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The Dynamics of the Monetary Policy Volatility: A Spectrum-vector Autoregressive Approach#

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ABSTRACT

This paper investigates the impact of the international and domestic volatility of monetary policy shocks on the economy of New Zealand using the spectrum-SVAR approach. We enrich the SVAR model by using time-varying global and domestic volatility as endogenous variables. The results show that although monetary policy shocks have transient effect on the real economy impact of the volatility of monetary policy shocks on the real part of the economy is permanent and relatively significant. Findings reveal that the supply shocks have a permanent impact on the supply side of New Zealand. The results of variance decomposition also show that New Zealand heavily depends on international shocks, so these types of shock can have a permanent impact on the local economy. Finally, the results of periodogram and significant pass filter suggest at least two deterministic cycles in the volatility of monetary policy.

Keywords: Spectral Analysis; Volatility of Monetary Policy; Structural VAR
JEL Classifications: C32, C54, E52

1. INTRODUCTION

In the past six decades, a lot of research has been carried out to find the effect of monetary policy on real economy (Bayoumi and Echingreen 1993, Eichenbaum and Evans, 1995, Kim, 2001, Sousa and Zaghini, 2007 and 2008, Mumtaz and Surico, 2009, Christiano, Eichenbaum and Evans, 1999, Ammer et al., 2010, Moosavi et al., 2012). But, in most of these articles, the impact of the volatility of monetary policy has been ignored. Recent financial world crisis has taught us that changing in the volatility of monetary policy can play an important role in the transmission mechanism of monetary policy. It seems that an increase in the volatility of monetary policy can decrease the amount of investment and these changes in the policy uncertainty lead to a collapse in the real part of the economy (Villaverde et al., 2012, Born and Pfeifer 2014, Mumtaz and Zanetti, 2013, Moosavi et al., 2014).

In a small country where any kind of monetary policy rule is adopted, an increase in the volatility of monetary policy will result a decrease in the interest rate, which in turn will dictate the prices to decrease and this fall in the price level can change the expectation of the public and finally lead to a permanent decrease in the real output. Furthermore, if we regard an economy as a dynamical system, complexity and chaotic behavior can occur especially in an open economy (Moosavi and Kilicman 2014), and thus the economy loses its stability.

New Zealand, as a small open economy, has frequently suffered from the consequences of international shocks. The East Asian crisis in the 1997-1998 and the current financial crisis in 2007-2008 are two important among them. Figure 1 shows the movements of the monetary policy rate in the 1988-2017 period. As it can be seen the reserve bank of New Zealand tried to run away from each of these crises by easing in the stance of the monetary policy. In the 1994-1996 period, the Reserve bank increased the policy rate against the inflationary pressures in the economy. Other notable demand pressure that led to a relatively stable long-term increase in the official cash rate (OCR) happened in the 1999-2008 period (Reserve Bank of New Zealand, 2008). In this period New Zealand experienced a large net inflow of migrants, and consequence of this immigration was a demand pressure to the economy. As it can be seen from Figure 1, the reserve bank tried to reduce this pressure by increasing the OCR.

Overall, if we look at the process of economic reform in New Zealand since 1984 "as one of the notable episodes of liberalization" (Henderson, 1995), we can find that two of the most significant key issues are adapting inflation target in 1990 and introducing OCR system for implementing monetary policy in 1999.

The main objective of this paper is to analyze the impact of international and domestic volatility of monetary policy shocks on New Zealand economy. As done by Moosavi et al. (2012), this study considers three different types of shocks: Domestic, regional and global. Specifically, we employ a large scale VAR model to find the dynamics of the volatility changes measured using the spectral analysis.

This paper is organized as follows. Section 2 explains the econometrics methodology and the structure of the model. Section 3 describes the empirical results. The last section summarizes the results and exhibits the concluding remarks.

2. STRUCTURE OF THE MODEL

In order to capture the dynamics of international and domestic volatility of monetary policy shocks and their impacts on demand and supply sides of the economy of New Zealand, this paper employs the spectral analysis to find the volatility and analyze its dynamics and studies the impact of the monetary policy volatility shocks using the structural VAR method. This section briefly describes the structure of the model.

2.1. Spectral Analysis

This section briefly describes the frequency domain or spectral analysis[1]. The goal of employing this method is to determine how important cycles of different frequencies are in accounting for the dynamic behavior of the volatility of monetary policy. For this reason the population periodogram can help us to find the probable deterministic cycles with different frequencies. Note that even the spectral analysis of a series does not require the specification of a model but directly depends on the covariance stationary assumption (Granger, 1969).

Let $\{y_t\}_{t=-\infty}^{+\infty}$ be a covariance stationary process with mean μ, and j^{th} autocovariance γ_j. Assuming that $\sum_{j=-\infty}^{+\infty} g_j < \infty$, then the autocovariance generation function is given by

$$g_Y(z) = \sum_{j=-\infty}^{+\infty} g_j z^j \quad (1)$$

Where z is a complex scalar. By dividing equation (1) by 2πat some $z = e^{-i\omega}$, then we can obtain the population spectrum.

$$S_Y(w) = \sum_{j=-\infty}^{+\infty} g_j e^{-iwj} \quad (2)$$

Where $i_2 = -1$, and ω is a real value scalar. Applying De Moivre's theorem and knowing that in a covariance stationary process $\gamma_j = \gamma_{-j}$, we can simplify equation (2) as follows:

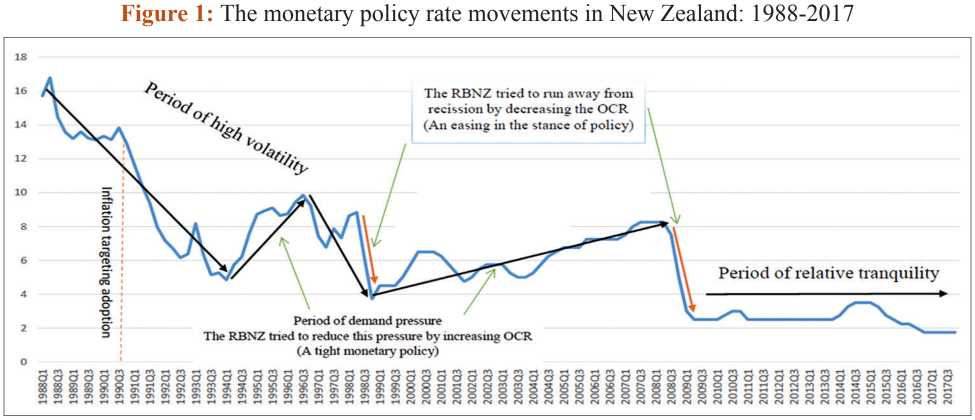
$$S_Y(w) = \frac{1}{2p}\left(g_0 + \sum_{j=1}^{+\infty} g_j \cos wj\right) \quad (3)$$

As we can see the spectrum is a periodic function of and symmetric around . Given an observed sample denoted by $\{y_t\}_{t=1}^{T}$, and for a given ω, we can estimate the sample variance and the sample autocovariance. By substituting them into equation (3) the sample periodogram can be achieved.

The sample periodogram is an inconsistence estimator of the spectrum, and we cannot solve this problem by increasing the sample size (Hamilton, 1994). Thus, for using the spectral analysis

1 For a detailed discussion, see Hamilton (1994), Chapter 6.

Figure 1: The monetary policy rate movements in New Zealand: 1988-2017



to decompose a stochastic process, one should produce the spectral density estimates by smoothing the periodogram (Orlov, 2006, Grossmann and Orlov, 2014a; b).

2.2. Vector Autoregressive (VAR)

Sims (1980) introduced the VAR model as an alternative for the traditional simultaneous equation systems. Later, Mills (1998), Stock and Watson (2001), as well as others described that VAR provides a reasonable approach to summarize data, data description, forecasting and policy analysis.

Let Y_t denote an $(n\times 1)$ vector of n variables at time t. We can let the time path of each variable in this vector, i.e., $y_t^i \in Y_t; \forall i = 1,\ldots,n,$ be affected by the past realizations of Y_t. Thus the dynamics of Y_t can be represented as:

$$Y_t = \psi_0 + \psi_1 Y_{t-1} + \psi_2 Y_{t-2} + \ldots + \psi_p Y_{t-p} + \varepsilon_t \quad (4)$$

Where $\varepsilon_t \sim iidN(0,\Omega)$. Equation (4) constitutes a *pth*-order VAR process.

The VAR model has been criticized as being devoid of any economic content (Cooley and LeRoy, 1985, Runkle, 1987). In response to this criticism, Sims (1986) and Bernanke (1986) introduced the structural VAR model, simultaneously. Later, Blanchard and Quah (1989) employed the SVAR model to decompose the structural shocks into long run and short run and Bayoumi and Eichengreen (1993) employed a variant of this model to deal with the issue of macro disturbances through econometric estimations.

Note that in the most of empirical macroeconomic studies, the transmission of shocks is mostly based on the small scale VARs. Stock and Watson (1996) argued that small-scale VARs are often unstable and provide a poor prediction of the future.

Now, the VAR model is a popular standard toolkit to analyze empirically multivariate time series, and can help to estimate the effect of unpredictable disturbances in an economy (Stock and Watson, 2017).

In this study, we employ an eight-variable VAR model to examine the dynamic effects of the volatility of monetary policy shocks on the New Zealand economy. We also consider three types of volatility shocks: Domestic, regional and global. The regional shocks affect New Zealand from the inside of that area but the global shocks affect it from outside of the area. The reduced form of our model can be presented as:

$$X_t = \psi(L)\, Xt-1 + \Phi Z_t + \xi_t \quad (5)$$

Where $X_t = (gdp^g, vol^g, gdp^r, vol^r, gdp^d, inf^d, vol^d, er^d)$ and $(Z_t = i^g, i^r, i^d)$, denotes the exogenous variables. Definition of the above variables are as follows:
gdp = growth domestic product,
inf = inflation,
er = exchange rate,
vol = the volatility of monetary policy,
i = The monetary policy rate.

The superscripts *g, r* and *d* refer to the global, the regional and the domestic, respectively. Now our structural model can be written as:

$$X_t = \Gamma(L)\, \zeta_t, \quad (6)$$

Where ζ_t denotes different types of serially uncorrelated and orthonormal shocks, and $\Gamma(L)=\Gamma_{ij}(L); \forall i,j$ is an (8×8) matrix that defines the impulse response of the endogenous variables to the structural shocks. To identify this model, we need to impose 28 contemporaneous restrictions on the coefficients of our structural model as follows:

$$\Gamma_{ij} = 0;\ \forall i<j.$$

3. RESULTS

This section uses the described models to estimate the volatility of monetary policy and analyze the impact of international and domestic volatilities on the economy of New Zealand.

3.1. Correlation of the Supply Shocks

Kydland and Prescott (1990) argued that supply shocks must be responsible for any business cycle that happened in any economy. So, we employ the correlation of supply shocks between New Zealand and the USA, the UK and the Euro zone to find the main source of the global shocks (Moosavi et al., 2014, Moosavi and Azali, 2014).

Table 1 shows that the correlation of supply shock between New Zealand and the UK is positive and of course is bigger than that between New Zealand-the USA and New Zealand-the Euro Zone. Thus the source of the global shocks assumes to be from UK. This study also assumes that the source of regional shocks is from Australian economy.

3.2. Dynamics of the Volatility

We know that the spectral analysis approach requires the assumption of stationary. Thus, all monetary policy rates have been tested for stationary using the HEGY seasonal unit root test proposed by Hylleberg et al. (1990). The results of the test suggest that there is no evidence of the seasonal unit root at two quarters and four quarters cycles.

Figure 2 shows the estimated volatility of monetary policy for New Zealand. During the period of this study, the Reserve Bank of New Zealand has three different governors[2].

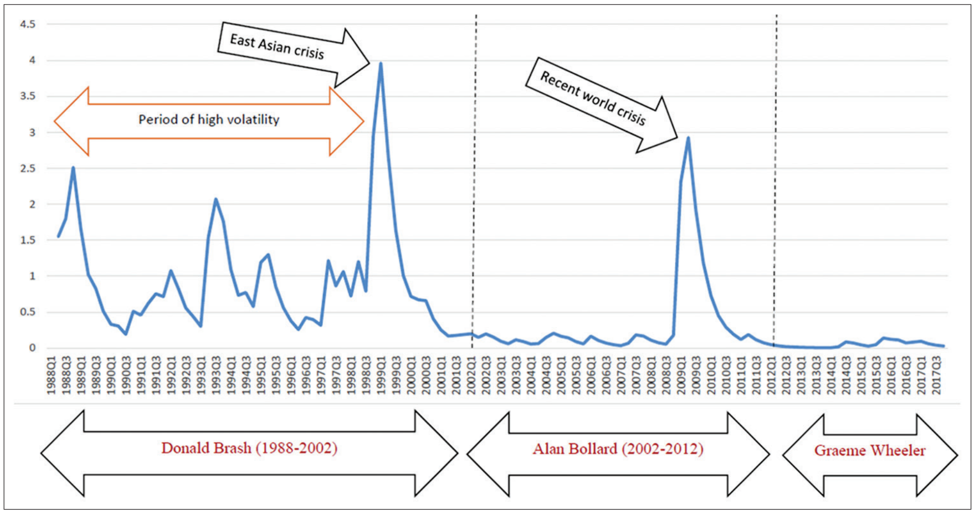
During Donald Brash's period, a large amount of volatility can be seen, due to several internal and external shocks: Economic reforms especially since 1984, Crash in the share market in the late 1987, Persian Gulf war in early 1990s, inflation targeting adoption since 1990, increase in the house price inflation due to the jump in the migration to New Zealand and finally South East Asian crisis in 1997-1998 (Reserve Bank of New

2 Donald Brash (1988-2002), Alan Bollard (2002-2012), Graeme Wheeler (2012-…)

Table 1: Correlation of supply shocks

Country	New Zealand	Australia	Euro Zone	UK	USA
New Zealand	1.0000	0.1672	0.1933	0.2109	0.0125
Australia		1.0000	0.1094	0.1687	0.2221
Euro Zone			1.0000	0.3731	0.3040
UK				1.0000	0.3080
USA					1.0000

Figure 2: The volatility of monetary policy in New Zealand: 1988-2017



Zealand 1996-1999, Evans et al., 1996). During the Bollard's period, New Zealand experienced a period of tranquility until the current financial crisis (Reserve Bank of New Zealand, 2009; Bollard, 2009). Since then, again we can see a period of tranquility.

Overall, New Zealand as an open small economy will be plunged into turbulent from the external shocks. As Bollard (2009) mentioned, "… when the world is in shock, it will be turbulent for New Zealand."

3.3. Frequency Domain Analysis

The volatility of monetary policy periodogram (Figure 3) suggests the presence of at least two important deterministic cycles with frequency 0.025 and 0.04 which correspond to 40 and 20 quarter cycles. The normalized integrated spectrum and the F tests also reject the null of non-significance of the cycle with respective frequency[3].

To find this underlying deterministic cycles we use the significant pass filter. The purpose of this filter is to find the deterministic components in all the spectrum, without imposing band restriction. This filter has the advantage of eliminating the possibility of spurious cycles (Ronderos, 2014). Figure 4 shows the sum of the deterministic components of the volatility of monetary policy. Note that the filtered series obviously present a 10-year cyclical behavior for the volatility of monetary policy started from 1988.

The cyclical analysis of significant pass filter suggests a probable volatility shock in the early future. However, as we mentioned, in the previous external shocks that led to the volatility of monetary policy, the OCR was high enough to allow the RBNZ to have an easing in the stance of policy such that the OCR was cut by 5.5 and 5.75% points in the 1998-1997 and 2008-2009 periods, respectively (Figure 2). While the current OCR is dramatically low (1.75% points), which makes a very difficult way to recovery from such a shocks that happened in 2008.

3.4. Results of the Structural VAR Estimation

This section reports the empirical results of the estimation of SVAR. Quarterly data from 1988:Q1 to 2017:Q3 are used. The data are collected from datastream: IFS. The number of lags in the model is equal to two and based on the Schwarz Information Criterion (SIC). The stability test indicates that our VAR has fulfilled these properties. Finally, the Eviews software is used for these estimations.

We report the results based on the impulse response and the variance decomposition. As we know the impulse response functions show the dynamic effect of shocks on the adjustment path of the variables. The variance decomposition measures the contribution of different type of shocks to the forecast error variables. The computation of these two measurements is useful in assessing how shocks to economic variables transmitted through a system.

3.4.1. Impulse-response function

Figures 5 and 6 present the impulse response of the global, regional and domestic volatility of monetary policy on the New Zealand economy. These results are based on our estimated SVAR model. To find the orthogonal innovations we employ the Cholesky decomposition with the recursive ordering as follows:

3 For more information look at Ronderos (2014).

$gdp^{g} \rightarrow vol^{g} \rightarrow gdp^{r} \rightarrow vol^{r} \rightarrow gdp^{d} \rightarrow inf^{d} \rightarrow vol^{d} \rightarrow er^{d}$

We discuss the results for the stability of macroeconomic variables first, then we turn our attention to the global and regional impacts of supply shocks on the New Zealand economy.

As we can see from Figure 5, the responses of inflation (inf^{d}), and exchange rate (er^{d}) to all types of the volatility shocks are significant but die out after at most 20 quarters. As we have already described, we expect the sign of the response on inflation and exchange rate to be negative. Figure 4 shows that our data-driven approach is in line with theoretical priors: An increase in the domestic monetary policy volatility shock decreases inflation and exchange rate. Focusing next on the response of (gdp^{d}) (first row of Figure 4) to the volatility shocks, we find that in all of these three cases, the impact of these shocks are permanent and never dies out even after 40 quarters. If we highlight this finding for the impulse of domestic volatility of monetary policy on domestic *gdp*, we can see that in the short run, any increase in the volatility has a positive impact on (gdp^{d}), and this positive impact lasts only for 3 quarters. After that, it turns to be negative, permanent but not very significant after 20 quarters.

Turning now to the response of the gdp^{d}, inf^{d} and er^{d} to the global and regional supply shocks. We can observe from Figure 6, the impact of the global supply shocks on all variables is significant and positive and never dies out even after 40 quarters. Finally, the response of the gdp^{d}, inf^{d} and er^{d} to the regional supply shock is almost negative and transient.

Figure 3: Spectrum of the Volatility of Monetary Policy

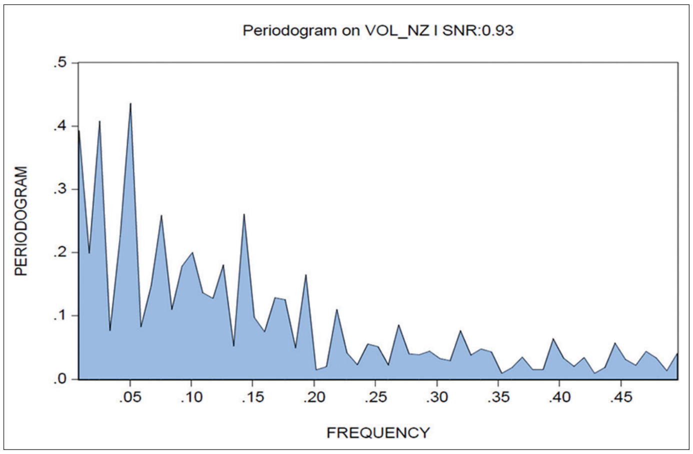
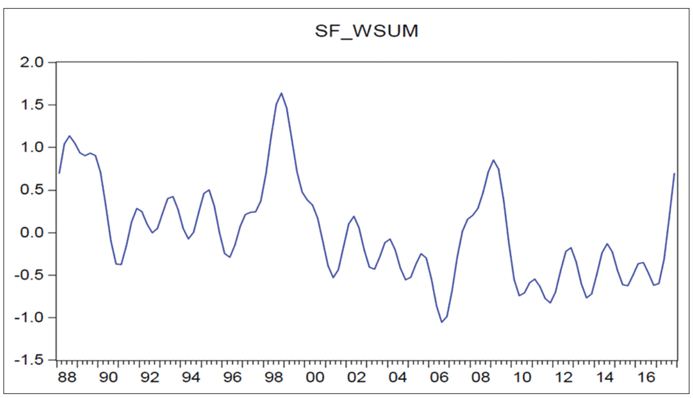


Figure 4: Significant pass filter for the volatility of monetary policy



3.4.2. Variance decomposition

The previous subsection examined the impact of the various shocks on some important variables in the New Zealand economy using impulse response function. This subsection complements the impulse response analysis with variance decompositions, which shows the relative cumulative contribution of each variable in our VAR model. Tables 2-4 report the variance decomposition of gdp^{d}, inf^{d} and er^{d} and the forecast horizon is 32 quarters.

Table 2 shows the forecast variance decomposition of *gdp* in New Zealand. In the first quarter, 94.5% of the variance of *gdp* is driven by its own innovation, and there are no significant instantaneous effects from other variables. But, during the time when the share of global *gdp* dramatically increased, for instance after 20 quarters, it reaches from 3.4% to near 32%. In the long run near 50% of the variance of gdp^{d} is driven by its own innovation and 40 and

Figure 5: Impulse response for the structural model: The volatility shocks

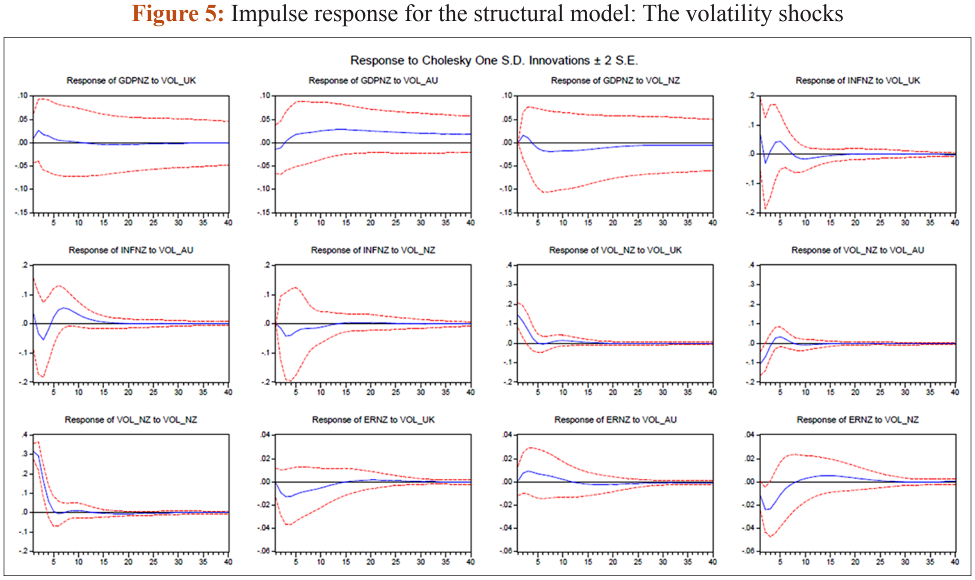


Figure 6: Impulse response for the structural model: Global and regional supply shocks

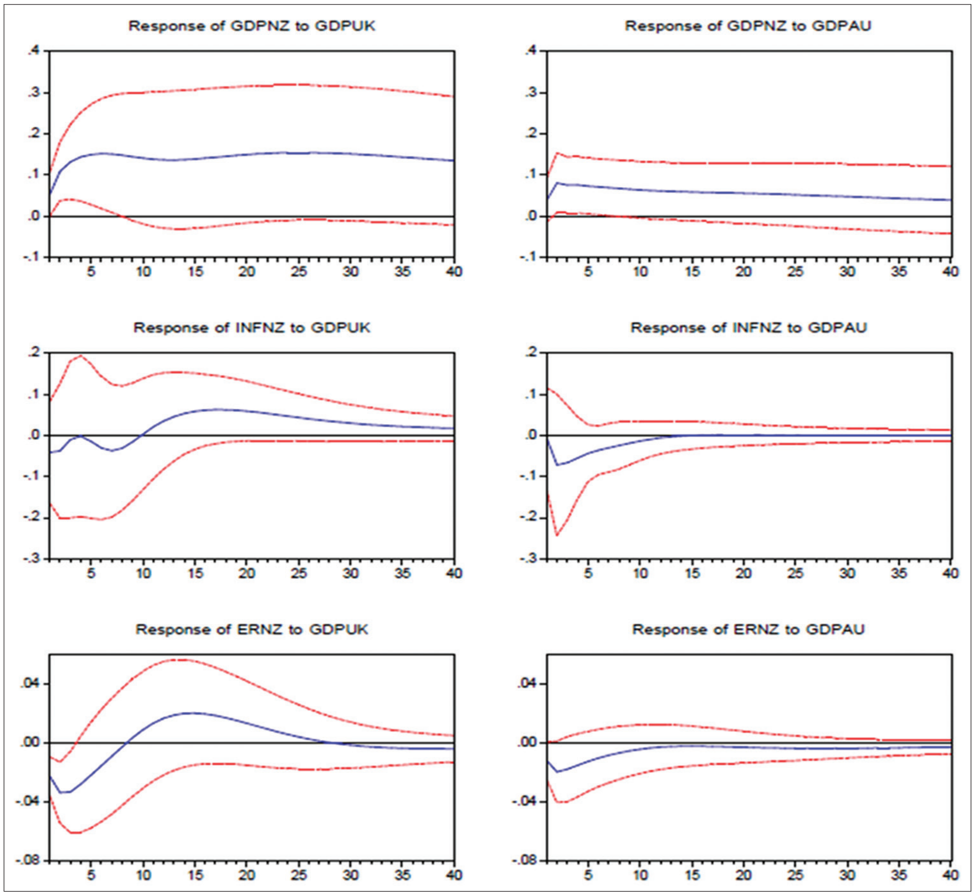


Table 2: Variance decomposition of the structural model: GDP

Period	*SE*	gdp^g	vol^g	gdp^r	vol^r	gdp^d	inf^d	vol^d	er^d
1	2.431	3.382	0.118	1.753	0.233	94.512	0.000	0.000	0.000
4	8.216	15.906	0.391	5.843	0.135	75.887	0.016	0.109	1.708
8	12.991	22.923	0.227	6.261	0.335	68.818	0.092	0.248	1.092
12	15.692	25.992	0.167	6.456	0.557	65.409	0.094	0.331	0.990
16	17.448	28.793	0.143	6.660	0.755	61.927	0.233	0.364	1.121
20	18.693	31.976	0.129	6.810	0.877	58.300	0.426	0.355	1.122
24	19.629	35.120	0.117	6.870	0.940	54.989	0.591	0.331	1.040
28	20.361	37.845	0.106	6.852	0.970	52.260	0.710	0.306	0.948
32	20.946	40.033	0.097	6.789	0.984	50.138	0.797	0.287	0.871

GDP: Gross domestic product

Table 3: Variance decomposition of the structural model: Inflation

Period	*SE*	gdp^g	vol^g	gdp^r	vol^r	gdp^d	inf^d	vol^d	er^d
1	0.481	0.380	1.012	0.010	0.253	2.972	95.369	0.000	0.000
4	0.683	0.280	0.640	1.106	0.497	6.981	90.071	0.307	0.112
8	0.697	0.543	0.825	1.407	1.136	6.499	84.676	0.409	4.501
12	0.707	0.676	0.862	1.417	1.382	6.445	82.739	0.430	6.044
16	0.712	1.613	0.860	1.396	1.383	6.481	81.815	0.426	6.022
20	0.713	2.747	0.849	1.378	1.366	6.412	80.857	0.428	5.960
24	0.714	3.540	0.841	1.366	1.353	6.367	80.173	0.427	5.928
28	0.714	3.986	0.837	1.359	1.346	6.376	79.766	0.425	5.901
32	0.715	4.226	0.835	1.354	1.343	6.401	79.531	0.424	5.882

6.7% of the variance of gdp^d are driven by global and regional , respectively. As we show in the impulse response analysis, this means that the supply side of the New Zealand economy is heavily affected by the global and regional supply shocks.

Table 3 represents the forecast error variance decomposition of inflation in the New Zealand economy. In the first quarter almost near 96% of the variance is driven by its own innovation. During the time the share of gdp^g, gdp^d and er^d increased. For instance

Table 4: Variance decomposition of the structural model: Exchange rate

Period	*SE*	gdp^g	vol^g	gdp^r	vol^r	gdp^d	inf^d	vol^d	er^d
1	1.276	9.756	0.027	2.734	0.013	0.280	0.099	2.724	84.363
4	2.552	12.34	1.437	3.739	0.714	5.144	1.349	5.440	69.829
8	4.066	9.272	1.557	3.096	0.713	15.73	6.691	3.684	59.252
12	5.430	8.785	1.473	2.718	0.625	23.782	8.656	3.173	50.784
16	6.607	10.648	1.360	2.529	0.593	26.009	8.640	3.092	47.124
20	6.607	10.648	1.360	2.529	0.593	26.009	8.640	3.092	47.124
24	8.389	12.334	1.319	2.528	0.618	25.802	8.348	3.081	45.966
28	9.074	12.353	1.319	2.608	0.626	25.764	8.334	3.078	45.914
32	9.670	12.359	1.318	2.686	0.629	25.749	8.324	3.074	45.856

after 20 quarters near 81% of the variance of the inflation is driven by its own innovation and global *gdp*, domestic *gdp* and exchange rate reach to 4, 6, and 6%, respectively. The results of Table 3 also illustrate the successful implementation of the inflation targeting in New Zealand during the period of the study.

Table 4 presents that as an immediate effect in the first period 84% of er^d is generated by its own innovation and near 10% by global *gdp*. During the time, the effect of domestic *gdp* increases, and after 20 quarters, for instance, reach to almost 26%. In the long-run, only 45% of the variance of domestic exchange rate generated by its own innovations and the fraction of global, regional, and domestic *gdp* reach near to 12, 3, and 16%.

Overall, and from these findings, we can see that New Zealand as a small open economy is heavily affected by international shocks, and these types of shocks have a relatively permanent impact on the local economy.

4. CONCLUDING REMARKS

This paper applies a structural VAR to determine the interaction between the international and the domestic volatility of monetary policy shocks and the level of other endogenous variables in the New Zealand economy. This dynamic interaction can show the impact of volatility shocks on the real economy. We use the spectrum to find the amount of volatility and employ a structural VAR to estimate the dynamic relations between volatility shocks and these variables. We also apply the periodogram and significant pass filter to find the probable deterministic cycles in the volatility of monetary policy. Our monetary policy spectrum in New Zealand show a highly volatile period of time before 1998. Since 1999, the South East Asian and the current financial crises are two important international shocks that the New Zealand economy suffered from. The results of the impulse response indicate that the volatility of monetary policy shocks has the permanent and relatively significant impact on the real economy. Although, there is a wide consensus in the literature that money has real effects in the short run and neutral in the long run, the volatility of monetary policy shocks has a long-run effect on the real parts of the economy. The main finding of the forecasting variance decomposition confirm the findings of impulse response function and of course show that due to the fact that New Zealand is heavily depends on international shocks, global and regional volatility of monetary policy shocks can have a permanent and relatively significant impact on the domestic economy. Finally, this paper also studies the frequency domain analysis of the volatility of monetary policy. Our finding from periodogram represents at least two deterministic cycles of 40 and 20 quarters. The significant pass filter reveals a probable volatility shock in the early future. However, as we mentioned, in the previous external shocks that led to the volatility of monetary policy, the OCR was high enough to allow the RBNZ to have an easing in the stance of policy. While the current low OCR can make a difficult way for the RBNZ to recover from such a shock that happened in 2008.

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