the natural output level. Rotemberg and Woodford show that the weights assigned to inflation and output deviations in the central bank loss function can be derived from a utility function that includes output and inflation variances.

An implication of this type of framework is that if the central bank is to maximise its objective function it must aim for convergence of inflation to its target over time. In general this would imply a gradual adjustment taking into account the implications for output variability. The speed at which central banks decide to pursue inflation targets will determine whether its procedure is characterised as strict inflation targeting, flexible inflation targeting or strict output targeting (Svensson, 2001). Strict inflation targeting, involving adjustment to target inflation at a faster rate, would only be optimal, for example, if there was no cost inflation or if there was no concern for output deviations from the target rate of output. It could also occur if for some reason the central bank had a higher preference for minimising inflation deviations and a lower preference for minimising output deviations than society.

This framework offers other important insights to guide monetary policy. These include the optimal response of monetary policy to demand and supply shocks and how monetary policy responses should be adapted in the presence of various forms of uncertainty, and the implications of improved monetary policy credibility and inflation inertia on the trade-off. In general, if price-setting depends on expectations of future economic conditions, improvements to policy credibility will improve the trade-off between inflation and output thereby enabling the central bank to converge on the inflation target with less cost in terms of output variability.[17] Also relevant to our analysis of the New Zealand experience are the implications of inflation inertia. In the presence of menu costs of price adjustment, Ball, Mankiw and Romer (1988) show that lower rates of trend inflation tend to induce inflation inertia and increase the output costs of lowering inflation.

Assuming the target inflation rate for the Reserve Bank is trend inflation, the inflation variability component in a central bank loss function of the type illustrated by expression (16), and drawing on expression (14), can be written as:

$$\left(\pi_t^a - \pi_t^T\right)^2 = \left(\pi_t^M\right)^2 + \left(\pi_t^O\right)^2 + 2\pi_t^M \pi_t^O \qquad (17)$$

Rearranging to isolate the impact of monetary policy gives

$$\left(\pi_t^a - \pi_t^T\right)^2 - \left(\pi_t^O\right)^2 = \left(\pi_t^M\right)^2 + 2\pi_t^M \pi_t^O \qquad (18)$$

The equivalent expression for output variability, drawing on equations (10) and (11), is

$$\left(y_t\right)^2 = \left(y_t^M\right)^2 + \left(y_t^O\right)^2 + 2y_t^M y_t^O \qquad (19)$$

Rearranging to isolate the impact of monetary policy gives

$$\left(y_t\right)^2 - \left(y_t^O\right)^2 = \left(y_t^M\right)^2 + 2y_t^M y_t^O \qquad (20)$$

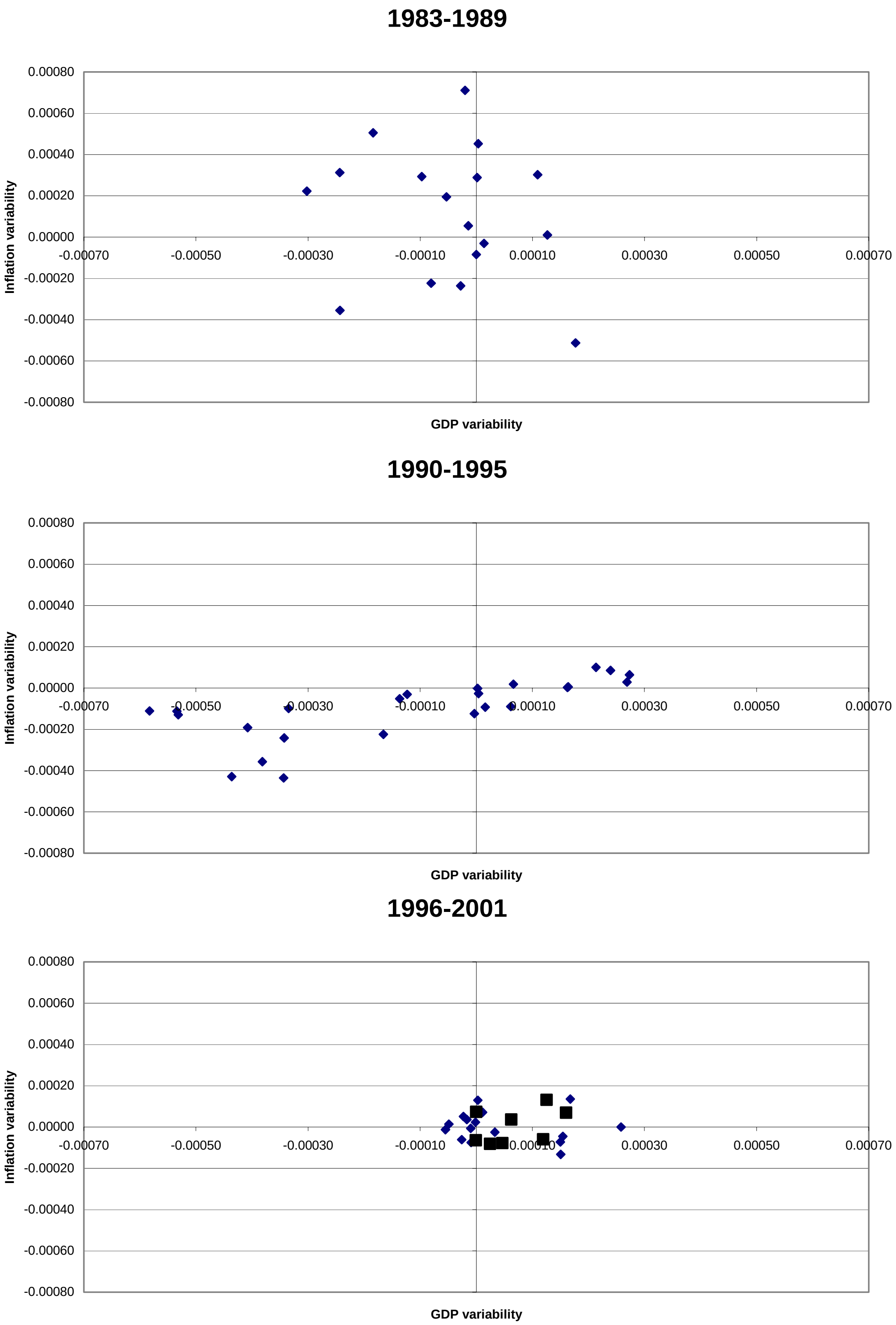
The impact of monetary policy on the output and inflation variability trade-off is interpreted as the impact on the contemporaneous pairing of the realised values in each quarter for equations (18) and (20). These are shown in Figure 5 which comprises three panels: the top panel is the period 1983 to 1989, immediately prior to the introduction of the Reserve Bank of New Zealand Act 1989; the middle panel is the period 1990 to 1995, the initial years of formal inflation targeting; the bottom panel is the period 1996 to 2001, the last six years of inflation targeting covered by the model estimation.

The realised values for expressions (18) and (20) can be either positive or negative. A positive realised value implies that monetary policy accentuated variability. A negative value implies that monetary policy reduced variability. To maximise a loss function of the type shown by expression (16), in the presence of other shocks to output and inflation, ideally observations for expressions (18) and (20) should all lie in the south-west quadrant of each panel.

In the period 1983 to 1989, prior to the advent of formal inflation targeting, the realised observations for equations (17) and (19) are scattered over all quadrants. There are more observations above the horizontal zero axis meaning that monetary policy was predominantly adding to inflation variability. The observations for output variability lay predominantly close to or left of the vertical zero axis. This indicates that monetary policy was predominantly reducing output variability.

[17] See for example the theoretical results in Clarida, Gali and Gertler, 1999; and the model simulation results in Amano, Coletti and Macklem, 1998 and in Dillén and Nilsson, 1998

Figure 5 – Monetary policy contribution to output and inflation variability before and during inflation targeting



Note: Each scatter point represents the contemporaneous realisations of monetary policy's contribution to output and inflation variability. The scatter points in the third chart that are represented by square markers show monetary policy's contribution during the MCI period.

A different pattern of realisations emerges for the period after formal inflation targeting was introduced. Moreover, the pattern for the first six years, shown in the middle panel of Figure 5 as 1990-1995, is different to the pattern for the second six years, which is shown in the bottom panel as 1996-2001.

In the first six years of inflation targeting (shown in the middle panel of Figure 5), many of the realisations lie in the south-west quadrant where policy reduces both inflation and output variability. All of the inflation variability realisations lie close to or below the horizontal axis implying that monetary policy was predominantly reducing inflation variability. The output realisations are scattered on both sides of the horizontal axis, but predominantly in the south-west quadrant. There are however some output variance realisations that are higher than the output variance realisations arising from the impact of monetary policy in the period prior to inflation targeting. The marked reduction in inflation variability in the first six years of inflation targeting is consistent with the idea of a change in the Reserve Bank's preference function with a higher preference given to the reduction of inflation variability compared to the earlier period.[18]

The fact that inflation variability was reduced without any significant adverse increases in output variability is an outcome consistent with enhanced monetary policy credibility. According to this argument, once lower inflation expectations are achieved, shocks that move inflation away from target can be brought back to target with less cost in terms of output variability. This outcome is also consistent with the findings of Fischer and Orr (1994) and Hutchison and Walsh (1998) who provide empirical evidence of improved monetary policy credibility during the early years of inflation targeting in New Zealand. Improved policy credibility also provides the opportunity for a central bank to shift its emphasis to flexible inflation targeting, an interpretation made by Svensson (1997).

Accordingly, we might expect to find a similar or even improved set of realisations during the second six years of inflation targeting. These realisations are shown in the bottom panel of Figure 5. The impact of monetary policy during the second six years of inflation targeting is not as favourable as the realisations for the first six years. Most of the observations lie close to and right of the vertical axis, implying monetary policy predominantly increased output variability in this period. The realisations for the impact on inflation variability are closely bunched around zero, and some realisations added to inflation variability to a greater extent than observed in the previous six-year period.

There are several possible explanations for these less favourable outcomes in the period 1996 to 2001. The Reserve Bank was operating monetary policy using the Monetary Conditions Index during part of this period. At no stage during the period when the MCI was operating did monetary policy reduce output variability and for all but two quarters it increased output volatility. Between 1996 and 2001 New Zealand experienced two large climate shocks whose effects on output may have been difficult to interpret. In addition, there was less scope for monetary policy to reduce variability as output and inflation variability from other sources were lower in this latter period.

The reduction of inflation variability over time has coincided with a reduction in the stochastic trend rate of growth of domestic prices. Similarly, trend output growth increased during the 1990s. The SVAR model used to evaluate the consequences of inflation targeting is a model of the growth cycle and does not model trend output and trend inflation. It may be the case that the observed fall in inflation and output variability is in part attributable to changes in trend growth for these variables. In this situation, estimates of monetary policy's contribution to reducing output and inflation variability may be biased downward.

[18] This interpretation is consistent with the Reserve Bank's interpretation that greater emphasis was placed on reducing inflation during the early stages of operating policy under the new Act (see Reserve Bank of New Zealand, 1999, page 12).

7 Conclusions

The principal aims of this paper were to attempt to answer the following three questions. Has the focus on inflation targeting in New Zealand since 1989 resulted in monetary policy accentuating or dampening business cycles? What was the impact of monetary policy on the variability of inflation? How has monetary policy affected the trade-off between the output and inflation variances?

We found that during inflation targeting, monetary policy has tended to have a countercyclical impact on New Zealand growth cycles. The general countercyclical nature of monetary policy in New Zealand is consistent with recent research evaluating Australian and United States monetary policy. Dungey and Pagan (2000) concluded that Australian monetary policy was generally countercyclical during the 1980s and 1990s. Clarida, Gali and Gertler (2000) concluded that the effect of monetary policy in the United States during the Volker-Greenspan era was also generally countercyclical.

However, there have been exceptions to this pattern. Monetary policy accentuated the business cycle upswing during 1994 and 1995. Monetary policy also accentuated the 1998 recession; athough its impact was small compared with the more substantial impact from adverse climatic conditions.

In general, monetary policy operating under inflation targeting has tended to reduce the variability of output and inflation around their trend levels. During the first six years of inflation targeting, monetary policy contributed to a fall in inflation variability. This result was associated with monetary policy inducing lower output variability in most quarters, an outcome that is consistent with improved monetary policy credibility.

From 1996 to 2001 monetary policy was less effective in reducing inflation variability and output variability. From June 1997 to March 1999 the Reserve Bank was using a Monetary Conditions Index (MCI) to guide the interest rate decisions. This period also included the impact of the Asian crisis and a large domestic climate shock. Although previous research has questioned the merits of using an MCI in a small open economy, it is difficult to identify whether the outcome was a consequence of using an MCI or whether the operation of monetary policy was rendered more difficult because of the unusual nature of the shocks and a lack of understanding of the dynamic effects of these shocks. There was, however, less scope for monetary policy to reduce variability as output and inflation variability from other sources were lower in this latter period. For whatever reason, the evidence suggests that at no stage during the period when the MCI was operating did monetary policy reduce output variability and for all but two quarters it increased output volatility.

The techniques used in this paper provide a basis for investigating the impact of other policy shifts and their impact on other macroeconomic variables. They could also be applied to compare the impact of policies across countries. For example, in view of the debate concerning the relative efficiency of Australian and New Zealand monetary policy in recent years, one extension could be to use these techniques to compare the relative contributions of monetary policy to New Zealand and Australian business cycles and inflation variability.

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