OIL PRICE SHOCKS AND ECONOMIC GROWTH: EVIDENCE FOR NEW ZEALAND, 1989-2006*

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Abstract

As an importer of oil and petroleum products, New Zealand's economy is potentially vulnerable to fluctuations in the world price of crude oil. The paper aims to examine what impact the changes in the world price of oil had on New Zealand's economic growth over the period 1989-2006. Several hypotheses concerning the impacts of oil price shocks on economic growth are empirically examined for petroleum market deregulation, i.e. post-1989 period. These issues have important policy implications that have received little attention in New Zealand. The issue of oil price shock impacts on economic growth is considered using the Vector Autoregressive methodology based on quarterly data. Three oil price measures are considered, given the various theoretical implications that oil price shocks have on economic growth. The short run impact of oil price shocks on economic growth has been considered in a multivariate framework. This allows to analyse the direct economic impact of oil price shocks, as well as the indirect linkages. The models estimated employ the linear oil price and two leading nonlinear oil price transformations to examine various short run impacts. Utilising the Wald and Likelihood Ratio tests of Granger causality, the later results indicate that linear price change, the asymmetric price increase and the net oil price variables are significant for the system as a whole, whereas the asymmetric price decrease is not. Following the causality analysis of oil price-growth nexus, the generalised impulse responses and error variance decompositions reaffirm the direct link between the net oil price shock and growth, as well as the indirect linkages.

Keywords: Oil Price Shock, Economic Growth, New Zealand
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1. INTRODUCTION

The economic importance of oil price shocks has been examined utilising the neoclassical theory in attributing the macroeconomic significance to such events. Hamilton's (1983) study identified a robust relationship between oil price increases and subsequent economic downturns for majority of the post-World War Two recessions in the United States (US) economy. Subsequently, a large literature has considered the oil price-economic growth nexus for a number of developed countries based on various theoretical linkages. Studies linking oil prices to the macro-economy through the channels of labour market dispersion (Loungani, 1986; Finn, 2000; Davis and Haltiwanger, 2001), investment uncertainty (Bernanke, 1983; Dixit and Pindyck, 1994; International Monetary Fund, 2005), consumption smoothing in durable goods (Hamilton 1988a, 2003; Lee and Ni, 2002) and the consequences for inflation (Pierce and Enzler, 1974; Mork, 1981; Bruno and Sachs, 1982) suggest that indirect transmission mechanisms may be the crucial means by which oil price shocks have macroeconomic consequences.

As an importer of oil and petroleum products New Zealand is potentially vulnerable to fluctuations in the world price of crude oil. Given that most studies suggest that oil price fluctuations have considerable consequences on economic activity this study extends the empirical literature first to examine the effects of an oil price shock in the case of New Zealand. Second, the relation between oil process and real activity is assessed utilising the linear and non linear approaches. To date no study, to our knowledge, has been undertaken to estimate these effects for New Zealand. Estimating the consequences of oil price shocks for growth is particularly relevant for the case of New Zealand since, as a small open economy, it has no real influence on the world price of oil. Furthermore, with very limited deposits of suitable oil resources imported oil resources play a vital role in the economy.

Oil resources make up more than 50 percent of New Zealand's total consumer energy, of which around 90 percent is imported. Demand for oil from the transport sector accounts over 85 percent of total demand each year (International Energy Agency, various). This can be explained by New Zealand's long, narrow physical geographical structure, low population density and domestic agriculture, manufacturing and service industries in both islands which result in high level of movement between the major destinations. Other relevant factors include the high ratio of automobile ownership amongst the population and the importance of the service sector vis-à-vis the primary and manufacturing sectors. A consequence of the transport sector's heavy demand for oil poses some macroeconomic risk due to its exposure to oil price shocks. In examining what impact the changes in the world price of oil has on economic growth over the period 1989-2006, this takes into consideration the period of deregulation in the domestic petroleum markets.

The Government implemented a package of reforms since 1984 based around an integrated theoretical framework that included new microeconomic theories of contestability, principal-agency and public choice alongside conventional theories underpinning macroeconomic restructuring (Silverstone *et al.*, 1996). The immediate targets of reform were capital markets, financial sector, industrial regulations, and international trade. By 1991 the successive governments expanded further reforms in the factor markets, monetary policy, taxation, government entity performance, labour markets, public expenditure, natural resource use and social services (Bollard, 1994; Silverstone *et al.*, 1996).

Financial sector liberalisation began with the removal of interest rate controls, followed by the removal of all price, wage, foreign exchange and bank ratio controls in 1985. The New Zealand dollar was floated in the same year, leaving the determination of exchange rates to international market forces to achieve a competitive environment wherever possible (Evans *et al.*, 1996). This also motivated international trade reforms (removal of major export subsidies and reduction in import protection); a broadening of the tax base and income tax reduction; and the narrowing of monetary policy to focus exclusively on reducing and containing inflation. Deregulation of the petroleum industry in 1988 reduced Government's involvement in the determination of production levels and prices, allowing the domestic price to reflect international trading conditions. Thus, its vital to examine the impact of oil price changes on growth. The paper is structured as follows: section 2 presents an overview of the existing oil price-growth nexus literature, with particular emphasis on the development of oil price shocks measures reflecting indirect transmission mechanisms. The models, data and methodology employed are discussed in the penultimate section. Section 4 presents the estimated results. Section 5 concludes the impact of oil price shocks on growth in New Zealand.

2. AN OVERVIEW OF THE LITERATURE

Despite the close proximity of the first 'oil crisis' in 1973 to the global recession of 1974, several studies presented arguments suggesting that the factor cost share of oil was too low to facilitate the observed reduction in the US output growth that followed the oil price hike (see Perry, 1977; Tobin, 1980; Nordhaus, 1980). Furthermore, the co-incidence of the end of the (Bretton Woods) pegged exchange rate regime, a substantial reduction in the US money supply growth in 1973 and 1974 and the removal of price controls in the US and elsewhere between 1973 and 1975 have cast doubt on a presumed oil price-economic growth relationship (see

Pierce and Enzler, 1974; Darby, 1982; Mork, 1994; Bohi, 1991; Romer and Romer, 1994; Darrat *et al.,* 1996; Bernanke *et al.,* 1997; 2004; Leduc and Sill, 2001; Barsky and Kilian, 2004; Rogoff, 2005; Kilian, 2006).

A number of studies thus reiterate that oil prices may be an important factor in affecting economic growth in the US and elsewhere (see Mork (1994), Hoover and Perez (1994), Ferderer (1996), Lee *et al.,* (1995), Hamilton (1997), Lee and Ni (2002), Balke *et al.,* (2002), Jiménez-Rodríguez and Sánchez (2005) and the literature cited therein). These studies present numerous theoretical perspectives on the oil price shock hypothesis, as well as empirical evidence on the estimated magnitude of such shocks impacting on growth through some of the speculated indirect channels. The implication of this literature is that indirect transmission mechanisms may be the crucial means by which oil price shocks have macroeconomic impacts.

Following the oil price declines of the mid-1980s, during which the world price of oil halved, the linear relationship between oil prices and economic growth appeared to break down (Mork 1989). Bohi (1991) notes in an algebraic evaluation of the production function that several further channels of transmission are potentially important for economic growth. He indicates that a direct price effect will cause output to decline, relative to the cost share of energy, because of the higher cost of energy resource inputs. However, there will also be indirect price effects given the substitution of capital and labour inputs for energy, thus, an energy price shock could be severely damaging to the economy even though the direct impact is small (Bohi, 1991, p. 149). There exits various causality analysis amongst many indirect energy prices and economic growth transmission mechanisms, macroeconomic adjustment costs appearing in labour and factor markets, and operating through inventory and final demand have been prominent in the literature such as allocative shocks and labour mobility (Lilien, 1982, Loungani, 1986). This reflects the fact that energy, and oil in particular, are ubiquitous in developed economies; consequently a price shock to these commodities can affect various factor, goods and financial markets. Consideration has also been given to the estimated impacts for capital inputs moving between sectors (Davis, 1987; Hamilton, 1988a).

Several studies have considered the direct impact of oil price changes on the investment decisions of firms and households. In addition to the utilisation of *existing* capital and labour resources, investment in *new* physical and human capital may be affected by allocative shocks. The pioneering work of Bernanke (1983) and others that examine the effect of such shocks on investment decision-making argues that allocative shocks, such as energy price movements, can depress some forms of capital investment substantially. This is because of the irreversible nature and considerable cost of undertaking specific investment projects (ibid). Further issues of energy sector investment in the climate of volatile energy prices are noted by Paddock *et al.,* (1988), Dixit and Pindyck (1994) and International Monetary Fund (2005). Alongside the hypothesised impacts on labour and capital of oil price shocks, it has been argued that energy is essential for implementing new technologies, and hence for productivity growth (Jorgenson, 1984). While this avenue may be a means for energy to impact on growth, it is difficult to assess empirically and thus has received little attention in the literature (Stern, 1993).

There are also a number of plausible demand-side instruments that may be important from an economic perspective (Mork and Hall, 1981; Bruno and Sachs, 1985). For net importers of key energy resources, one crucial possibility concerns the considerable terms of trade effects that can follow periods of energy price movements and heightened volatility. Given a rise in energy prices, the terms of trade effect refers to the transfer of purchasing power from domestic consumers to foreign owners of energy resources. Such transfers are likely to negatively impact on domestic demand, and may be the most important consequence of a price hike for some oil-importing countries given the impact on foreign reserves, exchange rates and the implications for overseas sector (Organisation for Economic Cooperation and Development, 2004).[1] Backus and Crucini (2000) consider this issue empirically for the US economy and note that "given the importance of oil as an internationally traded commodity and the volatility of its price, oil shocks could potentially explain virtually all of the terms of trade variation from the early 1970s to the mid-1980s" (p. 190). They find evidence that heightened terms of trade volatility is significantly related to increased oil price volatility, as opposed to fluctuations in nominal or real exchange rates that are both insignificant with respect to the terms of trade volatility.

As well as the terms of trade effect, the theoretical result that energy price shocks may trigger an external inflation spike has been pervasive in the literature. As inflation results from oil price movements and is not caused by an increase in domestic money supply it can have negative consequences for real balances. This in turn can lead to reduced consumption demand as consumers face a reduction in purchasing power, just as energy price increases may inhibit greater investment by the owners of physical and human resources (Mork, 1994). Pierce and Enzler (1974), Mork (1981) and Bruno and Sachs (1985) consider this avenue explicitly and find evidence in support of the theory for the US economy over various periods. They argue that the burden of this reduction in demand may fall disproportionately on the durable goods sector, which is also potentially vulnerable to demand-side effects of oil price shocks.

Combining the various demand-side impacts noted above suggests that an energy price shock can result in higher inflation and higher unemployment. In fact the 'oil crises' of the

[1] The magnitude of this net transfer is dependent on the extent to which export demand increases as a result of greater foreign purchasing power (Dohner, 1981).

1970s and early 1980s gave rise to both of these at the same time, known as the 'stagflation' phenomenon (Bruno and Sachs, 1985; Helliwell, 1988, Hooker, 2002). Such a combination should not happen according to the Keynesian theory of the Phillips curve, where inflation is "supposed to be the cost of good times, whereas recession sometimes has to be tolerated as the cost of loosening the grip of inflation" (Mork, 1994, p. 16). This is vital as the underlying the period of stagflation suggests that energy price *increases* could have recessionary macro consequences, then to the extent that demand channels are important, it also suggests that oil price *reductions* should result in sustained economic growth coupled with low inflation (Tatom, 1988).

Assessment of whether macroeconomic effects of oil price movements are symmetric has been specified separately in the growth regression framework. The finding reveals that correlations between energy price decreases and economic growth in the US were significantly different from those for energy price increases and "perhaps zero" over the post-World War Two period (Mork, 1989, p. 744). This implies an asymmetric energy price-economic growth relationship for the US, which is an important finding from the economic policy perspective. Mory (1993) also found an asymmetric relationship for the US, and argues that the oil-induced dislocations posited by Loungani (1986) and Hamilton (1988a) would be recessionary whether triggered by price increases or decreases.

Such a sequence of events seems plausible, and could render the net effect of a price decrease insignificantly different from zero as reported by Hamilton, 1988a; Mory, 1993; Jones *et al.*, 2004. Mork *et al.,* (1994) find evidence of asymmetries in the case of West Germany, France, the United Kingdom (UK) and Japan. On the other hand, both oil price increases and decreases are significant for the case of the US and for Canada. Norway, as an oil exporter, is an exception to this trend, with positive price shocks impacting growth positively and negative price shocks impacting growth negatively. This may be expected if demand effects (especially the terms of trade effect) are stronger than supply effects, particularly in a relatively small economy where oil exports are substantial.[2] The literature on energy prices and economic growth suggests that price shocks, especially to oil resources, led to recession. A number of different transmission mechanisms have been asserted, consistent with the ubiquitous nature of energy in modern economies (see Table 1 for various key empirical studies).

The empirical findings of various studies suggest that oil importing economies are negatively affected by oil price rises. While the structure of various economies may affect the extent to which economic growth is retarded following a price shock, these findings also imply

[2] Mork *et al.,* (1994, p. 20) note that "for a country of 4 million people that currently produces more than 2 million barrels of crude oil per day, this result is hardly surprising".

that oil price shocks contribute to the volatility in most of the countries (Jiménez-Rodríguez and Sánchez, 2005). As a net importer of oil, New Zealand's domestic economy is likely to be affected by oil price shocks for the same reasons as other countries. However, the overall structure of the economy and the energy system within it are inherently different from most industrialised countries. The section below presents the energy-economic growth models, data, methodology, and compare the findings of New Zealand to that of other studies.

Table 1 Macroeconomic Impacts of Energy Price Shocks: Selected Results

Study	**Data**	**Methodology and Variables**	**Is Energy Significant**
Hamilton (1983)	USA; Quarterly 1949-1972	VAR (Y, OP, MP, IP, UN, W, INF)	Yes
Burbidge and Harrison (1984)	US, Japan, Germany, UK, Canada; Monthly 1961-1982	VAR (Y, OP, MP, IP, R, W, INF)	Yes
Gisser and Goodwin (1986)	USA; Quarterly 1961-1982	OLS (Y, OP, MP, FP, UN, I, INF)	Yes
Mork (1989)	USA; Quarterly 1949-1988	VAR (Y, OP, MP, IP, UN, W, INF)	Yes
Mory (1993)	USA; Annual 1952-1990	OLS (Y, OP, MP, GOV)	Yes
Lee *et al.,* (1995)	USA; Quarterly 1949-1992	VAR (Y, OPV, MP, IP, UN, W, INF)	Yes
Ferderer (1996)	USA; Monthly 1970-1990	VAR (Y, OPV, OPV MP)	Yes
Hooker (1996)	USA; Quarterly 1947-1974	VAR (Y, OP, MP, IP, INF)	Yes
	USA; Quarterly 1974-1994	VAR (Y, OP, MP, IP, INF)	No
Hamilton (1996)	USA; Quarterly 1948-1994	OLS (Y, OPV, MP, INF, IP)	Yes
Darrat *et al.,*(1996)	USA; Quarterly 1960-1993	VAR (Y, OP, MP, FP, W, R)	No
Lee *et al.,* (2001)	Japan; Monthly 1960-1996	VAR (Y, OPV, MP, INF, R, CP, GOV)	Yes
Cuñado and Pérez de Gracia (2003)	15 European Countries; Quarterly 1960-1999	VAR (Y, OP, INF)	Yes
Jiménez-Rodríguez and Sánchez (2005)	9 OECD Countries; Quarterly 1972-2001	VAR (Y, OPV, INF, R, W, EX)	Yes

Notes: VAR is Vector Autoregression, Y is economic growth, MP is Monetary Policy, OP is oil prices, IP is import prices, UN is unemployment, W is wages, INF is inflation, R is interest rate, I is investment, OPV is oil price volatility, CP is commodity prices, GOV is Government expenditures, EX is exchange rate. 'Is Energy Significant?' indicates whether the coefficient on the energy price variable is significant. Note that the ordering of variables within the brackets does note reflect the order of the VAR within the corresponding study.

3. MODELS, DATA AND METHODOLOGY

Studies modelling the dynamic economic impacts of oil price shocks on the economy, in the recent years, have utilised the Vector Autoregression (VAR) methodology. The VAR model has been advantageous in this context as it does not require the arbitrary restrictions of the more-tightly structured models that are inappropriate, in light of various plausible transmission channels, suggested by economic theory (Sims, 1980; Burbidge and Harrison, 1984). The reduced-form VAR methodology includes for each variable a dynamic equation based on lags of itself and other variables within the model. The VAR system of equations can be represented in the following matrix form:

$$y_t = c + \sum_{i=1}^{p} \phi_i y_{t-i} + \varepsilon_t \qquad (1)$$

where y_t is a (n x 1) vector of endogenous variables, c = (c1, …, cn)' is the (n x 1) intercept vector of the VAR, ϕ_i is the ith (n x n) matrix of autoregressive coefficients for i = 1, 2, …, p, and $\varepsilon_t = (\varepsilon_{1t},...,\varepsilon_{nt})'$ is the (n x 1) vector of innovations.

The empirical oil price-shock models also include a number of the macroeconomic variables identified by Sims (1980) such as inflation, interest rate measures, wage and exchange rate variables, depending on the nature of assessment. The important considerations with respect to variable selection include the definition of oil price, the choice of appropriate variables to capture indirect linkages, and the non-linear price transformations in addressing the sectoral reallocation and price uncertainty effects.

There are three important issues to consider with respect to variable selection. First, while the primary relationship of interest here is between oil prices and economic growth, there exist many different 'oil prices' across various markets and countries. Consequently, which measure is most appropriate for the case of New Zealand is vital. Second, as the discussion has noted that oil price changes may affect economic growth through indirect channels; this requires which relevant variables to include that captures the indirect linkages. Third, the various transformations of the linear price change variable address the sectoral reallocation and price uncertainty effects.

The empirical studies on oil prices-economic growth nexus utilise several oil price measures. These include producer price indices for crude oil (for example, see Hooker, 1996; Lee *et al.*, 1995; Cuñado and Pérez de Gracia, 2003), refiner acquisition costs for imported crude oil (see Mork, 1989), spot prices for individual crude and refined petroleum markets (Carlstrom and Fuerst, 2005; Ferderer, 1996; Backus and Crucini, 2000; Jiménez-Rodríguez and Sánchez, 2004, 2005), and indices comprising several different market prices. Of the various price measures available, the Dubai spot price (in US$) per barrel of crude oil will be considered, deflated by the US Producer Price Index (PPI). Since Dubai is an internationally-traded variety of medium crude oil it is relevant to New Zealand, and this crude oil price is reported by the Ministry of Economic Development in their *Energy Data File*.

The variables in real terms avoid the problem of nominal price definitions that, owing to positive inflation, a comparable shock to the nominal price would induce a decreasing effect on real variables over the sample period (Jiménez-Rodríguez and Sánchez, 2004). This definition also means that changes in the level of the variable should be exogenous ‘shocks’ with respect to the New Zealand economic variables, since the nation is a price taker for this commodity in the international markets. The international price variable is preferred to domestic price as such a measure would necessarily include tax and retailer margin elements. Changes to a variable so-defined could arise from innovations in fiscal policy or monopolistic behaviour, and not necessarily the underlying product market. This would affect the interpretation of the results. The definition has the benefit of having consistent results that are comparable to majority of the previous studies (see Hamilton, 1983; Mork, 1989; Bernanke *et al.*, 1997; Cuñado and Pérez de Gracia, 2003; Jiménez-Rodríguez and Sánchez, 2005).

As noted above, the variables included in the regression are crucial to reflect the macroeconomic environment. Inflation and exchange rate channels, as well as interest rates and labour markets, may play crucial roles in transmitting oil price-shocks in the macro-economy. Therefore, in line with the literature the estimated models include real exchange rate, real wage and inflation. Under the Reserve Bank Act 1991’s Policy Target Agreement the aim of the monetary policy is to maintain consumer price inflation between 0 and 3 percent annually. Accordingly, the inflation variable should also capture the innovations in official interest rates. This assumption allows the model to address a range of indirect effects with a parsimonious structure, which is beneficial given the relatively modest size of the time series data.

The data sources include *Statistics New Zealand’s PC INFOS* for Nominal GDP (expenditure approach); Nominal Wages (average hourly earnings for both sexes, all sectors); Consumer Price Index (all groups); and Nominal Effective Exchange Rate data (Trade Weighted Index) is from the Reserve Bank of New Zealand and Statistics New Zealand. The data for the Nominal Dubai oil price; New Zealand Gross Domestic Product (GDP) deflator and the US Producer’s Price Index are from International Monetary Fund’s International Financial Statistics. The estimation period includes the reform period. As price regulation of the petroleum factor and product markets existed prior to the structural reforms, the pre- and post-reform periods (i.e. post-1988) are crucial to consider the impact of oil price shocks on economic growth. Quarterly data used, include the period March 1989 to March 2006 (i.e. 70 observations).

To address various oil price transformations the models below include oil price representations motivated by the break-down of the causal relationship between linear oil price change variables and growth in GDP that is found in many of the recent (i.e. post-1986) studies. Two such non-linear price measures utilised in the present study follow Mork’s (1989) asymmetric oil price change and Hamilton’s (1996) net oil price change. The asymmetric price specification models the positive and negative oil price changes separately. That is, the oil price shock variable is included in the regression framework as follows, where o_t is the rate of change of oil price in period t:

$$o_t^+ = \begin{cases} o_t & if\ o_t > 0 \\ 0 & otherwise \end{cases} \tag{2a}$$

$$o_t^- = \begin{cases} o_t & if\ o_t < 0 \\ 0 & otherwise \end{cases} \tag{2b}$$

The distinction in equations (2a) and (2b) has a theoretical basis in the sectoral shifts hypothesis developed by Lilien (1982), which suggests that both positive and negative price changes may alter the marginal product of factor inputs and spur the sectoral reallocation of various resources on the supply side of the economy.[3] On the other hand, investment and consumption uncertainty that may arise in a climate of volatile oil prices have been suggested by Bernanke (1983), among others, to be the important means by which oil prices can affect economic growth. This idea motivates several non-linear price measures first developed by Hamilton (1996) and Lee *et al.,* (1995).

Hamilton (1996) considers the rate of price increase in the current period relative to price movements over the past year, rather than over the previous quarter only. Defining o_t as the rate of change of oil price in period t, this 'net oil price increase' (NOPI) measure is given as:

$$NOPI = \max\ \{0, o_t - \max\{o_{t-1}, o_{t-2}, o_{t-3}, o_{t-4}\}\} \tag{3}$$

Transforming the price variable in this manner focuses on those price increases that occur after a period of relative stability, placing less emphasis on price changes that occur during periods of existing price volatility. Similarly, the scaled oil price measure developed by Lee *et al.,* (1995) models the conditional volatility of oil prices using Generalized Autoregressive Conditional Heteroscedasticity, i.e. AR(4)-GARCH(1,1) process.[4] The GARCH is not used due to small samples properties (Levy, 2001). As there is little theoretical basis *a priori* to distinguish the most-appropriate measure among the previously-discussed linear and non-linear alternatives for the case of New Zealand, and no precedent from the existing literature, the

[3] This effect would reinforce the negative direct demand effects of a positive increase but offset the positive demand effects of a price decrease, giving rise to asymmetric effects on economic growth. Mork's (1989) study provides empirical support to this theory, with the coefficients on all four lags of the price increase variable in the GDP equation statistically significant at the 5 percent level whereas none of the coefficients on the four lags of the price decrease variable are significantly different from zero.

[4] See Engle (2001) and Quantitative Micro Software (2004, Ch. 20) for a discussion on the GARCH modelling framework. Jiménez-Rodríguez (2002) notes that the GARCH specification is inferior to a non-linear function estimated by kernel methods. The application of kernel semi parametric method is also beyond the scope of the present study given the size of the time series data available.

present study will consider the linear, asymmetric, and net specifications separately to address the short run impact of oil price shocks. The VAR methodology has been employed.

Based on the VAR model given in equation (1), the vector *y* includes the following variables: real GDP, real oil price, real wage, real effective exchange rate, and consumer price level. The New Zealand macroeconomic variables are transformed into real series using the GDP deflator, the real oil price series is deflated with the US PPI. The variables (real GDP, real oil price, real wage, and real effective exchange rate) are expressed in log form, whereas the inflation variable is derived from the level of the Consumer Price Index (CPI). The various tests and methodology to be utilised in this approach, which follows the general structure of the majority of empirical studies, and the approach outlined in Jiménez-Rodríguez and Sánchez (2004; 2005) in particular, are briefly noted below.

The first stage of the estimation and modelling procedure is to identify the order of integration of the data series. The Augmented Dickey-Fuller (ADF) test and the alternative Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests have been undertaken using the software package EViews 5.0. Having ascertained the order of integration of each series, the next stage involves short run assessment of oil price shocks on economic growth. It includes Granger causality-type tests, impulse response functions and the error variance decompositions of the VAR models. The impulse response functions and error variance decompositions are estimated as they are more informative than the estimated variable coefficients and R^2 statistics of the models (Stock and Watson, 2001).

In order to ascertain whether there is a statistically significant relationship between oil prices and the important macroeconomic variables, pairwise Granger causality-type tests is performed on the system of variables using the standard Wald test.[5] The test is based on an unrestricted VAR(*p*), given as:

$$y_t = c + \sum_{i=1}^{p} \phi_i y_{t-i} + \varepsilon_t \qquad (4)$$

where y_t is a (n x 1) vector of endogenous first-differences, c = (c1, …, cn)’ is the (n x 1) intercept vector of the VAR, ϕ_i is the i^{th} (n x n) matrix of autoregressive coefficients for i = 1, 2, …, *p*, and $\varepsilon_t = (\varepsilon_{1t}, ..., \varepsilon_{nt})'$ is the (n x 1) vector of innovations.

Selection of the appropriate order of the VAR, *p*, is based on various selection criteria such as the Akaike Information Criterion and Schwarz Information Criteria (AIC and SBC, respectively). The parsimonious lag structure is chosen for all equations do not show any

[5] It is important to stress that this test is only valid for VARs containing differenced data. Where levels data are used, the modified Wald (MWald) test can be used; see Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) for a discussion of the underlying theory.

problems of serial correlation (see Pesaran and Pesaran, 1997; Quantitative Micro Software, 2004). Once the order of the VAR has been determined, the Wald test of Granger non-causality is performed for various pairs of variables within the system. This primarily determines whether different representations of oil price change *directly* Granger cause economic growth in New Zealand. Such a relationship would be implied by the rejection of the null hypothesis that all p lags of the oil price coefficient are jointly equal to zero in the GDP growth equation of the VAR. However, indirect linkages may be the important transmission mechanisms for oil price shocks, which have been hypothesised in the recent literature. The Likelihood Ratio test has been utilised to deduce whether or not an indirect relationship between oil price changes and the rest of the system exists. This provides the next step to test for the indirect transmission channels that are not addressed with the Wald test (Jiménez-Rodríguez and Sánchez, 2005).[6] Also, the pairwise tests provide the crucial insights into whether or not oil price shocks have an impact on the system of key macroeconomic variables for New Zealand. Under such circumstances, the magnitude of this impact can be quantified using the impulse response function and forecast error variance decomposition mechanisms.

4. EMPIRICAL RESULTS

The results of the estimated models, using quarterly data in constant 2000 prices for the period 1989 to 2006, are presented in this section. The estimated statistics of the ADF and KPSS stationarity tests are presented in Table 2 for each variable in both the level and first difference form. The results imply that each series in level is I(1), applying the first difference to attain stationarity. These results imply that the level form of each series is integrated of order one. The results of the alternative KPSS test shown in Table 1 do not reject the hypotheses that logGDP, real wage and real effective exchange rate variables are stationary in levels, but the results in the first-difference form imply that the null hypothesis cannot be rejected. Results support the ADF test conclusions that the levels of all the variables are I(1).

As all of the variables are I(1) processes, the next step determined the appropriate order of the VAR, p, the parsimonious VAR lag structure estimated is p = 3 for the linear and nonlinear price shock models. The following short run analysis is conducted using the reduced-form of VAR model in the first-difference form, as follows:

[6] The Likelihood Ratio test addresses the significance of a given variable with respect to the system as a whole, rather than in the context of a single equation. Specifically, it tests whether the coefficients on all oil price variables are jointly equal to zero in *all* of the equations in the system. Alternatively one could employ the Granger test of block exogeneity, which considers whether the coefficients on all of the lags of *all* variables other than the dependent variable are jointly different from zero. In the present case however, the LR test seems more appropriate.

Model I: [ΔLRGDP, ΔLROP, ΔLRWAGE, ΔLREER, ΔCPI]

Model II: [ΔLRGDP, ΔLROP+, ΔLROP-, ΔLRWAGE, ΔLREER, ΔCPI]

Model III: [ΔLRGDP, ΔNOPI, ΔLRWAGE, ΔLREER, ΔCPI]

where ΔLRGDP is the log difference of real GDP; ΔLROP is the log difference of real oil prices; ΔLRWAGE is the log difference of real wage rate; ΔLREER is the log difference of real effective exchange rate; ΔCPI is the first difference of Consumer Price Index; ΔLROP+ is the positive log difference of real oil price; ΔLROP- is the negative log difference of real oil price and NOPI is the net oil price increase.

Table 2 Results of the ADF and KPSS Unit Root Tests

Variable	ADF t-statistic	KPSS LM-statistic	Result	Variable	ADF t-statistic	KPSS LM-statistic	Result
LRGDP	-3.475*	0.108	Not I(0)	ΔLRGDP	-8.234***	0.285	I(0)
LROP	-1.998	0.217***	Not I(0)	ΔLROP	-4.144***	0.132	I(0)
LRWAGE	-2.517	0.079	Not I(0)	ΔLRWAGE	-8.988***	0.062	I(0)
LREER	-3.443*	0.107	Not I(0)	ΔLREER	-5.706***	0.089	I(0)
CPI	-2.544	0.119*	Not I(0)	ΔCPI	-5.396***	0.146	I(0)

Notes: LRGDP is log real GDP, LROP is log real oil price, LRWAGE is log real wage, LREER is log real effective exchange rate and CPI is Consumer Price Index. **Δ** is difference operator. 5% critical values for ADF test are -3.51 (levels), -2.93 (first-differences); 5% critical values for KPSS test: 0.14 (levels) and 0.46 (first differences). *, **, *** significance at the 10, 5, and 1% level, respectively. Critical values for the ADF test are from Mackinnon (1996), while the asymptotic critical values for the KPSS test are from Kwiatkowski *et al.,* (1992).

Results for the Causality Analysis

Several alternative causality tests are reported, demonstrating the short run impact of oil price shocks in the economy. Table 3 reports the estimated values for pairwise tests of Granger non-causality that all oil price coefficients are jointly zero in the GDP growth equation of the respective VAR models. The pairwise Wald tests of Granger non-causality and Likelihood Ratio tests are reported in Table 3. It is clear that the null hypothesis cannot be rejected for any of the price change specifications for the Wald tests. That is, neither the linear nor the asymmetric or net oil price variables Granger cause economic growth directly in New Zealand. This result is similar to the findings of Jiménez-Rodríguez and Sánchez (2005) on various pairwise price measures.[7] Cunado and Perez-de-Gracia (2003) also find that the linear, asymmetric and net oil price changes all do not Granger cause industrial production for Spain,

[7] They also consider the scaled oil price increase and decrease measures, which are not discussed here as they are not directly relevant to the present study. They find that the linear price measure is not significant in any of the nine OECD countries studied, while the asymmetric price increase is only significantly different from zero for the case of France and Germany. The asymmetric price decrease variable is not significant except for the full model of Europe and Norway. The net oil price measure does not Granger cause economic growth for any countries except for Germany, where the net oil price is significantly different from zero at the 5 percent level.

Italy, and Finland.. Hence, the finding that oil price changes do not directly affect economic growth in New Zealand is consistent with the evidence for similar countries.

Table 3 Wald and Likelihood Tests Results Granger Non-Causality Oil Price Specifications

Oil Price Model	Wald F-statistic	p-value	Likelihood Ratio Statistic	p-value
Linear	1.829	0.609	137.759	0.000
Asymmetric: Increase	1.505	0.681	180.403	0.000
Asymmetric: Decrease	1.617	0.656	11.442	0.721
Net	4.190	0.242	231.816	0.000

Notes: The relevant 5 percent critical value for the Wald F-statistic with 3 degrees of freedom is 7.814 (Griffiths *et al.*, 1993).

As Jiménez-Rodríguez and Sánchez (2005, pp. 209-210) state that rather than all of these economies being unaffected by oil price shocks it may be that the Wald test is not able to account for the system-wide impact of oil price shocks. The Likelihood Ratio (LR) test has been considered next to test the null hypothesis that all of the oil price coefficients are jointly zero in the VAR equations. The results of the LR test in Table 3 show that the linear price change, the asymmetric price increase and the net oil price variables are significant for the system as a whole, whereas the asymmetric price decrease is not.[8] These results of the LR tests imply that oil prices *are* significant in the context of New Zealand's economic growth. Therefore, the effect of an oil price shock can be simulated using the impulse response and variance decomposition techniques.

The next step determines the alternative specification of which model is the best representation of oil prices. Table 4 presents the results of the relative model performance using the AIC and SBC test statistics, where the lowest value is preferred in this case (Quantitative Micro Software, 2004, p. 708). Based on the estimated values it can be concluded that net oil price change model is superior to that of the linear and asymmetric models. The next step examines the macroeconomic impact of oil price shocks for New Zealand using the preferred net oil price specification.

Table 4 Relative Performance of Oil Price Shock Models

Oil Price Change Model	AIC test statistic	SBC test statistic
Linear	-25.483	-22.305
Asymmetric	-26.048	-22.870
Net	-26.838	-23.660

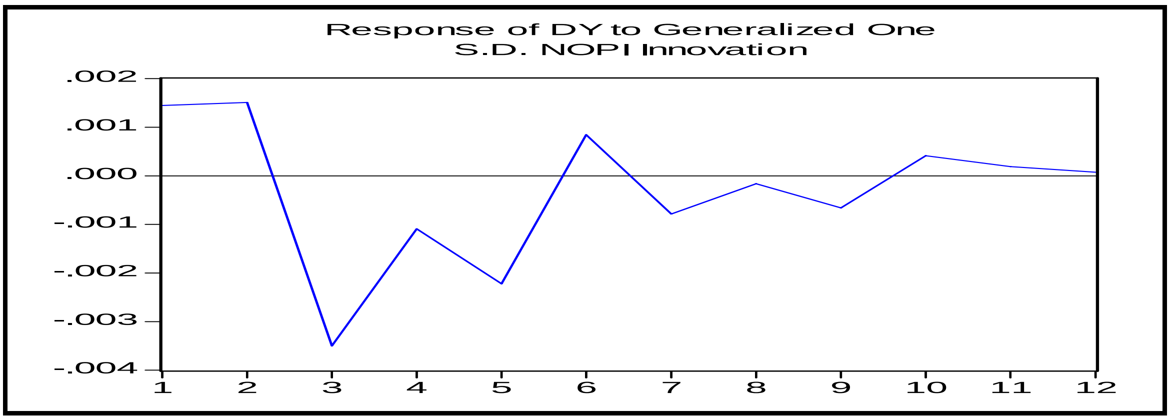
[8] This result is similar to the findings of Jiménez-Rodríguez and Sánchez (2005), except for the oil-producing countries of the US, the UK and Canada. See Cunado and Perez-de-Gracia (2003) and Hamilton (1996).

Impulse Response and Variance Decomposition Analysis

The generalised impulse response functions and the forecast error variance decomposition are examined based on the preferred net oil price shock model. Initially, the focus is on the direct impact of a simulated price shock on economic growth. In the next steps the potential indirect effects on economic growth and the relative contribution of oil price fluctuations to the volatility of the various endogenous series are considered. In examining the direct impact of a price shock, Figures 1 to 4 present the impulse responses of the log-differences of the endogenous variables, i.e. real GDP (ΔLRGDP), inflation (ΔCPI), real effective exchange rate(ΔLREER), and real wage (ΔLRWAGE), to a generalised one-standard-deviation net oil price shock. The horizontal axis indicates the quarterly intervals over a three-year period, i.e. 12-period length is where the impulse responses stabilise by that period.

The impulse response function presented in Figure 1 traces the impact of a shock to the net oil price equation on real GDP growth. It suggests that price shock affect in the second quarter that imposes a negative impact on economic growth; the largest negative impact occurs in the third quarter and remains negative over 2 years. This finding is consistent with that of Lee *et al.,* (1995) for GNP growth in the US, and Jiménez-Rodríguez and Sánchez (2005) for France, Italy, Norway and Canada. The y-axis indicates the rate of change impact of GDP accordingly, the third period negative impact is equal to nearly 0.4 percent on GDP growth. The cumulative effect is around 0.7 percent of GDP growth; however the impact asymptotes to 0 after the tenth quarter. This suggests that the impact of the net oil price shock on the growth rate of GDP is relatively short-lived.

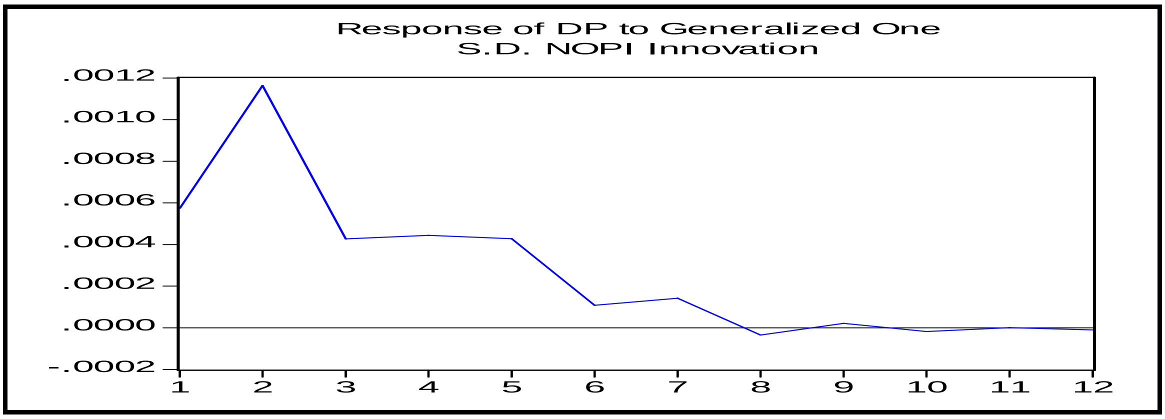
Figure 1 Generalised Impulse Response Function of GDP Growth to a One-Standard-Deviation Net Oil Price Shock



The impact on inflation through an oil price change is presented in Figure 2. It is seen that an oil price shock has an immediate and large effect on inflation. The dynamic profile of the impulse response suggests that the shock to inflation is immediate, increasing in the order of 0.1 percent in the second quarter due to a one-standard-deviation price change innovation.

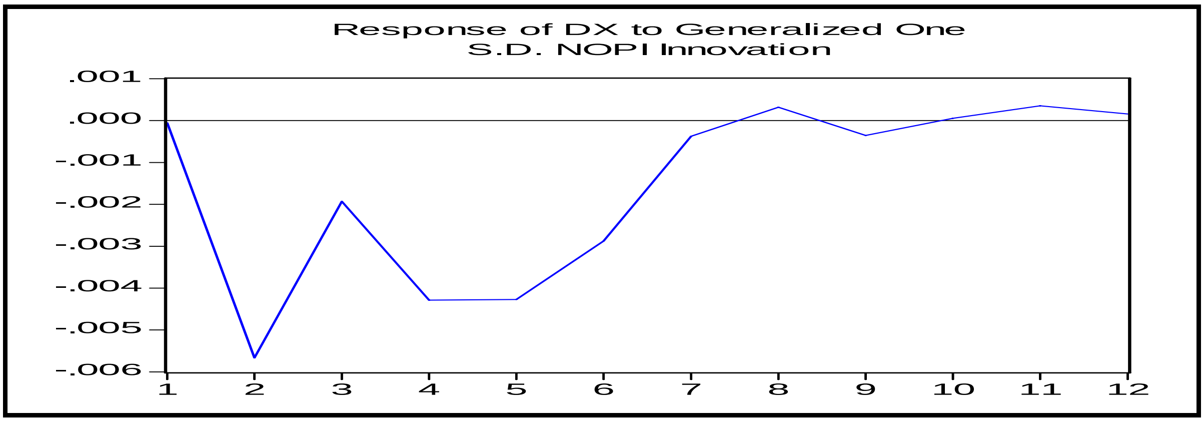
This is followed by a gradual decrease over the next 6 quarters before the impact stabilises to 0 in around 2 years. This impact implies the effect on inflation is transitory, though the effect on the level of consumer prices is permanent. The results of impulse response suggest a cumulative impact in the range of 0.3 percent. Given the narrow band for inflation targeting in New Zealand, the implication of the impulse response function is that oil price shocks contribute to a difficult macroeconomic and monetary policy environment. The impacts of lower GDP growth and increased inflation due to oil price shocks, as shown in Figures 1 and 2 are similar to the findings in the context of the US economy by Mork (1994) and Jones *et al.,* (2004). The impact of oil price shocks on the real effective exchange rate is considered next.

Figure 2 Generalised Impulse Response Function of Inflation to a One-Standard-Deviation Net Oil Price Shock



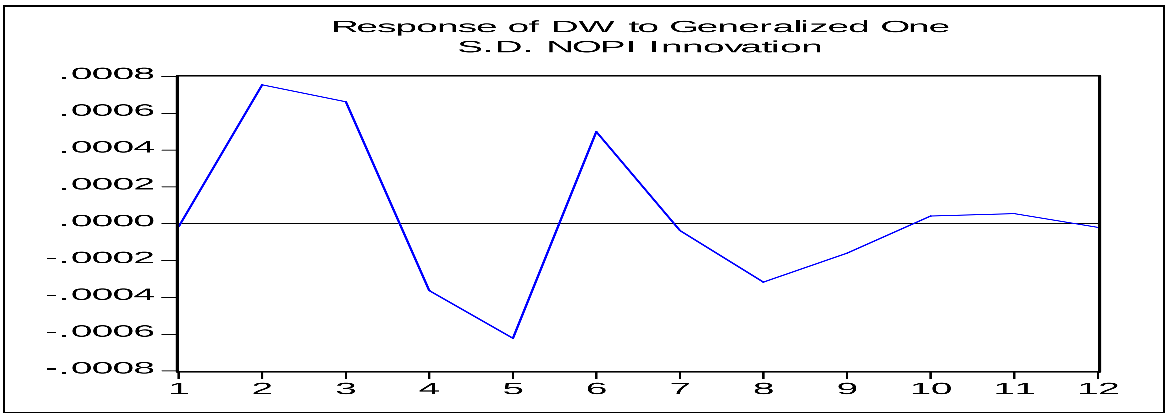
Before considering the implications of impulse response of oil price shock on real effective exchange rate, the definition is given for this variable. Real exchange rate is defined as where a decrease means a depreciation of the domestic currency in real terms. Such a movement would be expected to benefit exporters and harm importers. Accordingly, a sharp, negative response of the real exchange rate to the initial price shock suggests that domestic consumers would face higher prices for imported goods. On the other hand, export goods would be relatively more competitive in the world market, notwithstanding the oil price shock. Plot of impulse response for real exchange rate to a one-standard-deviation oil price shock in Figure 3 is persistent through to 10^{th} quarter (i.e. 2½ years). The magnitude of the sharpest fall occurs in the second quarter reaching nearly 0.6 percent, and the cumulative effect over time through 10 quarters is around 2 percent. This movement occurs at the same time as it impacts on GDP growth and inflation. Based on the results presented so far it would appear not to be a trivial effect, as the cumulative effect is high so it will impact on several economic activities, adversely affecting overall growth. The impact on real wage growth is presented next.

Figure 3 Generalised Impulse response Function of the Real Effective Exchange Rate to a One-Standard-Deviation Net Oil Price Shock



The impulse response function shown in Figure 4 indicates the impact on real wage growth due to net oil price shock. It can be seen that there is substantial volatility in the labour market in the year after the oil price shock. The time path of the impulse response indicates an initial appreciation in the real wage rate, before it decreases in the third to fifth quarters, and finally asymptotes to 0 in three years. This sequence can be rationalised as follows: the oil price shock initially induces substitution towards labour, as it is a relatively-cheaper factor input. After several periods however, it contributes to a reduced output growth (Figure 1) and lower exchange rate (Figure 3) that reduces demand, and also leads to a loosening of the labour market pressures. It is noted that the scale of effect is of smaller magnitude than those of previous factors (i.e. GDP, inflation and real exchange rate) shown in Figures 1 to 3. The maximum increase in the second quarter is around 0.07 due to one percentage change. Consequently, the smallest impact of real wage impulse response function suggests that the labour market is not as volatile as inflation or the exchange rate. In the next section the issue of macroeconomic importance of oil price event from the perspective that oil price shocks may contribute to the volatility in GDP growth and other series are examined. This is considered using the forecast error variance decomposition procedure.

Figure 4 Generalised Impulse response Function of Real Wage Growth to a One-Standard-Deviation Net Oil Price Shock



Variance Decomposition Analysis

The variance decomposition for each series (GDP growth, Net Oil Price, Real Wage Growth, Real Exchange Rate, Inflation) is further disaggregated to indicate the attributes of innovations within the system of endogenous variables. It shows how much of the unanticipated changes of the variables are explained by different shocks (Jiménez-Rodríguez and Sánchez, 2005, p.222). Tables 5 to 8 report the variance decomposition estimated over the 8-period horizon (i.e. 2 years) for each endogenous variable based on the VAR model, where the decomposition values converging to stable states.

The estimated variance decomposition of real GDP growth over the 2-year horizon is presented in Table 5 with other variables. This is useful for assessing the *relative* importance of oil price shocks vis-à-vis shocks to the other sectoral variables, e.g. labour market (represented by real wage shock) and foreign exchange shocks (represented by real exchange rate shock). In estimating the impact on GDP growth, it can be seen that oil price shock is a considerable source of volatility, i.e. it contributes substantially to around 9 percent of the volatility in output growth. Real wages growth also contributes as much to the volatility of around 9 percent. Inflation contribution is lower than NOP and real wage growth, i.e. less-than 6 percent. This compares to the US, the UK and Italian economies, where Jiménez-Rodríguez and Sánchez (2005) find the scaled oil price variable to contribute 9.6 percent, 9.9 percent, and 8.8 percent of the volatility in the GDP growth series, respectively. The real effective exchange rate is estimated to have the largest source of volatility on GDP growth. This can be explained by the relative importance of international trade to New Zealand's economy. A very similar result was found for Japan by Jiménez-Rodríguez and Sánchez (2005), where international trade is a similarly dominant activity. In light of these results, the net oil price shock also appears to be a key factor that contributes to the volatility of output growth over the two-year horizon in New Zealand. However, the indirect avenues need to be considered to gain a fuller understanding of the diverse impacts of oil price changes.

Table 5 Estimated Variance Decomposition of Real GDP Growth at the 8-period Horizon

Horizon	GDP Growth	Net Oil Price	Real Wage Growth	Real Exchange Rate	Inflation
0	1.000	0.014	0.041	0.022	0.001
1	0.930	0.230	0.035	0.017	0.038
2	0.841	0.079	0.053	0.048	0.035
3	0.702	0.069	0.087	0.146	0.058
4	0.685	0.083	0.083	0.144	0.056
5	0.677	0.085	0.086	0.149	0.057
6	0.671	0.086	0.087	0.148	0.056
7	0.670	0.085	0.087	0.148	0.056
8	0.668	0.087	0.088	0.148	0.058

Table 6 shows the estimated values of each variable due to innovation within the system through the effect of inflation. The net oil prices are the most crucial source of volatility in inflation. While the GDP growth and exchange rate variables contribute 3.7 and 4.3 percent to the inflation variance at the 8-period stage, respectively, the net oil prices contribute almost 10 percent to inflation. This also exceeds the real wage impact of 8.5 percent of the total in 2 years after the shock. These results are comparable to the results for France and Italy by Jiménez-Rodríguez and Sánchez (2005).

Table 6 Estimated Variance Decomposition of Inflation at the 8-period Horizon

Horizon	GDP Growth	Net Oil Price	Real Wage Growth	Real Exchange Rate	Inflation
0	0.001	0.022	0.003	0.004	1.000
1	0.011	0.091	0.002	0.009	0.93
2	0.022	0.091	0.052	0.026	0.887
3	0.035	0.093	0.068	0.038	0.865
4	0.034	0.100	0.074	0.041	0.852
5	0.037	0.099	0.083	0.042	0.843
6	0.037	0.100	0.085	0.043	0.840
7	0.037	0.099	0.085	0.043	0.840
8	0.037	0.099	0.085	0.043	0.839

Table 7 presents the estimated variance decomposition values to real wage rate growth and other variables over 2 year time horizon. It is seen that domestic macroeconomic variables in New Zealand play a minor role in determining the key bilateral exchange rates and the trade-weighted index, vis-à-vis the prevailing macroeconomic conditions abroad. Thus, while domestically real wage growth adds to the volatility of real exchange rate, it is not surprising that most of the volatility in the real exchange rate series is impacted by oil price shock. The net oil price volatility contributes nearly 6 percent of the volatility over the 2 year period. This is more than the estimated rate of 4 percent contribution of GDP growth, and the 2 percent contribution of inflation. On the other hand, the result for real wages of 31 percent suggests that real wage growth is internationally competitive and affects the exchange rate. This large volatility has not been reported for any of the country studies in the recent literature.

Table 7 Estimated Variance Decomposition of Real Effective Exchange Rate at the 8-period Horizon

Horizon	GDP Growth	Net Oil Price	Real Wage Growth	Real Exchange Rate	Inflation
0	0.022	0.000	0.214	1.000	0.004
1	0.030	0.028	0.227	0.951	0.012
2	0.030	0.031	0.226	0.948	0.012
3	0.041	0.041	0.307	0.874	0.013
4	0.040	0.053	0.307	0.862	0.013
5	0.042	0.058	0.309	0.847	0.018
6	0.043	0.057	0.312	0.837	0.018
7	0.043	0.057	0.312	0.837	0.018
8	0.043	0.057	0.311	0.837	0.020

The estimated values of the variance decomposition of real wage growth are reported in Table 8. It shows the volatility for real wage growth is not caused by oil price shocks. The estimated values imply that the macroeconomic effects of oil price changes are not transmitted through the labour market. This result supports the estimated impulse response results, suggesting that the labour market is relatively unaffected and so is unimportant in terms of the macroeconomic consequences of exogenous shocks to the world price of oil. Overall, the findings that net oil price shocks add substantial volatility to GDP growth, real exchange rate and inflation reaffirm the results of impulse response, i.e. oil price shocks have vital macroeconomic effects for New Zealand.

Table 8 Estimated Variance Decomposition of Real Wage Growth at the 8-period Horizon

Horizon	GDP Growth	Net Oil Price	Real Wage Growth	Real Exchange Rate	Inflation
0	0.041	0.000	1.000	0.214	0.003
1	0.053	0.006	0.967	0.204	0.007
2	0.066	0.010	0.891	0.186	0.066
3	0.062	0.010	0.799	0.240	0.063
4	0.073	0.013	0.783	0.238	0.062
5	0.072	0.014	0.781	0.234	0.074
6	0.073	0.015	0.777	0.241	0.077
7	0.073	0.015	0.777	0.243	0.077
8	0.073	0.015	0.777	0.244	0.077

5. Conclusion

The paper presents empirically the impact of oil price shocks on economic growth in New Zealand for the quarterly period 1989-2006. In the wake of market reforms conducted after 1984, this period coincides with deregulation of the oil markets in particular, and product and factor markets in general. A multivariate framework has been utilised to measure the short run impact of oil price shocks on economic growth, inflation, real wages and exchange rate. The models estimated employ the linear oil price and two nonlinear oil price transformations to examine various short run impacts. Using the Likelihood Ratio tests of Granger non causality, the results indicate that linear price change, asymmetric price increase and the net oil price variables are significant for the system as a whole, whereas asymmetric price decrease is not.

Following the causality analysis of oil price-growth nexus, the generalised impulse responses and error variance decomposition results reaffirm the direct link between net oil price shock and growth, as well as the indirect linkages via inflation and real exchange rate. These variables have key influences on the domestic economy. The results obtained for New Zealand are similar to various other developed country-studies and small open European economies that are similarly reliant on imported oil resources. The robust results of variance decompositions show oil price shocks are a considerable source of volatility in growth. Overall, it can be said that there is a crucial relationship between exogenous oil price shocks and economic growth and other variables. This is reinforced by the finding that oil prices have substantial effects on inflation and exchange rate in New Zealand. The real wage rate is not as volatile since the labour market reacts with only minor consequences; it does not appear to be an important transmission channel in the case of New Zealand, which is similar to other country case-studies. Given that oil consumption continues to increase in New Zealand the policy-makers have to consider all these variables as oil price shocks are a considerable source of volatility for many variables in the model.

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