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The Energy-Economic Growth Nexus: Empirical Evidence for New Zealand

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ABSTRACT

This study addresses the energy consumption and energy price-economic growth nexus for the case of New Zealand. Several hypotheses concerning the impacts of energy consumption and oil price shocks on economic growth are empirically examined, as these issues have important policy implications that have received little attention in New Zealand.

Utilising the Autoregressive Distributed Lag approach to cointegration, the energy consumption-economic growth relationship is analysed over the period 1960-2004. Two key approaches are followed in terms of a cointegration and causality framework to answer whether energy consumption is a stimulus for economic growth or if economic growth leads to energy consumption. The energy consumption-growth nexus are examined based on the theoretical arguments of the trivariate demand model, trivariate supply model and multivariate supply model. The results indicate that long run relationships exist between various sets of variables, i.e. energy consumption, energy prices, labour and capital. Given the central role of energy to New Zealand's domestic growth agenda as well as international climate change commitments, the estimated results provide a basis for policy prescriptions to deal with these issues for the short run and long run.

The related issue of oil price shock impacts on economic growth is considered for the period 1989-2006 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 estimated results are based on the concept of 'net oil price shocks', and indicate that such shocks impact significantly on several key macroeconomic variables in a manner that is consistent with the economic theory. The findings of this study provide policy implications based on the key elements of New Zealand's energy-growth relationships and energy policies, in light of energy scarcity, climate change issues, and the related policy responses.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
BP	Beyond Petroleum
CPI	Consumer Price Index
ECNZ	Electricity Corporation of New Zealand
ECT	Error Correction Term
EEC	European Economic Community
EU	European Union
GDP	Gross Domestic Product
GFK	Gross Fixed Capital Formation
GHG	Greenhouse Gas
GIC	Gas Industry Company
GNP	Gross National Product
IEA	International Energy Agency
IFS	International Financial Statistics
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange Multiplier
LOP	Linear Oil Price
LR	Likelihood Ratio
MP	Monetary Policy
MTA	Motor Trade Association
MTOE	Million Tonnes of Oil Equivalent
MW	Megawatt
NOPI	Net Oil Price Increase
NZ	New Zealand
NZIER	New Zealand Institute of Economic Research
NZRC	New Zealand Refining Company
OECD	Organisation for Economic Cooperation and Development

OPEC	Organization of the Petroleum Exporting Countries
PPI	Producer Price Index
RBC	Real Business Cycle
RMA	Resource Management Act 1991
SBC	Schwarz Bayesian information Criterion
SOE	State Owned Enterprise
SOPD	Scaled Oil Price Decrease
SOPI	Scaled Oil Price Increase
TCE	Total Consumer Energy
TLF	Total Labour Force
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
UK	United Kingdom
VAR	Vector Autoregression
VECM	Vector Error Correction Model

Chapter One

INTRODUCTION

Energy is the precursor of economies.

(Shelley, 2005, p. 1)

1.1 Aims and Objectives

The purpose of this study is to examine the issues of energy consumption and energy price shocks to New Zealand's growth. These are important issues in the current policy environment that have received little formal attention in New Zealand. Analysing the role of energy consumption and price signals to the process of economic growth, the study evaluates which energy resources interact with macroeconomic variables through the distinct channels of consumption and price effects to enhance growth.

The existing literature on energy consumption-growth relationships is based on the neoclassical and ecological economic theories of economic growth, which imply several relationships between energy and growth. Empirical time-series studies have considered the causal relationship between these variables for a range of country case-studies utilising several approaches to the issues of cointegration and causality. These studies provide mixed results that support both the neoclassical and the ecological economic hypotheses in different country contexts. Given the New Zealand Government's emphasis on achieving economic growth while simultaneously moving to a more sustainable energy system in the period of Kyoto Protocol commitments (New Zealand Government, 2002; Ministry of Economic Development, 2004), this study attempts to analyse the role of energy consumption and energy price shocks to economic growth, based on growth theories and their implications for economic and energy policies. To this end, several reduced-form models are utilised that are free of structural linkages. To examine the hypotheses of energy-growth in New Zealand, the models are estimated on time series annual data for the period 1960-2004 and quarterly data for the period 1989 Q1 to 2006 Q1. In light of the existing literature this study develops several models of energy-economic growth nexus for New Zealand. Based on the theoretical aspects, the

models are empirically examined using the Autoregressive Distributed Lag (ARDL) approach to cointegration so that the long run and short run Granger causality can be investigated, as well as utilising the additional information for energy price, capital and labour variables. The results of these models provide policy implications on macroeconomic, energy and environmental policies that relate to New Zealand's economic growth.

A second crucial issue concerns energy price shocks, which have also been argued to have macroeconomic consequences. These concern oil prices in particular following the well-known oil 'price shocks' that occurred in the 1970s. Hamilton (1983) has demonstrated that all but one of the recessions in the United States (US) that occurred between 1948 and 1972 were Granger caused by exogenous increases in the price of oil, which is at odds with the prediction of the neoclassical theory. The basic neoclassical theory posits that given the small cost share of energy in Gross Domestic Product (GDP), energy price effects should not be important for economic growth. However, numerous empirical analyses conducted since Hamilton's (1983) study have found a vital impact for oil prices on the economic growth of the US economy and elsewhere. These studies utilise several oil price transformations, the origins of which are embedded in various theories of factor mobility, investment uncertainty and asymmetric prices, to evaluate the macroeconomic impacts.

Given the 'price taker' status of New Zealand as a small open economy, this study addresses the impact of oil price shocks from the economic growth perspective utilising several of the leading oil price measures. In particular, the study examines the issue of oil price shocks during the period of oil market deregulation of 1989-2006. Given the volatility of oil prices, both historically and in the recent period, thus quarterly observations are taken into consideration using the Vector Autoregressive (VAR) modelling framework. The variables employed include oil prices, economic growth, effective exchange rates, wage rates and inflation. This system of macroeconomic variables are analysed to address the direct effects of oil price shocks, as well as the indirect effects that are hypothesised to operate through labour market, exchange rate and inflation channels, on New Zealand's economic growth performance.

In order to empirically estimate the energy consumption and price effects on economic growth, reliable indicators are needed. The single best measure of economic performance at the national level for any country is GDP, which for New Zealand has fluctuated between 10 percent and -3 percent over the period 1960-2004. The GDP growth has consistently been positive in the period since 1989 (International Monetary Fund, 2006b). At the same time, the total consumption of oil, gas, electricity, coal, geothermal and renewable energy resources has increased from less than four Million Tonnes of Oil Equivalent (MTOE) to more than 14 MTOE (International Energy Agency, various). Furthermore, the majority of the energy resources (i.e around 50 percent) currently consumed are oil resources. Thus, several questions arise as to the role of energy consumption in economic activities and the possible impact of oil price shocks on growth.

An analysis of the energy-growth nexus for New Zealand is valuable for a number of reasons. First, it is important to understand the relationship between energy resources and economic growth such that policies can be formulated which allow for the joint achievement of energy sector and macroeconomic objectives. These include, for example, developing the sustainable energy system and delivering the higher rates of economic growth that are sought in various policy documents (Cf. Ministry of Economic Development, 2004; New Zealand Government, 2002). Second, the initial commitment round of the Kyoto Protocol during the period 2008-2012 requires a reduction in New Zealand's greenhouse gas (GHG) emissions burden that can be achieved by either reducing the level of emissions (through energy conservation measures) or through purchasing emissions credits from countries which have surplus emissions allocations. Identifying the prospects for undertaking energy conservation policies from the economic growth perspective can assist policy-makers in deciding which of the available options may be the more efficient measure in the long run. Finally, the dearth of empirical analyses addressing energy and growth issues for the case of New Zealand suggest an assessment of this topic is warranted, such that findings may result into important policy decisions in addition to highlighting the specific areas of inquiry requiring further analysis and research.

This study has several key objectives. The first objective is to provide an overview of the theoretical and empirical literature concerning the issues of energy consumption and

energy price shocks and their relationship with economic growth in the developed and developing countries. The second objective is to synthesise the important elements of New Zealand's recent economic history, the key developments in the energy sector and the central elements of energy policy, focussing on the period since 1960. The third objective is to evaluate the energy consumption-economic growth relationship that could highlight the future direction of the energy sector in New Zealand. The final objective is to empirically address the issue of oil price shocks from the perspective of economic growth impacts over the short run, using several alternative definitions of oil price shock. Utilising vital variables of the labour market, foreign exchange market and inflation variables provide policy-makers the direction New Zealand needs to take. These areas of inquiry have been the subject of much theoretical and empirical research over the last 30 years, however little empirical work for New Zealand has been undertaken. It is anticipated that the findings from this study will inform policy-makers with simultaneously achieving energy policy objectives and a higher rate of economic growth, as well as providing useful information of this complex and little-known areas of energy resource-economic growth nexus in New Zealand.

1.2 Energy Resources and Economic Growth: An Overview

The supply and provision of numerous energy resources underscore various modes of economic production in both the developed and developing countries. Vast networks of trade in energy resources provide substantial wealth to the supplier countries and allow other nations to benefit from modern means of transport, production and social organisation. Undoubtedly, the harnessing of energy resources such as coal, oil and gas have been fundamental to the process of global industrialisation during the nineteenth and twentieth centuries (Goldstein *et al.*, 1997).

Various economic theories have been developed to explain the relationship between energy resources and economic growth, with two competing schools of thought placing vastly different emphases on the importance of energy resources to production in the industrialised economies. The mainstream neoclassical theory of economic growth highlights investment in capital, population growth and technological progress as the crucial drivers of growth in the historic processes of development. The role of energy as

a factor of production is downplayed in the neoclassical theory, given that factor substitution and technical progress are assumed to be able to ameliorate energy resource shortages and hence to enable prolonged economic growth (Stiglitz, 1997). Therefore, it is the rate of economic growth that determines the rate of energy consumption, and not vice versa.

In addition, the neoclassical theory posits that the small cost share of energy resources in GDP (generally around 3-5 percent for the developed economies) disqualifies the potential impact that a rapid increase in the price of energy inputs – i.e. an energy ‘price shock’ - could have on economic growth. Given these observations, in the neoclassical model energy should not be an important economic growth determinant. Contrastingly, the ecological economics school of thought argue that energy is the sole primary factor of production, with the development and utilisation of physical and human capital dependent on the availability of energy in various forms (Stern and Cleveland, 2004). From this perspective, economic growth is not feasible without energy resources. The implications of the competing theories for policy-makers differ greatly, and furthermore the empirical evidence supporting the neoclassical and ecological economics theories is mixed.

On the one hand, the observed one-third reduction in energy per unit GDP of the Organisation for Economic Cooperation and Development (OECD) countries over the period 1971-2000 suggests that energy resources may not be vital to production, in light of the substitution and technological progress opportunities (International Energy Agency, 2004). On the other hand, this may be explained - as ecological economists claim - by the substitution of low quality resources, such as coal for high quality fuels, such as electricity (Cleveland *et al.*, 2000). Similarly, the statistical causality from oil price shocks to economic recession that Hamilton (1983) reports, for all bar one of the United States (US) recessions between 1948 and 1972, suggests that energy prices are indeed significant macroeconomic variables that may impact on the macroeconomy multifariously, through indirect channels.

A growing consensus among researchers is that energy resource-economic growth relationships are dependent on country-specific factors (Altinay and Karagol, 2004). Accordingly, the use of cointegration and causality analysis for the case of a single

country study is prevalent in the recent empirical literature (for example, see Guttormsen, 2004). Furthermore, the use of appropriate models and methodologies is crucial in identifying the underlying relationship. Developments in the oil price-economic growth literature concern nonlinear transformations of the underlying price measures that are based on an array of theoretical extensions, and the potential importance of indirect transmission channels. These issues are all incorporated in the empirical analysis that follows in chapters 4 and 5 of this study. In the next section, the data and methodology issues used for evaluating the models are discussed.

1.3 Data and Methodology

The study utilises several models to analyse the energy-growth sector in New Zealand, evaluating various hypotheses relating to the energy-consumption growth relationships and energy prices-growth nexus. In order to develop each model datasets were constructed to capture the long run information and the behaviour of the variables. These data were collated from various sources. The primary data used in chapter 4 for GDP and capital variables were taken from the International Monetary Fund's *International Financial Statistics* (IFS) database, while the energy consumption data used in the models for chapter 4 are taken from the International Energy Agency's *Energy Balances of OECD Countries* (various). Labour force data are from the Groningen Growth and Development Centre's *Total Economy Database*. For the price-growth models in chapter 5, Statistics New Zealand's *Information Network for Official Statistics* (PC INFOS) database has been utilised to collate the primary data for the GDP, wage, inflation and exchange rate data. These have been supplemented by the IFS database for oil price data.

The primary data were supplemented by secondary energy-use data disaggregated by sector, and energy quality data disaggregated by resource type, that were provided by the Ministry of Economic Development and the New Zealand Centre for Ecological Economics, respectively. Nominal values have been transformed into real values (constant 2000 prices) using the relevant deflators as outlined in the text. All of the data are from reputable and generally-used sources of the studies, where these organisations have reliable data.

The methodologies employed to evaluate the various models include the most-current econometric procedures of the time series literature. In the case of the consumption models (chapter 4) based on 45 annual observations for the period 1960-2004, the Autoregressive Distributed Lag (ARDL) approach to cointegration is utilised given its advantageous small sample properties noted by Pesaran and Shin (1998b) and Pesaran *et al.*, (2001). Several different models are constructed based on demand-side and supply-side considerations of the energy-growth relationships, and Granger causality between the various variables is then explored by means of the Wald F-test. On the other hand, the oil price models (chapter 5) are based on 70 quarterly observations ranging over the period 1989 Q1 to 2006 Q1. Therefore the VAR modelling approach has been adopted to consider the short run causality between oil prices and real GDP growth, and the macroeconomic impacts of oil price shocks. Given the degrees of freedom available, parsimonious models with different specifications of the variables are constructed that incorporate the foreign exchange sector, macroeconomic and labour market impacts as well as the direct effect of oil prices on growth. These methodologies are appropriate given the modelling context of this study, as they allow for the formulation of policy-based discussion deriving from robust results that accurately reflect the underlying relationships between the variables. Detailed methodology for each modelling framework is discussed in the relevant chapters.

1.4 Chapter Outline

In examining the energy-growth nexus for New Zealand, the study is structured as follows. Chapter 2 provides a thorough review of the academic literature, discussing the range of relevant theoretical perspectives and presenting the existing evidence from empirical studies. Chapter 3 provides a background to the New Zealand macroeconomy over the twentieth century, tracing the important elements in the economic development of the nation. This is complemented by a detailed discussion of the energy sector and the critical aspects of energy and environmental policies as they relate to the economic growth performance. Chapter 4 presents an empirical evaluation of cointegration and causality between energy consumption and real GDP using a number of multivariate approaches that are based on economic theory of energy-growth nexus. Chapter 5 has a similar empirical focus; however the relationship of interest concerns oil price shocks

and their impact on economic growth. Three oil price shock formulations are considered here based on the recent theoretical literature, with potential labour market, inflation and exchange rate effects evaluated as well as the direct effects on economic growth. Finally, chapter 6 concludes the study by considering the implications of the various empirical findings for economic and energy policies. It also highlights the further research questions from the broad energy-growth nexus that remain open to further scholarship.