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Fiscal policy and sustainable economic growth with focus on Australian mining sector taxation: a hybrid macro-modelling approach

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DECLARATION

I, Abbas Mohammadzadeh declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Accounting, Economics and Finance of the Faculty of Business, University of Wollongong, is wholly my own original work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Abbas Mohammadzadeh

31 March 2015

To my beloved parents

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LIST OF ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ANZSIC	New Zealand Standard Industrial Classification
ASEAN	Association of Southeast Asian Nations
BREE	Bureau of Resources and Energy Economics
BT	Brown Tax
CGE	Computable General Equilibrium
ChAFTA	China-Australia Free Trade Agreement
CPI	Consumer Price Index
CVM	Chain Volume Measures
DAE	Dynamic Aggregative Econometric
DSGE	Dynamic Stochastic General Equilibrium
FDI	Foreign Direct Investment
FF	Flat Fee
FTA	Free Trade Agreement
FVI	Fisher Volume Index
GDP	Gross Domestic Product
GE	General Equilibrium
GFC	Global Financial Crises
GMM	Generalized Method of Moments
HDI	Human Development Index
HP	Hodrick-Prescott
IRF	Impulse Response Function
LNG	Liquefied Natural Gas
LRMC	Long Run Marginal Cost
LVI	Laspeyres Volume Index
MC	Marginal Cost
MCA	Minerals Council of Australia
MCMC	Markov Chain Monte Carlo
MH	Metropolis–Hastings
MRRT	Minerals Resource Rent Tax
NSW	New South Wales
PDF	Posterior Density Function
PPT	Progressive Profits Tax
PRRT	Petroleum resource rent tax
PRT	Petroleum Revenue Tax
QLD	Queensland
RBC	Real Business Cycle
RRR	Resources Rent Royalty
RRT	Resource Rent Tax
RSPT	Resource Super Profit Tax
SAVR	Specific or ad valorem royalty

SME	Small and the Medium Sized Enterprise
SOE	Small Open Economy
SWF	Sovereign Wealth Fund
TOT	Terms of Trade
TWI	Trade Weighted Index
UKCS	UK Continental Shelf
VAR	Vector Autoregressive
VIC	Victoria
WA	Western Australia

ABSTRACT

Natural resource abundance has played a prominent role in economic growth performance in many resource producing economies. Amongst them, the Australian economy has also experienced major impacts from non-renewable natural resource production and exporting since the mid-19th century. The conventional view in the literature characterises natural resources as a curse due to unwanted consequences upon non-resource sectors such as the manufacturing sector. However, some empirical evidence suggests that government could potentially play a dominant role to avoid the unwanted resource curse and convert it into a blessing, leading to economic prosperity for the country.

The aim of this study is to investigate the relationship between a resource price boom and the performance of major macroeconomic variables. More importantly the role of related fiscal policies and their consequences in response to a resource price hike are examined. Collecting the resource rent is considered to be one of the main tasks of the government in resource producing countries, especially when the resource price is increasing, therefore, as the first stage, the outcomes of a higher natural resource tax on major macroeconomic variables is examined. This will cover the main issues following a resource price boom on the revenue side. Then the outcomes of the ways the collected funds are spent by the government is of particular interest for this study as the next stage. The main goal in this stage is to establish whether the collected funds should be spend on investment or consumption expenditures in order to get a greater economic benefit, which leads to important empirical policy advice.

To reach to the above goals, the first step is to construct the required macroeconomic model. In this regard the original model of Cox and Harvie (2010) is further developed in a variety of aspects. Incorporating an endogenous resource producing sector into this model is one of the major developments to the model and this is the first step to fill an existing gap in the literature as the resource sector is generally viewed as an exogenous sector. The need to include this sector's characteristics in the model has resulted in this study using a hybrid macroeconomic modelling methodology. Therefore, some features of micro-founded macroeconomic models such as Dynamic Stochastic General Equilibrium (DSGE) models are applied from both a modelling and econometrics perspective. The model under study characterises the Australian economy using data for major macroeconomic variables for the period 1988:Q3–2011:Q3. Bayesian estimation techniques and a number of simulations are applied in order to obtain the required empirical results.

The overall outcome of the empirical study suggests that in order to gain economic benefits from a resource price boom, it is more appropriate for government to apply a higher natural resource tax. The results also show that both resource and non-resource sectors benefit from this taxation policy over the resource boom period. The applied scenarios for government expenditure also provide interesting results; during a resource boom it is better for the economy if the government allocates more of the collected funds from the resource sector to infrastructure investments and boosting human capital, such as improving health services or education levels, rather than allocating those funds to consumption expenditure. As the investment option would also transfer the benefits of the resource sector to future generations as well, this is consistent with the literature which recommends this method to achieve inter-

generational equity of resource usage in line with suggestions in Hartwick (1977) and Hannesson (2001). The results also reveal that if the government spends more on consumption expenditure than investment then, from an economic growth perspective, the overall impact of the resource boom by applying a higher resource tax during a resource price boom actually has a slight negative impact compared to the positive outcome in the scenario where the government allocates the funds for investment. This highlights the importance of creating a Sovereign Wealth Fund (SWF) for the Australian economy in order to ensure the spending of the collected revenue from the resource sector into the most appropriate investment options, as experienced by other advanced economies such as Norway.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The natural resource sector is a major contributor to the Australian economy and the economic rent generated from it is one of the main features of this sector. Its role has become more important with the resource price boom over the last decade caused by, among other reasons, the developments in economic growth patterns in Asian countries such as China and India and their increasing need for more energy and mineral resources as a result. These countries have been among the main buyers of Australian resource products and their high demand for resource products over the last decade has been one of the main reasons for the resource price boom which has boosted the influence of the resource sector over the economy. It is therefore very important to study the role of the resource boom in the economy and also to analyse the consequences of the government's fiscal policy in this context.

In general, natural resources have been thought of as a key factor in economic growth in both developed and developing economies (Smith and Krutilla, 1984), therefore, they have been carefully analysed in the literature from different aspects. There have been notable studies, for example by Stiglitz (1974a), that show how natural resources influence the optimal path for economic growth. In another research study, Stiglitz (1974b) analyses the role of natural resources in the presence of changing expectations about their future prices. In addition, the role of a resource boom and its consequences, including the Dutch Disease, in the short term has been widely studied (Corden and Neary, 1982; Buiter and Purvis, 1983; Corden, 1984;

Harvie, 1989). The consequences of a resource boom have been studied through the variety of channels by which they transmit to different sectors in the above mentioned studies. An exchange rate effect, income effect, wealth effect and resource movement effect are amongst the important channels (see, for example, Ali and Harvie, 2013). There has been a growing body of literature throughout the 1990s recognising and assessing the long term effects of resource booms by highlighting the role of the capital accumulation effect and foreign asset accumulation effect, as well as the role of flexible or fixed exchange rate systems (Harvie, 1991; Harvie, 1993; Harvie and Gower, 1993; Harvie and Thaha, 1994; Harvie and Van Hoa, 1994).

As for many other resource-producing countries, taxation of this sector in Australia, in other words collection of rent from this sector by the government, has considerable consequences for other sectors of the economy as well. The effects of resource taxation have been considered at a number of levels in the literature. Several attempts have been made to show the impact of natural resource taxation on the performance of extracting firms in terms of investment, rate of extraction and other firm-related decisions (Hotelling, 1931; Burxess, 1976; Conrad and Hool, 1981; Fraser and Kingwell, 1997). Some other groups of studies have explored the effects of a resource tax at an industry level (Lund, 1992; Osmundsen, 1995; Zhang, 1997). A partial equilibrium framework (studying only one market) has also been applied in other groups of studies to further analyse the consequences of a resource tax (Gamponia and Mendelsohn, 1985; Lund, 2002; Lindholt, 2008). However, for a sector as important as the resource sector, a partial equilibrium approach is not beneficial for decision makers as it does not show the consequences of changes in it

on other sectors, which is obviously important for government policy. Despite the above mentioned studies, a search of the literature revealed far too little attention has been paid to assessing the consequences of a resource tax at a macroeconomic level. In other words, while some studies have shown the role of a natural resource at the macroeconomic level, no study has shown the impact of natural resource taxation on all macro-economy variables, including for the Australian economy. Therefore, the purpose of this dissertation is to develop a macroeconomic model for a small, open, resource-exporting economy such as Australia by including an endogenous resource sector to explain the various issues in this context. The recent study by Cox and Harvie (2010) is developed and extended in this research to shed some light on the consequences of a resource tax as well as on public expenditure options as major parts of the Australian Government's fiscal policy components following a resource boom.

1.2 Research Objectives and Methodology

The main aim of this study is to develop a macroeconomic model to investigate the consequences of a number of resource tax policies following a resource price boom. The macroeconomic model introduced in this study reflects the features of a small, open, advanced, resource-exporting economy and is utilised for the Australian economy. Therefore, the consequences of resource taxation for major macroeconomic variables are highlighted to reflect the outcomes of such resource tax policies for the Australian economy following the recent resource boom. Another major objective of this study is to enable the model under study to explain the reaction of major macroeconomic variables to a variety of public expenditure policies. This allows the research to analyse and compare the outcomes of different

expenditure approaches. More specifically, the objective is to see whether the economy gains more from allocating the collected resource tax to investment expenditures (including infrastructure and human capital) or consumption expenditures. These two major objectives cover both the taxation and expenditure components of fiscal policy related to the resource sector for the Australian economy.

To achieve the above mentioned major objectives, this study has attempted to apply the most suitable methodology by evaluating the existing literature from both theoretical and technical perspectives. As was briefly mentioned in the previous section and will be further elaborated on in Chapter 2, there are several studies focusing on the effect of a resource tax at the firm and industry levels. Also, there are few studies in which the resource sector is included as an exogenous sector in a macroeconomic model. Therefore, from a theoretical perspective, the initial step has been to incorporate some of the microeconomic level concepts into an existing general equilibrium macroeconomic model. Some types of macroeconomic models are known to be fully micro-founded, such as Dynamic Stochastic General Equilibrium (DSGE) models, however due to shortcomings of these models for the aims of this research, such as being more appropriate for explaining monetary policy rather than fiscal policy, the current study has only borrowed theoretical concepts of these models where applicable, such as for consumer behaviour and the central bank's monetary policy equation. The resource sector has been modelled based on information from firm level studies (such as Heaps, 1985). Therefore, the methodology of this research is a hybrid macro-modelling approach which applies micro-founded concepts from DSGE models and firm level studies in a conceptual

macroeconomic framework. From a technical perspective, the advanced estimation (Bayesian) and simulation techniques applied in DSGE models are also utilised in this study.

1.3 The Developed Macroeconomic Model and Contributions

The original study by Cox and Harvie (2010) is among only a few macroeconomic studies incorporating exogenous resource production in a conceptual model for an advanced resource-exporting economy, and has been selected to be utilised and developed to satisfy the objectives of this research. The Cox and Harvie (2010) model is a dynamic long-run conceptual model which investigates the consequences of a permanent resource price shock upon major macroeconomic variables. The model includes product market, asset markets, aggregate supply and also the foreign sector. Agents are assumed to possess forward looking expectations and financial markets clear immediately, while there are sticky prices in non-financial markets. This model is further elaborated upon in Chapter 4.

One of the main developments/extensions to the Cox and Harvie (2010) model contained in this study is to replace exogenous resource production with endogenous resource production, which depends on a number of factors including the resource price, private resource capital, average world real income, exploration cost and exchange rates. These are amongst the main factors that have been influencing the Australian resource sector during the recent resource boom. The endogenous treatment of the resource sector in the model allows analysis of the role of a resource tax at a macroeconomic level, an issue which has been inadequately addressed in the literature. The capital stock in the current study is decomposed into resource and

non-resource capital, unlike previous studies (including the Cox and Harvie (2010) model). This helps to further explain the different behaviour of the resource and non-resource sectors during a resource price boom and also from subsequent resource taxes or expenditure policies. Including expectations about the future level of consumption and adding a monetary policy rule are further developments to the original model by this study. The forward looking and lagged variables included in consumption and monetary policy rule add to the dynamic aspect of the current model. The decomposition of public expenditure into its two main components of investment and consumption expenditure further adds to the theoretical framework of the model and does the groundwork to achieve the objectives of the study. Investment is also assumed to have two major sub-categories of infrastructure and human capital (including health and education). Another extension to the original model is that government consumption expenditure is not exogenous but depends on the revenues collected from both the resource and non-resource sectors, highlighting the possibility of an increase in public consumption in response to increased revenue from both the above mentioned sectors. Further extensions and more details are explained in Chapter 4.

1.4 Data, Estimation and Simulations

Australian macroeconomic data for the period 1988:Q3–2011:Q3 was applied to the required variables in this study. Due to the technical requirements of the applied method, the number of variables to which the data was applied (observable variables) is restricted to 8 variables being: real income; private consumption; non-resource trade balance; nominal interest rate; foreign assets; resource production; non-resource aggregate supply; and the nominal exchange rate. The data is derived from a

number of sources such as the Australian Bureau of Statistics (ABS), the Reserve Bank of Australia (RBA), the Bureau of Resources and Energy Economics (BREE) and dXtime (time series data management software).

The Bayesian estimation technique has been used to estimate the required parameters of the model. The advantage of using this technique rather than conventional classical econometric methods is that the Bayesian approach enables the researcher to add prior information to the already provided data for the estimation process. Two main simulation approaches are also applied in this study. A stochastic world interest rate shock has been applied in order to validate the stability of the model. The shock is a one-off shock. A temporary deterministic resource price shock which lasts for 8 periods is applied along with a variety of scenarios for resource taxes and government expenditure approaches. This has created several interesting discussions in line with the objectives of this study. A sophisticated software package called Dynare, which runs in MATLAB, was applied to various tasks including stability tests, estimation and simulation of the DSGE models in the literature and is used for the same purpose in the current study.

1.5 Structure of the Study

This research is comprised of eight chapters. Chapter 2 presents a comprehensive review of the literature related to this study including natural resources and macroeconomics, resource boom, resource curse and Dutch Disease, resource taxation, public expenditure policies and relevant modelling approaches. The relevant literature on natural resources and the consequences of a resource price boom is discussed. As the resource boom creates an economic rent in this sector the

role of a resource tax to collect this rent is justified. Government expenditure policies are also a vital part of the chain to warrant the best use of the collected tax from the resource sector, therefore the discussion on the nature of government expenditures and the outcome of the two major types of public expenditures - investment oriented expenditures and consumption expenditures - are also discussed. The last part of this chapter clarifies the overall direction of the study using a hybrid macroeconomic model based on a summary of the applied methods in existing studies and the necessity of selecting a hybrid method.

Chapter 3 provides an overview of the Australian economy and the related role of the natural resource sector because, following the growing demand in Asia which caused the resource boom in Australia over the last decade, the dynamics in this sector and the appropriate role of the government in this respect has become a central issue to maintain more stable economic growth for the Australian economy. With this aim in mind a historical review of natural resource booms in Australia is presented and the reason why the current resource boom is different from previous ones is discussed. The discussion is followed by an overview of the major macroeconomic variables for the Australian economy, setting the groundwork for the modelling chapter and also the later empirical chapters.

Chapter 4 mainly covers the theoretical modelling aspect of this study. The original model by Cox and Harvie (2010) is presented and summarised as the starting step for the macroeconomic modelling phase of the current study. The direction in which the above study is extended and improved by the current study is then discussed. In the next stage the equations of the developed model for a small, advanced, resource-

exporting economy, such as Australia, is presented. Extensions to the original model are further explained along with the introduction of each equation and its variables. This prepares the theoretical model of this study to be applied for further technical and empirical analysis in later chapters.

Stability testing of the developed model and application of Bayesian estimation of the required parameters of the model using the Australian data for the period 1988:Q3–2011:Q3 form the main discussion of Chapter 5. The model is first tested to see if it satisfies the Blanchard-Khan conditions and then the required parameters are estimated using the Bayesian technique. The advantage of using this technique compared to other classic econometric methods is being able to include prior information about the value of parameters from various sources including previous studies in the process of estimation.

The contribution of Chapter 6 is to validate model stability by subjecting it to an external stochastic shock. The world interest rate is selected as the external shock which is more relevant for the case of the open and advanced economy model such as that used in this study compared to that of a domestic shock.

Chapter 7 makes another major contribution to this study by assessing the consequences of three resource tax cases on major macroeconomic variables when the country is facing a resource price boom. The resource price shock is assumed to be temporary and only continues for 8 periods (quarters). This has been done to replicate a resource boom which only continues for two years (eight quarters). The pattern of the resource price boom is assumed to be gradually ascending and then

gradually descending until it returns to its baseline. This appears to be closer to reality than a sudden jump in the resource price and staying high for a long time. As mentioned earlier, the role of government expenditure is also considered in assessing the above mentioned issues by introducing two scenarios based on government expenditure behaviour. In the first scenario it is assumed that the largest portion of the collected tax from the resource sector is allocated for public consumption purposes, and only a minimum amount of 10 percent of the total is allocated to investment expenditure. However, in the second scenario investment expenditure is higher, constituting 50 percent of the collected resource tax, or five times higher than in scenario one. This has been undertaken in order to show the importance of the collected resource tax being spent on investment expenditure rather than on consumption expenditure. In each scenario the impacts of the three above mentioned resource tax cases are explored and the interesting results of each simulation are elaborated on. Furthermore, to compare the outcome of the resource tax cases and also compare the outcomes across the two scenarios, the cumulative percentage changes of each variable under study is calculated to provide a more precise measure when the outcomes are compared. For instance, some interesting results in the positive economic consequences of spending the resource tax revenue on infrastructure and human capital expenditure (as two clear examples of investments) rather than consumption expenditure are discussed in this chapter.

The final chapter of this study, Chapter 8, summarises the major innovations and contributions of this study as well as the key results. The relevant policy implications based on the results are then provided for the resource tax and public expenditure as major parts of the fiscal policy of the federal government. Finally, the last sections of

this chapter present research limitations and possible extensions to this study for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The aim of this study is to develop a macroeconomic framework for a small, open, resource-exporting country like Australia, focusing on resource taxation and its impact on the economy. In this chapter the role of the resource sector in macroeconomics and relevant theories in this area are highlighted and explained. The various classifications of natural resources, theories of resource extraction, challenges facing resource-extracting economies (such as the Dutch Disease), fiscal policy by the government in the resource sector including both taxation and expenditure policies, and other related issues are also highlighted and discussed. Focus is placed on the taxation of natural resources in the literature, which is explained through studies emphasising microeconomic, industry-level and macroeconomic frameworks. The literature review of resource taxation shows that most of the studies are focused on the micro level. To take advantage of the potentials of micro-level studies and also micro-founded macro-modelling approaches such as the DSGE approach, a hybrid macro-modelling approach is introduced. This approach incorporates some features of micro-level studies and DSGE models in a developed conceptual macroeconomic framework for an advanced resource-exporting economy. This approach will be applied in the context of this research. The details of this method are provided in Chapter 4.

2.2 Natural Resources and Macroeconomics

The role of natural resources and their interactions with economic systems has been one of the most challenging issues in economic science in order to achieve sustainable development, especially in resource rich economies. Suffice to say that its role can be as crucial as human capital accumulation in economic growth, for example its important role in economic growth in Norway, but it can also create serious economic challenges for economic growth if it is not properly managed by the government and decision makers. In fact, all the evidence in a recent study by Ali and Harvie (2013) shows that ownership of natural resources *per se* does not guarantee successful economic growth and development outcomes. Therefore, a study of the natural resource sector's interdependence with other sectors of the economy and, more importantly, the appropriate policies to manage it have become of interest to researchers in this area. Suitable policies in this case not only affect the total trend of the economy in terms of inter-generational equity or inter-temporal optimisation from an economic growth point of view, but also have an indirect impact on the environment as a consequence of negative externalities. Therefore, policy making in the area of natural resources has become more important because it affects production factors in terms of their quality and quantity. Appropriate policy for the natural resource sector also increases convergence between environmental and economic policies such as in resource extraction, resource exhaustibility, pollution reduction, carbon taxation and climate change.

2.2.1 Classification of Natural Resources

In the common categorisation of natural resources in terms of renewability, there are two types of resources: exhaustible (non-renewable) resources; and perpetual

(renewable) resources. Non-renewable resources include oil and gas and renewable resources include solar and wind energy. Besides this classification there are further classifications which are not of relevance in the context of this research, for instance classifications based on the origin of the resources such as organic resources (e.g. petroleum and fish) and non-organic resources (e.g. metals). This study is only interested in the macroeconomic modelling of exhaustible natural resources such as oil, gas, coal and metals. These resources cannot be naturally replenished, unlike renewable resources. Therefore, the term "natural resource", as used in the macroeconomic framework developed in this study, refers only to exhaustible resources[1] such as oil, gas or minerals.

2.3 Economic Growth Theories and Natural Resources

Natural resources received more attention and became more vital in economic growth models, especially after 1973, because of the global oil price shock, impacting on production activities in particular (Smith and Krutilla, 1984). Although the incorporation of natural resources was very rudimentary in earlier models of economic growth, their role and diversity has become more complicated in contemporary studies. In classical growth models such as Malthus' theory of growth, land was the only recognised resource factor impacting economic growth. The extraction and production of different types of natural resources over time has opened up a new era in applying different kinds of mineral and energy resource production within the context of economic growth and macroeconomic growth models. In the context of new growth theories there are some prominent studies such as Stiglitz (1974a; 1974b), which show the important role of resources in influencing

[1] As explained in the next sections in some economic growth theories land is assumed to be a resource and a production factor, but its supply is limited.

the optimal path of economic growth. A Cobb-Douglas production function was used in Stiglitz (1974a), which was the first study to show the new growth path with an exhaustible natural resource compared to one which only includes capital and labour. Stiglitz (1974b) portrays the role of natural resources in impacting economic growth when expectations about the future price of the resource changes.

While natural resources can potentially improve economic growth, negative externalities arising from resource or energy production (such as pollution and climate change) initiated studies to make production and consumption more costly by imposing different taxes on their production and consumption (by internalizing the cost of pollution for instance). The main issue inspiring these ideas is the aim of conserving the quality of the environment (which often results in introducing relevant taxes to satisfy this goal, such as introducing a carbon tax) and spreading the benefits from natural resources over a longer period of time. That is identifying an optimal production/consumption path. However, this research, where resource taxes are also under study, is more concerned with economic aspects dealing with resource rent for producers, the taxation of this resource rent by government, appropriate reactions of government to an increase in resource prices and the way that the government's resource tax revenue should be spent in order to get the best possible outcome and improve economic growth for both current and future generations.

The role of taxation of a natural resource by government, its role in efficiently distributing the resource tax revenue on growth-enhancing expenditures and other related issues are explained under fiscal policy in Section 2.7.

2.4 Natural Resource Taxation; Optimality and Inter-generational Equity in Extraction of Exhaustible Resources

One of the main questions in resource-extracting economies is how to allocate natural resources between different generations in order to benefit all generations of the country equally (or at least more equitably) and increase total utility. In this section a number of theories within the literature will be discussed to show the importance of taking a long-run perspective in economic models and the important role of resource taxation as one of the key tools to productive use of natural resources. To answer the above question, which is crucial for management of natural resources in a macroeconomic structure, theories related to the study of the utility of current and future generations are discussed first.

Most dynamic optimisation models used in economics follow basic Bentham[2] Utilitarianism Theory, which is to optimise the inter-generational social welfare function (see Hebert and Ekelund, 1984 p.46; Hartwick and Olewiler, 1986 p.11). In this theory the sum of the discounted utility of future generations is taken as a welfare index and the path that maximises this index is calculated. Earlier generations consume less compared to later generations in order to reach the economy's steady state (extrication of natural resources can be replaced with consumption in the context of this study). In most economic growth theories, consumption increases during the time period to reach a steady state. Obviously, if the aim of the economy is to just increase production then a high rate of extraction will result, decreasing the utility of future generations which is in contrast with Bentham's theory.

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[2] Jeremy Bentham is one of the famous philosophers of the 18th century.

Hotelling (1931) is one of the seminal studies based on Bentham's utility theory in terms of identifying the optimum path for extracting a non-renewable natural resource from a social welfare maximisation point of view. The optimum path from his point of view is a path where the net price of an exhaustible resource in the market grows at a rate equal to that of the nominal interest rate. If we assume that the stock of the resource is an asset for its owner then the rate of return of natural resource assets is different from normal physical assets such as buildings and machinery. For instance, if we assume that the asset is the stock of oil in the ground which is not reproducible and, as long as it is in the ground, also not productive then the marginal productivity of the natural resource is zero, which is different from other assets like machinery which provide some services (for more details on this issue please see Gaudet, 2007). Although Hotelling (1931) is one of the fundamental studies (even after almost 80 years) in natural resource economics, other empirical studies do not support this idea so that we now have new or modified versions of the Hotelling rule in the literature (see Krautkraemer, 1998; Aznar-Márquez and Ruiz-Tamarit, 2005). One of the main critiques to the Hotelling rule is that it is based on partial equilibrium assumptions, and it does not take spill-overs to other sectors of the economy into account. The other problem is that the interest rate in his model is assumed to be constant which is hardly close to reality.

Returning to the discussion about the optimal extraction path, there is another approach which is discussed by Solow (1974) using Rawls' theory of justice (see Rawls, 1971). This theory goes against the fundamentals of Utilitarian Theory. According to the theory of Rawls the social welfare function should maximise the

minimum utility which exists in the society, which is known as the "Max-Min" rule. The aim of this approach is not to maximise total utility which was the goal in Bentham's theory. Instead, under the "Max-Min" rule the higher utility levels, which can be related to individuals or different generations, in the social utility function become irrelevant and the goal is to maximise the utility of those with minimum utility in the utility function. Solow, in his study, first recalls the theory of Rawls for "inter-generational equity". Solow analyses Rawls' idea and says:

"He argues, in effect, that inequality in the distribution of wealth or utility is justified only if it is a necessary condition for improvement in the position of the poorest individual or individuals. In other words, if social welfare, W, is to be written as a function of individual utilities U_1, ... , U_n, then Rawls argues for the particular function W = min (U_1, ... , U_n), so that maximising social welfare amounts to maximising the smallest U_i. This welfare function is sensitive only to gains and losses of utility by the poorest person" (Solow, 1974, p. 29).

Although Solow believes that the statements of Rawls are ambiguous, he still applies the Max-Min rule on the optimal accumulation of capital in terms of inter-generational equity to find out its consequences. Different assumptions are applied for population growth, technological progress and natural resource extraction rates to examine this theory. Solow concludes that, except for two difficulties (a big enough "initial capital stock" or a case of high technology growth and a stationary population), the Max-Min theory seems to be a sensible method for inter-generational policy making. Solow believes that although including non-renewable natural resources to this particular structure of optimisation has interesting outcomes,

it does not provide a significant change in the area of inter-generational equity (Solow, 1974).

Another outstanding theory in this area, following that of Hotelling and Solow, is the famous “Hartwick Rule of Sustainability” introduced by Hartwick (1977). According to this rule the optimum way of using rent and profits from exhaustible resources is to invest all of it in reproducible capital such as machinery, infrastructure and financial assets, and consume all the profits from other assets. In this way the current generation transfers the revenues of exhaustible resources to future generations but does not save anything from the profits of other assets for them. In this theory the current generation does not decrease its consumption in order to save for the future generation but, instead, saves the natural resource assets for them. By using a Cobb-Douglas function (which is very similar to the one used by Hotelling) Hartwick (1977) shows that the level of consumption would be constant among different generations. Therefore, resource extraction would decrease during the time period but there would be an increase in the stock of reproducible assets on the other side, which is a trade-off between the generations. One of the ways to save the profit from natural resources is through the taxation of these resources, allowing the government to spend money on reproducible assets as emphasised by Hartwick (1977). This issue will be explained and discussed in more detail in Section 2.7.1 and will also be developed further in the next chapters, especially Chapter 7. The study by Hartwick is expanded upon by Hannesson (2001), who believes that revenue from the resource must be invested in either physical capital or human capital by means of government expenditure policy, for instance in infrastructure or education development.

2.5 The Resource Curse

The idea that a country with abundant natural resources grows less compared to those with fewer resources is known as the Resource Curse or the Paradox of Plenty. This term was first used by Auty (1993) to show the under-performance of resource-extracting countries compared to other non-resource abundant countries at the same stage of development. Empirical studies have also shown that developing countries with abundant natural resources are usually faced with macroeconomic difficulties. Revenue from the resource sector normally goes to activities which are not productive, and this, along with inefficient political structures (often along with corruption), leads to reduced economic growth in a country. For instance, a study by Sachs and Warner (1995) found that countries with a high resource export to GDP ratio for the period of 1971-89 had a negative relationship with economic performance. They used a simple endogenous economic growth model to explain this relationship. In other studies, such as Brückner (2010), it is argued that the size of this negative relationship is larger than most economists believe. There are more empirical studies on this issue, for example see Auty (2004) and Cai (2009). One of the important forms of the resource curse is explained in the next section, the so-called Dutch Disease Effect.

2.6 Resource Boom and Dutch Disease Effect

An increase in export revenue from natural resources following any new discoveries of resources or increases in price can result in a resource boom which increases a nation's revenue and aggregate demand. Based on the "Big Push" idea, a large expansion in demand, especially in developing economies, is necessary for economic development. This large expansion could be as a result of foreign aid assistance or as

a result of discovery or an increase in the price of natural resources (Sachs and Warner, 1999). Therefore, while a natural resource boom is a potentially positive factor for development and, based on some studies, is necessary at least for developing economies through the "Big Push" idea (see Rosenstein-Rodan, 1943; Rosenstein-Rodan, 1961; Murphy *et al.*, 1989), it can create some difficulties such as the Dutch Disease Effect which can result in negative effects.

The concept of the Dutch Disease is that any large inflow of foreign currency to an economy can cause a decline in the manufacturing sector. While the large inflow can be from sources such as foreign direct investment (FDI), increased revenue from natural resource exports is another clear example when there is a resource boom. The decline in the manufacturing sector happens for several reasons. The large inflow of foreign currency makes the currency of the country stronger, leading to an increase in imports of tradable goods where the central bank does not adjust the exchange rate with a high domestic inflation rate. The domestically produced tradeable goods become more expensive which increases the demand for foreign goods rather than domestically produced tradeable goods. An increase in the economy's revenue [3](domestic income and government revenue) increases demand. The increased demand for tradeable goods will encourage more products to be imported from overseas. Increased demand for non-tradable goods raises their relative price compared to tradeable goods; therefore, resources working in the weak tradable sectors such as the manufacturing sector are attracted to the non-tradable sector by increased prices and more profit. This creates additional pressure on the tradeable

[3] The increase in revenue could be due to a variety of reasons in the public or private sectors, such as increase in government taxation revenue followed by an increase in government expenditure, increase in private wealth and financial benefits from growing mining companies for the private sector, etc.

(manufacturing) sector leading to a decline in these industries which are then faced with more expensive resource costs (such as labour) as input and less demand for their products as output.

The term “Dutch Disease” was coined from the case in the Netherlands which received a significant increase in revenue from the export of natural gas in the 1960s. It was used by *The Economist* in 1977 to explain the above mentioned situation in this economy. After that, it became a popular term to use in the study of both developed and developing economies facing large foreign currency inflows from the production of natural resources.

A theoretical model to explain this phenomenon was provided by Corden and Neary (1982). They used a model based upon that of Salter (1959) with three goods (one non-tradable and two tradable) to show how the discovery of a new natural resource (tradable good) contributes to a decline in the exports of the other tradeable good (manufacturing). Two channels of resource movement effect and expenditure effect are used in Corden and Neary (1982) to explain the transmission of a resource boom into the economy. In this interpretation resource production requires a considerable transfer of resources (labour and/or capital) from the non-resource to the resource sector which is known as a resource movement effect. The Dutch Disease is more commonly associated with the expenditure effect arising from higher income and revenue (economic rent). The expenditure effect, generated from resource rent, is more appropriate for Australia as there has been little labour transfer and most capital has been obtained from overseas and not domestically to develop the resource sector.

While a resource boom can be expected to have a large impact, positive or negative, depending on whether the massive generated revenue is properly directed to productive investments and economic development (expenditure effect), we also need to have a brief look at Real Business Cycle Theory, a comprehensive macroeconomic framework, to explain the potential role of resource revenue. This framework provides the basis for part of the methodology to be used in this research and will be explained further in Section 2.11. Basically, if there is a resource boom in an economy and there are potential troubles for the economy arising from this, then how can a government best manage the resource movement and expenditure effects? As we saw earlier, based on Hartwick (1977), one of the optimum ways to deal with natural resources is to invest them in reproducible resources. Therefore, the role of government in terms of taxation and fiscal policy becomes very critical where the expenditure effect dominates and resource revenue needs to be re-cycled. The next section of this literature review will focus on the role of fiscal policy, specifically, in the context of natural resource taxation.

2.7 Fiscal Policy

The stabilization, or intervention, role of government has become more important since Keynesian economics, but has become increasingly more complicated in terms of taxation and spending during the last few decades. This is not only because of the basic reasons for intervention in the market to supply public goods or reduce externalities, but its role has become more important when the consequences of government's policies could affect the long-run economic growth or may even have short-run impacts to the market. Therefore, introducing any fiscal policy to the market can effectively change expectations about the future, which is more

recognisable in other policies such as monetary policy, for instance, when the central bank changes the interest rate. As a part of the government's taxation policy the focus of the next section is on the literature of natural resource taxation.

2.7.1 Natural Resource Taxation

Natural resources are one of the major components of many economies and the way they contribute to governments' revenue is one of the important decisions that need to be made in regard to this sector. This decision will not only affect the performance of the resource sector, but it is also crucial for the economic growth of the country arising from government spending of resource tax revenue. In this section the literature and some important concepts about natural resource taxation are discussed and explained. Natural resource taxation, considering the existence of economic rent within this sector, is studied under very different assumptions and methodologies, leading to diverse results and conclusions. The existence of rent by itself is not a core feature of the resource sector which makes it different from other sectors, but, rather, it is the quantity and also quality of the resource that creates the rent that makes it so important. As mentioned in the study by Boadway and Keen (2009) the fixed supply or non-renewability of certain production factors can create rent:

"In the resource context, the fixity of resource endowments ... and the diverse quality of deposits create evident scope for the existence of such rents. In other sectors, rents may arise from fixed factors in the form of protected intellectual property rights, superior management, better locations, as well as from barriers to competition. Again, it is the sheer scale and potential persistence of such rents that marks out the resource sector" (Boadway and Keen, 2009, p. 4).

Therefore, according to this study, the scale and the persistence of rent raised in this sector make it more important when compared to other sectors. Another aspect is that resources are not mobile between countries (Commonwealth of Australia, 2010). This makes the impact of taxation on the resource sector more sensitive for both companies and the government. While high profits in the resource sector make it more attractive for companies, governments have more diversified goals and objectives including social aspects and the long-run economic growth of the economy as well as inter-generational equity. Hence, all members of the society have an incentive to see natural resources well utilized. The study by Aznar-Márquez and Ruiz-Tamarit (2005) shows that the management of resources, including taxation of resources, is more important than the scarcity or abundance of the natural resource for economic growth. Many resource rich developing countries can be used as examples in this context. Poor governance and corruption can result in poor returns from resource abundance. This is the basis of the resource curse.

There are different categories of natural resource taxes in the literature. In a general resource tax classification in terms of tax base, there are two major types of resource taxes - profit based or output based. The profit based tax or "profit based royalties are levied on the net cash flow or some measure of the profit of a mining project" (Hogan, 2008, p. 3). The output based tax includes an *ad valorem* royalty which is a percentage of the production value of a mining company and a unit based (or a specific measurement) royalty which is a fixed fee per production unit (physical unit) (Hogan, 2008).

It needs to be mentioned here that the definition for "royalty" is slightly different to the definition for "tax" from a historical perspective, even though both of them provide revenue for the government[4]. It is believed that a natural resource has value, and because the owner of the resource is not the extractor at the same time the owner claims that value from the producer. The payment by the producer (resource extractor) to the owner of the natural resource is a royalty which can take various forms (Garnaut and Ross, 1983). This is in relation to the difference between natural resources and other assets which was explained earlier in Section 2.4. Usually, in the literature, taxation of a natural resource covers both royalties and other taxes.

Another classification, by Garnaut (2010), breaks natural resource revenue into six forms of resource rent taxes.[5] The first tax is a flat fee (FF) which is a "once for all payment" that provides the right to the investor to extract from the leased resource. "Specific or *ad valorem* royalty (SAVR)" is another tax which is used in various parts of Australia. This tax is mainly based on the quantity or the production value. The third tax in this classification is "the higher rate of proportional profits or income tax (HRIT)" which is mostly the same as corporate income tax. The next tax is "the progressive profits tax (PPT)" which is similar to the usual tax for corporate income but a higher rate is applied when the level of the income is more than a specified threshold. The fifth tax is "the resource rent tax (RRT)" where the net cash flow for the resource extracting company is considered as the tax base. This allows a deduction for all expenditure by the extractor against the total revenues in the same year. There are some exceptions such as financial expenses because they are an

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[4] From an Australian perspective, taxes are levied by the Federal government on resource production and profits while royalties go to state governments.

[5] This classification was first used in Garnaut and Ross (1983).

element of investment returns. The last tax in this classification is the "Brown tax (BT)" which is comparable to the RRT but there is a difference in that when there is a negative cash flow it provides a tax rebate for the extractor (Garnaut, 2010).[6]

In reality, there are many different combinations of the above mentioned taxes and there might be slight differences from the classic definition for each tax, particularly based on the negotiations between the government and resource extractors. The application of resource taxes generates some issues that should be taken into account for the economic analysis of these taxes. Some of these issues are explained briefly below.

2.7.1.1 Stability of Taxation Policy

It is very important for the government to provide a stable taxation system, especially for the resource sector. The large amount of necessary investment for resource extraction and existing risk in terms of the quality and quantity of the stock, in addition to the long term process of mining, makes decision making about taxation vital for investors. There can be a possibility for the government to increase a resource tax in the case of a resource boom and not to decrease it afterward (Lund, 2008). Taxation stability is important for all elements of the economy and it has both short and long-run impacts on the economy. Therefore, it is important for the government to take into account different options for the resource sector, such as a progressive taxation policy, when making decisions about resource taxation. A number of simulated scenarios on how the government would react to a resource

[6] For more information on the Brown tax please see Ergas *et al.* (2010) and Lund (2011).

price boom in terms of its resource taxation policy and the consequences are analysed in Chapter 7.

2.7.1.2 Distortionary Effect of a Resource Tax

There are several views in the literature on the possible consequences of a resource tax. To find these impacts, different phases of resource extraction and some relevant indexes are considered. Boadway *et al*. (1987) calculates a "marginal effective tax rate" for a modelled resource extracting company considering a number of the Canadian corporate and tax laws aspects. The definition for this index is "the difference between the before-tax rate of return on investment *(rg)* and the real cost of funds available on the market *(r)* as a proportion of *rg*" (Boadway *et al.*, 1987, p. 8). The results of this study show that the proposed mining tax generates a significant distortion on production structure and while the mining tax encourages development and exploration, it decreases investment and extraction. They believe that moving toward a "cash flow [based] tax" could decrease the existing distortion in 1985's tax law in Canada.

On the other hand, Zhang (1997), using an oil development field model, shows the impact of different types of taxation on development decisions. Indeed, in this study the author shows a rate of tax that can be neutral and economically efficient (in collecting the economic rent) at the same time. Results from this study show that the UK Petroleum Revenue Tax (PRT)[7] has been neutral in terms of changing

[7] The taxation regime in the UK Continental Shelf (UKCS) before 1993 included Corporate Tax, Royalty and Petroleum Revenue Tax. The latter was levied on oil and gas producers in the UK when they gained "super-profits" where 50 percent of the profit (in the case where profit was higher than a specific threshold) of the companies was taxed by the government.

development decisions by resource companies and is relatively efficient in collecting revenue for the government.

2.7.1.3 Tax Competition among Resource-Exporting Countries

As natural resources are generally immobile factors, there is an incentive for governments to set a high rent tax for them. But in the case of an open economy where many resource sector investors are from overseas, it is important to know what taxation is imposed by other resource abundant countries so as not to set domestic tax rates at levels that would provide a disincentive for multinational foreign investors to extract domestic resources[8]. It is obvious that setting a high tax reduces the chance of high foreign investment in the domestic resource sector. Therefore, the importance of setting a domestic resource tax is not only about addressing domestic issues but also about ensuring the ability to compete at the international level with other resource-abundant economies. As Osmundsen (2005) argues, there is a constraint for resource-producing countries in choosing tax levels for resource extraction, because they are in competition with other countries for the same investor companies. Political stability can also be another constraint for the resource taxation policies beside the economic reasons.

From the above mentioned issues, it is understandable that the structure of the studies related to resource tax can be different based on the goals of each study. If the aim of the study is just focused on the extraction process then a microeconomic framework can be used, but if it is to study the impact of the tax on other sectors of the economy

[8] The different quality of the resource needs to be taken into account too. For instance, light and heavy oil may have different refining costs and this could give the government some opportunity in negotiating a better deal.

a macroeconomic framework is more appropriate. The micro and macro frameworks to study the impact of a resource tax will be discussed in Sections 2.8 and 2.9.

2.7.2 Government Investment and Consumption Expenditure Policy

On the other side of fiscal policy it is very important that the government spends the resource tax revenue on productive assets such as human capital or infrastructure capital as explained earlier by Hartwick (1977) and Hannesson (2001). This would guarantee continuous and developing economic growth and would also benefit the next generations by accumulating more productive assets. In fact, resource income as a depreciating asset needs to be ultimately replaced by other income generating assets such as domestic and international financial assets. The idea behind investing resource tax revenue instead of paying for consumption expenditure is to increase productivity by increasing the human capital quantity and quality and also infrastructure facilities across the economy in order to generate sustainable future benefits. In fact, an increase in productivity and production factors would improve economic growth by increasing actual GDP and also potential GDP in the long-run. One of the well-known examples in the literature on spending resource revenue on investment rather than public consumption is Norway, which has created a sovereign wealth fund[9] for these revenues to be invested. Chile is another economy that has set up a fund to manage resource revenue. An empirical analysis of the possible application of the same idea in terms of benefits of investment on infrastructure and human capital for the Australian economy is further explained in Chapter 7.

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[9] The Government Pension Fund Global (previously known as The Petroleum Fund of Norway) was established in Norway in 1990 to invest the massive surpluses created by the collected revenue through taxing the petroleum companies in this country. This fund is managed by the Norwegian Central Bank.

2.8 Microeconomic Modelling Structure

As mentioned in previous sections taxation of resources is vital for the decision making of investors. Due to the importance of the tax burden for firms operating in this sector, the major part of the resource taxation literature focuses on the impacts of these taxes using microeconomic models from several perspectives. In this section some of the important studies at the micro level are explained.

Studies in the literature have looked at the resource taxation phenomenon from various aspects including the impacts on firm resource extraction, extraction patterns and inter-temporal aspects, and most have studied the optimality of the resource tax regime according to each of these. In addition, most of the research in this area has focused upon a hypothetical resource firm while a few have generated empirical results using data from a specific resource company. After the basic study of Hotelling (1931), the study of Burxess (1976) is one of the primary works on the impact of a non-renewable resource tax on the output of a resource producing firm.

In this study the reactions of the firm to different taxation policies were analysed. Different types of common taxes on resources including "a franchise (lump sum), severance (*ad valorem* or unit) and a profit tax" were applied to find the impact on the output of the firm. The results showed that in the case of a zero interest rate (discount rate), a franchise tax increases resource output but the other taxes leave resource production unchanged[10]. To get to this result an optimisation problem for

[10] The term "franchise" is used instead of lump sum tax in this study because, based on the definition, lump sum tax should not depend on any variable but in this study it depends on time.

the firm was defined and the above tax was included. It is assumed that the franchise tax, which depends on time is $\beta(t)$, and the firm maximises its profit as follows[11]:

$$\max \int_0^T e^{-rt}[px - C(x) - \beta]dt$$

$$subject\ to: \quad \dot{y} = -x(t)$$

$$y(0) = K$$

$$y(T) = 0$$

Where p and C are price and extraction cost respectively, both of which being time independent, where C is assumed to be dependent on production (x) and it is also possible to differentiate C twice continuously to define the maximum point. Time is assumed to be continuous so that optimal control theory is applicable, which is more convenient than discrete methods, r is the interest rate, y is the remaining reserve of the resource, K is the stock of reserves and T is the number of time periods in the planning horizon. The Hamiltonian as an interior solution is:

$$H = e^{-rt}[px - C(x) - \beta] - \lambda x$$

And necessary conditions are:

$$\dot{\lambda} = 0$$

$$(\partial H/\partial x) = 0 = e^{-rt}\left[p - \acute{C}(x)\right] - \lambda$$

At t=T, transversality requires that:

$$\lambda(T) = e^{-rT}\left\{p - \acute{C}[x(T)]\right\}$$

And:

$$[px - C(x) - \beta]/x = p - C\acute{(x)}$$

On the other hand because:

$$[p - C(x) - \beta]/x < max\{p - C(x)/x\}$$

[11] The same notations as used by Burxess (1976) are also used here.

At T, $[px - C(x) - \beta]/x = p - \acute{C}(x)$ then obviously *x(T)* is greater than in the no tax situation. Therefore, because $\lambda(t)$ is constant, it can be concluded that the franchise tax increases the extraction rate and resource depletion is earlier (Burxess, 1976).

Burxess (1976) examines other taxes such as the *ad valorem*, per unit and profit taxes with differing assumptions about the rate of the increase in tax compared to the rate of increase in the interest rate (then a non-zero discount rate) and also differing assumptions about whether the extraction market is competitive or subject to monopoly. For instance, an increasing per unit tax over time which is higher than the interest rate decreases output. In fact, the faster the increase in the per unit tax the greater the speed of decrease in output (Burxess, 1976). Then, based on the impact on the extraction time path and the aim of the social planner, a suitable combination of taxes can be levied on the resource sector.

While time is assumed to be continuous in Burxess (1976), in a study by Conrad and Hool (1981) it is assumed to be discrete. Therefore, in a two period model of a resource-extracting firm they tried to show the effects of three different mining taxes; severance taxes (*ad valorem* or per unit); property taxes; and profits taxes, on extraction timing, extraction rate, extracted quantity and efficient resource rent collection. A mining firm maximisation problem (to maximise the discounted value of a firm's revenue minus expenses over a long time period) is used to model the above factors. They also assume that the resource is not homogenous (e.g. different grades for extracted ore) and that its lifetime is finite. The quantity produced is endogenous; therefore, the taxation could affect the extraction quantity as well as

changes in the economically recoverable size and lifespan of the mine. The objective of the resource-extracting firm is to maximise its present value subject to some constraints like resource availability and technology. It is assumed that the firm knows the quality (the grade variety) of the ore and should decide about the quality and the quantity in each period (which is different from the study of Burxess (1976)). Extraction costs depend on total throughput of the ore and output is defined as a metal or concentrate of a given purity. X_{tg} is the quantity of the extracted ore of grade $g\ (g = 1, \dots, G)$ in period $t\ (t = 1, \dots, T)$. Therefore, $C_t(X_t)$ shows the extraction cost at period t, where:

$C_t(X_t)$ = extraction cost, $X_t \equiv \sum_{g=1}^{G} X_{tg}$ and $\acute{C_t} > 0, C_t'' \geq 0$

The output of the firm is $\sum_{g=1}^{G} \propto_g X_{tg}$, where $\propto_g$ shows the metal proportion in ore of grade g.

Therefore, the firm's optimisation problem is:

$$\max_{(X_{tg})} \sum_{t=1}^{T} \frac{1}{(1+r)^{t-1}} \left[P_t \sum_{g=1}^{G} \propto_g X_{tg} - C_t(X_t) \right]$$

$$\textit{Subject to: } R_g \geq \sum_{t=1}^{T} X_{tg},\ \ g = 1, \dots, G$$

$$X_t \geq 0, t = 1, \dots, G \textit{ and } g = 1, \dots, G$$

Where P_t shows the output price at period t in the market (if $t > 1$ then the expectation of the price will be used), R_g is the total units of ore in grade g which are actually available and r is the discount rate which is used by the firm. A profit tax with a cost depletion is introduced which changes the maximisation problem of the firm. The after tax problem is:

$$P_t \sum_{g=1}^{G} \propto_g X_{tg} - C_t(X_t) - k \left[P_t \sum_{g=1}^{G} \propto_g X_{tg} - C_t(X_t) - d \sum_{g=1}^{G} \propto_g X_{tg} \right]$$

$$= (1-k)\left[\left(P_t + \frac{kd}{1-k} \right) \sum_{g=1}^{G} \propto_g X_{tg} - C_t(X_t) \right]$$

Where k is the tax rate and d is a fixed allowance to define the cost of depletion. The depletion allowance raises the price when there is positive profit by $\frac{kd}{1-k}$. The results also show an increase in the mine lifetime and extraction decision changes from future to present (which is the same as the results of the property tax explained in Hotelling (1931)). The summarised results of Conrad and Hool's (1981) study are shown in Table 2-1. For instance a*d valorem* severance, which is a proportion of the resource price, does not change the extraction order of different grades but decreases the economic reserves of the mine. Whether the extraction, after introducing this tax, will mainly take place in the present or future depends on the pattern of discounted prices.

Table 2-1 Impacts of Different Taxes on Mining Decisions

Tax	Grade selection profile	Reserves(high-grading effects)	Extraction profile
Per unit severance on output	Present to future	Decreased	Present to future
Per unit severance on ore	None	Decreased	Present to future
Ad valorem severance	None	Decreased	Depends on path of discounted prices
Profits tax with cost depletion	Future to present	Increased	Future to present
Profits tax with percentage depletion	None	Increased	Depends on path of discounted prices
Property tax	Future to present	Increased	Future to present

Source: Conrad and Hool (1981p. 31)

The study conducted by Levhari and Liviatan (1977), unlike the above study but the same as Burxess (1976), assumes that time is continuous, and extending this

assumption allows for the extraction cost function to be increased with the extraction process cumulatively. They then studied the impact of only a severance tax on output extraction. While in the seminal work of Hotelling (1931) the firm continues extraction until the stock of resources is finished, any increase in cost for the firm might stop extraction before completion of the expected extraction time. Therefore, the assumptions about the cost of extraction change the conventional results of a resource tax. Information about resource extraction for the investor is another factor that may distort the results. Gaudet, Lasserre and Long (1995), using "optimal non-renewable resource royalty contracts", show that asymmetry of information about the cost of extraction shifts the extraction of the resource to the future compared to a full information case about the cost of extraction. While only one resource tax (a franchise tax) was analysed in this research, the study of Heaps (1985) extended the work of Levhari and Liviatan (1977) to include other resource taxes as well. Net profit from extraction in this study depends on the rate of extraction q and the remaining reserves X. The resource taxation policy is indexed by β and the net profit of the firm at time t is $B(q(t), X(t), t; \beta)$. The extracting firm's problem is to define the time period T for the operation of the mine and extraction profile to solve the optimisation problem:

$$\max V = \int_0^T B(q, X, t, \beta) e^{-rt} dt$$

$$\text{Subject to: } \dot{X} = -q$$

$$q \geq 0 \text{ , } X \geq 0 \text{ and } X(0) \text{ } given$$

It is assumed that the price of output rises but at a rate less than the discount rate. The time path for the extraction rate is calculated and then the impact of the resource tax on this is analysed. The optimal extraction program is:

$$\dot{X} = -q$$

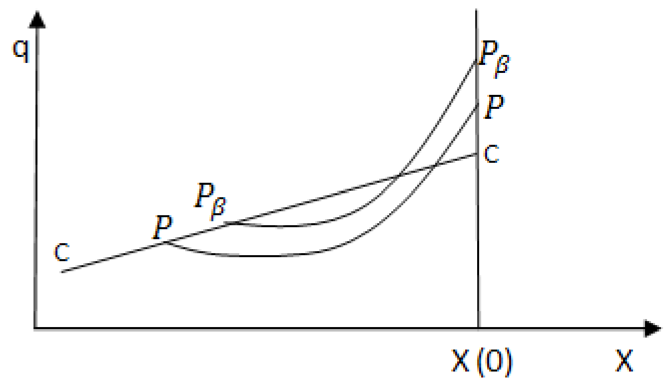
$$B_{qq}\dot{q} = qB_{qX} - B_X + rB_q - B_{qt}$$

The profit tax for the resource extracting firm influences the net profit:

$$B = \big(1 - S(t, \beta)\big)\pi(q, X, t)$$

The impact of an increasing profit tax $(\dot{S} > 0)$ on the optimal path of extraction is shown in the diagram below:

Figure 2-1 The Optimal Extraction Path for an Increasing Profit Tax



Source: Heaps (1985)

As shown in the diagram, as a result of the increasing profit tax $(\dot{S} > 0)$ and $\pi_t > 0$, the extraction rate becomes higher and after tax optimal path (P_β) shifts up, $T_\beta < 0$ and $X(T)_\beta > 0$[12]. The general conclusion from this study is that a resource tax levied by the government increases the extraction rate and reduces the extraction time and also the total amount of resource extracted.

As mentioned previously there are many different systems (or combinations of instruments) for the government to collect economic rent from the resource sector such as royalties and taxes. A study by Fraser and Kingwell (1997) aimed to identify

[12] For the purposes of this research the equations and the results are summarised. For the complete framework of this model please see the main source.

if a switch from a royalty (*ad valorem* royalty) to a resource rent tax (RRT) could increase a government's revenue and keep the firm's investment at an optimal level. This study assumes that the size of the resource is unknown and an optimal investment model is developed to find out the impacts of the royalty tax compared to the RRT. The expected profit for the resource-extracting firm in three cases, no resource tax, an RRT and an *ad valorem* royalty, are studied following on from Fraser (1993). The model provided in this study was analytically ambiguous so a numerical method is used to explain the changes. The overall result of this study was that in a situation where extraction is expected to be profitable, an RRT can increase tax revenue meanwhile leaving investment plans unaffected (Fraser and Kingwell, 1997).

The above assumption of an unknown resource size is adopted in the study of Fraser (1998) which obtains the same result as the previous study - that the RRT provides higher revenue for the government compared to the royalty but "the result is dependent on the initial level of uncertainty about the size of the resource deposit" (Fraser, 1998, p.203). Or, more clearly, "the paper has highlighted the ambiguous benefits of exploration for a government imposing an *ad valorem* royalty, while suggesting, at least for resource deposits with relatively low levels of pre-exploration uncertainty about size, that it may be in a government's interest to support exploration in the context of an RRT" (Fraser, 1998, p. 205). Therefore, he supports an RRT as the best option for a government to collect rent from the resource sector[13].

[13] For more information on the support for RRT in the Australian resource sector see Fraser (1999). This will be explained more in Chapter 3.

Research in the resource taxation literature has not only studied the impact of resource taxation on the extractor firm and the government, but also, from another aspect, looked at the resource sector as public capital that must be used equally by current and future generations. Therefore, the aim of some studies is to find the optimal resource taxation policy in terms of the inter-temporal allocation of a resource. The study of Dasgupta, Heal and Stiglitz (1980) shows the taxation impact of an exhaustible resource on the inter-temporal allocation of this resource as an example of this. In this study, based upon the basic idea from Hotelling (1931) that the growth rate of the resource price must be equal to the interest rate, and using a variety of resource taxes including a profit, sales and an *ad valorem* tax, it is shown that taxation of an exhaustible resource "can clearly be used as an instrument for changing the inter-temporal pattern of resource allocation" (Dasgupta *et al.*, 1980, p. 32). In another study by Conrad and Hool (1984), focus is placed on three variable rate taxes such as "time-dependent output taxes, price-dependent *ad valorem* taxes and progressive profits taxes" (Conrad and Hool, 1984, p. 319). By including the different quality of the resource (different grades) it is shown that the impact of variable rate taxes on natural resources can make allocation incentives qualitatively dissimilar to those with fixed rate taxes. For example,

"in the case of per-unit severance taxes, a constant-rate tax induces a reallocation from present to future (when the discounted unit tax will be smaller) and a decline in total extraction. These effects are reversed if the tax rate is variable and has a sufficiently high growth rate (higher than the discount rate by an amount that depends on the grade distribution)" (Conrad and Hool, 1984, p. 326).

The generational issue in resource extraction in the study of Hanf and Thampapillai (1992) is from another perspective and fairly straightforward. The basic assumption in this study is that the extraction cost of a resource for the future generation is higher compared to the current cost of extraction. The reason is that, for instance, it is easier and cheaper to extract the first layers of a resource[14] but on the other hand the quality of the resource extracted gets worse with more extraction. So the focus in this study is on the Marginal Cost (MC) concept and the Long-Run Marginal Cost (LRMC). LRMC is a function of the current and total extraction volume and it is increasing over time. The resource is also assumed to be quasi-infinite and some more simplifying assumptions are taken into account, such as whether or not the resource is exported or imported over time. The marginal loss and marginal welfare of an imposed resource tax is studied in this case and shows that the amount of the optimal tax gets smaller with a more inelastic demand function or a more elastic supply function. Furthermore, the optimal value of the resource tax gets gradually smaller when moving from the current to the future time period (Hanf and Thampapillai, 1992). Therefore, an optimal resource tax is studied from different perspectives in the literature. For instance, unlike the above study, research by Campbell and Lindner (1983) aimed at finding an optimal resource tax that increases government's revenue from the resource sector. Analysing a model resource firm which applies a Bayesian approach when it decides about exploration arrangements, shows that "if the explorer is risk neutral, then a zero tax rate maximises government revenue" (Campbell and Lindner, 1983, p. 263), although this is not probably of interest to any government that tries to collect rent from the resource sector. An overall look at the literature on resource taxation in a micro structure shows that the

[14] It is obvious that most resources, such as oil wells, require higher investment along with the process of extraction, even to extract the same quantity during a given time period.

policy impact of any policy is only at the firm level and it is not possible to explain the impacts in an economy wide model without including other markets in the model. Therefore, in the next section, some macroeconomic model studies in the literature are reviewed and explained.

2.9 Macroeconomic Modelling Structure

Natural resources are an important part of resource extracting and exporting countries and, as shown previously, taxation of this sector might have a major impact on the performance of the resource sector. One question that needs to be asked, however, is whether the impact of resource taxation is limited only to this sector. It is obvious that for most natural resource-exporting countries this sector is one of the main sectors, or even the leading sector, in economic development. Because of this, feedback effects from the non-resource sector back to the resource sector need to be studied. Thus, for instance, a change in the level of investment in the resource sector (as a result of resource taxation) could have a major impact upon the level of investment at the aggregate level for a resource-abundant economy. This could lead to a change in the export revenue of the country and eventually the balance of payments position. Moreover, any shock to foreign investors' decisions to invest in the resource sector as a result of a change in the tax burden in this sector could change the exchange rate of the country's currency and result in a change in export revenues for the country. Therefore, the impact of this on a non-resource sector like the manufacturing sector could be studied based on the Dutch Disease theory.

Therefore, it is necessary for the taxation of this sector to be studied along with other sectors of the economy. This will make it easier for policy makers to analyse the

interaction of the policy in this sector with other sectors or policies. For instance, any change in the taxation of this sector might change the government's revenue and if the collected revenue from the resource taxation is invested by the government then this could result in a crowding out effect. As another example, if the central bank changes the interest rate, following the famous Hotelling rule in the natural resource literature, the change in the price of the resource must be equal to the interest rate.

Although it is believed that the resource sector is capital intensive in nature and any change in it only affects this sector and does not affect the employment level, it could indeed affect employment (especially in non-resource-related sectors) in the country through fiscal transmission channels. But, on the other hand, some believe that because of the neutrality of resource taxation on the performance of this sector, taking the windfall profit from this sector and injecting it into the economy would provide more sustainable development for a country. On this side, even if the resource sector gains a higher profit and therefore provides more tax revenue for society and creates a higher GDP level, higher GDP does not necessarily mean higher welfare for the community[15]. Taxation of the resource sector (instead of letting the profit be completely retained within the resource sector or sent overseas if it is mainly foreign owned) and enabling higher government expenditure (preferably investment expenditures) can provide a better structure for sustainable development.

Therefore, it is obvious that in order to make the results of the economic model closer to reality, it is necessary to study these policies together which will allow us to

[15] Some other indices such as the Human Development Index (HDI) along with GDP show that the welfare level of a country mostly depends on a government's expenditures on health and education as productivity-enhancing expenditures.

have a better understanding of the interaction of the influences of the policies. While the importance of a macroeconomic structure to study the impact of a natural resource tax is explained above and looks more logical (compared to using only a micro framework), the literature on natural resource taxation suffers from a lack of studies at this level. There are only a few studies in the literature at the macroeconomic level, obviously less than studies in a microeconomic framework. There are some studies such as Van Geldrop and Withagen (1993) that include natural resources in their model, but natural resource taxation is less common.

The study by Sinn (1982) analyses inter-temporal aspects of taxation theory (in total and not just for resource taxation). Therefore, "a framework which is a synthesis between the neoclassical growth model, augmented by a (separable) sector of resource-extracting firms, and the Fisherian inter-temporal general equilibrium model" (Sinn, 1982, p.357) is used to analyse the above mentioned issue. The model in this study included four separate agents, a normal good producing firm, a resource extracting firm, a household and the government. Different types of taxation and their impact on welfare were examined. In the case of the resource sector a unit tax and a capital-gains tax were applied. The results showed that both had a distorting effect and decreased welfare. The unit tax, as a resource taxation instrument, causes lower present use of resources and the capital-gains tax makes the present use of the resource higher compared to the future. It is worth mentioning that the resource is assumed to be a consumption good and not a production factor, and the tax is on all "realised and unrealised capital-gains" in the natural resource sector. Also, the tax revenue is redistributed to the household by lump-sum aid (Sinn, 1982). In this study there is no central bank and, therefore, monetary policy is not included in the model.

While the above mentioned study is a theoretical general equilibrium model and there is neither simulation nor estimation of the model, the study of Fisher and Despotakis (1989) provides a computable (regional) general equilibrium (CGE) for the California economy to analyse the macroeconomic performance of two energy[16] taxes and the impact of an energy tax on energy consumption.[17] The model has three components including a factor market, goods market and overall balance. The uniform (on the price) tax and severance tax used in this study show a considerable impact on energy use in California.[18] Macroeconomic performance is limited to changes in the ratio of domestic or imported usage of oil (Fisher and Despotakis, 1989) which could affect the economy in different ways such as through changes in the current account, but this is not given emphasis in this study.

Energy taxation effects on the economy of Austria were studied by Koeppl *et al*. (1996). They linked an input-output model to a macro model. The simulation results of the proposed energy taxes showed the impacts on employment, inflation, economic growth, the current account and budget deficit. A variety of scenarios were analysed to show the impact of the energy tax on the above mentioned variables. The simulation results of the main scenario of the study ("labour cost reduction and technology promotion" (Koeppl *et al.*, 1996, p. 425)) showed that the energy tax increased the GDP level and employment compared to the baseline scenario which is

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[16] While the energy resources do not include total exhaustible natural resources (because of other resources such as metal minerals that are not used as an energy source) it is still believed to be an important element of the stock of natural resources in a country.

[17] Xu and Masui (2008) also use a CGE model to study the impact of an oil production tax.

[18] The results are shown by using a hypothetical amount of taxes and its impact on energy consumption.

without an energy tax (Koeppl *et al.*, 1996). The final users of energy are taxed in this model but not the initial resource extractors (which is the same as Fisher and Despotakis (1989)).[19]

The theoretical short-run macro model of a developing country by Murshed (1999) aimed to show the difference between economic growth patterns in Latin America and East Asia, emphasizing the role of natural resources. The model developed in this study included two tradable and one non-tradable sector. Natural resource is one of the tradable goods. Taxation in this study was not on the tradable goods (so there is no resource tax) but on the non-tradable goods. The aim was to decrease the Dutch Disease effects (resulting from a resource boom) which transfers the production factors from the tradable to the non-tradable sector (Murshed, 1999) (resource movement effect explained in Section 2.6). Some other scenarios are examined and explained in terms of different policies and decisions in East Asia and Latin America (but these are not relevant to our discussion in this research).

Groth and Schou (2007) used an endogenous growth model to show the role of resource taxation on long-run economic growth. This model was a one sector model and uses a Cobb-Douglas production function. Unlike the study of Sinn (1982) where the resource is viewed purely as a consumption good, Groth and Schou (2007) view natural resources as a production factor along with capital and labour, and this exhaustible resource was assumed to be essential for production. The economy in this model is assumed to be a closed economy and the government does not have any domestic debt. The impacts of a variety of policies on long-run economic growth

[19] For further information on the optimal oil taxation and capital taxation please see Petrucci (2009).

were analytically studied in this research. The authors of this research concluded that, unlike the standard theory of endogenous growth, neither an investment subsidy nor interest income taxes have a long-run effect on economic growth as they only affect levels, while resource taxes were crucial for long-run economic growth. What remains unclear in this model is the outcome of resource taxation if resource extraction is a function of production factors such as labour and capital instead of taking natural resources into account as a production factor itself (Groth and Schou, 2007).

While this research is interested in non-renewable natural resources the study by López and Schiff (2010) analysed a renewable natural resource and physical capital in "a general equilibrium context", where resource extraction has a dynamic impact upon the theoretical economy. Changes in resources and "man-made assets" were endogenous[20] over time. The aim of the research was to study the steady state of a small economy and one of the results of this study showed that "the introduction of a small import tariff or export tax results in a larger steady-state *NR* [renewable natural resource] and commodity output and lowers the risk of complete *NR* depletion" (López and Schiff, 2010, p. 1).

A recent development in the literature to appraise the impacts of changes in the resource sector (production and price) on macroeconomic outcomes is a study by Cox and Harvie (2010). They developed a generic long-run dynamic macroeconomic model for a developed, resource-exporting country, and analysed macroeconomic

[20] This is unlike the assumption in Groth and Schou (2007) where resource production is exogenous. However, the assumption of the resource sector being endogenous in López and Schiff (2010) is for a renewable resource sector rather than the non-renewable resource in the earlier study.

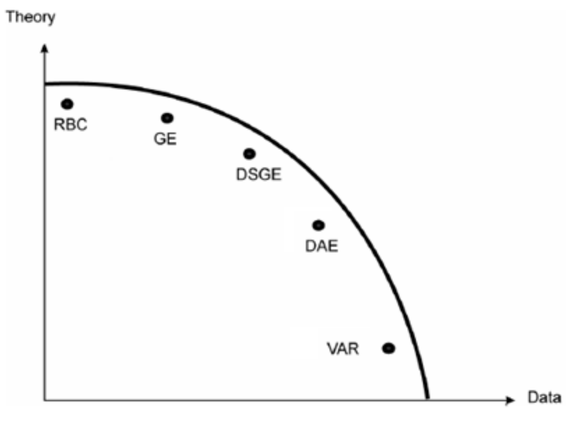
effects arising from a change in the price of the resource. The focus of this study was on outcomes of a price boom for the macro-economy arising from related changes in government fiscal policy. By using a numerical simulation approach they concluded that a permanent and positive resource price shock potentially could sustain an increase in private sector real income and wealth, but in the case of a temporary shock could at least result in a temporarily improved current account (Cox and Harvie, 2010). While this study is one of the most comprehensive new studies in terms of a macro model of a small, open, exporting country with exhaustible resources in a resource boom condition, it seems it should be possible to extend it to incorporate changes in taxation of the resource sector which could affect the resource sector's operations and the effectiveness of fiscal policy by the government from a spending perspective.

2.10 Micro-founded DSGE Modelling Approach

The literature on resource taxation in both micro and macro frameworks has been explained above. It was also explained that it is much more appropriate to study resource sector taxation in a macroeconomic framework if the outcomes of a number of fiscal policies related to this sector are aimed to be studied. While there are many studies in the context of a microeconomic framework, there are fewer studies at the macroeconomic level and even less in a general equilibrium context. However, one of the rapidly growing macroeconomic modelling methods in the last few years, especially in terms of the analysis of policy effects upon an economy, is the Dynamic Stochastic General Equilibrium (DSGE) model. The basic difference of this method compared to previous macro-modelling approaches is that it is based on micro-foundations, and the model is from the perspective of the main economic players

including a representative household, firm, central bank and/or government in a general equilibrium context. The DSGE modelling approach has been used mainly for analysing the impact of stochastic monetary shocks and been used mostly by various central banks and international monetary institutions in the last few years[21]. These models usually include a representative firm, household and decision making unit like a central bank or government.[22] All of these agents have their own optimisation problem which can be solved together in a general equilibrium framework. During the past decade most central banks, not only in developed countries but also in some developing countries, have started to adopt and calibrate a DSGE model for their economy to study the impact and effectiveness of stochastic monetary policies on the economy. As shown in Figure 2-2 this method takes both data and theory into account relatively equally as compared to other possible methods of macroeconomic modelling.

Figure 2-2 The Trade-off between Theory and Data for Macroeconomic Model Classification



Source: Bårdsen *et al.*(2006)
Notes: (RBC: Real Business Cycle models; GE: General Equilibrium models; DSGE: Dynamic Stochastic General Equilibrium models; DAE: Dynamic Aggregative Econometric models; VAR: Vector Autoregressive models)

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[21] See Hodge *et al.*(2008), Dagher *et al.* (2010), Millard (2011) and Langcake and Robinson (2013).

[22] Although other forms are also possible, these agents are included in almost all studies in this area.

Using these models to analyse fiscal policy started only a few years ago, and due to some technical difficulty in solving optimization problems for fiscal policies its application in this area has been limited. The results of studying fiscal policy in a DSGE framework have been rather ambiguous and, moreover, solving these models incorporating a taxation system has made them even more complicated. Also, the number of variables used in DSGE models is lower than in other macroeconomic models, making it less encouraging to use as a comprehensive macroeconomic model. Consequently, a methodology incorporating both DSGE and a conceptual macroeconomic framework will be adopted later in this study.

2.11 Resource Taxation Study Levels

To show more clearly possible structures for the study of natural resource taxation in this research, it is useful to categorise this at the firm and industry level, and in terms of partial and general equilibrium. Some firm-level studies have been explained in the context of microeconomic models in the above sections. A summary of a few more relevant firm level studies is summarised in Table 2-2.

Another possible level of study is to analyse the taxation of exhaustible resources at the industry level, including all firms operating in it. Some examples of these types of studies which are more relevant are summarised in Table 2-3.

Table 2-2 Summary of some Examples of Firm Level Studies

Year	Author	Aim	Method	Conclusion
1985	**Heaps**	To study the effects of non-replenishable natural resource taxation on optimal extraction patterns.	A general mine maximisation problem based on extraction patterns.	Taxation of an exhaustible resource will cause faster extraction in a shorter time period and reduce the total quantity of extraction.
1997	**Fraser and Kingwell**	To study a possible switch from an *ad-valorem* tax to a Resource Rent Tax (RRT) in order to increase government revenue while protecting a firm's optimal investment.	A model of switching tax regimes (a model of optimal investment of a mining company is used to maximise the firm's expected profit).	By using numerical analyses they conclude that while extracting the resource is expected to be relatively profitable, government tax revenue could be increased by an investment-protective RRT.
1998	**Fraser**	To study the relationship between uncertainty-reducing exploration and resource taxation in a resource extracting company.	A mining profit maximising model was applied to examine expected tax revenue in terms of *ad-valorem* royalty and RRT.	In terms of expected tax revenue for a government and the rate of extraction, this study supports an RRT compared to an *ad-valorem* royalty.

Some research exists in the context of a partial equilibrium framework. In this approach, at least two important sectors of an economy are analysed in order to show the particular relationships between those sectors. It might be possible to explain the impacts of the policies to the applied sectors but obviously it is not possible to analyse it in relation to the other non-included sectors. In terms of natural resource taxation there are a few studies that are explained in Table 2-4. It needs to be explained here that, as mentioned in Van Geldrop and Withagen (1993), using a partial equilibrium framework in research would not allow the study of spill-overs to other markets and it is not obviously possible to take into account the different level

of endowments of countries in order to have a clear analysis. On the other hand it is hard to believe that the rate of discount is exogenous, which is already used in most partial equilibrium models, and that its movement is separate from the resource price (Van Geldrop and Withagen, 1993).

Table 2-3 Summary of Example Industry Level Studies

Year	Author	Aim	Method	Conclusion
1992	**Lund**	To find the impacts of resource taxes on the petroleum industry in Norway.	The theoretical basis is contingent claims analysis from finance theory using incentive effects of resource taxation under uncertainty (by numerical methods and simulations).	The Norwegian resource tax on the petroleum industry has a strong distortionary effect compared to a cash flow tax or a no-tax situation.
1995	**Osmundsen**	To show the existence of asymmetric information within the resource industry in terms of taxation.	An optimal contract model including the petroleum industry taxation.	There is asymmetric information about the cost of extraction and the industry has information rent. The optimal way for a government is to distort the level of petroleum extraction, imposing some assumptions about the cost structure and setting the resource tax composed of a licence fee and a distortive royalty.
1997	**Zhang**	To show the impact of different types of taxation on development decisions and to find a rate of tax that can be neutral and economically efficient (in getting the economic rent) at the same time.	An oil development field model.	The UK Petroleum Resource Tax (PRT) has been neutral and relatively efficient in the period of this study.

The last possible structure to study resource taxation is a macroeconomic model in a general equilibrium context. The existing studies in this structure were explained in Section 2.9.

Table 2-4 Summary of Partial Equilibrium Studies

Year	Author	Aim	Method	Conclusion
1985	**Gamponia and Mendelsohn**	To analyse the efficiency and equity effect of four taxes (yield, unit, property and windfall profit taxes) on exhaustible resources.	Simulation using a partial equilibrium model.	The yield tax is the most efficient but if the base price is equal to or less than extraction costs then the windfall profits tax is the most efficient.
2002	**Lund**	To show one of the important reasons that make the resource rent tax unlikely to be neutral in practice.	A partial-equilibrium model including only one firm in a small, open economy framework.	With the existence of transfer incentives, it would be more optimal for a government to use a combination of a rent tax and a royalty in order to increase revenues from the resource sector.
2008	**Lindholt**	To study the rate of producer tax which maximises government's tax revenue from the oil sector in Norway.	A partial equilibrium global oil market model.	A decrease in the current tax on oil does not increase investment and production enough to increase the discounted tax revenue for the government.

2.12 Hybrid Macro-Modelling Approach

The current literature on resource taxes and possible methods to approach this area were analysed and elaborated in the previous sections. It was also mentioned that most of the studies in the literature on resource tax are at the micro level and that DSGE models are micro-founded and use some microeconomic characteristics such as household's consumption behaviour or firm's decision making factors in their framework. Therefore, this study will fill a gap in the literature by studying resource taxation in a macroeconomic framework and by incorporating selected characteristics of the DSGE models and also micro-level studies related to the resource sector into a

developed conceptual macroeconomic framework to build a comprehensive hybrid model. This is a valuable extension not only to study the impact of resource tax but also to analyse the effects of a range of public expenditure policies in a developed macro model.

It is worth clarifying the term "hybrid" used for the model in this study. As mentioned in Section 2.10, DSGE models are micro-founded and more focused on the theoretical coherence of the model while on the other hand Vector AutoRegressive models (VAR) rely on empirical and short-run consistency. Therefore, to take advantage of both theory and empirical experience, a group of studies have used prior information in DSGE models to estimate VAR models and these are known as hybrid DSGE-VAR models. However, the hybrid in this study uses some DSGE theoretical characteristics to add some microeconomic aspects such as household and resource producing firm behaviours to the conceptual macroeconomic framework of this study. Therefore, the hybrid model used in this study is not a combination of theory-data in the context explained earlier but rather a combination of micro-founded theory and a conceptual macroeconomic framework using estimation and simulation methods which are applied in the DSGE literature, such as Bayesian estimation and simulation of stochastic and deterministic shocks. Recent hybrid DSGE-VAR models have been used in a number of studies such as Liu *et al.* (2010) and Bekiros and Paccagnini (2013).

Also, from among the limited number of existing macroeconomic models in the literature, the conceptual macro model applied in Cox and Harvie (2010) has been selected to provide the foundation for attaining the aim of this study. This model, as

mentioned earlier, is set for an advanced, small, resource-exporting economy which makes it appropriate to be applied for the Australian economy. This model is further developed in a number of aspects which are explained in detail in Chapter 4.

2.13 Summary

In order to attain the aims of this study, a comprehensive literature review of resource taxation has been undertaken in this chapter. This review has facilitated the identification of gaps in the literature and the methodology which will be adopted in this research. The role of natural resources in the context of a macroeconomic model has been explained and the importance of taxation of this sector in terms of its impact on resource extracting firms and on the overall economy has also been explained. The methodology of the research following the literature review has been explained and will be discussed further in Chapters 4 and 5. As the aim of the study is to prepare a model that is applicable to Australia, a small, open, resource-abundant and exporting economy, the next chapter will briefly show the major components of the Australian economy with a focus on the resource sector.

CHAPTER 3

AUSTRALIAN ECONOMY

3.1 Introduction

The preceding chapter reviewed the current literature about the specific focus of this study. The purpose of this chapter is to provide an overview of recent developments in the Australian economy. In order to attain the goals of this study, a hybrid macroeconomic model of the Australian economy, developed in Chapter 4, is used. Before this model can be developed, a description of trends in key macroeconomic variables considered in developing the model is warranted. These developments are described in this chapter.

The Australian economy has been one of the most resilient developed economies in the world until recently. Although most of the developed economies are still in the process of recovering from the effects of the 2008 Global Financial Crises (GFC), Australia's economic performance during this period has been remarkable. The resource boom complemented by trade ties with major economies such as China and India, has played an important role in Australia's economic performance during this period.[23] The resource sector, it must be noted, is the most important contributor to the Australian economy in terms of economic growth, investment and exports. During the last two or three decades, the high potential of Australia in terms of

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[23] Beside the free trade agreements (FTA's) currently in force, the China-Australia FTA (ChAFTA) was finally concluded in November 2014 and the FTA with India is currently under negotiations. Australia already has a number of FTAs in force with a number of economies and economic blocks including ASEAN-Australia-New Zealand FTA (AANZFTA), Australia-Chile FTA (ACLFTA), Japan-Australia Economic Partnership Agreement (JAEPA), Korea-Australia FTA (KAFTA), Australia-New Zealand Closer Economic Agreement (ANZCERTA), Australia-United States FTA (AUSFTA), Malaysia-Australia FTA (MAFTA), Singapore-Australia FTA (SAFTA) and Thailand-Australia FTA (TAFTA) (Department of Foreign Affairs and Trade- Australian Government, 2014).

natural resources has attracted many multinational companies such as BHP Billiton and Rio Tinto to invest in this sector. Increased investment and extraction of natural resources has been encouraged by a number of factors such as high economic rent in this sector, a favourable resource tax regime and high resource prices as a result of particularly strong demand in China, providing the impetus for high domestic growth despite stagnating growth in the rest of the developed world.

An overview of the Australian natural resource sector constitutes a major part of this chapter. How best to use tax revenues from the sector is a topical issue for the Government. Changes to the Mineral Resource Rent Tax thus constitute another important component of this chapter. This description provides a basis for the model developed in Chapter 4.

3.2 An Overview of Australian Macroeconomic Indicators

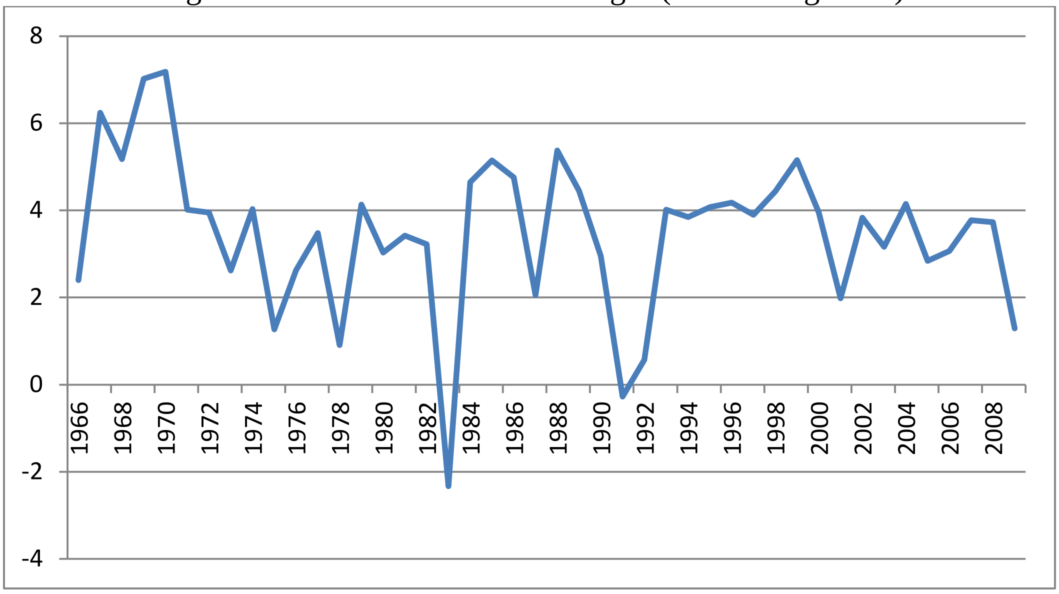
This section highlights some of the main macroeconomic indicators including GDP, inflation, unemployment, interest rate and exchange rate, for the Australian economy, particularly during the period of the recent resource boom.

3.2.1 Gross Domestic Product (GDP)

Australia experienced a high economic growth rate of more than 7 percent in the late 1960s. However, the economic growth declined sharply between 1982 and 1990. During the last decade, real GDP has grown by between 2 percent and 4 percent (World Bank, 2012). While economic growth appears to be relatively low by developed economy standards, the unemployment rate has not declined. A recent study by Gregory & Sheehan (2011) argues that the relatively low economic growth

and almost no change (a little increase) in unemployment level highlights the important role of monetary and fiscal policy that are arranged to control the possible negative impacts of the current resource boom on Australian economic growth in the non-resource sector (Gregory and Sheehan, 2011). There are also other factors that have played an important role in the process of making the robust Australian economy such as the contribution of trade, financial and other deregulations and reform during the 1990s and the floating of the exchange rate in 1983.

Figure 3-1 Annual Real GDP Changes (economic growth)



Source: World Bank (2012)

Figure 3-1 shows the trend of economic growth in Australia between 1966 and 2010. The data represents the change in annual real GDP. Figure 3-1 reveals that economic growth declined after the GFC in 2008–09 but this was not as strong as declines for instance in 1983 or 1991–92.

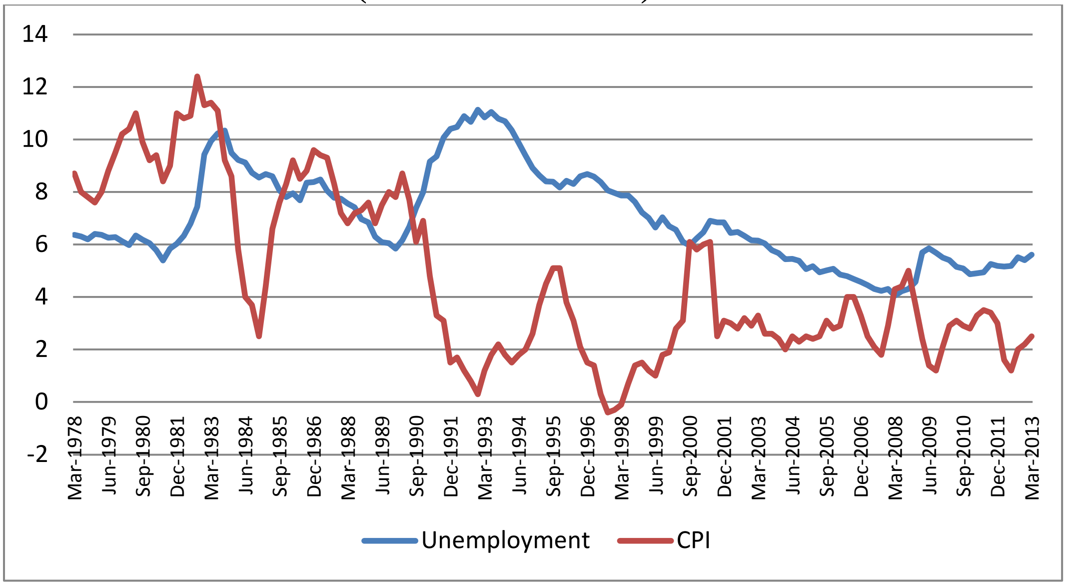
3.2.2 Unemployment and Inflation

Figure 3-2 shows the monthly trend of the unemployment rate and consumer price index (CPI) for the period February 1978 to January 2013. The unemployment rate includes both male and female who are looking for a full time job and shows the unemployment to population ratio.

While the unemployment rate was around 6 percent at the end of the 1970s it increased to over 10 percent by 1983. The unemployment rate then returned to around 6 percent by the end of the 1980s. In the early 1990s the Australian economy experienced an even higher unemployment rate of 11 percent in 1992–93 but returned to 6 percent by the end of this decade. After 2003 the unemployment rate went down further from 6 percent to 4.1 percent in 2008. Following the GFC the rate rose to 5.8 percent. It has since remained under 6 percent. This figure is technically close to the “full employment rate” which is normally about 5 percent natural unemployment (Dickens, 2009). The CPI, as a percentage change from the corresponding quarter of the previous year, is shown in Figure 3-2. The graph for the CPI shows that for most quarters during the recent mining boom, starting from the 2000s, the inflation rate has been mainly within the inflation target of 2 to 3 percent (Australian Bureau of Statistics, 2012). It is arguable that the resource boom made the real exchange rate appreciate which lowered the price level of non-resource imported products into the Australian economy and kept the inflation rate lower than otherwise. Following a mining boom it is expected that the production factors move away from non-resource production towards resource extraction which makes the non-resource sector products more expensive due to higher factor prices for non-tradable products (this would however depend on the importance of resource

movement effect). It appears that the declining pressure on CPI through the latter mechanism has considerably offset the increasing price of non-tradable products. Figure 3-2 reveals that inflation associated with previous mining booms was relatively higher than the recent boom. Beside the contribution of the floating exchange rate in 1983 on this phenomenon it might have an implication on the stronger role of the non-resource trade balance in keeping the inflation rate within the target rate. In other words, the manufacturing sector has declined continuously in Australia due to the cheaper manufacturing imports from China as the number one trading partner of Australia. On the other hand, as the non-tradable sector becomes costly, for example because of higher wage rates, it might explain a negative impact upon the unemployment rate as well. There are signs that the unemployment rate has continuously experienced an increasing rate from around 4 percent in 2008 to around 6 percent in early 2013.

Figure 3-2 Unemployment Rate in Percentage (ABS Cat No. 6202) and Consumer Price Index (CPI) As Percentage Change from Corresponding Quarter of Previous Year (ABS Cat No. 640101) in Australia.

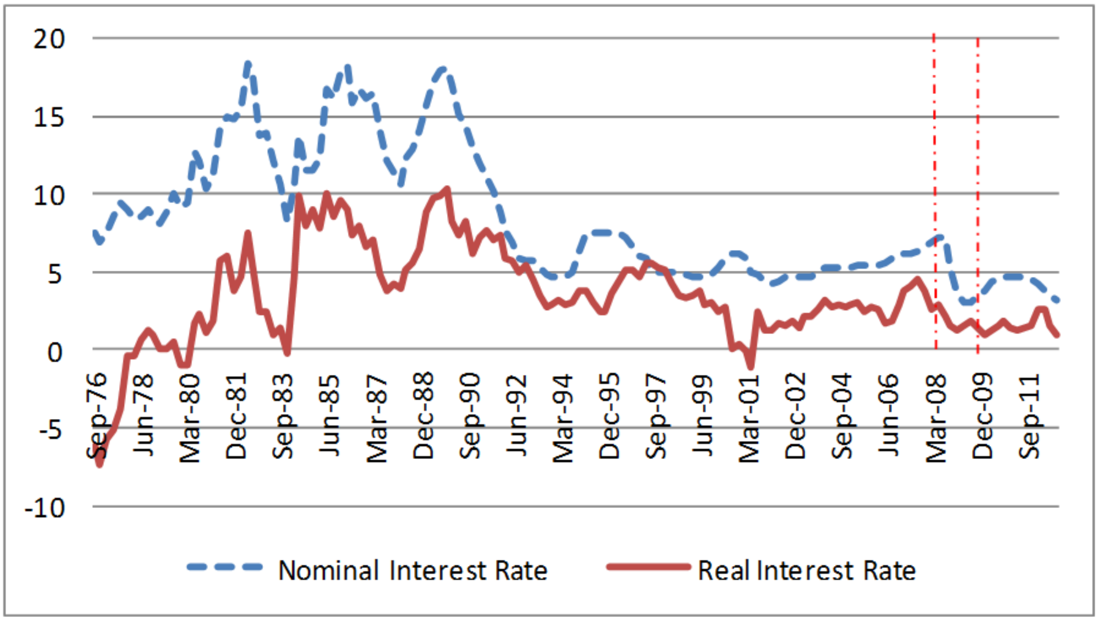


Source: Australian Bureau of Statistics (2012).

3.2.3 Interest Rate

The monthly interest rate for the Australian economy is shown in Figure 3-3. The nominal interest rate (interbank cash rate) in 1990 was relatively high and around 14 percent, later decreasing to around 5 percent in 2011 (Australian Bureau of Statistics, 2012). While the real interest rate was more than 10 percent at the end of 1989, it dropped to 1 percent at the end of 2012. It is reasonable to argue that the low level of the real interest rate has encouraged businesses, especially small and medium sized enterprises (SMEs), which are mostly dependent on start-up loans from the banking system, to invest more and create employment opportunities for Australians.

Figure 3-3 Real and Nominal Interest Rate in Australia



Source: Australian Bureau of Statistics (2012) (dXtime, ABS database, Table F01-1 & Table 6401-04)

The monetary policy adopted by the Reserve Bank of Australia has also been important in helping the economy maintain a reasonable rate of economic growth over time. Most industries were affected by the GFC in 2008–2009 and the RBA tried to adopt an expansionary monetary policy by decreasing the interest rate from

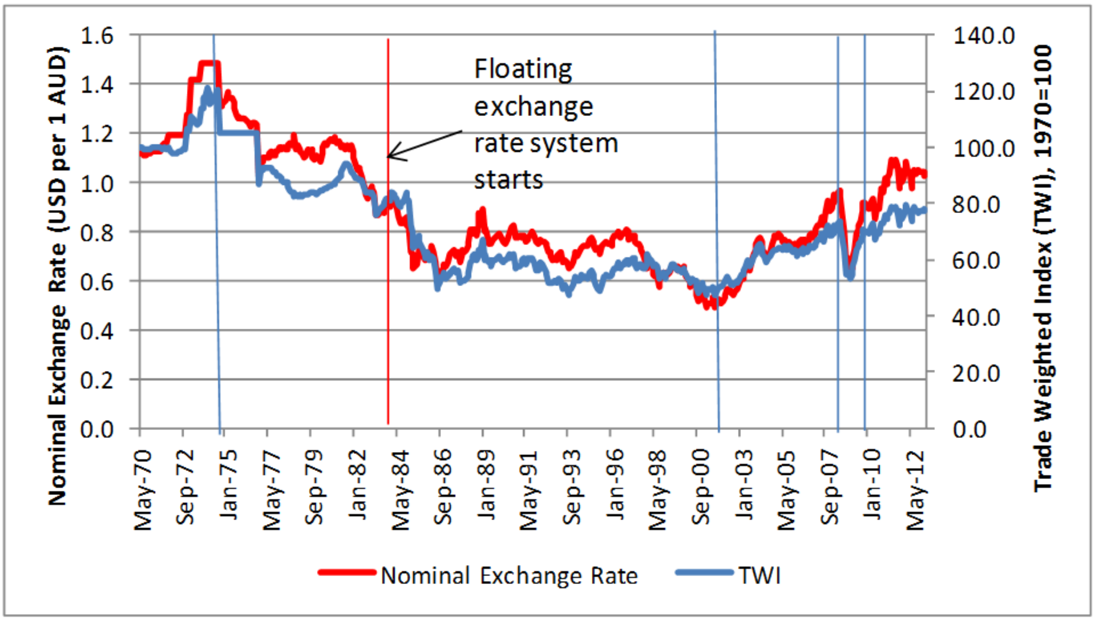
about 7 percent in early 2008 to about 3 percent during 2009 (Australian Bureau of Statistics, 2012). However, fiscal policy has been the more important in maintaining demand, growth and employment immediately after the GFC.

3.2.4 Exchange Rate

Two indices for the Australian nominal exchange rate are shown in Figure 3-4 below. The nominal exchange rate shows the number of US dollars per one Australian dollar. The data shows that the Australian dollar appreciated from 1970 to 1974 and depreciated on average until 2001. It appreciated from 2001 till the beginning of the GFC in mid-2008. It appreciated again from mid-2009 and has been almost above parity from early 2010 till the present.

The second index, which shows almost the same trend for the Australian dollar, is the Trade Weighted Index calculated by the RBA. While the first index only considers the value of the Australian dollar against the US dollar, the TWI consists of a basket of currencies of the major countries that have the highest bilateral trade with the Australia. The base year for this index is 1970 and is equal to 100.

Figure 3-4 Nominal Exchange Rate (Monthly data)



Source: Reserve Bank of Australia (2012).

However, the overall trend of the Australian dollar in both graphs during the last decade shows a currency appreciation, due to increased international demand for Australian export products, mainly resource products, arising from China's construction boom in particular, rising commodity prices and significantly improved terms of trade. Such developments are strongly related to the so called Dutch Disease phenomenon already discussed in Chapter 2.

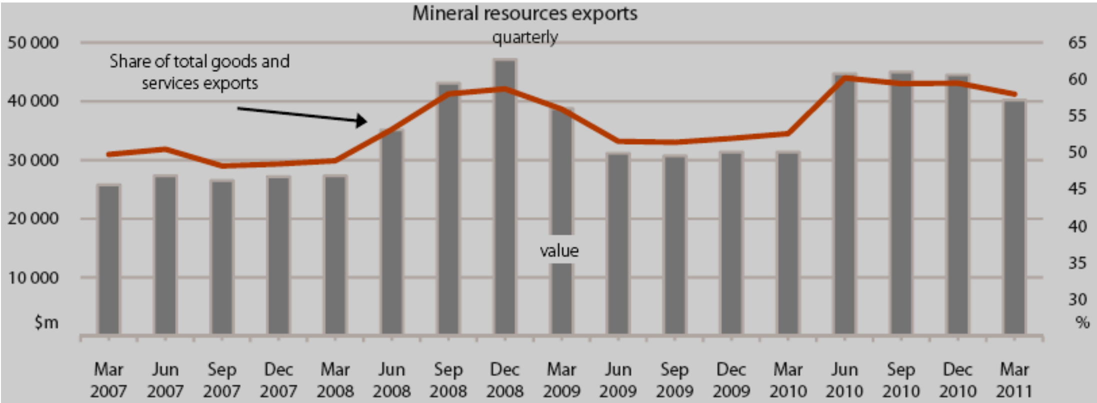
3.3 Natural Resource Production in Australia

The minerals sector is one of the important components of the Australian economy. In 2007–2008, the minerals sector accounted for 11.5 percent of Australia's GDP and 50 percent of total export revenues (Hogan and Mccallum, 2010)[24]. According to the Australian Bureau of Agricultural and Resource Economics (2011), the share of

[24] A "mineral economy" is defined by Auty (1993, p. 3) as an economy where 8 percent of GDP and 40 percent of exports comes from minerals. While this measurement is introduced for a developing country there is no clear definition in the literature for a developed mineral producing country.

mineral resources exports in Australia's total exports reached 60 percent in March 2011, as shown in Figure 3-5:

Figure 3-5 Australian Mineral Resources Exports (quarterly value and share of total exports)



Source: Australian Bureau of Agricultural and Resource Economics and Sciences (2011)

Mining tax reform in Australia has become a major challenge for the Federal Government, the mining industry and the Australian community in general. In addition, these challenges are not consistent for each of the three stakeholders. For instance, there is a clear disparity between the needs of government and major multinational enterprises (MNEs). As shown in Figure 3-5, mineral resource exports account for a significant proportion of the country's exports. Given the economic significance of the sector (11.5 percent of Australia's GDP in 2007–2008), it is critical that the potential impact of policies related to this sector be scrutinized and evaluated before they are implemented.

As the proportion of state governments' revenue, the following can be observed. In Western Australia (WA) the sector accounted for 29.3 percent of state revenues ($3,184 million) in 2008–2009, followed by the Northern Territory, with 21.6

percent ($227 million) and Queensland with 16.7 percent ($3,364 million). These are the most important mining states within Australia. Details of state revenues accounted for by the mining sector can be seen in Table 3-1.

Table 3-1 Governments' Mining Revenue from Different States 2008–09

	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	Total
Mining revenue ($m)	1,278	46	3,364	3,184	152	32	0	227	**8,286**
Mining revenue ($ per capita)	181	8	773	1,444	94	63	0	1,026	**382**
Proportion of State revenue (%)	5.2	0.2	16.7	29.3	2.4	1.9	0	21.6	**9.5**

Note: These revenues comprise royalties levied on mining companies and revenue from selling exploration permits.
Source: Commonwealth Grants Commission (2010)

Coking coal, iron ore, gold, steaming coal, base metals, crude oil, liquefied natural gas (LNG), alumina and aluminium are the major resource exports of Australia (Australian Bureau of Agricultural and Resource Economics and Sciences, 2011). Iron ore and coal in particular are by far the biggest.

Non-renewable natural resource production in Australia includes a broad variety of both mining and energy resources. Table 3–2 provides a summary of the volume and value of selected resources for Australia for the financial year 2011–12 and projections of the Bureau of Resources and Energy Economics (BREE) for 2017–18. Projections indicate a higher percentage annual growth of nominal export values for LNG, Uranium, Thermal coal and Alumina[25] for the calculated period. However,

[25] Please note that in the ABS classification Alumina is classified in manufacturing industry not in the mining industry. The ABS classification of the mining industry is based on the 2006 edition of the Australian and New Zealand Standard Industrial Classification (ANZSIC).

iron ore and coal with $62,695 million and $47,818 million respectively, have the highest nominal value among natural resource exports in 2011–12.

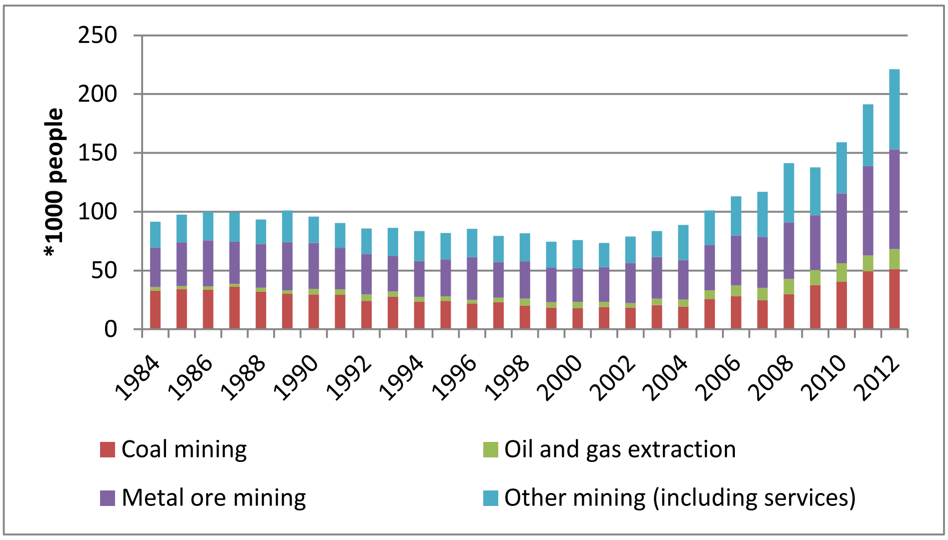
Table 3-2 Australia's Selected Energy and Mining Exports

	Volume				Nominal vlaue			
Commodity	unit	2011–12	2017–18 p	Annual growth %	unit	2011–12	2017–18 p	Annual growth %
Alumina	kt	16 592	20 392	3.7	$m	5 146	7 774	7.4
Aluminium	kt	1 693	1 488	– 2.1	$m	3 797	3 336	– 2.0
Copper	kt	889	1 155	4.5	$m	8 501	11 027	4.6
Gold	t	304 362	362	3	$m	15 462	15 028	– 0.3
Iron ore	Mt	470	821	9.8	$m	62 695	71 054	2.4
Nickel	kt	240	276	2.5	$m	4 056	5 381	5.5
Zinc	kt	1 572	1 586	0.5	$m	2 292	2 967	4.8
LNG	Mt	19	88	31.3	$m	11 949	60 953	33.3
Metallurgical coal	Mt	142	214	7.1	$m	30 700	34 692	3
Thermal coal	Mt	158	304	11.5	$m	17 118	26 770	7.8
Oil	ML	19 212	22 404	3.2	$m	13 205	15 478	3.2
Uranium	t	6 917	10 140	7.4	$m	607	1 050	10.1

P: Bureau of Resources and Energy Economics projections.
Source: Bureau of Resources and Energy Economics (2013)

The natural resource sector is heavily capital intensive (particularly from overseas FDI) with direct employment within the sector being relatively low. Employment in the mining sector is about 2 percent of total employment in Australia (Australian Bureau of Statistics, 2013). Hence, the resource movement effect is not important for Australia. Figure 3-6 shows employment trends in the sector between 1984 and 2012. Figure 3-6 reveals that full time employment in the resource sector was only about 220,000 in 2012, double that of 2006. Metal ore mining and other mining (mainly services) account for the highest share of employment in the sector.

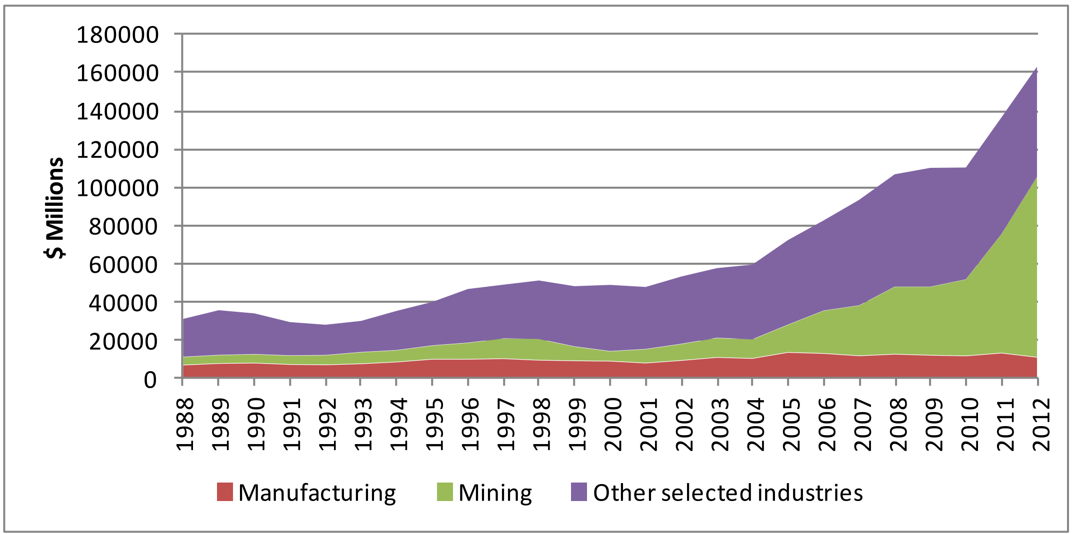
Figure 3-6 Employment in the Resource Sector in Australia (ABS, 6291.0.55.003 Table 06)



Source: Australian Bureau of Statistics (2013)

The mining industry has experienced a huge amount of investment during the last decade, mostly from overseas, compared to manufacturing industry. Figure 3–7 compares new private capital expenditure in mining, manufacturing and other industries over the period 1988–2012. New capital expenditure (annual flow) in the mining industry increased from about $4.9 billion in 2000 to about $94.5 billion in 2012, a sizeable jump for this industry. This was one of the main reasons to keep the Australian dollar strong over the current resource boom.

Figure 3-7 Private New Capital Expenditure in Australia, (ABS, 5625.0, Table 1A)



Source: Australian Bureau of Statistics (2013)

3.4 Resource Boom; a Brief Historical Review and the Current Boom

Increased output and investment in the mining sector and rising commodity prices are among important characteristics of a mining boom in a resource producing economy. This normally happens when there is an increase in the price of the exported natural resource. It could also be a result of major events such as new resource discoveries. From a historical point of view, Australia has experienced major mining booms during the last two centuries. The causes of each mining boom have been different and have happened in different macroeconomic situations, both domestically and internationally.

The first important mining boom in Australia was in the 1850s following the discovery of the first gold mine in New South Wales (NSW) and then in Victoria (VIC), which became known as the Gold rush. This discovery happened when there was high unemployment in the country (Blainey, 1963). Therefore, the main feature of this mining boom was that it was mostly based on the labour force and expanded employment while the role of capital as the production factor was negligible

(Blainey, 1963). This mining boom was very important in the history of Australia. For instance, this sector formed more than 35 percent of GDP in 1852[26] (Butlin, 1985, Table 1, p.2). This discovery encouraged many people to move to the states with the discovered gold mines, particularly Victoria, from other states and overseas. These enormous movements of labour and inflow of migrants tripled the population of Australia over ten years (up to 1.1 million) after the first gold discovery (Maddock and Mclean, 1984). Although the economy experienced Dutch Disease effects, such as a widespread resource movement effect and exchange rate effect, the overall impact on the economy was positive. There was a high demand for goods and services due to the high rate of immigration, increased expenditure on infrastructure such as roads to support the mining industry and GDP growth remained very high for almost a decade after the boom in the early 1850s (Blainey, 1963; Doran, 1984; Maddock and Mclean, 1984). Although the gold discovery provided a big source of income for Government through taxation and selling of mining licenses, because of the large amount of expenditure on infrastructure the Victorian Government was faced with a large budget deficit by 1853 (Doran, 1984).

The second mining boom occurred in the 1890s and for the same reason as the first mining boom. In this instance, there were many new gold and other metals discovered mostly in Western Australia (WA), Queensland and some parts of NSW (Blainey, 1963). The wage rate started to increase because of a general scarcity of labour due to increased demand in the mining sector (Blainey, 1963). The impact on migration was the same as the first mining boom with the population increasing rapidly in states like WA. This mining boom also decreased non-resource exports

[26] "Mining includes only gold mining and other South Australian mining" (Butlin, 1985, p.4).

such as wool and grains (because of the movement of factors of production (mainly labour) from the non-resource sectors to the resource sector)[27] and made the resource sector the leading export sector (Blainey, 1963).

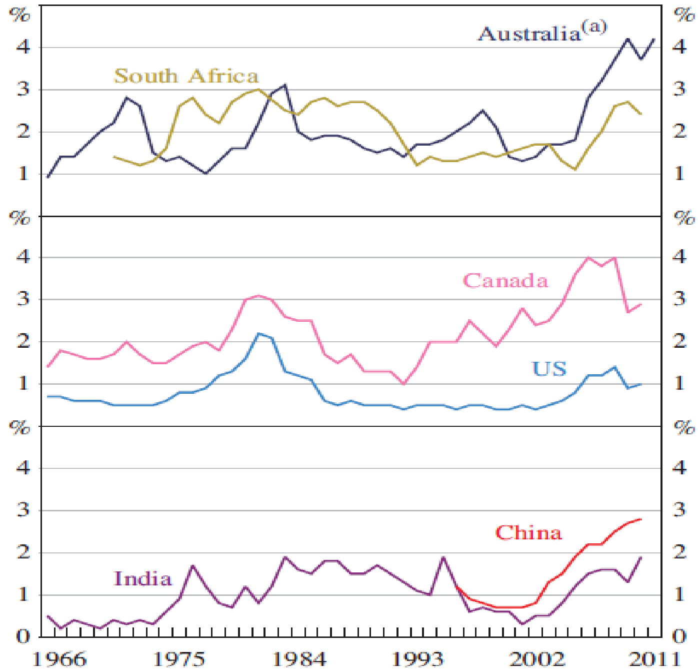
The next mining boom was in the late 1960s and early 1970s, mostly based on discoveries of bauxite and oil and the development of iron ore and coal mines. In contrast to previous booms, this boom was mostly capital intensive. Developments in world capital and financial markets during this period provided the necessary finance to pay for the capital investments in the sector. Increased commodity prices in the early 1970s also contributed to the mining boom (Battellino, 2010). During this period, a crawling peg nominal exchange rate system was in place, consequently most of the impact of the boom was on domestic prices and inflation rather than on the nominal exchange rate (Battellino, 2010).

The fourth mining boom occurred in the late 1970s and early 1980s and mostly because of developments in the energy sector, such as the oil and gas industry, following changes in the global economy such as the oil price shocks of 1973 and 1979, where energy price hikes made this sector more profitable. Therefore, investment in the mining industry increased significantly in 1981–82 due to the increase in oil price. This boom was rather short compared to previous booms, mostly because of the decrease in demand following the oil price shock and the global recession that followed. These changes caused the domestic economy to also go into recession (Battellino, 2010). A summary of the mining booms in the history of Australia is shown in Table 3-3.

[27] Referred to as the resource movement effect (see Corden and Neary, 1982).

High economic growth in some Asian economies such as China during the last decade has significantly increased the demand for mineral products, mainly for iron ore to facilitate the construction boom in China. This created a mining boom for Australia from the mid-2000s. This attracted a large amount of investment, mainly from overseas, to the mining industry and the share of investment in GDP from this industry increased. In Figure 3-8 mining investment as a percentage of nominal GDP is compared for the major mineral producing economies in the world for the period of 1996–2011. This figure indicates that Australia experienced an enormous increase in mining investment during this period. During 2009, mining investment was estimated at 4 percent of its GDP. Canada experienced the same level of investment but, as revealed in Figure 3-8, the increase in investment in Australia was far higher than that for Canada. Moreover, there was a stronger decline in the level of investment in Canada, following the GFC, compared to Australia. The fast growing resource sector in Australia during the GFC was primarily due to the growing demand for Australian commodities in China and India, complemented by a relatively stable economy compared to the other advanced economies, attracted more foreign investors and prevented a decline in investment in the resource sector experienced by other similarly affected economies.

Figure 3-8 Mining Investment (percentage of nominal GDP)

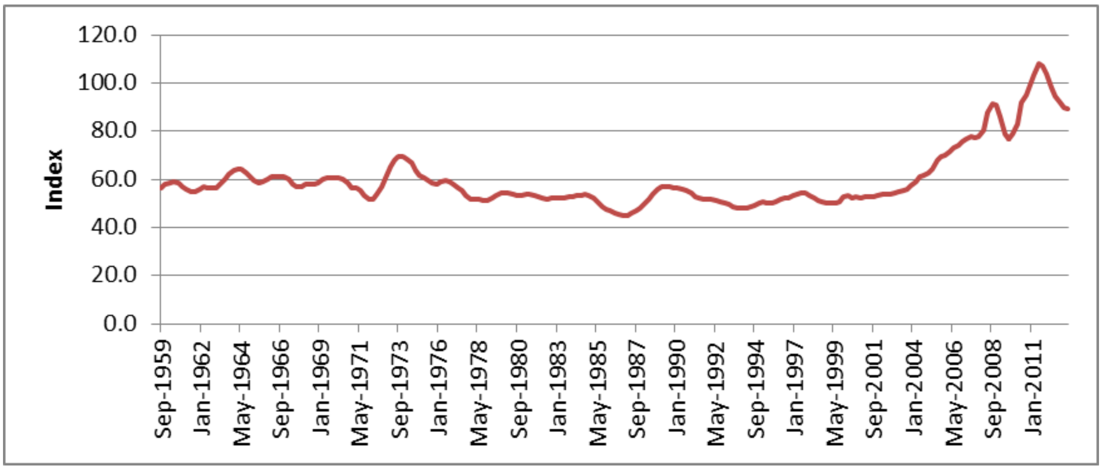


Note: (a) Financial years; 2010/11 estimate based on partial indicators to March 2011
Source: Connolly and Orsmond (2011)

The mining boom in these years has not only been in terms of the volume of exports but also from the increase in the price of mineral products. These resulted in a significant terms of trade effect for Australia. The other key difference in this mining boom compared to that of previous booms was that the exchange rate regime had changed to a floating one which reduced inflationary pressures in the economy and had become the critical variable in transmitting the impact of the resource boom to other non-resource sectors. Another factor that made the recent mining boom different from earlier booms is that investment in the sector as a percentage of GDP was at the highest level in the history of the mining industry in Australia. ABS data shows that investment in this industry reached its highest historical level of about 6.5 percent of GDP in 2012. The mining boom also dramatically improved Australia's terms of trade as shown in Figure 3-9 and was another important and distinct aspect

of this mining boom period and contributed to rising real income and expenditure, property price bubbles and rising household debt.

Figure 3-9 The Terms of Trade (TOT) in Australia, (quarterly data for September 1959– March 2013, ABS 5206, Table 1, December 2010=100)



Source: Australian Bureau of Statistics (2013)

On the other hand the same aspect of all these mining booms is that they all provided considerable revenue for resource producing firms and for the government through resource taxation.

Increased natural resource production during the last decade in Australia has been facilitated by increased exploration expenditure driven by foreign investment. Figure 3-6 shows exploration expenditure on natural resources, including mining and petroleum resources, from Sep 1988 to March 2013 (quarterly data).

Table 3-3 A Summary of Australia's Mining Booms, 1850–2012

	Time period	Major reason	State	Main features
1	1850s	Gold rush	NSW, VIC	Mostly based on the labour force, Mining was 35 percent of GDP in 1852 and triggered, huge migration to Australia
2	1890s	Discovery of gold and other metals	WA, QLD, NSW	Increasing wages because of labour force shortages, increasing migration, decrease in non-resource exports
3	Late 1960s and early 1970s	Discoveries of bauxite and oil	Most of the resource producing states	More capital intensive, increase in resource export prices
4	Late 1970s and early 1980s	Development in oil and gas industries	Most of the resource producing states	Shorter boom compared to the previous boom due to the oil shock and global recession
5	Mid 2000s-2012	Iron ore and coal	Most of the resource producing states	High demand for Australia's iron ore and coal from the Asian developing countries (mainly China), increase in resource prices to historic highs.

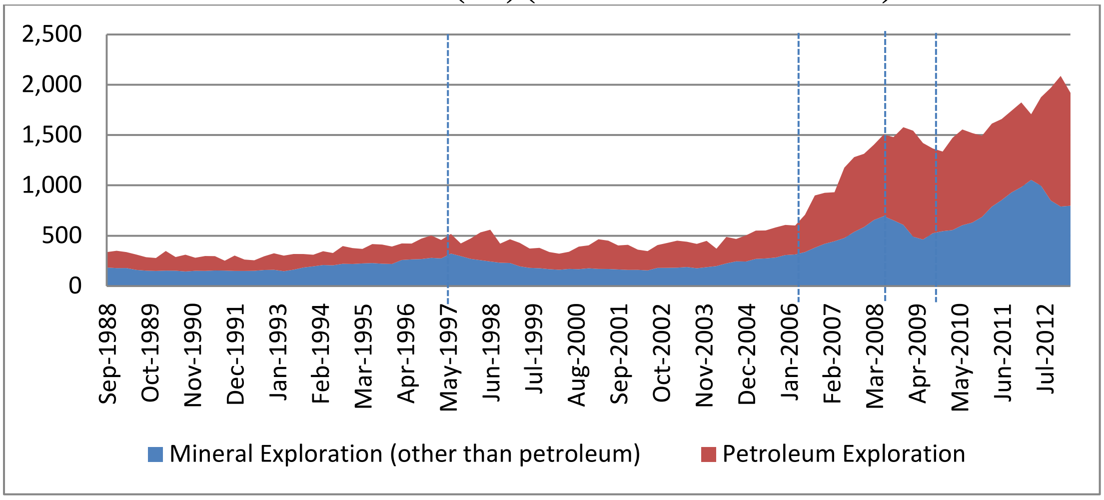
Source: Compiled by the author (see Blainey, 1963; Doran, 1984; Maddock and Mclean, 1984; Butlin, 1985; Battellino, 2010)

Inspection of Figure 3-10 reveals that expenditure on mineral exploration reached around $600 million in 1996–97. Following the 1997–1998 Asian financial crises, which affected some of Australia's important destinations for resource exports, exploration expenditures started to decline until 2001–02 (Hogan *et al.*, 2002). In 2001–02, 60 percent of minerals and 77 percent of energy exports by Australia was to Asia which shows the importance of the Asian economies for Australian resource exports at this time (Penm, 2002). The figures have increased further in recent years (see Figure 3-10).[28] However, this was negatively affected by the GFC during 2008–

[28] China is the largest market for Australian resource exports with a value of more than $83 billion in 2013 (Department of Foreign Affairs and Trade- Australian Government, 2014).

09. Quarterly data from September 1988 to March 2013 shows that exploration expenditure on minerals was about $1 billion in March and on petroleum up to about $1.3 billion in Dec 2012. Overall mineral and petroleum expenditures reached $7.6 billion in 2012 (Australian Bureau of Statistics, 2013).

Figure 3-10 Mineral and Petroleum Exploration Expenditure in Australia September 1988–March 2013 ($m) (ABS- 8412002 & 8412007)



Source: Australian Bureau of Statistics (2013)

It is increasingly recognised that countries with abundant natural resource endowments might suffer from lower economic growth despite generating high revenues from the resource sector (Corden and Neary, 1982). As explained in Chapter 2, this phenomenon is referred to as the resource curse. Some studies argue that it does not necessarily follow that the standard of living declines for this group of countries. For instance, Matsuyama (1992) believes that for countries like Australia and Kuwait, with high levels of resource endowments, there might be a lower level of economic growth at some points but it does not necessarily mean a lower living standard (Matsuyama, 1992, p. 327). The role of fiscal and monetary

policies become important as any inappropriate decision might affect the economy adversely, therefore, the quality of institutions and government policy are critical in this context.

The Australian government has implemented fundamental changes in taxation of natural resources, as part of Australia's Future Tax system, since July 2012. This topic is discussed in the next section. Hart (2010) also emphasizes the potential role of a revenue fund (Sovereign Wealth Fund) as an option besides changes in fiscal policy. The importance of fiscal policy in the context of the Dutch Disease is highlighted in this study.

3.5 Tax Reform in Australia and the Mining Sector

The Australian mining boom in the last few years as well as the dynamics in global economic conditions has led to a remarkable capital inflow to Australia. This has contributed to financing natural resource sector investments and resulted in the Australian Government proposing a new taxation system (the so-called Henry Tax Review). This report was prepared for the Treasury in December 2009 (in two sub-reports) and included all the details about changes in taxation policies in different areas including resource taxes.[29]

One of the proposed changes was to increase tax on the resource sector which caused considerable debate within the mining industry. However, the decision that was made to increase the tax rate for mining companies was based on economic theory

[29] For more information on this please see (Commonwealth of Australia, 2009a; Commonwealth of Australia, 2009b).

discussed in Chapter 2. The taxation of this sector is even more important as it appears that most of the investors in the sector are foreign investors, with a major part of their profit going overseas. In a report prepared for the Greens Party, it was estimated that 83 percent of the mining sector is foreign owned and about $50 billion in profits goes overseas each year in dividend payments (Edwards, 2011). Therefore, if the Government is not actively collecting the massive economic rent in this sector then it is in contrast with the idea of Hartwick (1977). Economic rents imply super profits from the resource sector and this needs to be taken into consideration to benefit the owners of the resources (Australian citizens). According to Hartwick (1977), all rents and profits from the resource sector should be invested in reproducible capital, which also highlights the equity aspect of using natural resources within the economy. The new proposed mining tax was expected to help the Australian Government collect more tax from the mining sector and invest inside the country rather than letting it flow overseas.[30] The Government needs to consider that the returns for the resource sector have to be adequate enough to encourage foreign investors to invest in this sector while ensuring that the owners of the resources obtain a fair return too. However, to consider this the proposed tax was actually replaced with a new resource taxation system or Minerals Resource Rent Tax (MRRT).

Although the first announced tax policy for this sector by the Rudd Government was changed (from a Resource Super Profit Tax at 40 percent to a Minerals Resource

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[30] Another possibility however is to allocate all tax revenue raised from the mining sector to a Sovereign Wealth Fund (SWF) such as that in Norway for the case of oil revenue. The SWF fund can be used for a number of purposes: stabilization policy (demand side), productivity purposes (supply side) and financial investment. A sovereign wealth fund is a government-owned investment fund that invests in both real assets and financial assets.

Rent Tax (MRRT) at 30 percent) by the Gillard Government, the importance of the mining sector in the economy in terms of export returns for the country and revenues for the Government through mining taxation makes it a significant contemporary and future issue.

3.6 Natural Resource Taxation

While natural resources in Australia are owned by the community, one of the most important roles of the Government, as an intermediary between the resource sector and the rest of the economy, is to ensure that taxes are efficiently collected from the high level of rent from the mining sector so as to maximise returns to community assets, while maintaining the competitiveness of the sector and making it attractive for foreign investors. It is also important to have a risk sharing approach to resource taxation and in this case "an optimal tax is likely to be one in which both the government and private [mineral] firms share risk" (Hinchy *et al.*, 1989, p. 2).

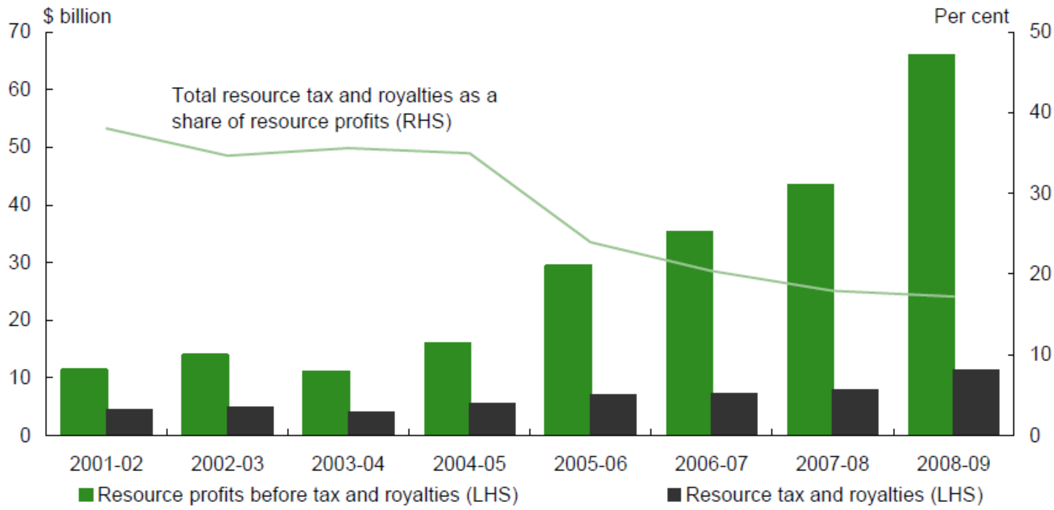
As a reaction to the increase in the resource tax, the Minerals Council of Australia (MCA) has been one of the major sources of opposition against it. They argue that there are many reasons why the resource sector is "a key pillar" in Australia (Minerals Council of Australia, 2010). For example, it accounted for a relatively large part of the economy during the last decade. It contributed over 50 percent of total goods and services exports from 2007 to 2012 and investment in this sector has been growing very fast and reached over 6 percent of GDP in 2012 (Minerals Council of Australia, 2010). It is not important in terms of employment, not even direct employment, but it provides hundreds of thousands of job opportunities indirectly for the community. A high level of investment has increased the potential

for high growth and development for the community. The MCA also believes that a high proportion of exports from the sector have created around half of the country's export revenues during most of the last decade. This industry has already provided considerable revenue for the government through tax payments. Most Australians hold their superannuation or shares in resource sector based firms and most parts of the goods and services used in the resource sector are from domestic production etc. (Minerals Council of Australia, 2010). However, in order to have sustainable development and equity between generations in terms of resource consumption, it is necessary for the Government to implement an optimal taxation policy to collect an adequate amount of the resource rent to meet this objective.

Measurement of the resource rent, which is the justification for resource taxation, is not easy to calculate and an estimated economic rent is often applied as a proxy for that. "Economic rent is the excess profit or supernormal profit earned in the market, and is equal to revenue less costs where costs include normal profit or a 'normal' rate of return to capital (including a risk free component and a risk premium that compensates risk-averse private investors for the risks incurred in the activity). In the mining sector, economic rent is a long term concept that takes into account the costs of exploration, development, production and closure" (Hogan and Mccallum, 2010, p. 16–17). Therefore, it seems that the reasons advanced by the MCA to avoid a higher rate of taxation are not based on a long term analysis but mostly on a short or mid-term time span. This is clearly in contrast with the government's interest which should be taking a long term inter-generational stance.

As shown in Figure 3-11 the share of total resource tax and royalties from resource profits decreased significantly after 2005, while profit from the resource sector has been increasing which suggests that revenues collected by the state or Federal Government from this sector does not experience the same increase. It is necessary, in terms of maintaining inter-generational equity, to revise taxation of this sector (Commonwealth of Australia, 2009a). The issue of investing revenue from resource sector taxation for future generations is also important as these resources will eventually run out, and alternative sources of income generation will have to be put in place.

Figure 3-11 The Share of Resource Tax and Royalties of the Resource Profit



Note: Resource profits before tax and royalties are measured using income less an allowance for corporate capital.
Source: Commonwealth of Australia (2009a, p. 47)

It is important, therefore, for the government to set an optimal resource tax for this sector. Emerson & Lloyd (1983), using a mine production model based on the study of Leland (1978), suggest an optimal resource tax plan for Australia. According to them, it is not feasible to attain a completely optimal resource tax for the Government and their model is not the same as reality due to over-simplified

production aspects or ignoring political constraints. They also argue that it gets more complicated for Australia, specifically because the taxation decision is divided between two authorities (state and commonwealth). Two important resource taxes in Australia are summarised in Table 3-4 below.

Table 3-4 Key features of Australia's two recent major resource taxes

Tax	Key features
Minerals Resource Rent Tax (MRRT)	• The rate was 30 precent and was levied on coal and iron ore production in Australia from 1 July 2012 • Only companies with an annual profit of over $75 million needed to pay MRRT. This was originally $50 million but was increased to support small businesses in this industry. • MRRT was a replacement for the previously proposed Resource Super Profit Tax (RSPT) under the Rudd government. • Over 300 mining firms were potentially affected. • This tax was repealed in 2 September 2014
Extended Petroleum resource rent tax (PRRT)+	• PRRT is applied to all Australian oil and gas production activities both offshore and onshore from 1 July 2012. • The rate is 40 percent and is levied on gas and oil projects and is a profit based tax. • The original version of this tax was first introduced in 1987. • This tax is still operative.

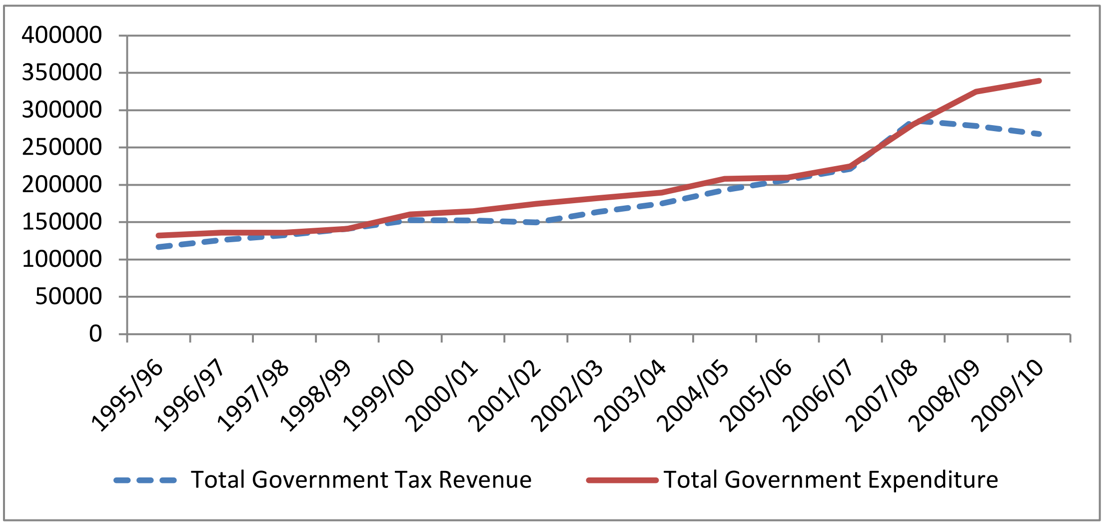
+: There are some more taxes on oil and gas projects such as the Resources Rent Royalty (RRR) and Offshore petroleum royalties. For more information on these please see the sources below.
Sources: Comlaw (2013) and Department of Resource Energy and Tourism (2013).

3.7 Government Expenditure

As can be seen from Figure 3-12 Australian Federal Government expenditure has increased and has been greater than Federal Government tax revenues since 2007–2008 (Australian Bureau of Statistics, 2012). The need for tax reform has become more vital for the Government in order to maintain economic growth as well as having a better budget balance. Especially as MRRT was repealed in September 2014 it is necessary to fully implement the Henry Tax Review recommendations to

construct a more efficient replacement. The resource boom of the last decade has made it very important for the Government to take this opportunity and develop the required capacity to collect the rent created in the resource sector to diversify the economic base and decrease Dutch Disease effects. It is important for the Government to spend the resource revenue in a way that ensures that it includes the concept of the Hartwick rule which says “invest all profits or rents from exhaustible resources in reproducible capital” (Hartwick, 1977, p. 972). However, with increasing pressure on Government to spend more on social services in the future (especially with the aging population) it might be difficult for the Government to isolate the resource tax revenue form the general tax revenue as the theory suggests. This is likely to require tax reforms in other ways and not just those in the resource sector.

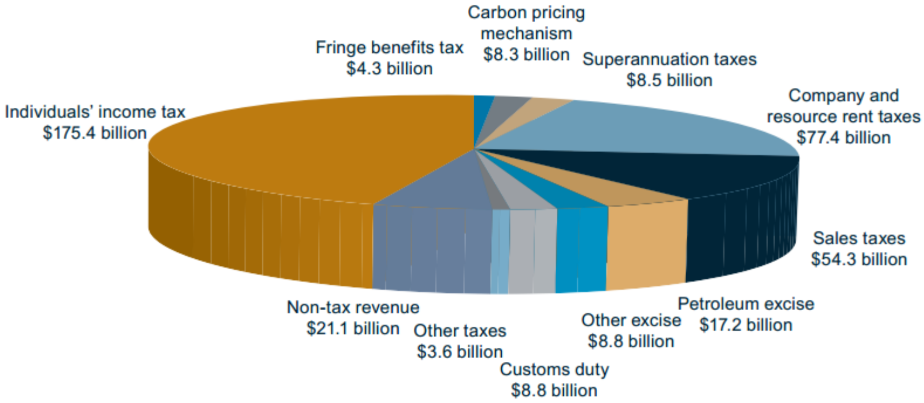
Figure 3-12 Total Federal Government Tax Revenue and Expenditure



Source: Australian Bureau of Statistics (2012)

In the commonwealth budget for 2013-14 expected government revenue is $387.7 billion and expected expenditure $398.3 billion (Australian Commonwealth Budget, 2013). As shown in Figure 3-13, the major component of the Government's revenue comes from individual's income tax ($175 billion). The second major source of revenue is the company and resource tax ($77.4 billion).[31]

Figure 3-13 Expected Commonwealth Government Revenue 2013–14



Source: Australian Commonwealth Budget (Budget overview, Appendix G, 2013)

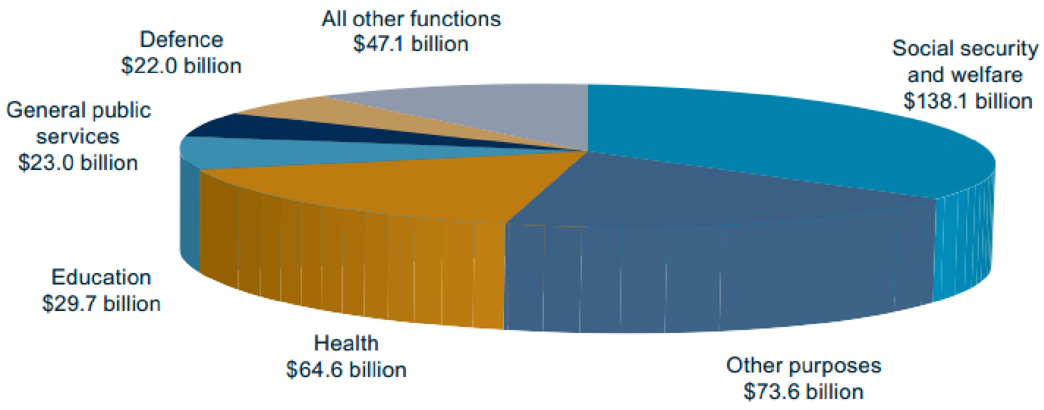
The money collected from taxpayers from all sectors is planned to be mainly spent on social security and welfare, health, education and other purposes (see Figure 3-14). However, as there is no specific fund for the revenues from the resource sector, as is the case in Norway, for example, it is not clear what the tax collected from the resource sector is going to be spent on, since this is included in general government revenue.[32] The Gillard Government, however, announced that schooling, superannuation and infrastructure were among the areas that revenue generated by

[31] It is worth mentioning that the budget outcome shows that the deficit is higher than expected ($48.5 billion) mainly due to the lower level of revenue following the fall in commodity prices.

[32] This fact clearly highlights the importance of establishing a Sovereign Wealth Fund for the Australian economy to make sure that all the revenue from this sector is spent on productive expenditures. This is a major recommendation from this study.

MRRT would benefit them (Comlaw, 2013)[33]. In the model developed in Chapter 4, it is assumed that the tax collected from the resource sector is going to be spent mainly on infrastructure and all items that increase the country's human capital aimed at enhancing productivity and potential GDP. The model also allows the government to disburse all collected funds from the resource sector on consumption expenditure and investment expenditure.

Figure 3-14 Expected Commonwealth Government Spending 2013–14



Source: Australian Commonwealth Budget (Budget overview, Appendix G, 2013)

3.8 Resource Boom Transmission Channels in Australia

The resource movement effect and spending effect were highlighted in Chapter 2 as being among the main channels through which a resource boom affects the economy (Corden and Neary, 1982; Cox and Harvie, 2010). The resource movement effect deals with the movement of production factors between the resource and non-resource sectors in a resource boom period. Production factors such as labour may be absorbed by the resource sector which leaves the non-resource sector in a difficult position as the shortage in labour market increases the wage rate and therefore

[33] However, MRRT was repealed by the Abbot Government in 2 September 2014.

production cost and this triggers loosing competition for the non-resource producers competing with producers overseas. Labour and capital are normally considered as the main production factors. As the labour market in Australia discussed earlier in this chapter, only 2 percent of the employment in Australia is in mining industry (Australian Bureau of Statistics, 2013) and the capital is mainly provided by international investors not domestic sources, therefore a major reallocation of production factor has not taken place in Australia and the *resource movement effect* is not important for this economy and other channels including the spending effect, income effect, exchange rate effect, current account effect and wealth effect are more appropriate in order to elaborate the resource boom in Australia. This is considered in scaffolding the theoretical model of this study in Chapter 4 by assuming that the resource sector is only capital intensive and on the other hand government expenditure helps the non-resource sector, for instance, by productivity-enhancing investments on infrastructure and human capital.

In addition, more government expenditure due to the higher revenue from the resource sector, in the form of a higher resource tax for instance, creates another channel in which the economy gets influenced by a resource boom (a taxation induced government *spending effect*). The Federal Government also introduced a new resource tax known as the Minerals Resource Rent Tax (MRRT) in 2012 and this believed to increase the income for the government to satisfy high government expenditure but then repealed by the Abbot Government in September 2014 due to generating a very low level of income. This shows that the resource tax should be restructured to be made more effective in collecting economic rent from the resource sector. On the other hand, higher capital expenditure by the government on

infrastructure and human capital increases the demand for non-resource products and consequently a higher price level and also appreciating of the exchange rate. The increase in government expenditure following the current resource boom is shown in Figure 3-8 based on data from the Australian Bureau of Statistics (2012).

The impact on the exchange rate is not only from the domestic demand side, as the appreciation of the exchange rate is also triggered by higher foreign demand for Australian natural resource exports as well. This is known as the *exchange rate effect* of a resource boom. The nominal exchange rate experienced a 40 percent increase during the recent resource boom in Australia (Reserve Bank of Australia, 2012) which exerted a considerable impact upon the economy and makes it important to be covered in the model of this study. The resource boom also increases private sector wealth (private assets) and this influences private sector consumption as well, which is associated with the spending effect and is included in the private consumption equation in the model of this study as well.

As mentioned earlier 50 percent of total exports and also 11.5 percent of Australia's GDP has been associated with the resource sector in 2007–2008 (Hogan and Mccallum, 2010). The larger quantity of exports due to the resource boom has a considerable impact upon the current account balance, known as the *trade effect* (current account effect) of resource boom (see Harvie, 1989) and on the other hand the resource boom has a substantial direct and indirect impact upon the real income in Australia which is known as the *income effect.* For these reasons resource exports are included in the current account equation and the resource sector is included in the real income equation of the theoretical model of this study.

3.9 Summary

The purpose of this chapter has been to provide an overview of the key developments in the Australian economy that relate to the aim of this study. The chapter highlighted the main macroeconomic variables which are to be used in developing the hybrid macroeconomic model used in this study in the next chapter. The chapter also provided a historical review of the resource booms in Australia and their changing character, future taxation strategy, resource taxation and government expenditure. The key channels in which the economy is affected by a resource boom and a discussion of these effects in the context of the Australian economy was conducted in the last section of this chapter, which also highlighted some of the key features and characteristics of the macroeconomic model to be developed in the next chapter.

CHAPTER 4

THEORETICAL MODEL AND MACROECONOMIC FRAMEWORK

4.1 Introduction

This chapter describes and develops a hybrid-macroeconomic model which this study relies on to analyse the role of resource taxation and its impact on key macroeconomic variables in a representative model of the Australian economy. The model is an extension of the Cox and Harvie (2010) model referred to in Chapter 2. This model is designed for a small open natural resource producing and exporting economy in which the spending effects from resource production predominates. The model highlights the role of government as the major owner of natural resources, and main recipient of resource rents. Consequently, analyses of the impact of changes in the resource sector on the macro-economy will be strongly linked to government and its policy responses as highlighted in Chapter 3.

Worth noting is that the Cox and Harvie (2010) model is developed for an advanced economy with sophisticated financial markets and a flexible exchange rate system. The economy under consideration in this study has similar characteristics. It is thus reasonable to use this model as a starting point. Extensions to the Cox and Harvie (2010) model described in this chapter allows us to analyse the impact of shocks and policy changes with a focus on the resource sector (resource price shock and resource tax).

This chapter is structured as follows. In Section 4.2 the theoretical background on the modelling approach based on the literature review in Chapter 2 is provided which

creates the modelling framework. A brief review of the model applied in Cox and Harvie (2010) and the extensions to this model in the current study is explained in Sections 4.3 and 4.4 respectively. The Model and its equations are presented in Section 5 and are explained in Section 4.5.1 to 4.5.6. Finally, a summary of this chapter is presented in Section 4.6.

4.2 Theoretical Background of the Modelling Approach

Resource booms and their effect on the economy have been a subject of interest in the literature since the 1980s following the experience of what has come to be known as the Dutch Disease (Corden and Neary, 1982; Corden, 1984). As explained in Chapter 2 the Dutch Disease refers to the adverse impact of resource booms on non-resource sectors such as manufacturing[34]. Ali and Harvie (2013) highlight some of the channels through which the effects of resource booms can be transmitted through the economy in the short-run. According to Ali and Harvie (2013), the effect of resource booms on the economy can be transmitted through the *resource movement effect* (also see Corden (1984). Other transmission channels include *revenue effect, spending (wealth) effect, exchange rate effect* and *current account effect* (see Eastwood and Venables, 1982; Buiter and Purvis, 1983; Harvie, 1989; Ali and Harvie, 2013).

Harvie (1989), whose model is an extension of Buiter and Purvis (1983) captures long-run effects of resource booms by incorporating the current account in his model

[34] The high revenue gained through exporting natural resources may also create political conflicts and crises by motivating the rent seeking behaviour of investors and government officials especially in developing countries with lower institutional development. This will often lead to corruption, resource allocation inefficiency and failure of economic policies in most cases (see for example Bannon and Collier, 2003; North *et al.*, 2006).

economy (based on Branson, 1979; Branson and Halttunen, 1979). By allowing for analyses of long-run effects of resource booms on the economy, the Harvie (1989) model permits assessment of the impact of resource booms on the economy and the optimal policy responses to effectively address possible adverse effects of resource booms. A number of studies have used this model as a starting point to analyse the long-run effects of resource booms in different contexts (see for example Harvie, 1991; Harvie, 1993; Harvie and Gower, 1993; Harvie and Thaha, 1994; Harvie and Van Hoa, 1994).

Another contribution to this literature has been the dynamic long-run macroeconomic model developed by Cox and Harvie (2010), which permits analyses of macroeconomic adjustments arising from a positive resource price shock and various policy responses by the government for a developed resource-exporting economy. However, while resource exports are treated endogenously in the Cox and Harvie (2010) model, resource production is treated as exogenous.

Although this study relies on the Cox and Harvie (2010) model as a starting point, an important departure of the study from the model is its endogenous treatment of resource production. It is the view of the researcher that treating the resource sector as exogenous does not sufficiently reflect the impact of resource taxes on the sector itself and the rest of the economy. Treatment of the resource sector as endogenous represents an important contribution of this study. The study relies on some features of micro-founded models such as DSGE models as well. Consumer behaviour, resource producing firms' behaviour and the Taylor rule monetary policy equation for the interest rate constitute major extended components of the model.

Section 4.3 provides a brief description of the Cox and Harvie (2010) model. A description of this study's extension to this model is then described in Section 4.4.

4.3 A Brief Review of the Cox-Harvie Model

As mentioned before, Cox and Harvie (2010) describe a long-run dynamic model for an advanced resource-exporting economy that facilitates assessment of optimal policy responses by the government to resource price shocks. The model's equations are presented in four main blocks, including, product market, asset markets, aggregate supply and wage/price nexus and also the overseas or external sector as shown in Table 4-1.

Table 4-1 Cox-Harvie Model[35]

Product market
1) $No^d = \alpha_1 c^p + \alpha_2 ci^p + \alpha_3 g + \alpha_4 T$
2) $c^p = c_1 No^s + c_2 w^p$
3) $i^p = \eta q$
4) $\dot{k}^p = \eta q$
5) $c^g = \bar{c}^g$
6) $i^g = \varphi(k^{g^*} - k^g)$
7) $\dot{k}^g = \varphi(k^{g^*} - k^g)$
8) $g = \mathrm{B}_1 c^g - \mathrm{B}_2 No^s + \mathrm{B}_3 i^g$
9) $g - t^x = \mathrm{X}_1(\dot{m} - \dot{p}) + \mathrm{X}_2(\dot{b} - \dot{p})$
10) $t^x = \gamma No^s + (1 - \gamma)(o^a + pres + e - p)$
11) $T = \lambda_1(e + p^* - p) - \lambda_2 y + \lambda_3 y^*$
12) $y = \nu No^s + (1 - \nu)o^a + (1 - \nu - \mu_2)pres + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^*$
13) $y^p = \nu No^{sp} + (1 - \nu)o^p + (1 - \nu - \mu_2)pres + (\mu_1 - \nu)(e - w) - (1 - \mu_1 - \mu_2)p^*$
Asset markets
14) $m - p = \sigma_1 y - \sigma_2 r$
15) $R = \theta_1 No^s - \theta_2 k^p + \theta_3 k^g$
16) $\dot{q} = \delta_3^{-1}[q - \delta_1 R + \delta_2(r - \dot{m})]$

[35] The same notations as in Cox and Harvie (2010) are applied here.

17) $w^p = \Omega_1(f + e - p) + \Omega_2(k^p + q) + \Omega_3(m - p) + \Omega_4(b - p) + \Omega_5 y^p$

18) $\dot{m} = \varsigma(\overline{m} - m)$

Aggregate supply and wage/price nexus

19) $p = \mu_1 w + \mu_2(e + pres) + (1 - \mu_1 - \mu_2)(e + p^*)$

20) $\dot{w} = \psi_1(No^d - No^s) + \psi_2 \dot{m}$

21) $No^s = \phi_1 k^p + \phi_2 k^g - \phi_3(w - p)$

Overseas sector

22) $\dot{f} = \varepsilon_1 T + \varepsilon_2 r^* f + \varepsilon_3(O^{ne} + pres) - (1 - \varepsilon_2 - \varepsilon_3)(e - p)$

23) $O^{ne} = \tau(o^a - y)$

Definitions

$c = e - w$ $\quad$ $B = b - w$

$l = m - w$ $\quad$ $\dot{e} = r - \dot{r}$

Source: Cox and Harvie (2010, p. 470)

The model is based on the assumption of rational or forward looking expectations. While financial markets are assumed to clear immediately, prices are assumed to be sticky in non-financial markets. The asset markets comprise four financial assets, namely, money, domestic bonds, foreign bonds and equities. Domestic bonds, foreign bonds and equities are assumed to be perfect substitutes. In the long-run steady state, capital stock accumulation ceases and the fiscal budget and current account must be in balance otherwise wealth will continually accumulate and the model will not attain a steady state. Government consumption expenditure is assumed to be exogenous and so is resource production, while resource exports are assumed to be endogenous. This means that any external or domestic shock to the economy does not have any impact on resource production. As highlighted earlier, this model is used as a starting point in this study. An extension of the model, on which this study relies, is described in the next section.

Table 4-2 Explanation of Symbols in Cox-Harvie Model

Endogenous variables	
No^d Aggregate demand for non-resource output	T Trade balance
No^s Aggregate supply of non-resource output	O^{ne} Net resource exports
c^g Government consumption spending	p Domestic price level
c^p Private consumption	q Tobin's q
i^g Government investment spending	i^p Private investment
k^g Actual public capital stock	k^p Private capital stock
g Total government expenditure	t^x Total tax revenue
w^p Real private sector wealth	f Foreign asset stocks
w Domestic nominal wage	R Real profit
b Nominal domestic bonds	B Real domestic bonds
e Nominal exchange rate	c Real exchange rate
r Domestic nominal interest rate	l Real money balance
y^p Permanent real income	m Nominal money supply
y Real income	
Exogenous variables	
$\bar{c}^g$ Desired government consumption expenditure	k^{g^*} Desired public capital stock
No^{sp} Permanent non-resource income	o^a Resource production
O^p Permanent resource income	$pres$ Resource price
$\bar{m}$ Policy determined money stock	p^* World price level
r^* World nominal interest rate	y^* World real income

Source: Cox and Harvie (2010, p. 470)

4.4 Extension of the Cox-Harvie Model

As noted in the introductory section, this study extends the Cox-Harvie model to incorporate aspects that permit analyses of the impact of resource price shocks and resource taxes on key macroeconomic variables in the Australian economy. This section describes this study's extension of the Cox-Harvie model.

1. The first aspect, as identified in the literature review chapter, is the treatment of natural resource production as endogenous. While the Cox and Harvie (2010) model assumes that resource production is exogenous (o^a in Equation 23), this study treats natural resource production as endogenous. An endogenous resource production sector is considered a more realistic assumption for developed economies such as Australia for a number of reasons. First, the majority of investment in the sector is from international private investors. This highlights the importance of profits for

them and that any policy changes in the economy, including fiscal and monetary policy, may change resource production and profitability.

Second, while the resource price is considered to be exogenous, any change in the resource price not only changes the profit level but future resource sector investment and production. Third, the increasing foreign demand for Australian resource products, mostly from the fast growing emerging economies of Asia, such as China and India, is a key factor for the recent *resource boom* in Australia. Therefore, to sufficiently capture the reaction of the resource sector to the recent resource boom and changes in average world GDP, it is necessary to treat the resource sector as endogenous.

Fourth, the resource sector is not only sensitive to external foreign changes, but also to domestic policies. As the Government also needs to provide inter-generational equity in terms of consuming the exhaustible natural resources, it may change resource tax policies which may impact on costs and profits relating to resource production. To capture the reaction of the resource sector to government taxation policies, it is essential to treat the resource sector as endogenous. This becomes more important as resource production is subject to economic rent and the role of an optimum resource tax is to collect this rent. Therefore, dynamic resource production which reacts to all foreign and domestic shocks and policies makes the performance of the model in explaining the resource sector's reaction closer to reality compared to that of the Cox and Harvie (2010) model.

Fifth, beside the foreign and domestic reasons that might change resource production, decisions by resource companies may also change the production level. For instance, if a resource company decides to spend more on resource exploration then this would increase future resource production. Therefore, besides the external factors explained above, resource exploration cost is included in the resource production equation as an internal factor, which highlights the importance of treating the sector as endogenous in the model.

2. Private capital stock is decomposed into resource and non-resource capital stock (Equation 4 in Cox-Harvie model needs to be amended). This makes the model capable of identifying capital which is allocated to the resource and non-resource sector, which shows the available options for the private sector. As explained previously, any shock or policy which affects the resource sector may change investor's behaviour based on the profitability of this sector. This decomposition assists in tracking the impact of the resource movement effect involving capital flows.

3. Private consumption in this model becomes dynamic, that is a function of consumption expectations relating to the next period (Equation 2 in Cox-Harvie model needs to be amended). Consumers are thus assumed not to make big changes to their consumption level in the current period without considering the level of consumption in the next period (consumption expectation). Moreover, the consumption decision depends on the interest rate and also inflation expectations as well.

4. The interest rate is introduced in the model as a Taylor rule type of equation. This enables the model to incorporate the dynamics of the components involved in determining the interest rate.

5. While the Government could invest in different areas such as health, education, infrastructure and so on (aimed at enhancing productivity on the supply side); in this model it is assumed that government investment is only focused in two areas, - human capital and infrastructure. To make the model closer to reality, therefore, government investment in the original model of Cox and Harvie (2010) is decomposed into human capital and infrastructure investment (Equation 6 in Cox-Harvie model needs to be amended). With this extension it is reasonable to argue that higher investment in infrastructure by the Government is likely to increase productivity and real profit in both the resource and non-resource sectors (Aschauer, 1989b; Aschauer, 1989a).[36]

6. Government's consumption expenditure is not exogenous at a desired level (Equation 5 in Cox-Harvie model), but depends on government's revenues from the resource and non-resource sectors. This extension captures the fact that domestic and international exogenous changes (particularly in relation to the resource sector) could change the level of government consumption spending due to higher than anticipated revenues. This is also more interesting as government revenue from the resource and non-resource sector might change based on some other policies such as the resource tax.

[36] It is implicitly assumed here that it is relatively costless for the government to verify whether an investment in infrastructure and human capital is productive. In reality, however, the government may need to spend on a comprehensive cost-benefit analysis to identify productive investments among others.

7. While the government's total tax revenue is from the resource and non-resource sector, as in the Cox and Harvie (2010) model, the assumption that any change in the resource tax does not have any impact upon resource production is no longer available, as the resource tax is considered to affect resource production in the endogenised resource sector of the model. In fact the resource producer companies consider the tax as a production cost which affects the profit and the amount of resource production.

While these are the main extensions to the model of Cox and Harvie (2010), some other details such as including wage expectations in the labour market (Equation 20 in Cox-Harvie model to be amended) because expectations about the wage rate in the future from the labour side is one of the factors which affects the wage rate and this is explained in the next section.

4.5 The Model

The extended version of the Cox and Harvie (2010) model based on including the above changes is now discussed in this section. The equations are summarised in Table 4-3 and explanation of the symbols applied in the model is provided in Table 4-4. The equations are further explained under a number of categories including product market, asset markets, wage/price nexus, aggregate supply, monetary policy and overseas sector.

Table 4-3 Macroeconomic Model Equations

$No_t^d = \theta_1 c_t^p + \theta_2 I_t^{pno} + \theta_3 g_t + \theta_4 T_t$	(4.1)
$c_t^p = \alpha_1 c_{t+1}^p - \alpha_2(r_t - \pi_{t+1}) + \alpha_3 PA_t$	(4.2)
$\dot{k}_t^{pno} = \eta_1 q_t^{no}$	(4.3)
$\dot{k}_t^{po} = \eta_2 q_t^o$	(4.4)
$I_t^i = \dot{k}_t^i = \zeta_1(\ddot{k}_t^i - k_t^i)$	(4.5)
$I_t^h = \dot{k}_t^h = \zeta_2(\ddot{k}_t^h - k_t^h)$	(4.6)
$\ddot{k}_t^i = \gamma_1(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t)$	(4.7)
$\ddot{k}_t^h = \gamma_2(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t)$	(4.8)
$I_t^{pno} = \dot{k}_t^{pno}$	(4.9)
$g_t = \beta_1 c_t^g + \beta_2 I_t^i + \beta_3 I_t^h$	(4.10)
$c_t^g = \lambda No_t^s + (1 - \gamma_1 - \gamma_2)(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t)$	(4.11)
$tx_t = \lambda No_t^s + (1 - \lambda)(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t)$	(4.12)
$g_t - tx_t = \delta_1(\dot{m}_t - \pi_t) + \delta_2(\dot{b}_t - \pi_t)$	(4.13)
$T_t = \mu_1(x_t + \widehat{p_t^*} - p_t) - \mu_2 y_t + \mu_3 \widehat{y_t^*}$	(4.14)
$y_t = \varepsilon No_t^s + (1-\varepsilon) o_t^u + (1 - \varepsilon - \Omega_2)\widehat{pres}_t + (\Omega_1 - \varepsilon)(x_t - w_t)$ $-(1 - \Omega_1 - \Omega_2)\widehat{p_t^*}$	(4.15)
$y_t^p = \varepsilon No_t^{sp} + (1-\varepsilon) o_t^p + (1 - \varepsilon - \Omega_2)\widehat{pres}_t + (\Omega_1 - \varepsilon)(x_t - w_t)$ $-(1 - \Omega_1 - \Omega_2)\widehat{p_t^*}$	(4.16)
$m_t - p_t = \varphi_1 y_t - \varphi_2 r_t$	(4.17)
$R_t^{no} = \rho_1 No_t^s - \rho_2 k_t^{pno} + \rho_3 k_t^i + \rho_4 k_t^h$	(4.18)
$R_t^o = \sigma_1(o_t^u + pres_t + x_t - p_t) - \sigma_2 k_t^{po} + \sigma_3 k_t^i$	(4.19)
$\dot{q}_{t+1}^{no} = \chi_3^{-1}[q_t^{no} - \chi_1 R_t^{no} + \chi_2(r_t - \dot{m}_t)]$	(4.20)
$\dot{q}_{t+1}^o = \Phi_3^{-1}[q_t^o - \Phi_1 R_t^o + \Phi_2(r_t - \dot{m}_t)]$	(4.21)
$PA_t = \nu_1(f_t + x_t - p_t) + \nu_2(k_t^{pno} + q_t^{no}) + \nu_3(m_t - p_t) + \nu_4(b_t - p_t) + \nu_5 y_t^p +$ $\nu_6(k_t^{po} + q_t^o)$	(4.22)
$p_t = \Omega_1 w_t + \Omega_2(x_t + \widehat{pres}_t) + (1 - \Omega_1 - \Omega_2)(x_t + \widehat{p_t^*})$	(4.23)
$\dot{w}_t = \xi_1(No_t^d - No_t^s) + \xi_2 \widehat{\dot{p}_t^{targ}} + (1 - \xi_2)[w_{t+1} - w_t]$	(4.24)
$No_t^s = \Psi_1 k_t^{pno} + \Psi_2 k_t^i + \Psi_3 k_t^h - \Psi_4(w_t - p_t)$	(4.25)

$$No_t^{sp} = No_{t-1}^{sp} + \Theta_1(No_t^s - No_t^{sp}) \quad (4.26)$$

$$o_t^u = \Lambda_1 k_t^{po} + \Lambda_2 \widehat{ec}_t + \Lambda_3 \widehat{pres}_t + \Lambda_4 \widehat{y_t^*} - \Lambda_5(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t) \quad (4.27)$$

$$o_t^p = o_{t-1}^p + \Theta_2(o_t^u - o_t^p) \quad (4.28)$$

$$r_t = \Gamma_1 r_{t-1} + (1-\Gamma_1)\left[\Gamma_2\left(\pi_t - \widehat{\dot{p}_t^{targ}}\right) + \Gamma_3\left(y_t - y_t^p\right)\right] + \widehat{ers} \quad (4.29)$$

$$\dot{f}_t = \psi_1 T_t + \psi_2\left(\widehat{r_t^*} f_t\right) + \psi_3(o_t^e + \widehat{pres}_t) - (1 - \psi_2 - \psi_3)(x_t - p_t) \quad (4.30)$$

$$o_t^e = \mathrm{Z}(o_t^u - y_t) \quad (4.31)$$

$$pres_t = \mathrm{K}\, pres_{t-1} + \widehat{\mathrm{H}}_t \quad (4.32)$$

$$x_{t+1} = x_t - r_t + \widehat{r_t^*} \quad (4.33)$$

$$re_t = r_t - \pi_t \quad (4.34)$$

$$\pi_t = p_t - p_{t-1} \quad (4.35)$$

A dot (˙) over a variable indicates the rate of change of that variable.
A double dot (¨) over the variable shows the desired level of that variable.
A star (*) over the variable shows the world value of that variable.
A hat (⌒) over the variable shows that the variable is exogenous.

Table 4-4 Explanation of the symbols

Symbol	Variable
No_t^d	Aggregate demand for non-resource output
c_t^p	Private consumption
I_t^{pno}	Private non-resource investment
g_t	Government expenditure
T_t	Trade balance
r_t	Domestic nominal interest rate
π_t	Inflation rate
PA	Private asset stock (real private wealth)
k_t^{pno}	Private non-resource capital stock
k_t^{po}	Private resource capital stock
q_t^{no}	Non-resource Tobin's *q*
q_t^o	Resource Tobin's *q*
I_t^i	Infrastructure investment
I_t^h	Human capital investment
k_t^i	Infrastructure capital stock
k_t^h	Human capital stock
o_t^u	Resource production
$\widehat{pres}_t$	Resource price
x_t	Nominal exchange rate
p_t	Domestic price level
$\widehat{RT}_t$	Resource tax
c_t^g	Government consumption expenditure

tx_t	Total tax revenue
m_t	Nominal money supply
b_t	Nominal domestic bonds
No_t^s	Aggregate supply of non-resource output
$\widehat{p_t^*}$	World price level
y_t	Real income
$\widehat{y_t^*}$	World real income
w_t	Nominal wage
y_t^p	Permanent real income
No_t^{sp}	Permanent non-resource income
o_t^p	Permanent resource income
R_t^{no}	Non-resource real profit
R_t^o	Resource real profit
f_t	Foreign asset stock
$\widehat{\dot{p}_t^{targ}}$	Target inflation rate
$\widehat{ec_t}$	Resource exploration cost
o_t^e	Net resource exports
$\widehat{r_t^*}$	World nominal interest rate
r_t	Domestic Nominal Interest rate
re_t	Real domestic interest rate
$\widehat{\mathrm{H}_t}$	Resource price stochastic component

4.5.1 Product market

The model separates production into resource and non-resource sectors. Aggregate demand in the non-resource sector (No_t^d) is a function of private consumption expenditure (c_t^p), private non-resource investment expenditure (I_t^{pno}), government expenditure (g_t) and the non-resource trade balance (T_t)

$$No_t^d = \theta_1 c_t^p + \theta_2 I_t^{pno} + \theta_3 g_t + \theta_4 T_t \tag{4.1}$$

The private consumption equation is the amended Euler equation of that used in the DSGE model for Australia by Lim, Li and Bao (2007) in log-linear form. While cash

holding[37] in their model increases the utility of the consumer and could increase consumption through a *liquidity effect*, this is replaced by private assets (wealth) which increases consumption through a *wealth effect* in this model. The consumption function is as below:

$$c_t^p = \alpha_1 c_{t+1}^p - \alpha_2 (r_t - \pi_{t+1}) + \alpha_3 PA_t \tag{4.2}$$

Where, c_t^p is private consumption, c_{t+1}^p is expected consumption in the next time period, r_t is the nominal domestic interest rate, π_{t+1} is expected inflation and PA_t shows private assets (wealth). Based on this equation consumption is anticipated to have a positive relationship with consumption expectations and private wealth but the real interest rate (considering the inflation expectation) will have a negative impact on consumption.

Private investment in the resource and non-resource sector is based on Tobin's q (Tobin, 1969) in each sector, as follows:

$$\dot{k}_t^{pno} = \eta_1 q_t^{no} \tag{4.3}$$

$$\dot{k}_t^{po} = \eta_2 q_t^{o} \tag{4.4}$$

Where, $\dot{k}_t^{pno}$ and $\dot{k}_t^{po}$ represent investment in the non-resource and resource sectors respectively, and q_t^{no} and q_t^{o} are Tobin's q in the non-resource and resource sectors respectively.

[37] Money in the Utility Function (MIUF) is one of the New Keynesian features of DSGE models in the literature (see for example Batini *et al.*, 2008; Burriel *et al.*, 2009; Fernandes-Villaverde, 2009).

Government investment spending is assumed to be focused on two areas - human capital and infrastructure. Investment on education, health, insurance and superannuation funds are all included as various types of human capital investment. Infrastructure spending increases productivity in the non-resource sector and boosts both the supply and demand sides of the economy. Investment in these two areas is fully financed by tax revenue from the resource sector. However, there is the possibility that the government will not use all the tax revenue from the resource sector to invest in human capital and infrastructure but leave some for consumption expenditure as well, but this only boosts the demand side of the economy. Therefore, a key policy decision by government is to decide on the proportion of the resource tax revenue to be spent on infrastructure (γ_1), human capital (γ_2) and $(1-\gamma_1-\gamma_2)$ on consumption expenditure unlike the case of an SWF where expenditure is only on capital investment and in income generating financial assets.

The equations for investment on human capital and infrastructure are as follows:

$$I_t^i = \dot{k}_t^i = \zeta_1(\ddot{k}_t^i - k_t^i) \tag{4.5}$$

$$I_t^h = \dot{k}_t^h = \zeta_2(\ddot{k}_t^h - k_t^h) \tag{4.6}$$

The amount of investment in each area is dependent upon the policy determined desired capital stock in that area based upon the proportion of resource tax revenue that the government wants to invest in each area,

$$\ddot{k}_t^i = \gamma_1(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t) \tag{4.7}$$

$$\ddot{k}_t^h = \gamma_2(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t) \tag{4.8}$$

$$I_t^{pno} = \dot{k}_t^{pno} \tag{4.9}$$

The amount of tax collected from the resource sector depends on resource production (o_t^u), the resource price ($\widehat{pres}_t$) which is exogenous and determined in international markets, the exchange rate (x_t), domestic price level (p_t) and the ad valorem resource tax rate ($\widehat{RT}_t$).

The government's expenditure (g_t) includes three components as follow,

$$g_t = \beta_1 c_t^g + \beta_2 I_t^i + \beta_3 I_t^h \qquad (4.10)$$

Where, c_t^g is government consumption expenditure, I_t^i is infrastructure investment and I_t^h human capital investment. Government consumption expenditure, as explained earlier, is financed from tax collected from the non-resource sector and possibly from the resource sector depending on the government's fiscal policies.

$$c_t^g = \lambda No_t^s + (1 - \gamma_1 - \gamma_2)(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t) \qquad (4.11)$$

Government expenditure is financed by total tax revenue (tx_t) from the resource and non-resource (No_t^s) sector, as follow,

$$tx_t = \lambda No_t^s + (1 - \lambda)(o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t) \qquad (4.12)$$

Any fiscal deficit in this model economy is financed by monetary accommodation or bonds issued by the government.

$$g_t - tx_t = \delta_1(\dot{m}_t - \pi_t) + \delta_2(\dot{b}_t - \pi_t) \qquad (4.13)$$

The trade balance for the non-resource sector depends on the real exchange rate$\left(x_t + \widehat{p_t^*} - p_t\right)$, domestic real income ($y_t$) and world real income (y_t^*), as follows:

$$T_t = \mu_1\left(x_t + \widehat{p_t^*} - p_t\right) - \mu_2 y_t + \mu_3 \widehat{y_t^*} \tag{4.14}$$

Actual real income (y_t) and permanent real income (y_t^p) equations are based upon the original contribution of Buiter and Purvis (1983) as follows:

$$y_t = \varepsilon No_t^s + (1-\varepsilon)o_t^u + (1-\varepsilon-\Omega_2)\widehat{pres}_t + (\Omega_1-\varepsilon)(x_t - w_t)$$
$$-(1-\Omega_1-\Omega_2)\widehat{p_t^*} \tag{4.15}$$
$$y_t^p = \varepsilon No_t^{sp} + (1-\varepsilon)o_t^p + (1-\varepsilon-\Omega_2)\widehat{pres}_t + (\Omega_1-\varepsilon)(x_t - w_t)$$
$$-(1-\Omega_1-\Omega_2)\widehat{p_t^*} \tag{4.16}$$

Where, No_t^s and No_t^{sp} are actual and permanent non-resource income or production and o_t^u and o_t^p are resource production and permanent resource income respectively. The resource production included in this equation highlights the *income effect* arising from a resource boom discussed in Chapter 3.

4.5.2 Asset Markets

The model contains five financial assets, namely, money, foreign bonds, domestic bonds and equities (which determines Tobin's q) of the resource and non-resource producer companies. The money market equilibrium is as follow,

$$m_t - p_t = \varphi_1 y_t - \varphi_2 r_t \tag{4.17}$$

Where the demand for real money balances ($m_t - p_t$) is a positive function of real income and a negative function of the nominal interest rate (r_t).

Aggregate non-resource sector supply (No_t^s), infrastructure capital stock (k_t^i) and human capital stock (k_t^h) are assumed to have a positive relationship with real profit

in the non-resource sector. The stock of private non-resource capital has a negative impact on real profit in this sector as it is assumed that capital stock has diminishing marginal productivity in this sector. However, real profit in the resource sector depends positively on resource production, negatively on the private capital stock in the resource sector (diminishing marginal productivity argument again), and positively on the infrastructure capital stock. As the resource sector is assumed to be primarily capital intensive the human capital stock is excluded from influencing real profit in the resource sector.

$$R_t^{no} = \rho_1 No_t^s - \rho_2 k_t^{pno} + \rho_3 k_t^i + \rho_4 k_t^h \tag{4.18}$$

$$R_t^o = \sigma_1(o_t^u + pres_t + x_t - p_t) - \sigma_2 k_t^{po} + \sigma_3 k_t^i \tag{4.19}$$

Changes in Tobin's q for the non-resource and resource sector are as below, which are calculated by equalising the expected real return on holding equities in both of these sectors and the expected real return on domestic and foreign bonds.

$$\dot{q}_{t+1}^{no} = \chi_3^{-1}[q_t^{no} - \chi_1 R_t^{no} + \chi_2(r_t - \dot{m}_t)] \tag{4.20}$$

$$\dot{q}_{t+1}^{o} = \Phi_3^{-1}[q_t^{o} - \Phi_1 R_t^{o} + \Phi_2(r_t - \dot{m}_t)] \tag{4.21}$$

Private assets ($\mathrm{PA_t}$) consist of the value of foreign assets which are domestically held, non-resource and resource private capital stock, real money balances and permanent real income (which represents the present value of future income flowing from both the resource and non-resource sector to the private sector).

$$PA_t = \nu_1(f_t + x_t - p_t) + \nu_2\left(k_t^{pno} + q_t^{no}\right) + \nu_3(m_t - p_t) + \nu_4(b_t - p_t) + \nu_5 y_t^p + \nu_6(k_t^{po} + q_t^o) \tag{4.22}$$

4.5.3 Wage/Price Nexus

The domestic price level is a weighted average of the domestic nominal wage (w_t), the prices of the resource and the domestic currency price of the imported non-resource product.

$$p_t = \Omega_1 w_t + \Omega_2(x_t + \widehat{pres_t}) + (1 - \Omega_1 - \Omega_2)(x_t + p_t^*) \tag{4.23}$$

The Phillips curve equation is shown as below, where the nominal wage change depends upon excess non-resource demand relative to supply, targeted inflation and the difference between the expected wage and the current wage.

$$\dot{w}_t = \xi_1\left(No_t^d - No_t^s\right) + \xi_2 \widehat{\dot{p}_t^{targ}} + (1 - \xi_2)[w_{t+1} - w_t] \tag{4.24}$$

4.5.4 Aggregate Supply

Aggregate non-resource supply is a function of the stock of private capital in the non-resource sector, human capital stock, infrastructure capital stock and real wage. As shown in the equation below the first three factors have a positive relationship with aggregate supply, however a higher real wage makes production more expensive leading to a negative impact upon non-resource aggregate supply.

$$No_t^s = \Psi_1 k_t^{pno} + \Psi_2 k_t^i + \Psi_3 k_t^h - \Psi_4(w_t - p_t) \tag{4.25}$$

$$No_t^{sp} = No_{t-1}^{sp} + \Theta_1(No_t^s - No_t^{sp}) \tag{4.26}$$

Unlike the usual assumption in most macroeconomic models, resource production is assumed to be endogenous in this model. Resource production (o_t^u) is assumed to be a positive function of private resource capital (k_t^{po}), exploration cost (ec_t), resource price ($pres_t$), world real income (y_t^*) and negatively depends on the amount of tax collected from the resource sector (Equation 4.27). The resource sector in this model

is assumed to be a capital intensive industry. It is also assumed that more exploration cost increases the chances of discovering new resource stocks which enhances resource production. For a country facing a resource boom, exploration costs are likely to be increasing to find new mines for more investment which is the case in the recent Australian mining boom. As most of the resource production in this model is for export, demand from international markets is a key factor impacting on resource sector production. The higher is world real income the greater the likelihood that global demand and exports will stimulate resource production. The resource sector in this model includes all energy and mining production. Equation 4.28 shows the process in which the permanent resource production depends to the current resource production.

$$o_t^u = \Lambda_1 k_t^{po} + \Lambda_2 \widehat{ec}_t + \Lambda_3 \widehat{pres}_t + \Lambda_4 \widehat{y_t^*} - \Lambda_5 (o_t^u + \widehat{pres}_t + x_t - p_t + \widehat{RT}_t) \quad (4.27)$$

$$o_t^p = o_{t-1}^p + \Theta_2 (o_t^u - o_t^p) \quad (4.28)$$

However, a resource tax is assumed to have a negative impact on resource production as it is considered a part of production cost. The higher the cost of production the lower will be profitability and investment. This is likely to reduce the level of resource production.

4.5.5 Monetary Policy

Monetary policy follows a Taylor rule. The central bank is assumed to stabilize both output and inflation by keeping the equilibrium interest rate equal to or close to Equation 4.29. This equation is an extended version of the one used in the model of Hodge, Robinson and Stuart (2008). It includes the target inflation rate and

permanent real income. The exchange rate is assumed not to be a component of the Taylor rule here as Lubik and Schorfheide (2007) find no evidence that the central banks in Australia and New Zealand consider nominal exchange rate movements in their policy rules. It is worth to mention here that the purpose for incorporating this equation is to improve the dynamics in the model by identifying the factors which affect the interest rate such as the interest rate in previous period but assessing or simulating the role of monetary policy and the related discussion is not the aim of this study and the focus is made to be on fiscal policy and its determinants for a resource-exporting economy.

$$r_t = \Gamma_1 r_{t-1} + (1-\Gamma_1)\left[\Gamma_2\left(\pi_t - \widehat{\dot{p}_t^{targ}}\right) + \Gamma_3\left(y_t - y_t^p\right)\right] + \widehat{ers} \tag{4.29}$$

Where Γ_1 is the interest rate smoothing degree (the higher this coefficient the smoother is the change in the nominal interest rate by the central bank), Γ_2 represents the weight on the difference between actual inflation and target inflation, and Γ_3 shows the weight on the difference between real income and permanent real income. If the economy is not operating at full employment then the central bank boosts real income to get back to the steady state by decreasing the interest rate.

4.5.6 Overseas Sector

The change in foreign assets held domestically is equal to the current account balance, and depends on the trade balance, interest income from foreign assets ($\widehat{r_t^*} f_t$), net resource exports (o_t^e) and the real exchange rate which has a negative impact. The steady state value of the current account in the long-run must be zero otherwise the wealth effect generates further macroeconomic adjustments. In addition, the

resource export in this equation increases following a resource boom and creates a *current account effect* (trade effect) as discussed in Chapter 3.

$$\dot{f}_t = \psi_1 T_t + \psi_2\big(\widehat{r_t^*} f_t\big) + \psi_3(o_t^e + \widehat{pres_t}) - (1 - \psi_2 - \psi_3)(x_t - p_t) \tag{4.30}$$

Net resource exports (o_t^e) is a proportion (Z) of the ratio of resource production (o_t^u) to real income (y_t) and by transferring it to log form it can be expressed as follows:

$$o_t^e = \mathrm{Z}(o_t^u - y_t) \tag{4.31}$$

Finally, the resource price (*pres*) is assumed to be dependent on a proportion of the resource price in the previous period and also contains a stochastic part ($\widehat{\mathrm{H}_t}$) as follows:

$$pres_t = \mathrm{K}\, pres_{t-1} + \widehat{\mathrm{H}_t} \tag{4.32}$$

4.6 Summary

The main goal of this chapter has been to outline the model to be subsequently used to analyse the role of resource taxation and its impact on key macroeconomic variables in the representative model of the Australian economy as one of the main goals of this study. The model represents an extension of the Cox-Harvie (2010) model in a number of aspects which adds to the novelty and uniqueness of this study. The hybrid macroeconomic model constructed to characterise the Australian economy includes an endogenous resource sector as one of the main extensions to the original model of Cox-Harvie (2010). This novelty is important in particular for the aim of the current study as it makes the model capable of explaining the macroeconomic dynamics arising from a resource sector boom, unlike treating it as an exogenous sector which is usual in this area of study. In addition, important resource boom transmission channels highlighted in previous literature such as the

income effect, resource movement effect, spending effect, current account effect, wealth effect and *exchange rate effect* have been embedded in the theoretical framework, and steps have been taken to effectively track them in the model. For instance, in order to show the details of a *resource movement effect* within the private sector, private sector capital is decomposed into resource and non-resource capital which makes it possible to see the behaviour of the private sector in allocating funds to resource or non-resource capital during the period of a resource boom.

The model equations highlighted in this chapter will be used in Chapter 5 to run an initial check on the stability of the model, which means the model must have a solution using the prior parameter values and must Blanchard-Khan conditions. The required parameter values are then estimated using Bayesian techniques using the tested prior values. This will prepare the model to be used for a number of scenarios in Chapters 6 and 7. The extensions to the model in this chapter provide an opportunity to evaluate the consequences of a number of domestic and external shocks and policies to the economy. The world interest rate as one of the external shocks to the economy will be assessed in Chapter 6. The impact of different government expenditure policies on consumption and investment (comprising human capital and infrastructure) sourced by resource tax revenue on the macro-economy is another extension to the model, and various scenarios will be assessed and compared along with resource tax policies in a resource boom period in Chapter 7.

CHAPTER 5

STABILITY TEST OF THE MODEL AND BAYESIAN ESTIMATION

5.1 Introduction

This chapter applies an initial stability test and then Bayesian estimation of the parameters of the hybrid macroeconomic model described and developed in Chapter 4. The first step involves applying an initial dynamic stability check to ensure the model is stable and which shows the model has a solution for prior values of the parameters. To achieve this, the equations identified in the model are tested using Dynare (version 4.3.3)[38] by providing prior values for the parameters which are drawn from Cox and Harvie (2010) and a few other studies such as Jääskelä and Nimark (2011), or are imposed on the model based on beliefs about the value of parameters, for instance, through available data.

Once the stability of the model is satisfied with the nominated prior values, the parameters of the behavioural equations are estimated using the Bayesian approach. The main advantage of this approach is that it helps the model characterise the Australian economy. This is done by providing prior parameter values as well as the shape of the prior density functions. The Bayesian combination of the prior information with the observable data provides the estimated posterior distributions for the parameter values.

[38] While Dynare is the most popular software applied for handling macroeconomic models (DSGE and OLG in particular), Iris and Yada are also two other software packages which are used in the literature. See http://iristoolbox.codeplex.com/ and http://www.texlips.net/yada/ respectively for more information about the Iris and Yada software.

Australian time series data for eight key observable variables for the period 1988:Q3–2011:Q3 are applied. The estimated coefficients are subsequently used to simulate the reaction of the model to stochastic shocks, in particular, a world interest rate shock. The results from this stochastic simulation are analysed in Chapter 6 (whilst Chapter 7 further analyses the simulations of selected deterministic policy shocks).

The rest of this chapter briefly describes the data sources and the variables in Section 5.2. The way in which some indices, such as the quantity index proxying resource production, are calculated is also explained. Section 5.3 discusses the initial stability test of the model and provides the parameter values used in the unit root tests and the Blanchard-Khan condition. The Bayesian estimation is applied in Section 5.4 to estimate the parameters using prior information and data. Section 5.5 briefly summarises the chapter.

5.2 Observable Variables and Data

The number of observable variables must be equal to or smaller than the number of possible shocks in the model in order to apply the Bayesian estimation approach. In this study there are eight shocks defined, therefore, eight observable variables is the maximum possible number to be used in the estimation of the model. The main variables comprise real income (y_t), private consumption (c_t^p), non-resource trade balance (T_t), nominal interest rate (r_t), foreign assets (f_t), resource production (o_t^u), non-resource aggregate supply (No_t^s) and the nominal exchange rate (x_t). Quarterly data for these variables was collected from various sources as shown in Table 5-1 for

the period 1988:Q3–2011:Q3[39]. The time series plots of the observable variables in log form (except the interest rate) are available in the Appendix A.

Table 5-1 Data Sources and Explanations

Variable	**Symbol**	**Data source**	**Explanation**
Real income	y_t	Australian Bureau of Statistics (ABS), (dXtime)	GDP per capita, seasonally adjusted, chain volume measures (CVM), Catalogue No. 5206, Table 02.
Private consumption	c_t^p	Australian Bureau of Statistics (ABS), (dXtime)	Household final consumption expenditure, chain volume measures (CVM), seasonally adjusted, Catalogue No. 5206, Table 21.
Non-resource trade balance	T_t	Australian Bureau of Statistics (ABS)	Total non-resource trade balance, seasonally adjusted, Catalogue No 5302.0.
Domestic nominal interest rate	r_t	Reserve Bank of Australia (RBA)	Interest rate, money market, bank accepted bills (30 days), Table F01–1.[40]
Foreign asset	f_t	Australian Bureau of Statistics (ABS) (website)	Total foreign assets, Catalogue No. 5302, Table 03.
Resource production	o_t^u	Bureau of Resources and Energy Economics (BREE)	Data for coal and iron ore (as the main natural resources) from Resources and Energy Quarterly, September quarter 2012.
Aggregate supply of non-resource output	No_t^s	Australian Bureau of Statistics (ABS) (website)	GDP excluding mining industry, Australian National Accounts, Catalogue No. 5206, Table 06.
Nominal exchange rate	x_t	Reserve Bank of Australia (RBA)	AUD per one USD, Table F11–01.

[39] The time period under study has been only restricted by the availability of quarterly data for all variables including those in the resource sector and 2011 was the latest available data when data analysis for this research started in 2012.

[40] Following a number of Australian studies in the literature (see Lim *et al.*, 2007; Dungey and Pagan, 2009; Liu, 2010a; Liu, 2010b) the bank bill rate, instead of the overnight cash rate, is applied which is extremely close to the overnight cash rate as the policy variable and also satisfies the dynamic requirements of the model.

Following Jääskelä and Nimark (2011) it is assumed that economic growth follows a stochastic path (see Altig *et al.*, 2005) so that pre-filtered data is not necessary for the estimation.[41]

It is worth mentioning that a quantity index for each of the two major mining productions in Australia (coal and iron ore as outlined in Chapter 3) is constructed as the proxy for natural resource production. The Fisher volume index (*FVI*), which is the geometric mean of the Laspeyres volume index (*LVI*) and the Paasche volume index (*PVI*), is used:

$$FVI = \sqrt{LVI \times PVI}$$

where LVI and PVI are calculated as follows:

$$LVI = \frac{\sum(p_0 q_t)^{coal} + \sum(p_0 q_t)^{iron}}{\sum(p_0 q_0)^{coal} + \sum(p_0 q_0)^{iron}}$$

$$PVI = \frac{\sum(p_t q_t)^{coal} + \sum(p_t q_t)^{iron}}{\sum(p_t q_0)^{coal} + \sum(p_t q_0)^{iron}}$$

This index is calculated as a proxy for the resource production variable using the quarterly data for the period 1988:Q3–2011:Q3.

5.3 Initial Stability Test of the Model and the Blanchard-Kahn Conditions

The model is tested using the parameter values applied in Cox and Harvie (2010) as well as imposed values from a few other studies. Testing the stability of the model is important as it provides evidence of the relevance of the theoretical framework and the selected parameter values. Stability test ensures that any stochastic shock to the

[41] In order to filter the data the Hodrick-Prescott (HP) filter (with λ = 1600) is normally applied in the literature.

system would lead to a stable condition and that the variables will return to their initial steady state.

The prior values for all parameters of the model are provided in Table 5-2. Those values drawn from Cox and Harvie (2010) are shown with an asterisk. The remaining parameters are taken from other related studies (for example Jääskelä and Nimark, 2011) or based on the researcher's knowledge, where specific equations have not been considered in previous studies, for example, the endogenous resource production equation. It is important to note that the model is not meant to be a complete reflection of the real world Australian economy, but rather a step towards the characterisation of major economic relationships in the context of the Australian economy.

Table 5-2 shows the parameter values for the non-resource aggregate demand equation (Equation 4.1) including θ_1, θ_2, θ_3 and θ_4 obtained from the Cox-Harvie (2010) model. The consumption equation (Equation 4.2) assumes household expectations about future consumption have a significant impact on current consumption. The related coefficient, α_1 , is therefore set to 0.8. The coefficient for private assets is assumed to be 0.2 which is slightly larger than the 0.1 applied in the Cox-Harvie (2010) model. Unlike the Cox-Harvie model, consumer behaviour in this model is also a function of the interest rate. The consumer is thus more sensitive to the value of private assets, and hence the value of this coefficient is greater than in the Cox-Harvie model. It is also assumed that the sensitivity of private investment in the resource sector is greater than that in the non-resource sector in terms of the value of the coefficients for Tobin's q in Equations 4.3 and 4.4, due to the existence of

resource rent and hence higher profitability in the resource sector. Therefore, the value of η_2 is assumed to be greater than η_1, that is 0.8 against 0.5.

In addition, it is assumed that the speeds with which the quantity of infrastructure and human capital stock adjust to their desired levels are higher in this model, and, therefore, ζ_1 and ζ_2 are both set to be 0.5 (rather than 0.2 in the Cox-Harvie model). One justification for this is that the higher amount of infrastructure and human capital stock increases productivity in both the resource and non-resource sectors. Furthermore, as the resource sector is endogenous in this model, it provides more funds for the government to invest in these two areas, reaching the desired level more quickly.

Table 5-2 Parameter Prior Values as Applied in the Stability Test

Parameter	*Value*	***Parameter***	*Value*	***Parameter***	*Value*	***Parameter***	*Value*
$\boldsymbol{\theta_1}$	*0.5**	$\boldsymbol{\delta_1}$	*0.5**	$\boldsymbol{\sigma_2}$	*0.4*	$\boldsymbol{\Psi_2}$	*0.4*
$\boldsymbol{\theta_2}$	*0.1**	$\boldsymbol{\delta_2}$	*0.5**	$\boldsymbol{\sigma_3}$	*0.5*	$\boldsymbol{\Psi_3}$	*0.4*
$\boldsymbol{\theta_3}$	*0.5**	$\boldsymbol{\mu_1}$	*0.7*	$\boldsymbol{\chi_1}$	*0.4*	$\boldsymbol{\Psi_4}$	*0.4**
$\boldsymbol{\theta_4}$	*0.3**	$\boldsymbol{\mu_2}$	*0.5**	$\boldsymbol{\chi_2}$	*0.4*	$\boldsymbol{\Lambda_1}$	*0.8*
$\boldsymbol{\alpha_1}$	*0.8*	$\boldsymbol{\mu_3}$	*0.3*	$\boldsymbol{\chi_3}$	*0.8*	$\boldsymbol{\Lambda_2}$	*0.3*
$\boldsymbol{\alpha_2}$	*0.5*	$\boldsymbol{\varepsilon}$	*0.3*	$\boldsymbol{\Phi_1}$	*0.5**	$\boldsymbol{\Lambda_3}$	*0.9*
$\boldsymbol{\alpha_3}$	*0.2*	$\boldsymbol{\Omega_1}$	*0.6*	$\boldsymbol{\Phi_2}$	*0.5**	$\boldsymbol{\Lambda_4}$	*0.7*
$\boldsymbol{\eta_1}$	*0.5*	$\boldsymbol{\Omega_2}$	*0.3*	$\boldsymbol{\Phi_3}$	*0.5**	$\boldsymbol{\Lambda_5}$	*0.2*
$\boldsymbol{\eta_2}$	*0.8*	$\boldsymbol{\Theta_1}$	*0.2*	$\boldsymbol{\nu_1}$	*1.0**	$\boldsymbol{\Gamma_1}$	*0.9*
$\boldsymbol{\zeta_1}$	*0.5*	$\boldsymbol{\Theta_2}$	*0.2*	$\boldsymbol{\nu_2}$	*1.0**	$\boldsymbol{\Gamma_2}$	*0.1*
$\boldsymbol{\zeta_2}$	*0.5*	$\boldsymbol{\varphi_1}$	*0.7*	$\boldsymbol{\nu_3}$	*1.0**	$\boldsymbol{\Gamma_3}$	*0.9*
$\boldsymbol{\gamma_1}$	*0.2+*	$\boldsymbol{\varphi_2}$	*0.5**	$\boldsymbol{\nu_4}$	*1.0**	$\boldsymbol{\psi_1}$	*0.8*
$\boldsymbol{\gamma_2}$	*0.1+*	$\boldsymbol{\rho_1}$	*0.8*	$\boldsymbol{\nu_5}$	*1.0**	$\boldsymbol{\psi_2}$	*0.5*
$\boldsymbol{\beta_1}$	*0.6*	$\boldsymbol{\rho_2}$	*0.5*	$\boldsymbol{\nu_6}$	*1.0*	$\boldsymbol{\psi_3}$	*0.4*
$\boldsymbol{\beta_2}$	*0.2**	$\boldsymbol{\rho_3}$	*0.8*	$\boldsymbol{\xi_1}$	*0.9*	$\boldsymbol{Z}$	*0.8*
$\boldsymbol{\beta_3}$	*0.2*	$\boldsymbol{\rho_4}$	*0.2*	$\boldsymbol{\xi_2}$	*0.9*	$\boldsymbol{K}$	*0.5*
$\boldsymbol{\lambda}$	*0.8**	$\boldsymbol{\sigma_1}$	*0.8*	$\boldsymbol{\Psi_1}$	*0.4**		

Notes: * Cox and Harvie (2010), + Policy parameter.

Some of the coefficients in Table 5-2, such as γ_1 and γ_2, are policy parameters. These coefficients show the portions of the tax revenue gained from the resource

sector that are spent on infrastructure and human capital. Their values are assumed to be 0.2 and 0.1 respectively, which assumes the government spends 20 percent of tax collected from the resource sector on infrastructure and 10 percent on human capital. The rest, that is 70 percent, is assumed to be allocated to government consumption expenditure. These values are only assumed for the Australian economy where there is no specific fund, such as a Sovereign Wealth Fund, to enable the resource income to be saved. It is thus not possible to determine what percentage of the tax collected from the resource sector is directed to investment purposes. This discussion is further developed in Chapter 7 as one of the governments' possible spending policies.

Government consumption expenditure is assumed to be a more important component of overall government expenditure (the proportion of 0.6 being only marginally higher than the 0.5 in the Cox-Harvie model) than investment in infrastructure and human capital (being equal to 0.2 each in the Cox-Harvie model). As in the Cox-Harvie model the non-resource aggregate supply has a significant role in determining the government total tax revenue. Its consumption expenditure and the parameter value of the non-resource aggregate supply (λ) in both Equations 4.11 and 4.12 is therefore set equal to 0.8. A fiscal deficit is assumed to be equally financed through a monetary accommodation and selling bonds to the private sector, so δ_1 and δ_2 are both equal to 0.5 (Equation 4.13), as they are in the Cox-Harvie model. The parameter values for μ_1, μ_2 and μ_3 (Equation 4.14) are respectively set as 0.7, 0.5 and 0.3 in this study. Due to the important dynamic role of the exchange rate in affecting the trade balance, a higher weight of 0.7 is considered for its coefficient (μ_1) than the 0.5 in the Cox-Harvie model. The coefficient of non-resource aggregate

supply (ε) in determining real income (Equation 4.15) is assumed to be 0.3, which gives it greater weight for the resource sector.

The domestic price level (Equation 4.23) is assumed to be mainly affected by the wage rate ($\Omega_1 = 0.6$) and then the domestic resource price ($\Omega_2 = 0.3$), whilst the remaining $(1 - \Omega_1 - \Omega_2)$ comes from the imported goods prices. This is slightly different from the original Cox-Harvie model where $\Omega_1 = 0.7$ and $\Omega_2 = 0.1$. Domestic money demand is a function of real income ($\varphi_1 = 0.7$) and the nominal interest rate ($\varphi_2 = 0.5$). The coefficients of non-resource aggregate supply and resource income (ρ_1 and σ_1 respectively) are assumed equal (0.8 each) in the non-resource sector's real profit and the resource sector's real profit (Equations 4.18 and 4.19 respectively). In addition, it is assumed that infrastructure capital stock has a higher impact on the profitability of the non-resource sector than the resource sector. Therefore, the values of $\rho_3 = 0.8$ and $\sigma_3 = 0.5$ are imposed on the model. The parameters in the non-resource sector's Tobin's q equation (χ_1, χ_2 and χ_3) are assumed by the researcher and the parameters in the private asset equation (ν_1 to ν_5) are taken from the Cox-Harvie model.

The determinants of non-resource aggregate supply are assumed to have equal weight in Equation 4.25 and following the Cox-Harvie model the respected coefficients (Ψ_1, Ψ_2, Ψ_3 and Ψ_4) are assumed to be equal to 0.4. The coefficients of resource production are also imposed on the model. However, the resource price and private resource capital are assumed to have a greater impact on resource production ($\Lambda_3 = 0.9$ and $\Lambda_1 = 0.8$) than the other variables. The interest rate smoothing parameter, Γ_1, is usually considered to be greater than 0.7 in the literature (see for

example Hodge *et al.*, 2008; Jääskelä and Mckibbin, 2010; Jääskelä and Nimark, 2011) and is set equal to 0.9 in this study. However, Γ_2 and Γ_3 are not limited to any specific range in the literature and they depend mostly on the setting of the Taylor rule with the smoothing parameter playing the major role and the other parameters having a much lower weight in determining the interest rate. Therefore these two parameters are set to be equal to 0.1 and 0.9 respectively which also satisfies the model stability.

The output from the stability test of the model provided in Table 5-2 shows that there are six modulus eigenvalues larger than 1 for the six forward-looking (non-predetermined or jump) variables which include expected consumption and inflation, expected Tobin's *q* for both the resource and non-resource sectors, plus the expected wage and exchange rate. This satisfies the Blanchard-Kahn condition where the number of modulus eigenvalues larger than 1 must be equal to the number of non-predetermined variables. This result also shows that there is no unit root problem in the model as there is no modulus equal to 1 in the results.[42] The imaginary component for the six eigenvalues means that oscillatory behaviour is expected in the endogenous variables which will be explored in Chapter 6.

Table 5-3 Eigenvalues of the Model

Modulus	**Real**	**Imaginary**
4.809e-17	-4.809e-17	0
1.311e-16	-1.311e-16	0
0.5000	0.5000	0
0.6590	0.6570	0.05025
0.6590	0.6570	-0.05025
0.6667	0.6667	0

[42] A unit eigenvalue (unit root problem) may have several consequences for the model such as not having a unique steady state, the impulse responses from a stochastic simulation may diverge, etc.

Modulus	**Real**	**Imaginary**
0.7192	0.6979	0.1736
0.7192	0.6979	-0.1736
0.8333	0.8333	0
0.8874	0.8785	0.1253
0.8874	0.8785	-0.1253
0.9408	0.9408	0
0.9623	0.9623	0
1.0940	1.0940	0
1.7310	1.7310	0
2.1820	2.1820	0
2.6160	2.6160	0
11.9300	11.9300	0
Inf	Inf	0

Notes: Calculated using Dynare version 4.3.3.
There is an infinite eigenvalue among these roots, however this is not considered to be a problem in the Blanchard-Kahn conditions as an infinite eigenvalue is "counted as explosive roots of modulus larger than one" (see Grioli, 2010, p. 43).

5.4 Bayesian Estimation

Bayesian time-series econometric methods are becoming very popular in the estimation of hybrid or DSGE macroeconomic models (see for instance Schorfheide, 2000; Smets and Wouters, 2003; Adolfson *et al.*, 2007; An and Schorfheide, 2007; Jääskelä and Nimark, 2011).[43] Schorfheide (2000) applies the Bayesian approach to compare two DSGE models. Smets and Wouters (2003) apply this technique to estimate a DSGE model of the Euro zone with sticky wages and prices and seven major macroeconomic variables. Adolfson *et al*. (2007) also apply the Bayesian approach to estimate an open economy DSGE model for the Euro area as a developed version of the closed economy model in Christiano *et al*. (2005). An and Schorfheide (2007) use Bayesian estimations to compare linear and non-linear DSGE

[43] This method has become popular not only in economics but in many other sciences such as computer science, weather forecasting, engineering and health sciences (see Hagan and West, 2010). Therefore, using "generalised method of moments" (GMM), "maximum likelihood" (ML) and "indirect inference" (II) methods that were popular in traditional macroeconomic model estimation have been mostly replaced by Bayesian techniques in DSGE models (Guerrón-Quintana and Nason, 2012).

models, as well as VAR models. Jääskelä and Nimark (2011) have also estimated a DSGE model of the Australian economy using the Bayesian technique.

Due to the complexity of the hybrid model used in this study, the Bayesian estimation approach is applied. The method has a number of advantages especially for DSGE and hybrid model estimation. The use of prior values for the coefficients allows researchers to overcome possible misspecifications of the DSGE model (see for example Geweke *et al.*, 2011). Applying the prior value as the weight for the coefficients in the Bayesian estimation helps the posterior distribution not to peak at points which are not in line with the data. This is important where parameters might come from other empirical studies or are simply policy parameters (Canova, 2011). This also helps to solve identification issues in DSGE models (Hashimzade and Thornton, 2013, p. 489).

Unlike classic econometrics, Bayesian econometrics includes a prior weighting on parameter. The estimated parameter value is a combination of data information plus this *a prior* information (Greenberg, 2008). The expectations about the value of a parameter may differ from one person to another. Based on Bayes' theorem, a posterior density function (PDF) is derived from the sample information $\left(\frac{f(x|\omega)}{f(x)}\right)$ as well as from prior distribution $g(\omega)$ as follows:

$$g(x|\omega) = \frac{f(x|\omega)}{f(x)} g(\omega)$$

As the first step, it is necessary to assign a density function for the prior distribution. Commonly used densities include uniform, normal, beta, gamma and inverse gamma

(see Table 5-4). In this study a beta density prior function is applied due to the logarithmic specification used for the variables of the model.[44] The parameters are therefore elasticities and the beta distribution forces them to be less than unity, ensuring stability of the hybrid model.[45]

The choice of prior values for the parameters, based on previous studies or the researcher's own knowledge, is an important part of the estimation which must also satisfy the dynamic stability of the model.

Table 5-4 Prior Shapes

Prior density function (PDF)	**Corresponding distribution**	**Range**
Normal	$N(\mu, \sigma)$	$\mathbb{R}$
Gamma	$G_2(\mu, \sigma, p_3)$	$[p_3, +\infty)$
Beta	$B(\mu, \sigma, p_3, p_4)^*$	$[p_3 = 0, p_4 = 1]$
Inverse Gamma	$IG_1(\mu, \sigma)$	$\mathbb{R}^+$
Uniform	$U(p_3, p_4)$	$[p_3, p_4]$

Notes: $^*p_3$ and p_4 show the range of parameters which are 0 and 1 by default.
Source: Grioli, (2010, p. 50)

The Metropolis–Hastings (MH) algorithm, being one of the Markov Chain Monte Carlo (MCMC) methods, is applied to numerically approximate the posterior distribution. The algorithm provides a random sample from the prior probability distribution, the number of iterations is set to 500,000 and half of this number, 250,000, are kept as the sample size for the posterior estimation.

[44] The Beta distribution is also applied for the prior standard errors in the process of the estimation.
[45] As per Cox & Harvie (2010).

The prior means and standard deviations of the coefficients of the behavioural equations 4.2, 4.14, 4.17–21, 4.24–25, 4.27 and 4.29–30, are provided in Table 5-5 and The Bayesian estimated results are provided in Table 5-6.

Table 5-5 Prior Mean and Standard Deviation Values

Parameter	**Prior Mean**	**Prior Standard Deviation**	**Parameter**	**Prior Mean**	**Prior Standard Deviation**
α_1	0.800	0.3000	Φ_1	0.500	0.3000
α_2	0.500	0.2000	Φ_2	0.500	0.3000
α_3	0.200	0.1000	Φ_3	0.500	0.3000
μ_1	0.700	0.3000	Γ_1	0.900	0.1000
μ_2	0.500	0.2000	Γ_3	0.900	0.1000
μ_3	0.300	0.2000	ξ_1	0.900	0.2000
φ_1	0.700	0.3000	ξ_2	0.900	0.2000
φ_2	0.500	0.2000	Ψ_1	0.400	0.2000
ρ_1	0.800	0.3000	Ψ_2	0.400	0.2000
ρ_2	0.500	0.3000	Ψ_3	0.400	0.2000
ρ_3	0.800	0.3000	Λ_1	0.800	0.3000
ρ_4	0.200	0.1000	Λ_2	0.300	0.2000
σ_1	0.800	0.3000	Λ_3	0.900	0.2000
σ_2	0.400	0.3000	Λ_4	0.700	0.2000
σ_3	0.500	0.3000	Λ_5	0.200	0.1000
χ_1	0.400	0.2000	ψ_1	0.800	0.2000
χ_2	0.400	0.2000	ψ_2	0.500	0.2000
χ_3	0.800	0.3000	ψ_3	0.400	0.2000

Table 5-6 Bayesian Estimation Results of the Model

Parameter	**Posterior Mean**	**90% Confidence Interval**		**Parameter**	**Posterior Mean**	**90% Confidence Interval**	
α_1	0.6651	0.6641	0.6661	Φ_1	0.9340	0.9339	0.9341
α_2	0.3782	0.3781	0.3782	Φ_2	0.7306	0.7298	0.7314
α_3	0.1647	0.1646	0.1649	Φ_3	0.7003	0.7001	0.7005
μ_1	0.6834	0.6830	0.6840	Γ_1	0.8189	0.8186	0.8192
μ_2	0.5325	0.5323	0.5329	Γ_3	0.7802	0.7800	0.7803
μ_3	0.4743	0.4737	0.4750	ξ_1	0.6549	0.6544	0.6553
φ_1	0.8061	0.8060	0.8062	ξ_2	0.8923	0.8919	0.8927
φ_2	0.3778	0.3776	0.3779	Ψ_1	0.4240	0.4238	0.4242
ρ_1	0.9698	0.9697	0.9698	Ψ_2	0.5826	0.5825	0.5827
ρ_2	0.4526	0.4520	0.4532	Ψ_3	0.6287	0.6285	0.6288
ρ_3	0.8983	0.8982	0.8983	Λ_1	0.9984	0.9984	0.9985
ρ_4	0.2814	0.2814	0.2815	Λ_2	0.5046	0.5043	0.5049
σ_1	0.7935	0.7929	0.7943	Λ_3	0.8688	0.8687	0.8690
σ_2	0.1828	0.1809	0.1847	Λ_4	0.5620	0.5618	0.5623
σ_3	0.0265	0.0263	0.0267	Λ_5	0.1643	0.1641	0.1645
χ_1	0.4353	0.4352	0.4354	ψ_1	0.9249	0.9248	0.9250
χ_2	0.3105	0.3104	0.3107	ψ_2	0.4259	0.4258	0.4260
χ_3	0.5454	0.5451	0.5457	ψ_3	0.2108	0.2106	0.2109

Note: The results are obtained from Dynare version 4.3.3.

Table 5-6 shows the posterior mean for each parameter and their 90 percent confidence intervals. The literature suggests an average acceptance rate (the rate of accepted draws) of between 20 percent and 40 percent for the MH-MCMC samples (see Grioli, 2010) and the acceptance rate for this estimation is between 33.67 percent and 34.06 percent which falls in the acceptable range of 20 percent to 40 percent.[46]

The posterior confidence intervals do not include the prior means. This is due to the very low variances of the posterior means, which implies the data is very strong in explaining the posterior means and heavily outweighs the priors. The priors are therefore relatively less important and were only initially required to ensure stability, so the estimation could be done. The estimated posterior means are informative as they add to knowledge about the behaviour of the Australian data. For instance, the estimated parameter value for exchange rate (μ_1) in determining non-resource trade balance (Equation 4.14) is equal to 0.68 which is very close to the set prior value of 0.7. Due to the importance of the exchange rate in the non-resource trade balance this value was increased from the initial value of 0.5 in Cox-Harvie model to 0.7 in this study and the estimation result agrees with this. In the same equation, the estimated parameter value of the average world income (μ_3) has a greater value of 0.47 than the prior value of 0.3 which reveals the information provided by the data on the greater influence of the world demand for Australian products on the trade balance as an advanced open economy.

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[46] If the acceptance rate is too low then it shows that the optimiser is rejecting many candidate draws and if it is too high then it is not moving quickly enough around the parameter space (Lam, 2008).

As another example, the role of private capital in resource sector appears to be more significant in determining the level of resource production than what was expected (Equation 4.27) as the parameter value for this variable (Λ_1) is estimated as 0.99 than the expected prior value of 0.8. As the estimated parameters help the model to characterise the Australian economy therefore they are used instead of their respective prior values for further analysis in the next chapters.

5.5 Summary

The purpose of this chapter has been to estimate the key parameters of the macroeconomic model used in this study. This involved assessing firstly the stability of the model with the parameter values used from other studies or from the researcher's own knowledge to ensure the model achieved steady state and that there were no unit root problems in the variables. Prior information was then used to estimate some of the coefficients using the Bayesian technique on Australian data. The usage of the data in estimation of the required parameters revealed some interesting information about the significance of some variables. For instance it showed the greater significance of exchange rate and the average world income on the non-resource trade balance as well as the greater role of private capital in resource sector compared to the relevant prior information in determining the production level in this sector. The prior values are therefore replaced with their estimated values in the rest of this study. The estimated parameters as well as the imposed coefficients based on the researcher's knowledge, policy parameters and those taken from other studies will be used to further evaluate the model in Chapters 6 and 7.

CHAPTER 6

STOCHASTIC SHOCK AND DYNAMIC BEHAVIOUR OF THE MODEL

6.1 Introduction

This chapter aims to conduct a numerical simulation using the parameter values of the model discussed in Chapter 5 in order to analyse the dynamic characteristics of the model. The behaviour of a number of key variables in the model in response to a stochastic external shock are examined to make sure their dynamics are consistent with the theoretical foundations of the model. External shocks may have a less significant impact on the economic activity compared to domestic shocks, such as a monetary policy, in less open economies (Kose and Riezman, 2001). But an advanced open economy like Australia with developed financial markets and an export oriented resource sector will be obviously affected by external factors. These can range from changes in global financial markets to changes in global resource prices. A world interest rate stochastic shock is considered in this chapter and a deterministic shock to the world resource price is considered in the following Chapter 7.

Among the few available external shocks to the model (e.g. world real income, world price level, world interest rate and resource price) the average world interest rate suits more to the aim of this chapter as it is more likely to experience an unexpected shock which is relevant to a stochastic shock (the stochastic shock is more appropriate to assess the dynamic behaviour of the model and its stability characteristics compared to a deterministic shock which is applied in the next

chapter). The resource price is also a relevant candidate but it has been applied in Chapter 7 in creating policy scenarios in a resource price boom era.

The parameter values estimated using the Bayesian technique in Chapter 5 contribute most of the coefficient values applied in simulating the impact of the world interest rate shock to the model in this chapter. The other parameters applied in this chapter are those from previous related studies, while policy parameters and those parameters for which information is not available are imposed. This chapter summarises these parameters in the following Section 6.2. Section 6.3 gives a brief introduction on the role and importance of external shocks to a small open economy in general and to the model of this study. The analysis of the effects of the shock are grouped into the financial sector, macro-economy variables, resource sector and external sector in Sub-sections 6.3.2 through to 6.3.5. The impulse response graphs obtained from running the stochastic world interest rate shock on the model their expected dynamic behaviour in the model. Finally, a brief summary is provided in Section 6.4.

6.2 Parameter Values of the Model

As shown in Table 6-1, 36 parameter values are obtained from the Bayesian estimation of the relevant equations, 13 parameter values are from Cox and Harvie (2010), two parameters are based on policy related values and the other 16 parameters are imposed on the model, based on the researcher’s knowledge, in order to maintain the dynamic stability of this complex model making 67 parameter values for the 8 equations of the model to be simulated.

The estimated posterior parameters values, as discussed in Chapter 5, are applied for the impulse response function[47] simulations as a reaction to the stochastic world interest rate shock provided in the next section. It is important to note that the stochastic shock is unexpected and it may contribute to some sharp fluctuations of variables especially in early periods after the shock.

Table 6-1 Parameter Values Applied in the Model to Generate Impulse Response Functions (IRFs)

Parameter	*Value*	***Parameter***	*Value*	***Parameter***	*Value*	***Parameter***	*Value*
$\boldsymbol{\theta_1}$	*0.5*[*]	$\boldsymbol{\delta_1}$	*0.5*[*]	$\boldsymbol{\sigma_2}$	*0.18*[◊]	$\boldsymbol{\Psi_2}$	*0.58*[◊]
$\boldsymbol{\theta_2}$	*0.1*	$\boldsymbol{\delta_2}$	*0.5*[*]	$\boldsymbol{\sigma_3}$	*0.03*[◊]	$\boldsymbol{\Psi_3}$	*0.63*[◊]
$\boldsymbol{\theta_3}$	*0.5*[*]	$\boldsymbol{\mu_1}$	*0.68*[◊]	$\boldsymbol{\chi_1}$	*0.43*[◊]	$\boldsymbol{\Psi_4}$	*0.4*[*]
$\boldsymbol{\theta_4}$	*0.3*[*]	$\boldsymbol{\mu_2}$	*0.53*[◊]	$\boldsymbol{\chi_2}$	*0.31*[◊]	$\boldsymbol{\Lambda_1}$	*0.99*[◊]
$\boldsymbol{\alpha_1}$	*0.66*[◊]	$\boldsymbol{\mu_3}$	*0.47*[◊]	$\boldsymbol{\chi_3}$	*0.54*[◊]	$\boldsymbol{\Lambda_2}$	*0.5*[◊]
$\boldsymbol{\alpha_2}$	*0.38*[◊]	$\boldsymbol{\varepsilon}$	*0.3*	$\boldsymbol{\Phi_1}$	*0.93*[◊]	$\boldsymbol{\Lambda_3}$	*0.87*[◊]
$\boldsymbol{\alpha_3}$	*0.17*[◊]	$\boldsymbol{\Omega_1}$	*0.6*[*]	$\boldsymbol{\Phi_2}$	*0.73*[◊]	$\boldsymbol{\Lambda_4}$	*0.56*[◊]
$\boldsymbol{\eta_1}$	*0.5*	$\boldsymbol{\Omega_2}$	*0.3*	$\boldsymbol{\Phi_3}$	*0.70*[◊]	$\boldsymbol{\Lambda_5}$	*0.16*[◊]
$\boldsymbol{\eta_2}$	*0.8*	$\boldsymbol{\Theta_1}$	*0.2*	$\boldsymbol{\nu_1}$	*1.0*[*]	$\boldsymbol{\Gamma_1}$	*0.82*[◊]
$\boldsymbol{\zeta_1}$	*0.5*	$\boldsymbol{\Theta_2}$	*0.2*	$\boldsymbol{\nu_2}$	*1.0*[*]	$\boldsymbol{\Gamma_2}$	*0.1*
$\boldsymbol{\zeta_2}$	*0.5*	$\boldsymbol{\varphi_1}$	*0.80*[◊]	$\boldsymbol{\nu_3}$	*1.0*[*]	$\boldsymbol{\Gamma_3}$	*0.78*
$\boldsymbol{\gamma_1}$	*0.2*[+]	$\boldsymbol{\varphi_2}$	*0.38*[◊]	$\boldsymbol{\nu_4}$	*1.0*[*]	$\boldsymbol{\psi_1}$	*0.92*[◊]
$\boldsymbol{\gamma_2}$	*0.1*[+]	$\boldsymbol{\rho_1}$	*0.97*[◊]	$\boldsymbol{\nu_5}$	*1.0*[*]	$\boldsymbol{\psi_2}$	*0.42*[◊]
$\boldsymbol{\beta_1}$	*0.6*	$\boldsymbol{\rho_2}$	*0.45*[◊]	$\boldsymbol{\nu_6}$	*1.0*	$\boldsymbol{\psi_3}$	*0.21*[◊]
$\boldsymbol{\beta_2}$	*0.2*[*]	$\boldsymbol{\rho_3}$	*0.90*[◊]	$\boldsymbol{\xi_1}$	*0.65*[◊]	$\boldsymbol{Z}$	*0.8*
$\boldsymbol{\beta_3}$	*0.2*	$\boldsymbol{\rho_4}$	*0.28*[◊]	$\boldsymbol{\xi_2}$	*0.89*[◊]	$\boldsymbol{K}$	*0.5*
$\boldsymbol{\lambda}$	*0.8*[*]	$\boldsymbol{\sigma_1}$	*0.79*[◊]	$\boldsymbol{\Psi_1}$	*0.42*[◊]		

Notes: [◊] The estimated posterior mean using the Bayesian estimation technique, [+] Policy parameter, [*] Cox and Harvie (2010).

[47] An impulse response function represents the dynamic response of a variable to the shock.

6.3 External Stochastic Shock and Dynamic Behaviour of the Model

The dynamic behaviour of the model, in response to an unanticipated external shock, is evaluated for the financial, domestic, external, resource sectors. The world interest rate as an exogenous variable in the model which transmits external shocks to this model economy is selected for this purpose. It is assumed that there is an unanticipated positive shock to the average world interest rate[48] which impacts the open model economy. The world interest rate only increases for one period and then disappears (a one-off shock).[49] It is common in the literature that a world interest rate shock is more compatible with a stochastic shock rather than a deterministic shock. Among only a few available external shocks in this model the world interest shock is selected to evaluate the dynamic behaviour of the model.

6.3.1 Open Economy Linkages with the Rest of the World

A small open economy, with a significant resource-exporting sector, has several channels in which the economy links with the rest of the world. This in turn requires the economy to respond to possible exogenous shocks or changes which is then transmitted into the economy through related variables. There are several channels through which a small open economy links to the world economy, amongst the most well-known channels are the financial, trade and resource sectors. The financial

[48] In some studies such as Uribe and Yue (2006) the US interest rate is applied as the proxy for a world interest rate shock rather than the average world interest rate. In this study, however, it is assumed that there is a shock in the average world interest rate to reflect the rest of the world in general rather than focusing just on the US economy. This assumption is more important in particular for the model of this study as the foreign investors (in the mining sector for instance) in Australia are not necessarily from the US but also from other economies such as India.

[49] The size of the shock is set to be equal to one standard deviation (which is assumed to be equal to 25 basis points in this model). A one-off interest rate shock is artificial but is assumed merely to evaluate the dynamic behaviour of the model. It also makes the process to be more transparent by isolating one period shock and it helps the tracking of the effects through the transmission channels.

channel is particularly important in the context of this chapter and the latter being more important in Chapter 7.

The financial channel is one of the important means by which changes in the rest of the world are transmitted to the domestic economy. For instance, a shock to the average world interest rate is an important factor for a country with high capital mobility and a floating currency (see Glenn, 1997; Muhanji and Ojah, 2011; Zhang *et al.*, 2014), as this will likely influence capital movements and the exchange rate, resulting in further possible reactions from both domestic and international players.[50] As shown in Equation 4.30 in Chapter 4, an increase in the world interest rate is one of the factors likely to increase holdings of foreign assets, assuming all other factors (such as differential risk) remain the same. On the other hand a positive world interest rate shock is an important factor impacting the nominal exchange rate. Theoretically the domestic currency becomes less attractive relative to other currencies and so demand for the domestic currency falls, matched by an increase its supply, which leads to a depreciation of the exchange rate. Uncovered interest rate parity means the exchange rate instantaneously depreciates to a point where it generates expectations of an exchange rate appreciation to offset the greater interest rate differential (Dornbusch, 1976).

Trade balance may also benefit from the above mentioned trend in the exchange rate too as the depreciated exchange rate would increase demand for Australian products in global markets by making the total price cheaper for foreigners. However, this process would also make the import price higher for domestic residents. In addition,

[50] There are however some studies such as Correia et al. (1995) and Kose and Riezman (2001) that show external shocks are less important, compared to domestic shocks.

an increase in the average world income, as an external shock, can lead to a higher demand for the small open economy's exports and this can lead to an increase in domestic real income through boosting the trade balance.

For a resource-exporting economy, a global resource price shock is another important factor which plays an important role in transmitting external shocks into the economy. An increase in the resource price[51] may also boost the resource sector and increase resource production and exports. This will likely have wide ranging impacts on, for example, the trade balance, investment in the resource or non-resource sectors and real income etc. This process and its impacts upon the economy are analysed in more detail in Chapter 7.

All of the above mentioned factors may be considered as external shocks to an economy. As mentioned previously, the goal of this chapter is to examine the dynamic behaviour and stability of the simulated model in response to a stochastic shock specifically that of a global interest rate shock, in the following sections.

6.3.2 Financial Sector

The financial sector in Australia would typically instantly react to a stochastic world interest rate shock, hence money and financial market shocks are under focus in

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[51] A resource price shock may happen for a variety of reasons and may emanate from the demand side (e.g. an unexpected demand hike for natural resources in emerging economies), supply side (e.g. lack of capital investment in major resource producing companies and fall in extraction level) and for political reasons etc. For instance, a war in one of the resource producing countries may increase the resource price which may benefit other resource producing countries as a result. Development patterns in main resource importing countries such as China may also be considered as a factor to decrease the demand for the natural resource and lead to a decline in the resource price. This has been the subject of intense debate on the impact of reduced Chinese demand for Australian resource products (stalling of real estate and other construction development in China (e.g. iron ore in particular).

DSGE modelling. One of the factors which boost the immediate effect of the stochastic shock on the financial market is because of the expectations about the future or the so called *herding behaviour*[52] in this market. The financial investment declines as the consequence of decline in the Tobin's *q* index in response to the shock and therefore the natural reaction of the financial markets is to express it in a lower profitability in both resource and non-resource sectors.

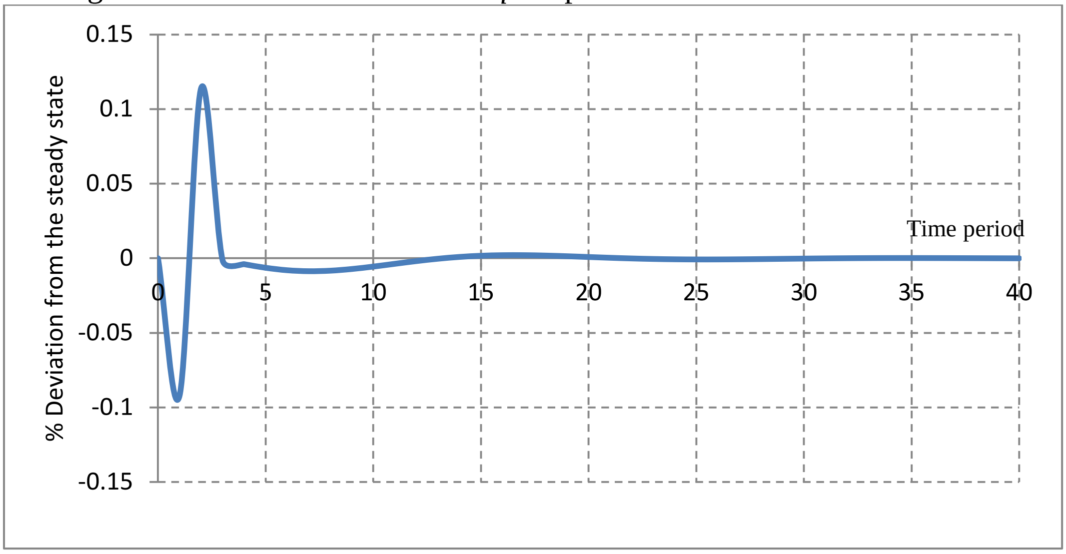
The responses of the Tobin's *q* for both the non-resource and resource sectors are shown in Figure 6-1 and Figure 6-2[53], which reveal that the reaction of the resource sector in terms of diminishing profitability as a reaction to the stochastic world interest rate shock is more than two times the size of the decline of that in the non-resource sector. This clearly shows the sensitivity of the resource sector to external shocks in the structure of this model. In fact, as most of the financial investment in the resource sector is funded by international investors this may explain this sensitivity in Australia (as it is easier for international investors to quickly shift to another financial investment in another country). However, for the capital (FDI) investors which are likely to be locked in is not possible to easily move and they may find it easier to mothball the capital stock and cut production. This different reaction of Tobin's *q* in resource and non-resource sectors suggests that sectors which heavily depend on exporting (e.g. resource sector) are more likely to be adversely affected by global disturbances, that is, experience a greater stock price fall, in comparison to the

[52] This is a well-known term to show behaviour in share markets where the investors suddenly try to sell or buy shares, only to follow the crowd and not necessarily for any specific or rational reason (see Hey and Morone, 2004).

[53] The Figures provided in this chapter are the Impulse Response Functions (IRFs) extracted from running a stochastic external shock (world interest rate) on the model of this study using the Dynare package (see www.dynare.org).

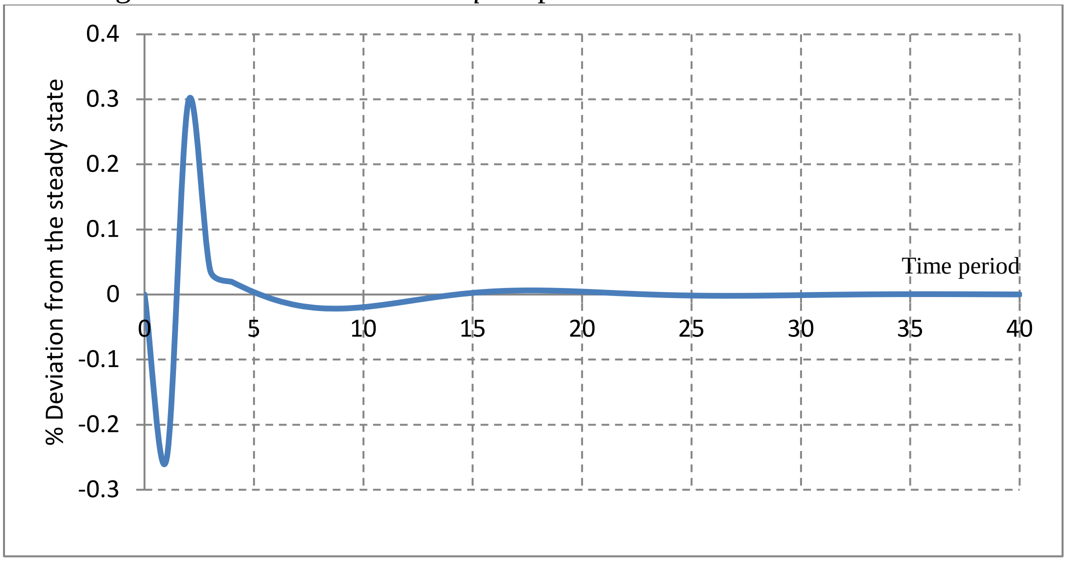
stock prices of less export dependent sectors. This also highlights the significance of resource allocation in the domestic economy.

Figure 6-1 Non-resource Tobin's *q* Response to a World Interest Rate Shock



On the other hand, once the shock is over, the resource sector Tobin's *q* shows that the increase in profitability of this sector is almost three times higher in comparison to the same situation in the non-resource sector. The reason might be the high profits (and rents) which exists in this sector and can quickly recover after the shock and even compensate the low profitability in previous periods (compared to the steady state value). In addition, a lower profitability leads to the existing capital stock utilisation and a lower level of capital stock (both in resource and non-resource sectors as it is shown in Equations 4.3 and 4.4 in Chapter 4) and this is in line with the study of Gente and León-Ledesma (2006).

Figure 6-2 Resource Tobin's *q* Response to a World Interest Rate Shock

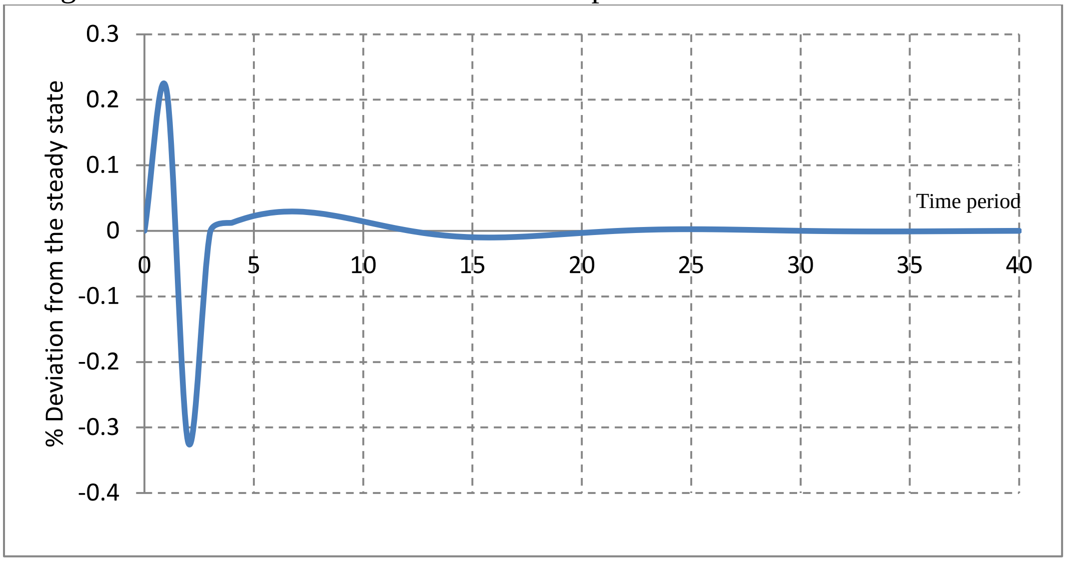


The domestic interest rate is another key variable identified here and its response to the world interest rate shock is shown in Figure 6-3. The reaction of the domestic interest rate is a bit smaller than the world interest rate shock. The importance of the world interest rate in determining the domestic interest rate in a small open economy is highlighted in the study of Neumeyer and Perri (2005) by considering the world interest rate as one of the two components of the domestic economy (beside the country risk). This explains the similar reaction of the domestic interest rate to the world interest rate shock in this study as the result shows in Figure 6-3. This positive response of the domestic interest rate to the world interest rate is also in line with Dornbusch and also Mundell-Fleming models (see Kouri, 1981).

The pattern of the domestic interest rate response is in line with the literature as mentioned by Kouri (1981, p.14) that "with rational expectations the domestic interest rate does not increase by the full amount of the increase in the foreign interest rate" (as exchange rate expectations also change) which is consistent with assuming the unanticipated interest rate stochastic shock. In the steady state the

domestic interest rate would come up to the world level so as to maintain uncovered interest rate parity.

Figure 6-3 Domestic Real Interest Rate Response to a World Interest Rate Shock



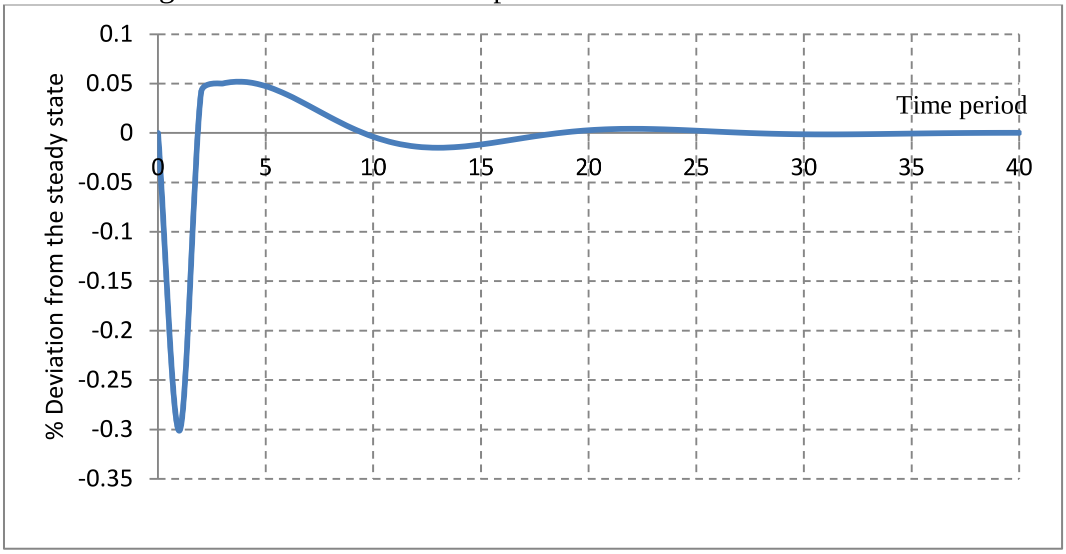
There are also a group of studies in the literature exploring the relation between the world interest rate and the exchange rate, such as Peters (2009), Sousa (2011) and Muhanji and Ojah (2011). The exchange rate in this study appreciates following the increase in the world interest rate which shows a positive relationship which is in line with the results of Peters (2009) and Muhanji and Ojah (2011). This might be as a result of the quick increase in the domestic interest rate or a change in the expectations about the future business environment in Australia compared to the rest of the world. However, there are also other studies showing the negative relationship between these two which is closer to the economic intuition behind it (see Sousa, 2011).

6.3.3 Macro-economy

The impact of external shock on a small open economy will vary depending on its size and also the stage of its economic cycle. This impact will also very heavily depend on the size and importance of the external sector, in terms of the relative importance of natural resource exports and related foreign investment flows. For instance, a decline in international investors' tendency to invest in a particular country, which is already in recession, may lead the economy to be worse if they rely on foreign investment and more so for an economy heavily dependent upon a particular sector such as the resource sector.

As shown in Figure 6-4 the initial reaction of real income is negative, being opposite to the change in the world interest rate and is in line with the results of studies such as Muhanji and Ojah (2011) and Sousa (2011). Once the one-period shock is over real income overshoots and even becomes greater than the steady state due to the decline in the domestic interest rate. It returns to its steady state in just over 15 periods after the period in which the shock occurred. The negative impact of the stochastic shock on real income is quickly reversed which highlights the role of financial sector variables. The oscillatory behaviour of real income is a result of the finding of the complex eigenvalue solutions, reported in Chapter 5 (that is the 6 eigenvalues with imaginary components).

Figure 6-4 Real Income Response to a World Interest Rate Shock

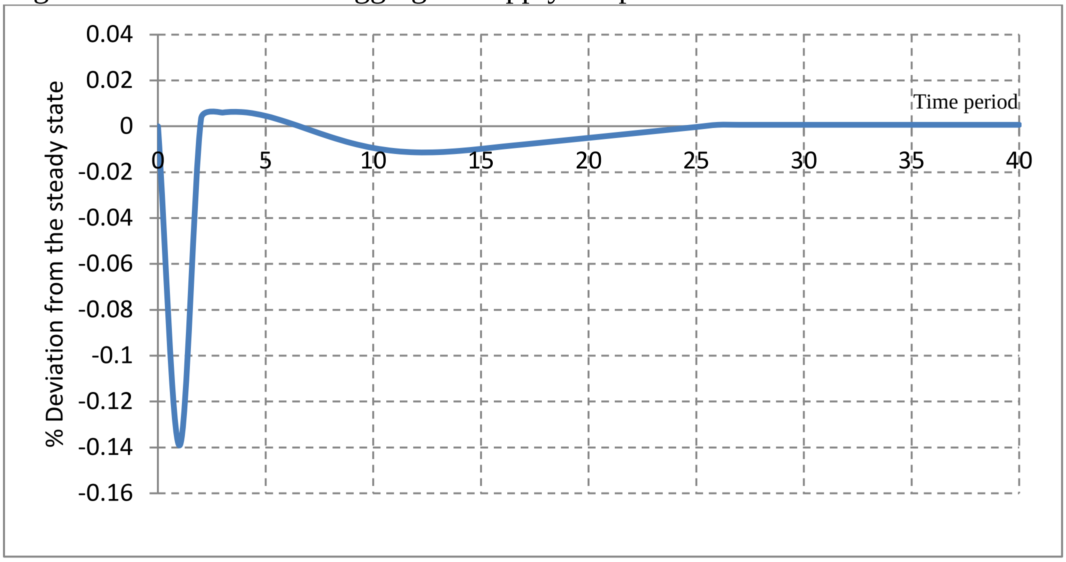


This reaction of real income could be due to various factors. The first is the negative impact on financial market variables such as the decline in the value of equities and then decline (with a lag) in foreign investment in the domestic economy especially in the resource sector as foreign investors may find investing elsewhere more profitable and hence shift from the resource sector to another option with a higher interest return. The direct implication is that resource production would decline which will lead to a direct decline in real income. Non-resource investment may also be negatively affected, not only by the lower level of foreign investment but also because of the domestic capital flowing overseas to gain the higher interest relative to the domestic rate.

Thirdly, the lower level of resource production means a lower level of collected revenue for the government from the resource sector which would decline the human and physical capital, as they are funded by the government, and this, along with the decline in non-resource private capital (due to the change in the domestic investors attitude), leads to the decline in non-resource aggregate supply, as shown in Figure 6-

5. This decline would obviously lower real income as a result of the hike in the world average interest rate.

Figure 6-5 Non-resource Aggregate Supply Response to a World Interest Rate Shock

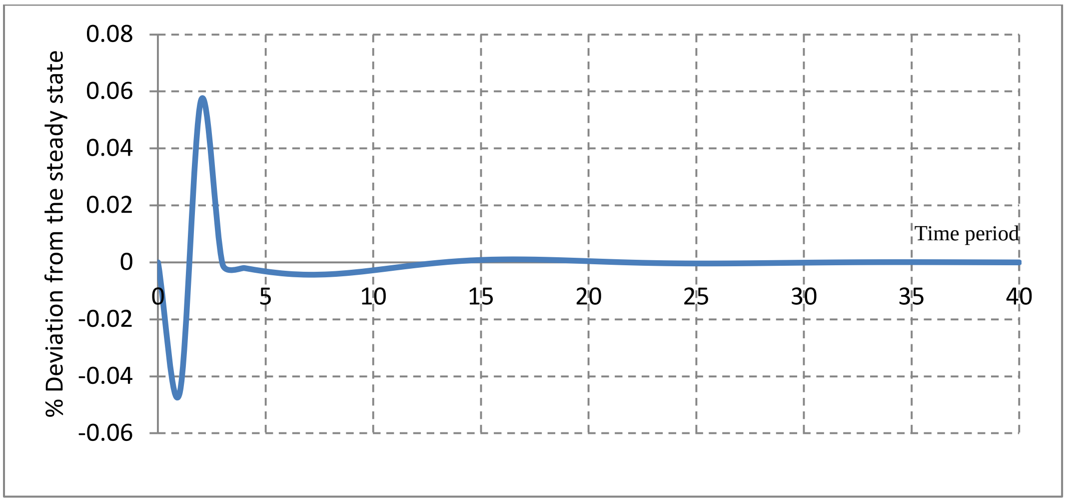


Another factor which may play a role is the impact on the exchange rate following the stochastic shock of the world interest rate. A weaker Australian dollar may increase the demand for Australian products especially resource products which might actually help the real income but the overall impact depends on the magnitude of decline in resource production from the lower investment or increase in the resource demand (leading to a higher resource production) due to lower prices for foreign buyers. This is an important factor especially for a country such as Australia by having a currency that was the fifth most traded currency globally in April 2013 (Reserve Bank of Australia, 2015).

As the average world interest rate becomes higher compared to that in Australia, there is the tendency for the domestic investors to shift to overseas leaving the

domestic economy with the lower level of investment which will decrease the non-resource private capital stock and will eventually lead to the lower non-resource aggregate supply (see Equation 4.25 in Chapter 4).

Figure 6-6 Non-resource Private Investment Response to a World Interest Rate Shock



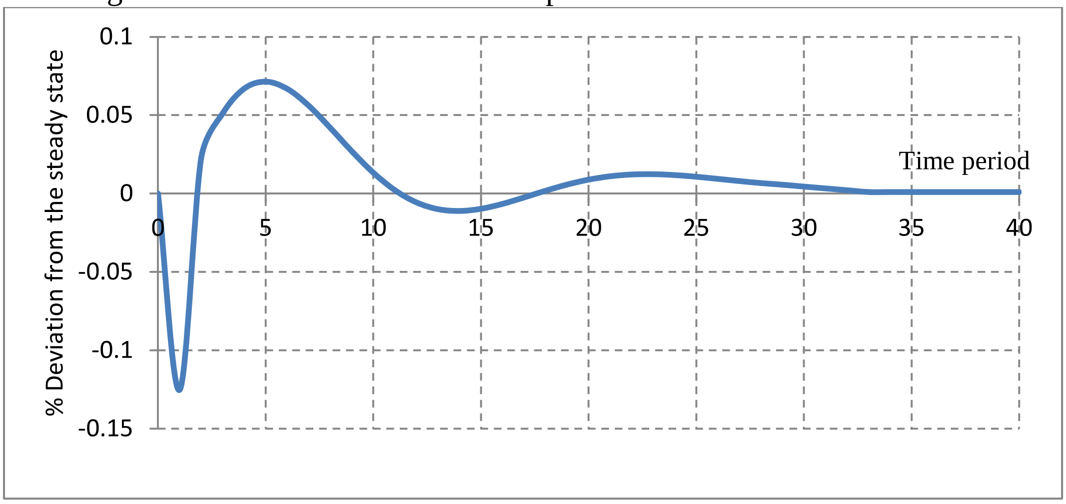
High mobility of financial flows and the fact that a higher world interest rate may move some parts of the domestic funds to overseas leaves the non-resource private investment with a relatively small decline, however, this is fully covered by the higher level of investment after the world interest rate moves back to its steady state. In fact, a rise in average world interest rate makes Australian financial assets less attractive as well as return from investing in the domestic resource and non-resource sectors (reflected in a decline in the *q* ratios for these two sectors as explained in Section 6.3.2). Lower relative return in these two sectors creates the incentive to invest elsewhere and cut production. This is also one of the factors which decline the real income in response to the positive world interest rate shock as well.

6.3.4 Resource Sector

Most external shocks to small, open and resource dependent economies very likely affect the resource sector as they are mainly exporters of resource products. In fact, this sector is vulnerable to external shocks such as the world interest rate shock. This becomes more important if the resource sector highly benefits from foreign investment to continue to explore and increase natural resource production. Therefore, any change in global financial markets may lead the global investor to revise their decision in financial investment in the Australian resource sector.

As Figure 6-7 shows, following an increase in the world interest rate resource production declines on impact relative to steady state. This may occur due to the influence upon the international investors trying to stop financial investment in the Australian resource sector and possibly shift to assets with a higher rate of return in other countries.

Figure 6-7 Resource Production Response to a World Interest Rate Shock



Therefore, the initial impact of the stochastic world interest rate shock is on financial markets and this then affects investment flows and resource production with a lag. So the financial impact indirectly affects the resource production. There is also a subsequent relatively large and prolonged increase above the steady state which is related to the increase in the profitability of the resource sector as reflected in the higher Tobin's *q* once the stochastic shock is over as discussed earlier.

6.3.5 External Sector

The world interest rate, as mentioned earlier, is one of the factors in the model which increases the return obtained from investing in foreign financial assets. There are also other factors that may change the return from foreign financial assets (see Equation 4.30 in Chapter 4) such as trade, resource exports, resource price or exchange rate. Figure 6-8 shows that the accumulation of foreign assets increases following the world interest rate shock, due to the surplus in current account, and declines over the next few periods.[54] The initial increase in financial assets is very likely due to the direct impact of the world interest rate through the current account; however, being higher than the steady state for a few periods (although diminishing) might be due to the other factors mentioned above such as resource exports or non-resource trade balance. As it is shown in the previous section, for example, resource production increases shortly after the shock is over and might be one of the reasons that the foreign assets still remains higher than the steady state for a couple of periods. In fact, this reflects the Dornbusch (1976) model assumption that financial variables

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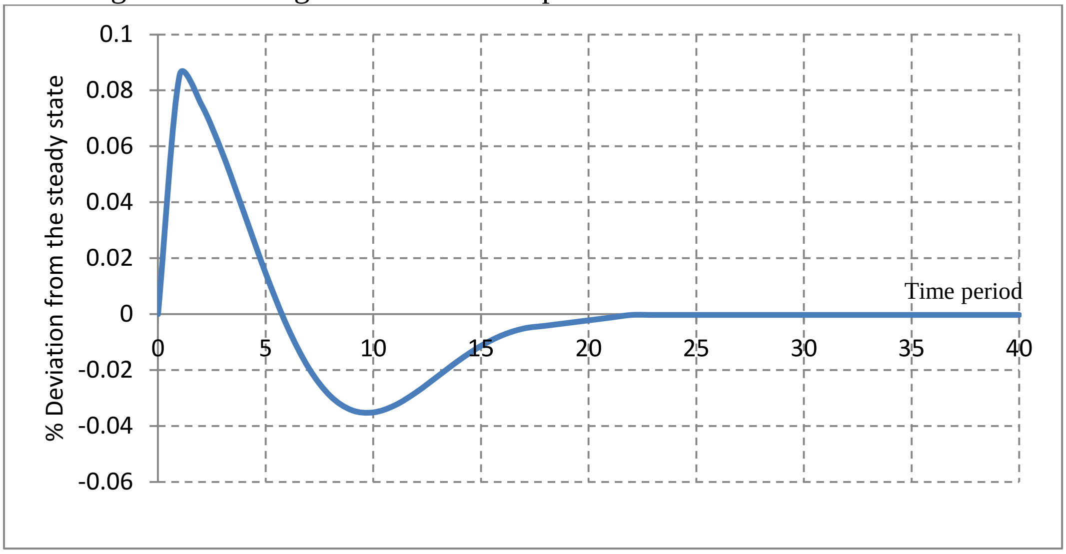
[54] In some studies such as Sousa (2011) the world interest rate shock is treated as an external volatility to the model (as a result of falling output and consumption) and hence assume households tend to hold less foreign assets, however, this negative relation is not the first reaction in this research but it does have a relatively small subsequent negative impact from period 5-20 according to Figure 6-5.

continuously adjust to ensure financial markets are in equilibrium but non-financial markets are subject to lags and takes time to adjust, hence, repercussions continue for some period of time.

Figure 6-8 Foreign Asset Stock Response to a World Interest Rate Shock



The increase in foreign assets would in turn influence wealth, private asset composition and private sector spending. Similarly, holdings of private assets also depend on several other factors at the same time including private resource and non-resource capital and also resource and non-resource Tobin's q which are shown in Equation 4.22.

6.4 Summary

In this chapter the behaviour of the dynamic model, in the sense that whether the model behaves according to theory and data following a stochastic external shock (world interest rate) has been analysed. More specifically it has been examined if the dynamic interdependencies are sensible in direction, magnitude and time. This is necessary to prepare the ground for a deeper impulse response function analysis of changes in resource sector markets and also government fiscal responses to these

changes. In addition, despite many endogenous variables in the model, there are only a few exogenous variables existing to be considered as an exogenous shock and amongst them the world interest rate is selected as the stochastic shock to the model. Due to the nature of a stochastic shock being unpredictable, this variable is a more reasonable option compared to the few other available shocks in this model such as the average world real income.

The results provided in this chapter in the form of impulse response functions reveal the stability of the model and that all the major variables under study return to their required steady state values. Meanwhile, the results show how a small open economy, with the characteristics of that of Australia, is sensitive to external shocks. It also shows how the effects are instantly transmitted to the financial sector variables and then the real economy. These changes may not be that significant compared to domestic shocks but are surely essential in analysing economic outcomes for policy makers. A broader range of simulations with focus on a number of possible fiscal policies for the Australian economy in a mining boom era are discussed in Chapter 7.

CHAPTER 7

RESOURCE PRICE SHOCK AND FISCAL POLICY SCENARIOS

7.1 Introduction

The objective of this chapter is to conduct a number of simulations relating to resource price shocks and policy responses using the macroeconomic model developed in Chapter 4, estimated and further discussed and assessed in Chapters 5 and 6. This chapter provides some valuable insights into outcomes from simulating the interactions of resource price shocks and fiscal policy responses for major variables of the economy under study. Evaluating the results sheds some light on the performance of the small, open, resource-exporting economy under study and the dynamics of adjustment involved. More importantly, it provides important insights for policy makers on the adjustment processes involved and the consequences of alternative policy scenarios.

Exploring the impact of a resource tax policy on the economy in a macroeconomic model with an endogenous resource sector is one of the main goals of this research and a major focus of this chapter. In addition, the model developed in this study is also capable of analysing a number of fiscal expenditure policies concurrent with resource taxation. The two main settings of the model economy in terms of public expenditure policies are provided in Sections 7.2 and 7.3. In the first scenario the government mainly spends the collected revenue from the resource sector on consumption, or current expenditure, and only a minimum amount of 10 percent from revenues is spent on investment (capital) expenditures. This includes both infrastructure and human capital expenditures (5 percent each). In the second scenario, the government spends 50 percent of the collected revenue from the

resource sector on investment expenditures. This allows a comparison of the impacts of a variety of resource taxation and spending simulations.

The next stage is to set the external shock and the taxation and expenditure related policies. The time frame under study is categorised as the boom period and the post-boom period to make the analyses clearer. Unlike the shock pattern in Chapter 6 where a one-off stochastic shock was applied, in this chapter it is assumed that the resource price experiences an inverse U shaped progress over the boom period. In fact, in the simulated boom period the resource price increases and once it reaches its peak it then declines back to its original baseline value.

In each of the two scenarios, three resource tax policy cases are assumed in reaction to a resource price boom. The first, Case A, assumes no policy reaction by the government to change the resource tax rate following a resource price boom. In Cases B and C, however, the resource tax is increased by 2.5 percent and 5 percent (at its peak). For each case the impulse response of key variables is analysed for six sectors of the economy. These sectors are the domestic economy, the private sector, the public sector, the external sector, the resource sector and the financial sector as presented in Sections 7.2.1 to 7.2.6 respectively. Section 7.3 highlights the consequences of a more investment oriented fiscal expenditure response, therefore the sectors of the economy explored in Section 7.3 are limited to those believed to be more relevant to the discussed issue.

The cumulative variation from the baseline is another interesting element calculated for each variable in both scenarios and this is presented in Sections 7.2.7 and 7.3.6.

This is another important part of the analysis in this chapter as it clearly provides a precise tool to measure the overall impact in each simulation for each time period of the study. It also allows comparing the performance of the economy in the two main scenarios by showing the precise gain (or possible loss) for the economy by spending more on infrastructure and human capital rather than mainly spending on consumption expenditure. A number of very interesting results and possible policy reactions are discussed in this chapter as well.

7.2 Resource Price Shock and Natural Resource Tax Scenarios

The macroeconomic model developed in this study is further analysed by simulating its reaction to a resource price shock as well as examining the three resource tax policies that could be applied by the government. The positive resource price shock is selected to reflect one of the significant aspects of the resource boom in Australia over the last few years. The increase in resource price is set to be gradual, such that it rises to 1 percent over the baseline in the first period and then continues to increase up to 5 percent (remaining at this level over quarters 4 and 5) and then declines symmetrically back to its steady state value at the end of period eight (see Table 7-1 for more details). The set shape for the resource price boom is applied due to its similarity to the increase and decline in the price of major resource products in Australia such as iron ore and coal. This allows analysis of the behaviour of key macro variables in two sub-periods; first, when the price is higher than the original steady state and still ascending and, second, when the price is similarly higher than the steady state but is gradually descending.[55] Therefore, as in both situations the

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[55] This is particularly different from the simulations in Cox and Harvie (2010) where the resource price increases and remains at the same level for the entire period under study. The dynamic pattern

resource price is higher than its steady state, the first eight quarters contain resource price behaviour consistent with what we describe as a resource price boom period.

Policy action by the government in terms of resource sector taxation is also categorised in three scenarios. In Case A, the increase in the resource price is not met with any change in the tax rate imposed on the resource sector by the government. In this case, the government allows the resource sector to obtain additional economic profits from the resource price boom and only applies the existing rate of resource tax (see Table 7-1). This may be due to the government believing the resource sector is leading the economy during the boom period so any increase in resource tax would play against resource producers and hence could hinder or slow down the economic growth. The Case B response by the government is to increase the resource sector tax rate by half of the resource price increase. Therefore, when the resource price reaches a peak at 5 percent over baseline, the resource tax is 2.5 percent higher than its initial steady state rate (see Table 7-1). Finally, in Case C, change in the resource price is precisely matched by an equivalent proportional change in the resource tax, whether it is increasing or decreasing. From a taxation perspective this suggests that if the government decides to increase the resource tax then it is important that it be linked to proportional changes in the resource price.

While conducting these scenarios assists in explaining the reactions of key variables in our macroeconomic model (which includes an endogenous resource production sector) to a resource boom, it also enables analysis of how the government plays a

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applied here is closer to the fluctuations of resource price in the global markets (as a resource price boom generally happens for a limited period of time and is not permanent) and is recognised as a temporary deterministic shock in its technical aspect.

critical role in impacting economic outcomes through imposing a variety of resource tax strategies on the resource sector. Therefore, the behaviours of key variables during the resource boom as well as their reaction to differing policy responses are monitored through the simulations applied to the model under study.

Table 7-1 Resource Price Shock and Resource Tax Scenarios

Time period	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9-50*
Resource price	0	1	2	3	5	5	3	2	1	0
Resource tax - Case A	0	0	0	0	0	0	0	0	0	0
Resource tax - Case B	0	0.5	1	1.5	2.5	2.5	1.5	1	0.5	0
Resource tax - Case C	0	1	2	3	5	5	3	2	1	0

Note: The numbers in this table reflect the percentage deviation from initial steady state.

The values of a few coefficients (γ_1, γ_2 and ε) are changed slightly to satisfy the different policy scenarios discussed and also to make it closer to reality when compared to the respective values applied in Chapter 5. In Sections 7.2 and 7.3 it is assumed that the government spends a major part of the revenue collected from the resource sector for consumption expenditure purposes, and the rest is equally spent on infrastructure and human capital (including health and education). Therefore, γ_1 and γ_2 (the coefficients related to infrastructure and human capital respectively) are considered to be 0.05 (5 percent) each (rather than the 0.2 and 0.1 respectively in Cox-Harvie). This will be discussed further in Section 7.3. The weight of the resource sector $(1-\varepsilon)$ in the real income equation (Equation 4-15 in Chapter 4) is also assumed to be equal to 0.07 which reflects the average contribution of the resource sector to GDP in Australia (7 percent) over the period of the recent resource boom.

The results are considered for two main periods consisting of the boom period (assumed to continue for 8 periods as mentioned) and the post-boom period (12 periods after the resource price shock is over) to analyse the behaviour of variables after a resource boom and to also consider the impact of lagged variables, specifically the non-financial variables. The overall results are provided and summarised for six sectors - the external sector, the public sector, the private sector, the domestic economy, the resource sector and the financial sector. Interaction between these sectors makes the transmission of shocks across several sectors at the same time unavoidable.

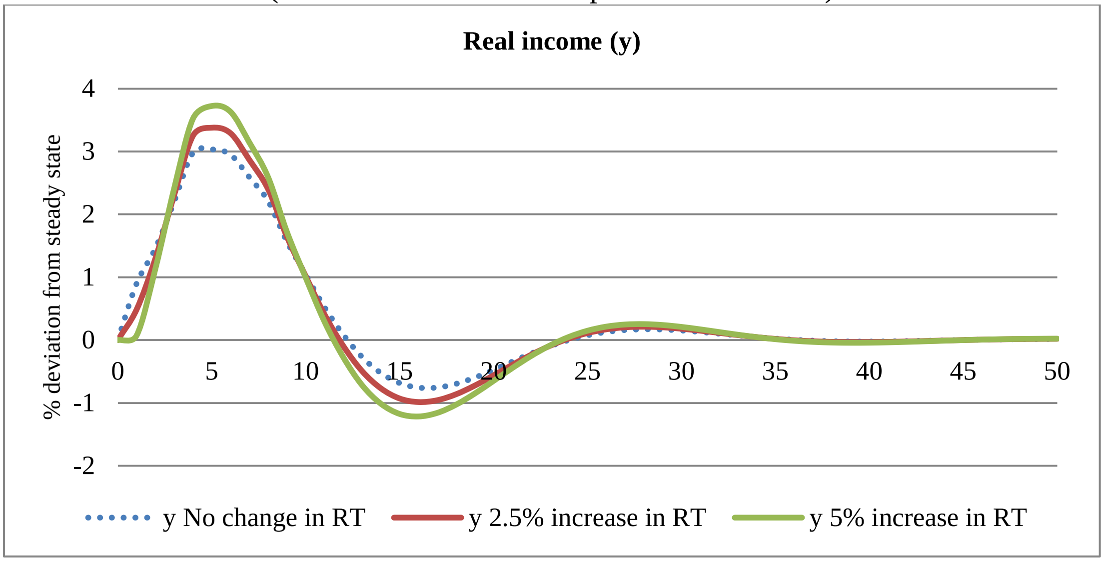
7.2.1 Domestic economy

The development in real income, which consists of both production in the resource sector and the non-resource aggregate supply, is quite sizable compared to the resource price boom. As shown in Figure 7-1, the real income impulse response function (IRF) for all three cases is higher than the baseline as a result of the resource boom, which reflects the positive impact of a resource boom on an economy discussed in Chapter 3 as the *income effect*. In fact, an increase in resource prices stimulates an increase in resource production which directly impacts real income.

Figure 7-1 shows that real income continues to stay higher than its long run steady state for about four quarters after the resource price boom is over and then returns back to its steady state. This may be due to the lagged adjustment of the non-financial factors in the real income equation (such as the non-resource aggregate supply segments). Once the post-boom period starts, real income is still higher than the baseline due to the lagged adjustments.

Another interesting outcome of this simulation highlights the important role of the government in a resource price boom period. When the economy is experiencing the peak price for natural resources, a higher tax on resource products further increases real income during the quarters with the highest resource prices due to government spending related to the high tax revenue.

Figure 7-1 Real Income Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



Note: The 2.5 percent or 5 percent increase in the resource tax rate (RT) shown in all the graphs in this chapter refer to the maximum increase over the resource boom which is not a flat rate.

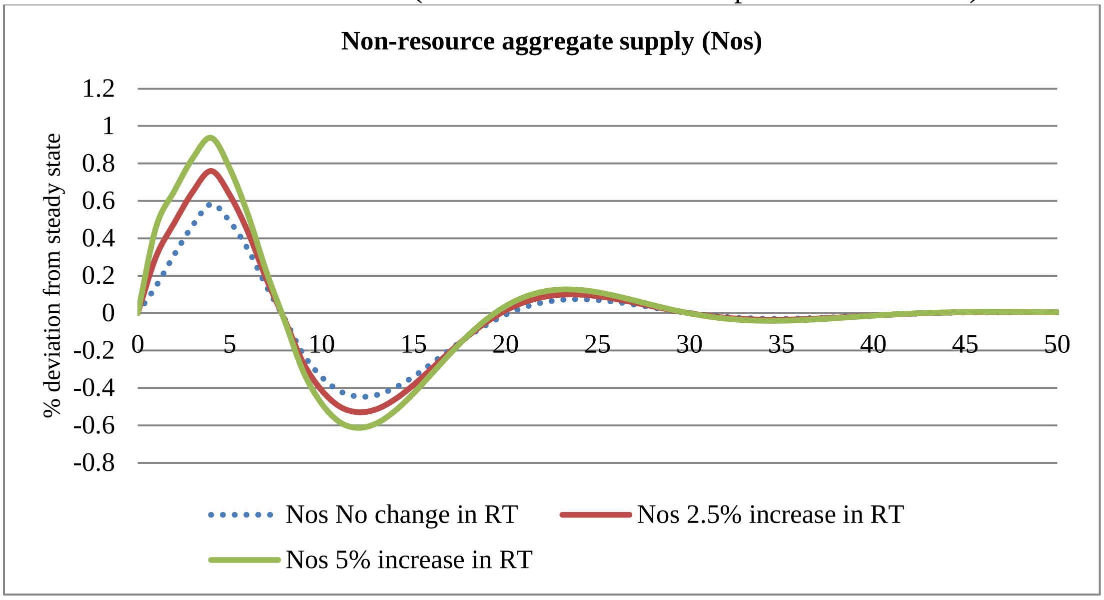
Following the explanation of the change in real income, production also clearly increases in the resource sector. To explore production in the non-resource sector, the reaction of non-resource aggregate supply (indicative of production in the non-resource sector) is presented in Figure 7-2 and shows an increase during the boom period. This is due to the fact that while the increase in infrastructure capital, human capital and non-resource private capital exert upward pressure on non-resource aggregate supply, upward pressure on nominal and real wages works in the opposite direction and curtails the non-resource sector production from the resource boom.

However, an increase in the resource tax during the boom period helps to bring about higher non-resource aggregate supply since the higher taxation generates more government spending on productivity-enhancing measures in the non-resource sector (such as infrastructure, health and education). One reason that the non-resource aggregate supply attains a higher level following an increase in the resource tax is explained by increases in the q ratio in the non-resource sector which encourages more investment and leads to a higher non-resource private capital stock. Additionally, an increase in total productivity in the economy following a higher stock of human capital and infrastructure also explains the increase in non-resource aggregate supply.

The results also show that the increase in non-resource aggregate supply following a resource price boom is not considerable (about 0.6 percent in Case A and about 0.9 percent in Case C) compared to the resource price increase of 5 percent at its peak. It can be argued that non-resource aggregate supply elements such as non-resource private capital stock, infrastructure capital and human capital fail to exert enough pressure to increase it. In other words, as investors move towards the resource sector rather than the non-resource sector, it is therefore not expected that private non-resource capital will experience a substantial increase over this period. In addition, in the scenario where there is a minimum of investment by government in terms of infrastructure, health and education, there is not enough upward movement in infrastructure and human capital. This is clearly another reason that the non-resource sector is not getting a sizable benefit from the resource boom. However, as discussed earlier, government policy may improve the outcomes for the non-resource sector following a resource price boom.

One may also argue that based on the *resource movement effect* discussed in the resource boom literature in Chapter 3, more inputs, including labour, will move towards the resource sector and will leave the rest of the economy with a shortage of labour which leads to a higher wage rate and this can be considered as another reason for the relatively poor performance of the non-resource aggregate supply. In the case of Australia, however, and as discussed in Chapter 3, due to the very low level of labour in the resource sector (only about 2 percent of total employment) it is often considered that this sector is mainly capital intensive (as is assumed in the theoretical model). Also the capital is mostly provided by foreign investors which makes the resource movement effect less relevant in the performance of the non-resource aggregate supply following a resource price boom.

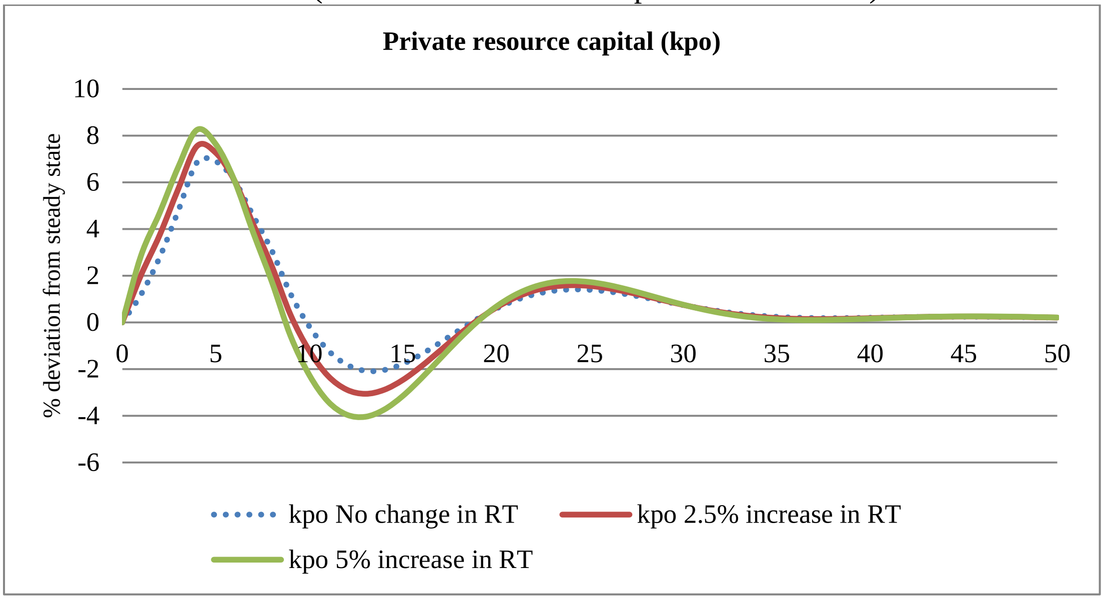
Figure 7-2 Non-resource Aggregate Supply Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



7.2.2 Private sector

The private sector also benefits from the resource boom due to an increase in private capital, but the distribution between private resource capital and non-resource capital is not the same as shown in Figures 7-3 and 7-4. The private resource capital shows a greater increase during the boom period compared to private non-resource capital.

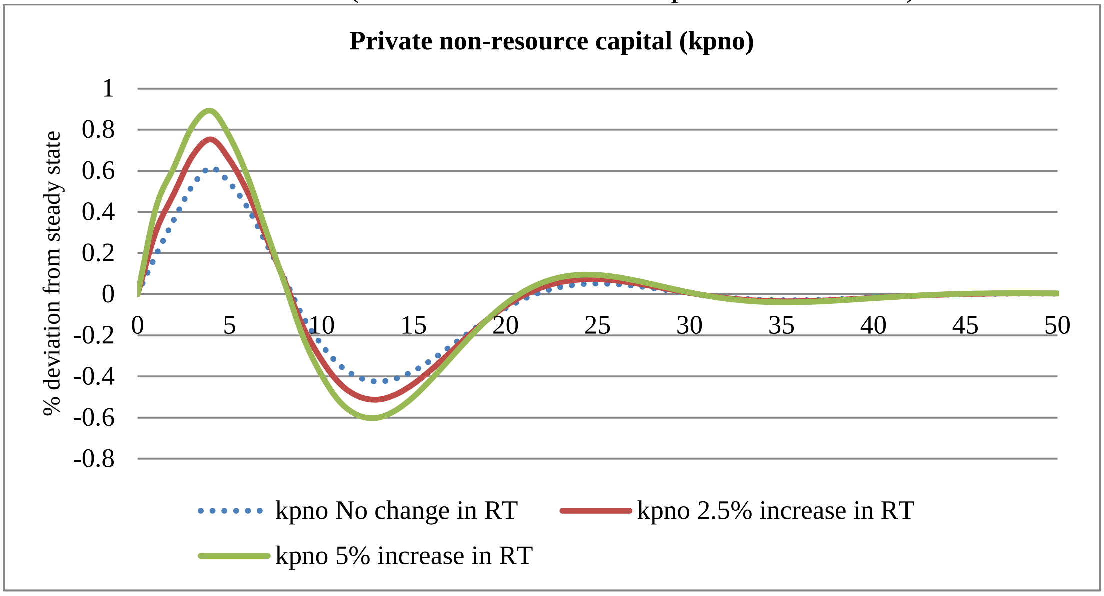
Figure 7-3 Private Resource Capital Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



The real profit from the non-resource sector declines during the boom period as shown in Figure 7-5 which shows that it is inversely related to capital stock accumulation based on the diminishing marginal productivity of capital (see Equation 4-18 in Chapter 4). The higher capital is, the lower marginal productivity and real profit are. In addition, a higher wage rate increases the costs of production for the non-resource sector and the appreciation of the exchange rate decreases non-resource exports which both reduce the non-resource real profit. Likewise, the increase in the interest rate, as the cost of capital, makes the non-resource real profit lower during the boom period. In other words, the economy suffers from Dutch Disease symptoms. However, resource real profit experiences an increase while the

resource price is continuously increasing and becomes negative once the resource price level declines back towards the baseline (see Figure 7-6). The resource profit starts to recover once the resource price becomes equal to the steady state value.

Figure 7-4 Private Non-resource Capital Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)

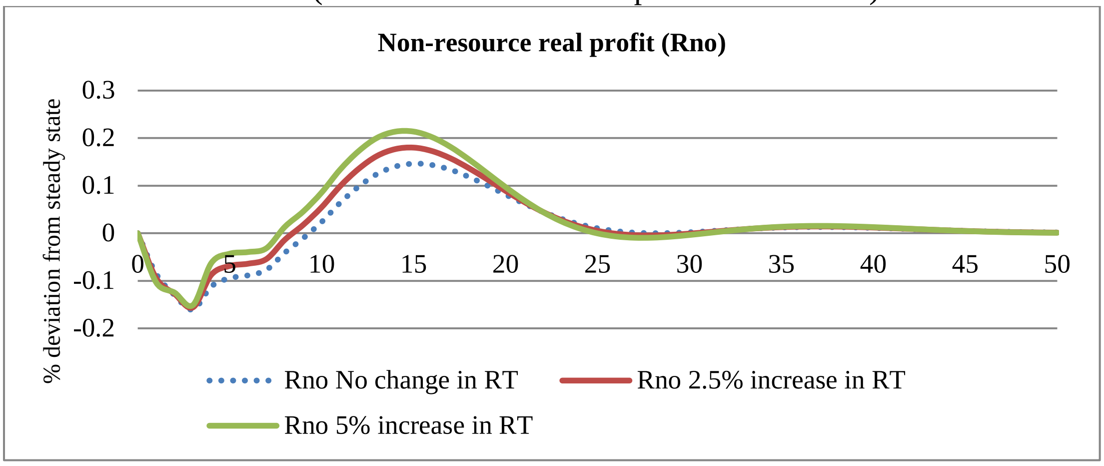


The interesting outcome of the simulation of the non-resource real profit shown in Figure 7-5 is that as the post-boom period starts, this variable starts to increase due to the inverse relationship between non-resource private capital and real profit in this sector as explained in the previous paragraph. It also shows that while the increase in resource tax during the resource boom does not have a significant impact upon the decline of non-resource real profit during the post-boom period, the non-resource real profit, in the case of an increase in resource tax rate, is higher. This may happen as a result of the higher investment expenditure on infrastructure and human capital during the boom period. Considering that an increase in the productivity of the non-resource sector as a result of the increase in investment during the boom period would take place with a lag, then an increase in non-resource real profit at the end of

the boom period would occur. There are also other factors involved in this reaction, such as a possible decline in wage rates and depreciation of the exchange rate as the post-boom period starts. The high sensitivity of resource sector real profit to the slowdown in the resource price shock (which shifts the production factors towards the non-resource sector earlier than expected) is another factor which highlights the strong role of expectations about real profit in the resource sector.

A positive reflection of the increase in resource tax over the boom period is that the non-resource real profit stays at a higher level as compared to the case where there is no change in the resource tax. This highlights the important role of the government in taxing the resource sector over the boom period which helps the non-resource sector to be in a better position during the post-boom period.[56]

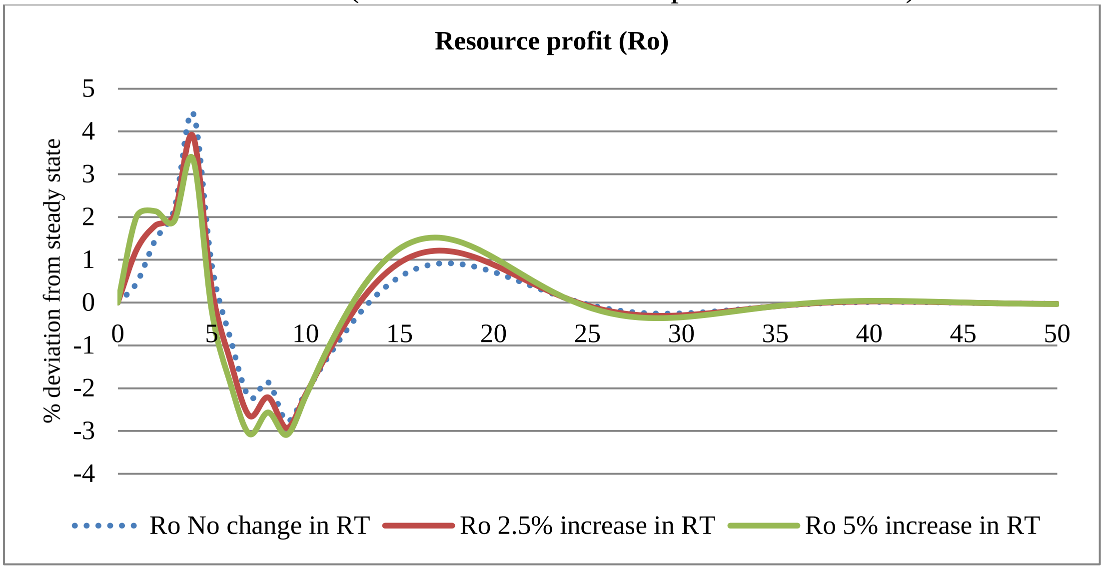
Figure 7-5 Non-resource Real Profit Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



[56] The relatively low level of increase in non-resource real profit over the post-boom period in the case of increased resource tax compared to no change in resource tax is due to the fact that in this scenario only 10 percent of the tax revenue collected from the resource sector is invested, therefore, it would not be expected to have a considerable positive impact for the non-resource sector.

The results from simulating the resource sector real profit response presented in Figure 7-6 reveals that while real profit in this sector increases by up to about 4 percent higher than the baseline (which is significantly higher than the non-resource real profit), the pattern of the change is interestingly different between the first half of the boom period when the resource price is continuously increasing and the second half of the boom period when the resource price is decreasing. In the first half, as previously mentioned, real profit in the resource sector is increasing but in the second half it quickly declines and it gets even lower than the baseline value. This is explained by possible ambitious and costly development plans which make the profitability of the resource sector even lower during the decline in the resource price.

Figure 7-6 Resource Sector Real Profit Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



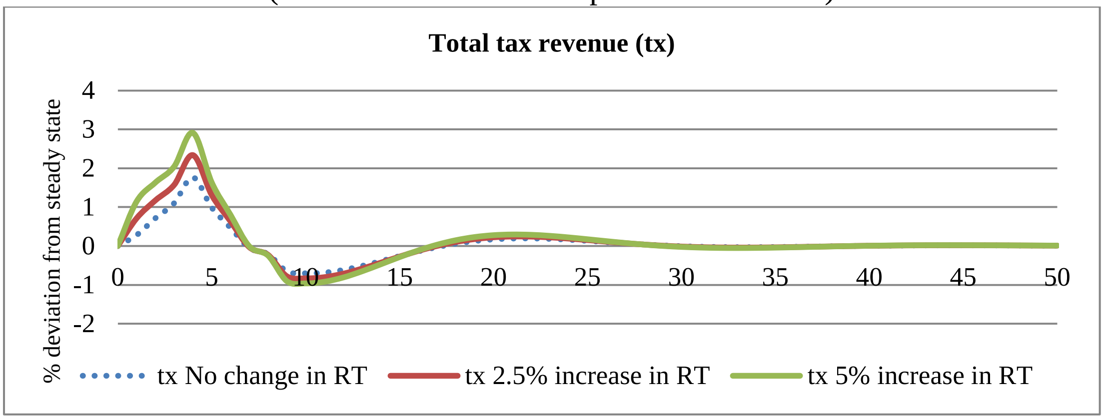
7.2.3 Public sector

Government tax revenue increases with the positive resource price shock. One may argue that an increase in the resource tax rate during the boom period may reduce total tax revenue by damaging both the resource sector and the already vulnerable

non-resource sector during the resource boom. The results provided in Figure 7-7, however, suggest that for the entire period of the resource boom where the resource price is above the steady state, any increase in the resource tax would increase total tax revenue where the maximum increase in resource tax is equal to the resource price shock (5 percent in this simulation scenario). In addition, the increase in the total tax revenue also highlights the *revenue effect* of the resource boom. In other words, the increase in resource price also increases the government's revenue from this sector and obviously this impact becomes stronger if the government decides to increase the resource tax over the boom period as well. An interesting policy issue is to what extent the government can increase the resource tax to effectively take the super profit from the resource sector.

The abovementioned revenue effect could be misleading to some extent as the government may also start ambitious projects and plans relying on the increased income, however based on the results (considering the volatilities of government expenditure presented in Appendix B) this eventually increases the government's budget deficit as a negative side-effect.

Figure 7-7 Total Tax Revenue Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



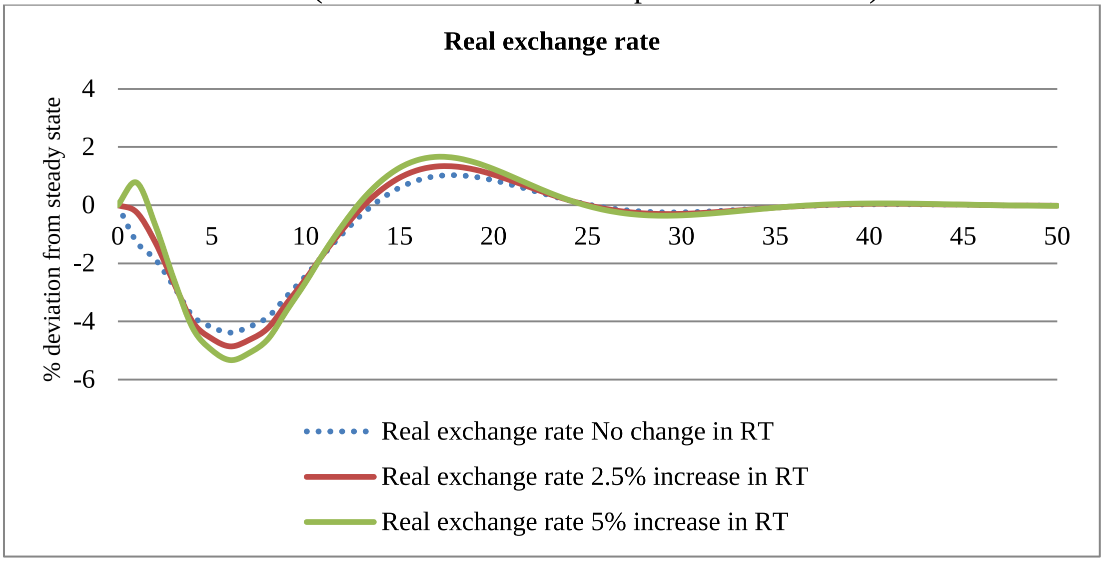
The study finds that while government expenditure is growing during the boom period, its magnitude is higher than the increase in the total tax revenue which puts the government budget into deficit for the short term (it appears that this has actually been the case in Australia during the resource boom). However, once the boom is over, the budget deficit starts to decline over the post-boom period and gets back into balance after that. In addition, it is assumed in this simulation that a major part of the government's revenue from the resource tax is used to cover the government's consumption expenditure and only 10 percent of the increase in resource tax revenue is spent on infrastructure and human capital investment. Therefore, infrastructure and human capital expenditure is subject to an increase following a resource price shock. While the increase is not relatively sizeable, it is strongly linked to the reaction of the government in terms of increasing the resource tax rate. A higher resource tax during the boom period would increase the infrastructure and human capital stock which is also pushed up by an increase in productivity-enhancing expenditure on human capital (including health and education) and infrastructure which benefits the non-resource sector.

7.2.4 External sector

The simulations show that the resource price increase leads to an appreciation of the real exchange rate for the boom period. The appreciation of the exchange rate following a resource boom is also known as the *exchange rate effect* in the literature. The adjustment in the exchange rate is reflected in Figure 7-8 and it shows that even when the resource price gets back to its steady state, the currency is still stronger than its baseline value, although getting closer to this value over time. One reason

which may explain this lag is the continuing capital investment by foreign investers in the resource sector which may not decline as fast as financial investments once the boom is over and the higher demand for Australian currency continues its appreciation (albeit diminishing) and delays its return to the baseline.

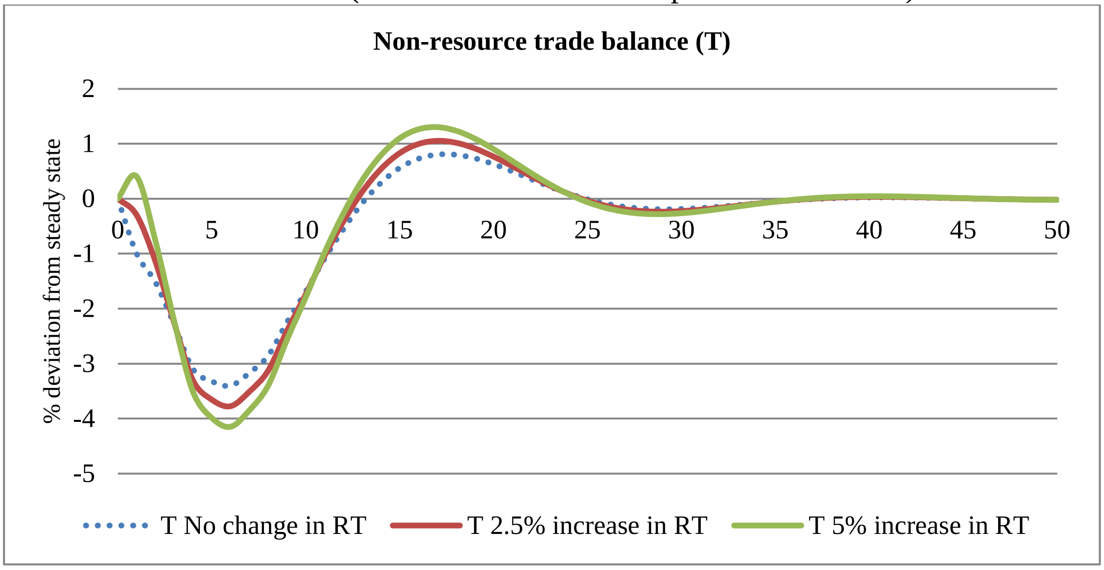
Figure 7-8 Real Exchange Rate Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



This appreciation of the real exchange rate causes non-resource exports to lose competitiveness in the global markets which results in a deterioration of non-resource exports and the non-resource trade balance. A similar pattern for both the decline and adjustment in the non-resource trade balance and the real exchange rate suggests that the non-resource trade balance has been directly affected by the appreciation of the real exchange rate. This is consistent with the Dutch Disease effect which tends to emphasise the role of the exchange rate in transmitting the effects of resource shocks. It can be observed from the simulation result presented in Figure 7-9 that an increase in the resource tax would put the non-resource trade balance in a better position initially but would not have a major impact in the

medium term. This may also be because of the slight depreciation of the exchange rate for a short time at the very beginning stage of the resource boom as well.

Figure 7-9 Non-resource Trade Balance Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)

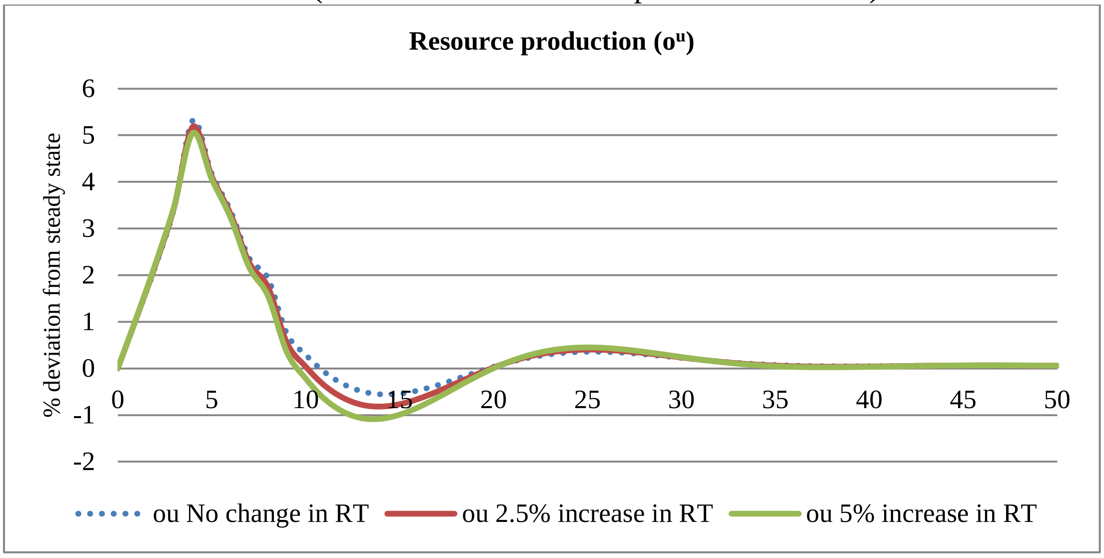


7.2.5 Resource sector

Most importantly the resource sector responds directly to the pattern of change in the resource price and increases resource production at the same pace as that of the increase in resource price. The interesting finding from the simulation of resource production shown in Figure 7-10 is that it does not seem that there is actually any reaction to the increase in the resource tax in the boom period. In other words, an increase in the resource tax does not result in a decrease in resource production. However, the decrease in resource production during the post-boom period is higher in the case where the resource producers have been paying a higher tax during the boom period. One possible explanation is that during the resource boom the natural resource extractors have preferred to increase their production from the current mines rather than increasing their exploration cost (especially when the resource tax rate is

getting higher) which leads to lower production in the post-boom period as they need to spend more on finding new mines once the boom is over.

Figure 7-10 Resource Production Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



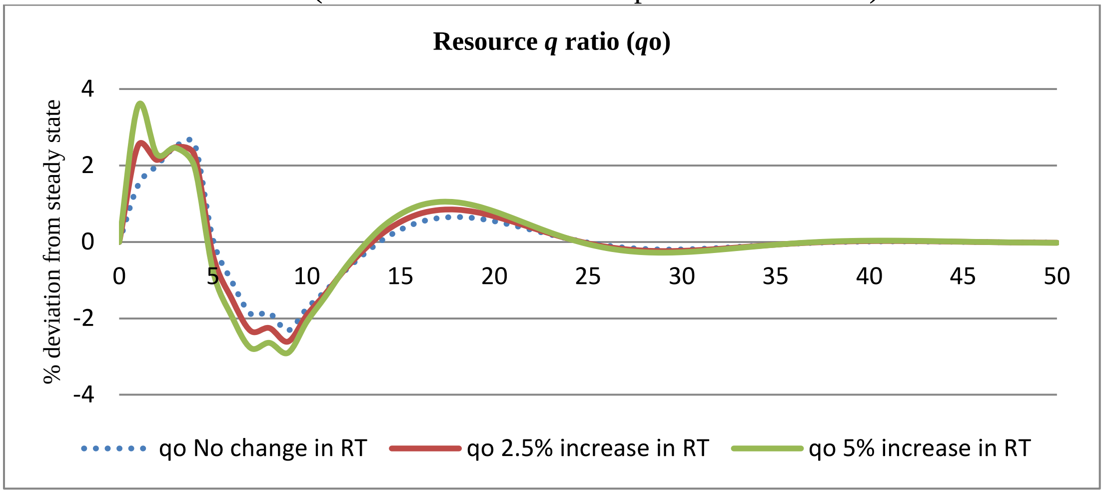
7.2.6 Financial sector

Developments in the *q* ratio of the resource sector are shown in Figure 7-11. In the first half of the resource boom period, where the resource price is increasing, the *q* ratio is also increasing as an encouraging indicator for investors to invest in this sector; however, once the resource price starts to decline, the market quickly reacts by decreasing the resource sector *q* ratio. This is similar to the pattern of developments in real profit in the resource sector discussed earlier. Based on this result, it appears the direction of change in the resource price is an important factor in explaining changes in the *q* ratio or profitability of this sector regardless of the resource price level compared to its steady state level. For instance, in the second half of the resource boom the resource price level is higher than the steady state but is diminishing and this is reflected in a declining *q* ratio in this sector which drops

even lower than its baseline value. It seems that a resource price boom with a gradual increase in the resource price may provide a more stable situation and an increasing *q* ratio for the market, while a sudden increase in the resource price may not satisfy these features for the capital market.

Another outcome from simulation of the *q* ratio for the resource sector is that the government's intervention seems to increase uncertainty over the new tax regime leading to an increase in financial market instability and fluctuations in the *q* ratio in both the resource boom period and the post-boom period. As can be seen in Figure 7-11, as the resource tax is introduced to the market following the resource price boom, the *q* ratio becomes even higher. This explains how this action indirectly transmits the feeling to investors that the government, by increasing the resource tax, is taking this resource price increase seriously and this may be a sign that the resource sector may experience a significant profit in the near future, thus helping the *q* ratio to become higher in the first stages of the resource price boom. This suggests that greater certainty or clarity about government policy measures relating to the resource sector is significant for financial sector stability.

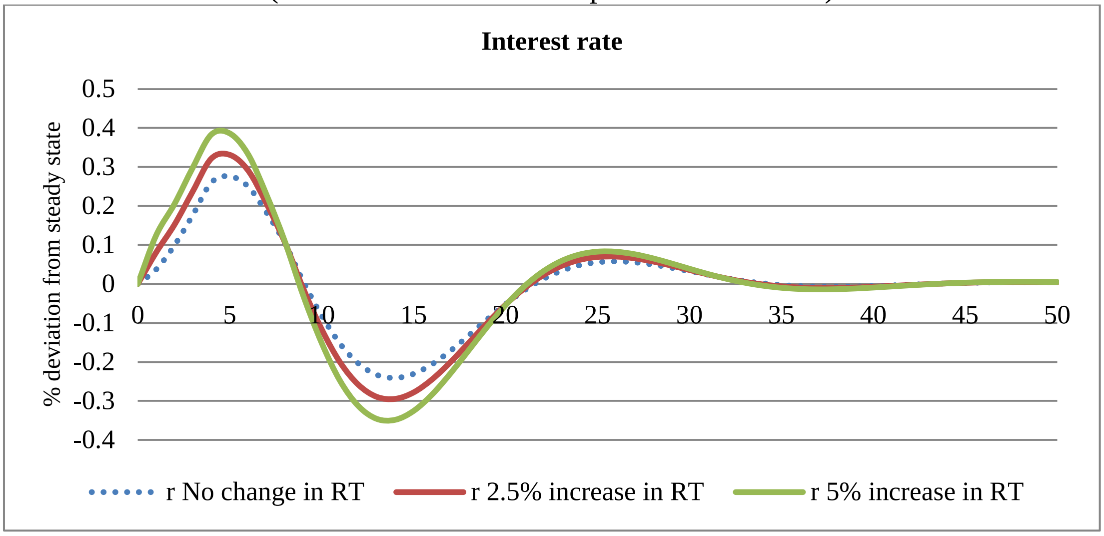
Figure 7-11 Resource Sector *q* Ratio Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



The increase in the interest rate during the boom period, as presented in Figure 7-12, is due to the upward pressure on prices caused by excess demand for non-tradable commodities which is triggered by the *wealth effect* (or *revenue effect*) following the resource boom and the need for a higher interest rate in order to control inflation. The *resource movement effect* may also increase the wage rate and contribute to inflation and so for the same reason increase the interest rate but, as discussed before, this resource boom effect is not significant in the Australian economy. The increase in the interest rate presented in Figure 7-12 is consistent with the results reported in Plumb *et al*. (2013) and also similar to the interest rate behaviour in the base scenario of Cox and Harvie (2010).[57]

[57] The interaction of fiscal and monetary policy over the resource boom period is not specifically discussed in this research; however, such a discussion is a very interesting extension and use of the model under study.

Figure 7-12 Interest Rate Impulse Response Function to a Resource Price Shock (minimum investment expenditure scenario)



7.2.7 Boom period, post-boom period and long-run adjustment

In this section the overall impact of a resource price boom for three different cases is quantified based on the cumulative percentage variation from the baseline which is the value of the integral for each graph (related to each scenario) over the three intervals being the boom period (quarters 1-8), the post-boom period (quarters 9-20) and the overall study period (quarters 1-50). This is conducted in order to gain a better understanding and a more precise discussion of the results.

The results in Table 7-2 show that over the boom period the overall cumulative percentage increase in real income (*y*) is higher if the government increases the resource tax. More specifically, the cumulative impact over the resource boom period increases from 16.77 percent in Case A (with no increase in resource tax) to 18.90 percent in Case C (where the magnitude of the increase in the resource tax is the same as the increase in the resource price). While the cumulative impact of the resource price boom on real income is considerable and positive over the boom

period, as shown in Table 7-2, the size of the overall impact for the three cases shows that when there is no tax during the resource boom (Case A) the overall long-run positive impact is slightly higher than the other two scenarios (16.86 percent compared to 16.44 or 16.01 percent in Case B and Case C respectively). It appears that for the first few quarters of the boom period, as shown in Figure 7-1, introducing the resource tax has a negative impact on real income compared to the case with no resource tax and this may cause the overall impact of the resource boom on real income in this simulation to be slightly lower than in the cases with increasing resource tax over the resource boom period.

The overall outcome for non-resource aggregate supply is also very interesting. The results show that a higher resource tax in total has a positive cumulative impact on this variable while with the absence of the resource tax the cumulative impact on non-resource supply is negative. In more detail, the overall impact for this variable with no increase in resource tax is a negative 0.64 percent while increasing the resource tax in proportion with the increase in the resource price leads to a cumulative increase of 0.44 percent in non-resource aggregate supply, showing an increase in this variable. This finding indicates the importance of government intervention to increase the resource tax when the resource price boom occurs as it provides a better situation for non-resource aggregate supply overall.

Table 7-2 Cumulative Percentage Variations from Baseline* **

Variable	Periods	Case A	Case B	Case C
Real income (y_t)	Boom period +	16.77	17.83	18.90
	Post-boom period +	-2.08	-3.84	-5.60
	Overall +	16.86	16.44	16.01
Aggregate supply for non-resource output (No_t^s)	Boom period	2.40	3.27	4.15
	Post-boom period	-3.14	-3.59	-4.04
	Overall	-0.64	-0.10	0.44
Private non-resource capital (k_t^{pno})	Boom period	2.88	3.53	4.21
	Post-boom period	-3.21	-3.77	-4.36
	Overall	-0.34	-0.15	0.04
Private resource capital (k_t^{po})	Boom period	34.09	36.77	39.45
	Post-boom period	-10.55	-17.80	-25.06
	Overall	40.35	35.82	31.29
Non-resource real profit (R_t^{no})	Boom period	-0.73	-0.61	-0.50
	Post-boom period	1.13	1.44	1.75
	Overall	0.69	1.12	1.55
Resource profit ($\mathrm{R_t^o}$)	Boom period	5.20	3.58	1.96
	Post-boom period	-1.13	1.12	3.37
	Overall	1.38	1.74	2.09
Total tax revenue (tx_t)	Boom period	5.03	7.24	9.46
	Post-boom period	-3.37	-3.74	-4.10
	Overall	2.23	4.16	6.10
Exchange rate (x_t)	Boom period	-23.82	-24.33	-24.83
	Post-boom period	-1.84	0.32	2.48
	Overall	-28.80	-27.44	-26.09
Trade balance (T_t)	Boom period	-18.71	-19.34	-19.98
	Post-boom period	-0.33	1.44	3.22
	Overall	-21.50	-20.61	-19.72
Resource production (o_t^u)	Boom period	22.37	21.96	21.55
	Post-boom period	-2.47	-4.65	-6.82
	Overall	24.98	22.41	19.85
Resource Tobin's *q* (q_t^o)	Boom period	4.78	4.14	3.50
	Post-boom period	-2.22	-1.25	-0.28
	Overall	-0.50	-1.05	-1.59
Domestic interest rate (r_t)	Boom period	1.32	1.63	1.95
	Post-boom period	-1.77	-2.17	-2.57
	Overall	-0.03	-0.05	-0.08

Notes: * The values in this table are calculated using the TRAPZ function in MATLAB.
** Monitoring the economic welfare or social welfare is not feasible in this modelling framework, however, the simulation graph for private consumption (as a possible proxy for social welfare) is provided in Appendix B.
+ Boom period (quarters 1-8), Post-boom period (quarters 9-20), Overall (quarters 1-50).

Private non-resource capital (k_t^{pno}) and non-resource real profit (R_t^{no}) also get benefits from the increasing resource tax in total as well. A comparison of the overall impact of a resource price boom for the three cases shows an increase for these two variables. While the private resource capital stock, as would be expected, experiences a low but overall positive effect in the case with the increased tax rate, real profit in the resource sector also gains from a higher tax rate following the

resource price boom. This in particular shows that even the resource sector is getting a greater benefit in the long run by paying a higher tax rate as, when the collected tax is spent on infrastructure for instance, it also benefits the resource sector (see Equation 4-19 in Chapter 4). This channel is discussed in more detail in Section 7.3.6.

The total tax revenue (*tx*) received by the government obviously increases through the introduction of a higher resource tax. This goes against the idea that if the government increases tax on a leading sector in the economy it may reduce overall tax collected in the long run. The outcome of the calculations provided in Table 7-2 show that this is not the case, at least for scenarios with a resource price boom. It is worth mentioning that the non-resource sector and the resource sector are the two sources of total tax revenue (as discussed in Equation 4-12). The 0.8 parameter value for non-resource aggregate supply (λ) in this equation and the increase in this variable (maximum less than 1 percent as shown in Figure 7-2) reveals that the increase in total tax revenue is due to the increase in the tax revenue from both the resource and non-resource sectors.

As discussed earlier, the real exchange rate appreciates following the resource boom, an anticipated development, and the higher resource tax reduces the size of the overall or cumulative appreciation (but not in the resource boom period). One may argue that this is another positive impact of the higher resource tax as it helps non-resource export products to be in a slightly better competitive position over the whole adjustment period. However, the results also indicate that an increase in the resource

tax during the boom period produces a larger appreciation of the exchange rate which puts increased pressure on the competitiveness of non-resource output.

Table 7-2 shows that the overall cumulative negative impact on the non-resource trade balance is slightly lower in the case with a higher resource tax rate (as compared to no increase). This could be explained by, based on the earlier discussion, the non-resource aggregate supply and non-resource capital improvements from a higher resource tax and this could be reflected in a better position for the non-resource trade balance (although not a significant improvement). However, the smaller overall appreciation of the exchange rate with an increase in the resource tax is likely to be more important in explaining the overall improved non-resource trade balance. It is noticeable, however, that the imposition of a resource tax deteriorates the non-resource trade balance by more during the resource boom period itself, a reflection of the increased appreciation of the exchange rate during this period.

The cumulative effects of resource production and the *q* ratio for the resource sector decline due to the higher resource tax; however, the overall impact on resource production is still positive while the *q* ratio for the resource sector remains lower than the baseline in the post-boom period, suggesting a long term decline in investment and equity prices in the sector. There is an overall cumulative decline in the *q* ratio for the resource sector and this is greater with the increased resource tax imposed. Interestingly, there appears to be greater volatility in the *q* ratio where a resource tax is imposed. So the government intervention in the form of fiscal policy (resource tax and related expenditure) may increase fluctuations in financial markets.

On the other hand, the interest rate, as another financial variable experiencing an upward trend when moving from Case A to Case C as explained earlier in Figure 7-12, experiences a cumulative overall decline for all cases as can be seen in Table 7-2, but this is greater where a higher resource tax is imposed. This is in line with the results in Cox and Harvie (2010) when the government actually starts to implement various types of fiscal policy in response to the resource price shock to the economy.

7.3 Resource Price Boom, Resource Tax and Increased Public Investment

This section further examines the importance of expenditure by the government arising from the revenue generated from a resource tax. It also explores the consequences of two major public expenditure approaches to the higher tax revenue from the resource sector which is caused by a resource price boom. As discussed in Chapter 2 it is crucial for the government to spend the tax revenue collected from the resource sector on productive assets to secure the stability of economic growth in a resource-exporting economy (Hartwick, 1977; Hannesson, 2001). This would also help address negatively affected sectors from the resource boom, such as the manufacturing sector, to survive through enhanced productivity and competitiveness, and, hence, will help the economy to avoid or reduce adverse Dutch Disease symptoms. With this aim in mind it is also of interest for resource-exporting countries to isolate the revenue generated from the resource sector from general government revenue through the introduction of a sovereign wealth fund (SWF). Funds in the SWF would then be allocated to the sole purpose of investment in productivity-enhancing assets such as infrastructure (e.g. transportation (roads, ports, railways), power networks, water systems and telecommunications infrastructure (e.g. broadband)) and human capital (e.g. public schools, universities and hospitals))

(see Clark *et al.*, 2013 for more information)[58]. While the model has not been specifically designed to incorporate an SWF (this will be left for future research, see Chapter 8), it has the capability to shed some light on related issues and provides a framework to assess government expenditure policies and their impact on key macro variables. More specifically, the impact of a resource price boom and government resource tax policy is assessed where the government increases spending from 10 percent to 50 percent of the increase in the collected resource tax on investment expenditures, split 25 percent on infrastructure and 25 percent on human capital (see Table 7-3).

Table 7-3 Summary of Public Expenditure Scenarios

	Proportion of resource tax revenue to be invested in infrastructure (γ_1)*	Proportion of resource tax revenue to be invested in human capital (γ_2)*	Proportion of resource tax allocated for public investment purposes ($\gamma_1 + \gamma_2$)	Proportion of resource tax allocated for public consumption ($1 - \gamma_1 - \gamma_2$)*
Scenario 1 (in Section 7.2)	0.05	0.05	0.10	0.90
Scenario 2 (in Section 7.3)	0.25	0.25	0.50	0.50

Note: * See Equations 4-7, 4-8 and 4-11 in Chapter 4.

The focus is placed on analysing the impact of a resource price shock (similar to the price shock in first scenario) under various government expenditure scenarios on the five major sectors. The varieties of resource tax policies are explored in a new setting of the model where investment expenditure (sourced by resource sector tax revenue) is 40 percent higher than the setting of the model in Section 7.2. Section 7.3 not only elaborates the overall outcomes from the variety of tax scenarios again in three

[58] Replacing a depleting income-generating asset (resources) with a replaceable and sustainable alternative income-generating asset, for instance infrastructure, human capital, and more importantly focusing on investment in financial assets (domestic or overseas) is similar to the approach adopted by Norway where, as a small, open economy, it has many ways to invest in productive, income-generating assets.

different time periods but more interestingly it also explores the possible gains for the economy in moving towards a more investment oriented expenditure approach than the first scenario.

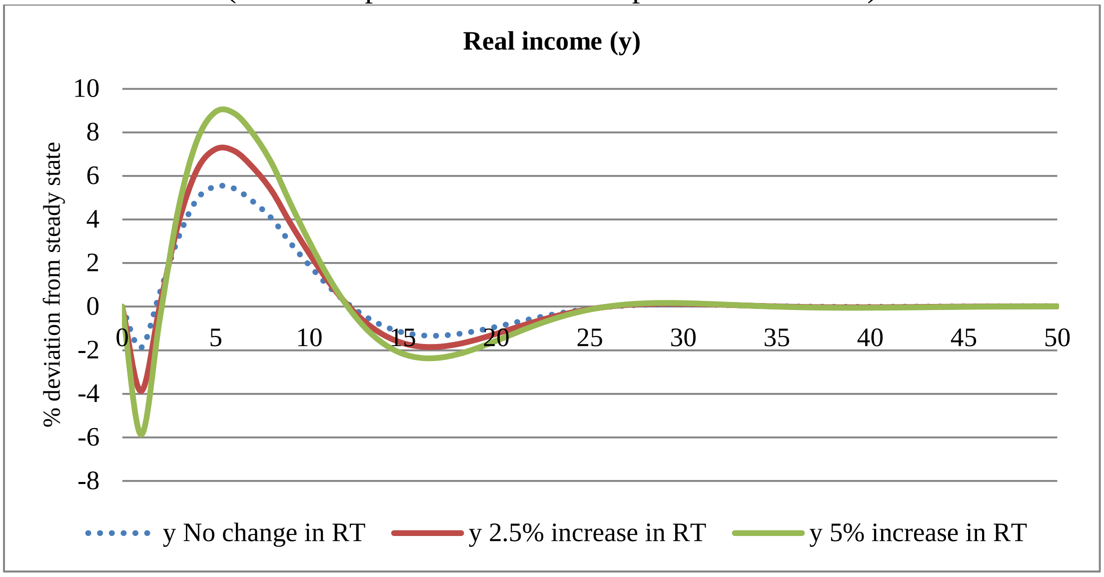
7.3.1 Domestic economy

As shown in Figure 7-13, real income declines at a very early stage of the resource price boom but is then it rises until peaking in period 6 and remains above baseline until period 12. This decline of real income over the first two quarters may be due to the fact that the government in scenario 2 has an investment expenditure orientation and hence an increase in the resource price and, consequently, resource tax revenue, may encourage the government to invest those funds in new infrastructure or human capital projects. But there is a lag before these projects actually become part of the economic cycle and it takes a while before real income responds. Another explanation may be related to an appreciation of the exchange rate and its impact over the very short run on real income, however the increase in non-resource aggregate supply and resource production eventually offsets this impact.

Another outcome based on the IRF’s for Cases B and C reveals that increasing the resource tax at this stage pushes real income down even further. This raises a policy issue as to the timing and extent of a higher resource tax rate in order to minimise adverse effects on the overall macro-economy which suggests that considering lags before increasing the resource tax rate may be of interest to the government. However this needs to be done carefully in line with resource production, the resource sector’s *q* ratio and the position of the economy in its business cycle. For instance, if the country is experiencing an inflationary gap then no policy change

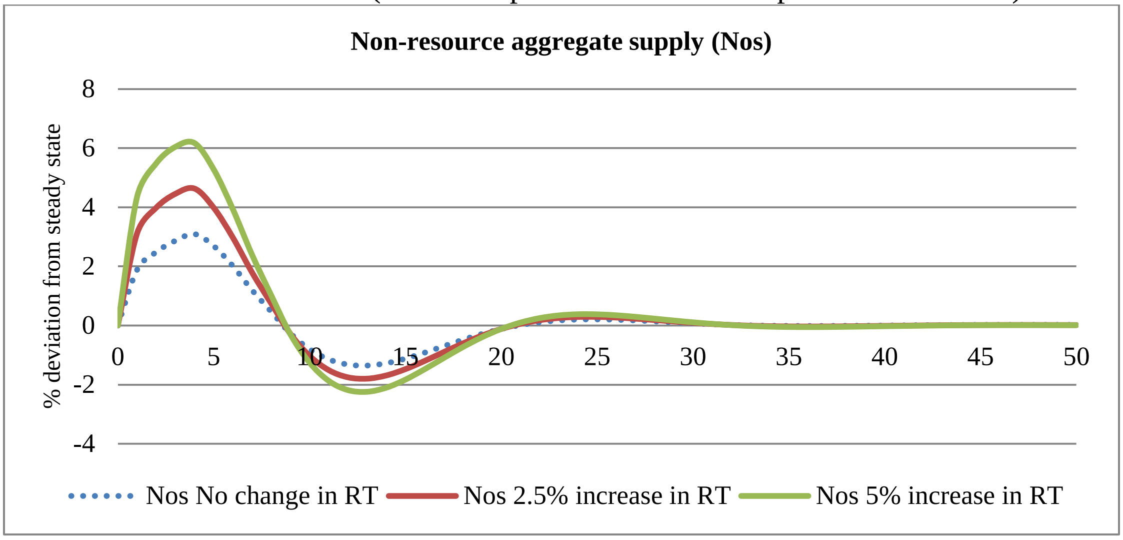
might be a smarter option as the slow-down in economic growth actually helps the economy to get closer to full employment or its potential GDP.

Figure 7-13 Real Income Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)



The non-resource aggregate supply is in a better position in tis second scenario, as can be seen in Figure 7-14, compared to the first scenario in Figure 7-2. As expected, non-resource production benefits from a resource price boom if the government spends more on infrastructure and human capital. The results suggest that an increase in the resource tax rate has a very positive impact on this variable due to the way in which the tax is spent. It seems visually clear from this figure that non-resource sector production benefits from the tax and spending strategy.

Figure 7-14 Non-resource Aggregate Supply Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)

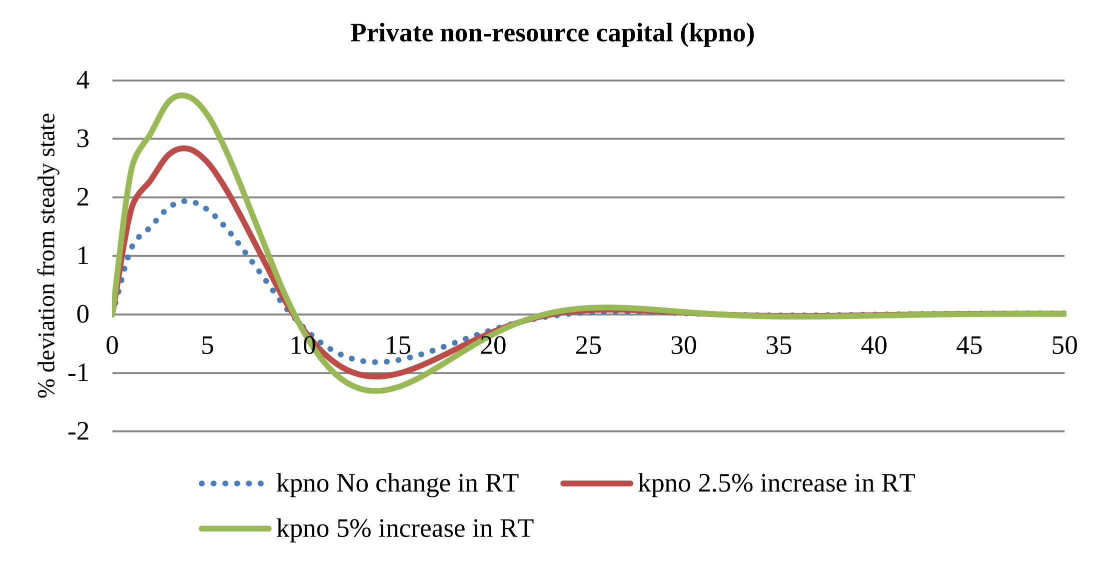


7.3.2 Private sector

The outcome of the private non-resource sector capital stock response simulation is provided in Figure 7-15, which shows this variable follows the same pattern as the resource price shock. This increase in private non-resource capital (*Kpno*) in scenario 2, which is higher than that of Scenario 1 in Figure 7-4, is clearly due to the higher level of productivity-enhancing investments by the government on infrastructure and human capital. As discussed in the literature (Aschauer, 1989a) government spending on these two items would increase the marginal productivity of private capital and have a crowding-in effect on private sector investment that increases private capital accumulation (Aschauer, 1989a). Therefore, the results presented here are consistent with this viewpoint in the literature.[59]

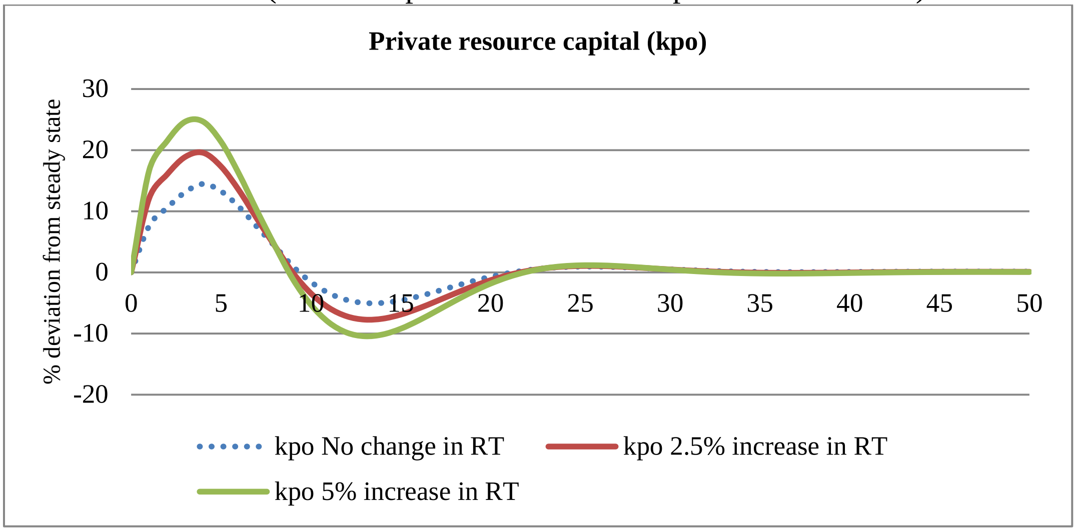
[59] Morrison and Schwartz (1996) also suggest production cost reduction as an outcome through a productivity-enhancing channel for the private sector, offsetting the loss of international competitiveness arising from the strong appreciation of the exchange rate.

Figure 7-15 Private Non-resource Capital Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)



In addition to the benefits for the non-resource private capital stock from the resource price boom and considering the higher investment expenditure approach and the related issues discussed above, the resource sector private capital stock also increases due to the high profitability of the resource sector experiencing the resource price boom as shown in Figure 7-16. In fact, it is more attractive for the private sector to invest in the resource sector than the non-resource sector based on relative changes in the q ratio in the resource and non-resource sectors which leads to relatively high capital stock in the resource sector. Another interesting outcome of the simulation suggests that the private resource capital stock is also experiencing an increase following the introducing of the higher resource tax by the government, which highlights the importance of collecting the economic rent from this sector by the government and investing it on income generating assets such as infrastructure or human capital which eventually leads to a better performance of the resource sector itself.

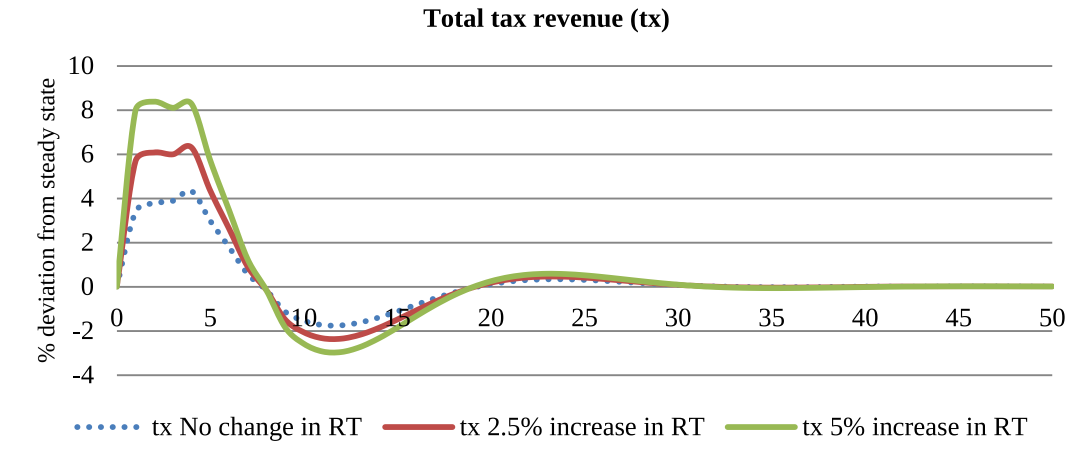
Figure 7-16 Private Resource Capital Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)



7.3.3 Public sector

Figure 7-17 also indicates the increase in the total tax revenue for the government throughout the resource boom period and beyond. The IRF's show that once the government increases the resource tax by 5 percent the total tax revenue increases. However, once the resource price boom is over, the adjustment process shows a decline in total tax revenue due to the decrease in the two main sources of the total tax revenue, that is non-resource and resource production, which are shown in Figures 7-14 and 7-19 respectively.

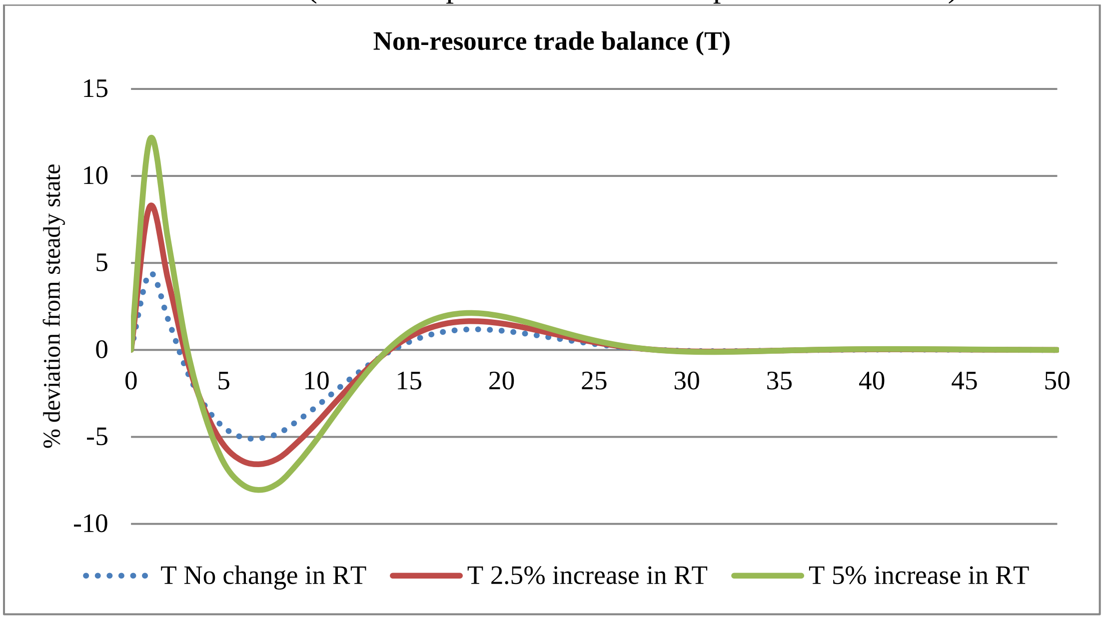
Figure 7-17 Total Tax Revenue Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)



7.3.4 External sector

The non-resource trade balance presented in Figure 7-18 indicates relatively large fluctuations over the boom and post-boom periods. Considering that the government spends 50 percent of the tax collected from the resource sector on investment and the fact that this would help to support the non-resource sector, the IRF for the non-resource trade balance shows an increase in the non-resource trade balance over the very early boom period. However, this does not continue for a long time and it experiences a decline which is almost the same size as the increase, but lasts longer. This shows that the non-resource trade balance again suffers from the resource boom. On the other hand, the higher resource tax rate puts the non-resource trade balance in a better position for the first three quarters of the boom period but this is not enough to create an overall positive impact for the non-resource trade balance throughout the development process for this variable.

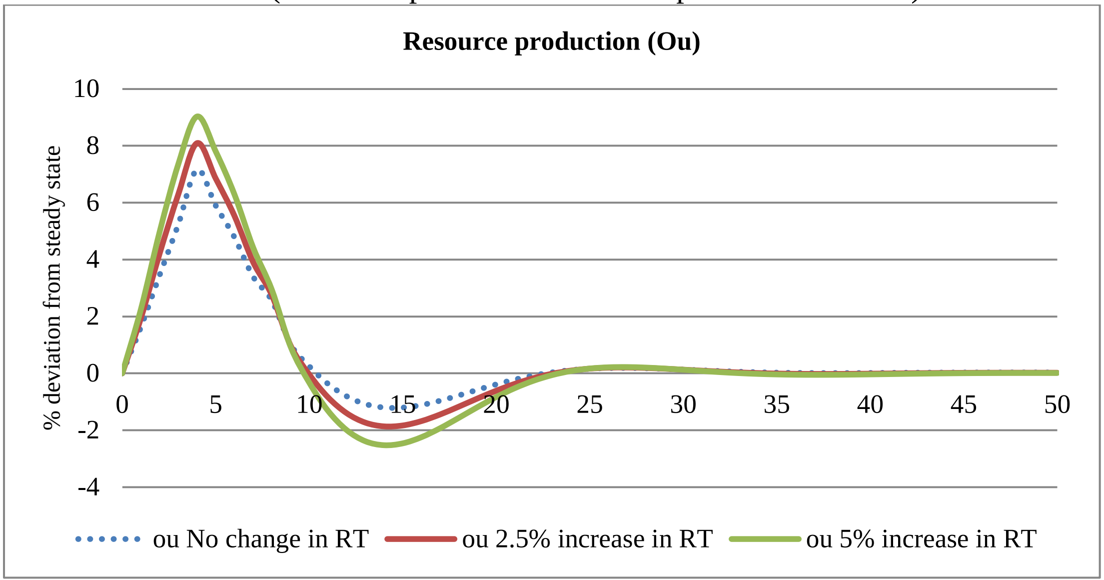
Figure 7-18 Non-resource Trade Balance Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)



7.3.5 Resource sector

Similar to Figure 7-10 in the first scenario, resource production in Figure 7-19 also positively responds to the resource price boom and stays significantly over its baseline value for the entire boom period while following the same pattern as the resource price shock (see Figure 7-19). The only difference noticeable here is that unlike the first scenario where resource production has an almost identical response to the three different resource tax cases (indicating a very low elasticity to the change in resource tax), in this scenario with the higher level of investment it appears that resource production is interestingly higher in Cases B and C compared to Case A. This clearly suggests that in a framework where more collected revenue from the resource sector is invested in infrastructure and human capital, a higher tax rate would also benefit the resource sector by increasing its production level as well.

Figure 7-19 Resource Production Impulse Response Function to a Resource Price Shock (increased public investment expenditure scenario)



7.3.6 Investment benefits: boom period, post-boom period and long run adjustment

This section provides a numerical summary of the simulation results (based on the integral value of the impulse response function for simulated variables) in Sections 7.3.1 to 7.3.5. In addition, this section also provides a tool to compare the overall impacts on each variable in the two main scenarios presented in Sections 7.2 and 7.3. This helps to simply see the advantages of spending the collected tax from the resource sector on income generating investments. It is a very interesting tool to analyse both resource tax policy and also expenditure policy as the major components of fiscal policy by the government during a resource boom.

The results reported in Table 7-4 indicate that almost all the variable outcomes presented (except the non-resource trade balance) improve from the implementation of a resource tax and then using such revenue for public expenditure that expands productivity in the non-resource sector. In other words, the majority of the economy benefits when the government spends more on infrastructure and human capital,

rather than spending the majority of the collected funds from the resource sector on consumption expenditure.

Table 7-4 Cumulative Percentage Variations from Baseline (Scenario 2) and Benefits from Increased Public Investment Expenditure (A Comparison of Scenarios 1 and 2)*

Variable	Periods/Gain	Case A	Case B	Case C
Real income (y_t)	Boom period +	25.53	31.55	37.57
	Post-boom period +	-3.48	-5.53	-7.58
	Overall +	23.74	28.10	32.45
	Overall (Scenario 1)	16.86	16.44	16.01
	Gain from more public investment	**6.88**	**11.66**	**16.44**
Aggregate supply for non-resource output (No_t^s)	Boom period +	15.52	23.75	31.99
	Post-boom period +	-9.58	-12.48	-15.38
	Overall +	7.40	13.36	19.31
	Overall (Scenario 1)	-0.64	-0.10	0.44
	Gain from more public investment	**8.04**	**13.46**	**18.87**
Private non-resource capital (k_t^{pno})	Boom period +	10.44	15.45	20.46
	Post-boom period +	-5.98	-7.58	-9.18
	Overall +	4.58	8.32	12.07
	Overall (Scenario 1)	-0.34	-0.15	0.04
	Gain from more public investment	**4.92**	**8.47**	**12.03**
Private resource capital (k_t^{po})	Boom period +	75.42	102.09	128.77
	Post-boom period +	-34.80	-55.79	-76.78
	Overall +	50.31	54.16	58.01
	Overall (Scenario 1)	40.35	35.82	31.29
	Gain from more public investment	**9.96**	**18.34**	**26.73**
Non-resource real profit (R_t^{no})	Boom period +	5.24	8.57	11.91
	Post-boom period +	-3.32	-4.78	-6.24
	Overall +	3.97	6.18	8.38
	Overall (Scenario 1)	0.69	1.12	1.55
	Gain from more public investment	**3.28**	**5.06**	**6.83**
Resource profit ($\mathrm{R_t^o}$)	Boom period +	12.35	14.62	16.89
	Post-boom period +	-9.31	-10.45	-11.59
	Overall +	3.75	5.33	6.91
	Overall (Scenario 1)	1.38	1.74	2.09
	Gain from more public investment	**2.37**	**3.60**	**4.82**
Total tax revenue (tx_t)	Boom period +	18.96	29.02	39.08
	Post-boom period +	-11.32	-15.05	-18.77
	Overall +	9.41	16.24	23.07
	Overall (Scenario 1)	2.23	4.16	6.10
	Gain from more public investment	**7.19**	**12.08**	**16.97**
Trade balance (T_t)	Boom period +	-17.45	-17.43	-17.40
	Post-boom period +	-4.83	-5.17	-5.51
	Overall +	-23.00	-23.28	-23.56
	Overall (Scenario 1)	-21.50	-20.61	-19.72
	Gain from more public investment	**-1.50**	**-2.67**	**-3.85**
Resource production (o_t^u)	Boom period +	32.03	37.25	42.48
	Post-boom period +	-7.51	-12.68	-17.86
	Overall +	27.36	26.86	26.37
	Overall (Scenario 1)	24.98	22.41	19.85
	Gain from more public investment	**2.38**	**4.45**	**6.52**

Notes: * The values in this table are calculated using the TRAPZ function in MATLAB. The IRF's for *Ro* and *Rno* are available in Appendix B.
+ Boom period (quarters 1-8), Post-boom period (quarters 9-20), Overall (quarters 1-50)

From Table 7-4 it can be seen that real income shows an increase following the investment expenditure approach undertaken by the government. It is interesting to note that in the first scenario, when the government increases the resource tax rate, real income actually experiences a slight overall decline (moving from the cumulative percentage deviations from the baseline of 16.86 percent to 16.01 percent), unlike the ultimate goal of introducing the resource tax which is to increase real income. However, one of the important policy-relevant results of this study indicates that increased allocation of funds collected from the resource sector on investment expenditures (such as infrastructure and human capital) has a significant impact on shifting the above mentioned trend in real income to an increase. In other words, only if the government spends more of the collected resource tax funds on investment expenditures does increasing the resource tax benefit the economy with a higher real income; otherwise, the results suggest it may be better for the country, from this perspective, not to change the resource tax rate policy in response to a resource price boom.

In addition, the results further support the idea of the positive role of investment expenditure in an improved performance of the non-resource sector rather than consumption expenditure. While increasing the resource tax in Scenario 1 has a negligible positive impact on non-resource aggregate supply, moving towards more investment expenditure has a significant impact on boosting this sector as expected and offsetting adverse Dutch Disease consequences.

Similarly, non-resource private capital also benefits more under scenario 2. While an increase in the resource tax has only a relatively small impact on the non-resource

capital stock, the results in the second scenario indicate this variable, even in Case A, is much better than for the first scenario. This explains how a more sophisticated expenditure policy benefits the non-resource private capital stock. Increasing the resource tax is an additional factor for non-resource private capital to gain more from the resource price boom.

The lack of investment expenditure in the first scenario causes the cumulative variation in resource capital stock to decline by increasing the resource tax rate (moving from Case A to Case B and then Case C) as discussed earlier. However, increasing investment expenditure has created some interesting and, to some extent, unexpected outcomes in the second scenario. The results show that in the second scenario the increase in the resource tax rate benefits the resource capital stock as well. This clearly highlights the benefits from spending the revenue collected from the resource sector (following the increase in resource tax rate) on income-generating investments not only for the non-resource sector but also for companies operating in the resource-producing industry over a wider time frame.

Moreover, real profit in both the resource and non-resource sectors also increase in the second scenario by increasing the resource tax rate which follows the same pattern in the first scenario. Non-resource profit again benefits under the second scenario which means that more infrastructure and human capital spending by the government following a resource boom creates better opportunities for the non-resource sector. This spending policy however should be followed by appropriate timing of increasing the resource tax rate to benefit the economy and the non-resource sector in particular to avoid Dutch Disease symptoms.

Unlike scenario 1 where an increase in the resource tax rate benefits the non-resource trade balance by decreasing its deficit, (being in deficit is due to the appreciation of the exchange rate and other reasons that deteriorate the manufacturing sector as discussed in Chapter 2), in scenario 2 the deficit in the non-resource trade balance becomes larger and an increase in the resource tax rate makes the deficit slightly larger as well. This is explained by the higher real income in scenario 2 which will result in more imports than in the first scenario. It is also due to the fact that, in scenario 2, when the government spends more on infrastructure, such as building roads and airports or buying more equipment for hospitals, then it may need to import many of the required capital from overseas and this may eventually put the non-resource trade balance (indirectly) into a larger deficit position.

Finally, although resource production declines in scenario 2, similar to the case for the first scenario, comparison of the cumulative variations from the steady state show that in each of the three cases, resource production gains from an increased public investment expenditure policy. The productivity-enhancing aspect of investment expenditure for the non-resource sector also plays an important role in enhancing the resource production level.

7.4 Summary

The aim of this chapter has been to examine the role of alternative tax and expenditure policies related to a small, open, resource-exporting economy which is facing a resource price boom. Several numerical simulations of the model, developed

in this study, were undertaken[60] to facilitate the assessment of different fiscal policy reactions to a resource boom, from both taxation and expenditure aspects, and their consequences. In this context, two settings of the model representing two types of government expenditure behaviour were applied to monitor the resource tax policy impacts on key macroeconomic variables. The first scenario assumes that the government mainly spends on consumption expenditure with a minimum on investment expenditure and the second scenario allocates half of the collected revenue from the resource sector for investment expenditure. Resource tax policies have been also modelled in the simulations. The IRF of each variable is closely analysed by differentiating between the boom period and the post-boom period as well as the overall adjustment process. In addition, for each IRF, the cumulative variation from the steady state has been calculated in order to provide an accurate tool facilitating the precise analysis of policy consequences for each period under study.

The results for the two government expenditure settings are mainly in line with the literature and expectations. As the model developed in the previous chapters covers a number of identified gaps in the literature, some of the results obtained contribute to our knowledge. Running a variety of simulations in this chapter highlights the capabilities of this model in terms of covering a broad combination of shocks and respective fiscal and monetary policy responses and at the same time provides very precise technical tools for assessing related outcomes. The results and policies presented here and in the previous chapters, as well as the policy recommendations and conclusions, will be summarised in Chapter 8.

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[60] Using the Dynare package which runs on Matlab.

CHAPTER 8

SUMMARY AND CONCLUSIONS

8.1 Introduction

The main purpose of this research has been to investigate the effects of an increased resource tax rate implemented during a resource price boom period upon a small, resource-exporting country, which characterises the Australian economy, focusing specifically upon major macroeconomic variables. The study initially reviewed the literature and, based on existing theoretical contributions, identified gaps in the literature. A conceptual dynamic macroeconomic model was developed extending upon the study by Cox and Harvie (2010). The constructed model was then tested for stability and also estimated with Bayesian techniques using data for the Australian economy covering the period 1988:Q3–2011:Q3. The dynamic behaviour of the model was examined by simulating the effects of a stochastic world interest rate shock to the economy. Then two main scenarios relating to government expenditure policy were applied and the effects of a resource tax rate were analysed. The cumulative percentage deviations from the baseline for key macroeconomic variables were calculated to assess and compare the overall effect of each policy in the two scenarios.

Section 8.2 discusses the major research innovations and contributions to the literature made by this study. The results of the scenarios analysed in Chapter 7 are summarised and the related policy implications for the government for both resource taxation and expenditure policies are discussed in Section 8.3. Limitations of the current study and possible extensions for future studies are provided in Sections 8.4 and 8.5 respectively.

8.2 Research Innovations and Contributions to the Literature

This research has provided a unique dynamic macroeconomic model for a small, advanced, resource-exporting economy which characterises the case of the Australian economy. There is considerable literature devoted to analysing and assessing the effects of natural resource production for both developing and developed countries. These studies have been conducted from many different aspects, for instance showing the Dutch Disease consequences on different sectors of a resource-exporting country occurring through several channels, as explained in earlier chapters, such as the income effect, the revenue effect, the resource movement effect, the exchange rate effect, the spending effect and the wealth effect (Buiter and Purvis, 1983; Corden, 1984; Harvie, 1989). Other studies have focused more on the effects of an external resource price shock on key aspects of a resource-exporting economy (Harvie, 1993; Harvie and Gower, 1993; Cox and Harvie, 2010). A deeper assessment of the macroeconomic models applied in these studies shows that resource production is often considered to be exogenous and external shocks or domestic changes are not actually linked with resource production. An outcome from this is that resource production is not actually playing any dynamic role in the economy and does not respond to shocks such as a resource price shock that would surely modify its behaviour in the real world. Therefore, the first innovation and one of the main contributions to the literature this model presents in this study is that of an endogenous resource producing sector in a dynamic macroeconomic model for a developed economy where natural resource production reacts to a variety of external and domestic variables. This has been a particularly useful base from which to add more innovations in this study and is the major contribution to the literature of

macroeconomic modelling of resource-exporting countries. It is also a unique macroeconomic model that characterises the Australian economy.

Second, the macroeconomic framework developed in this research enables the studying of the effects of government fiscal policies specifically related to resource sector tax revenue and expenditure in a dynamic context. Taxation of the resource sector has been one of the most challenging and controversial issues facing the Australian government and economy during the recent resource boom period. While some studies in the literature have focused only on the effects of a resource tax at the firm or industry level (as discussed in Chapter 2), there has been a gap in the literature in providing a conceptual framework enabling analysis of the results of tax policies in the resource sector at the macroeconomic level. Therefore, there has been a need to develop a model to explain the consequences of government policies relating to this leading sector of the economy, such as the introduction of a mineral resource rent tax[61] by the Gillard Government in Australia. A key innovation has been the development of this vital tool to analyse the behaviour of the economy and the resource producing sector in response to the government's taxation policy and alternative government expenditure strategies.

Third, government spending of revenues generated from the imposition of taxation on natural resource products is of importance. The way in which it is spent can

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[61] A Resource Super Profit Tax (RSPT) was initially proposed by the Rudd Government as a response to the Australia's Future Tax System Review (the Henry Tax Review), on May 2010. This resource tax was one of only a few recommendations accepted by the Rudd Government out of more than 130 recommendations by the Henry Tax Review. The RSPT was planned to be introduced from July 2012 but was subsequently replaced by the Minerals Resource Rent Tax (MRRT) after Julia Gillard was appointed as Prime Minister of Australia in late June 2010. The Gillard Government made the implementation of the tax a key policy priority.

directly assist in minimising the negative impacts of the so-called Dutch Disease. Government expenditure in this study comprises consumption and investment, and investment expenditure is decomposed into infrastructure and human capital (such as education and health care) expenditure as another contribution to this unique macroeconomic model for the Australian economy. This has enabled the study to explain how and to what extent the economy benefits from shifting government consumption expenditure (demand side focus) to higher levels of investment expenditure (demand and supply side focus). The latter places more emphasis on productivity-enhancing measures. Analysis of the fiscal policies, including the resource taxation and expenditure policies, has provided some interesting indicative outcomes for a resource-exporting economy such as Australia.

Fourth, private capital was decomposed into resource and non-resource capital stock in the model. This is an important development as it enables the model to monitor the effects of any resource shock and fiscal policy (or a combination of both) on the behaviour of the resource and non-resource sectors and helps to shed more light on the dynamics behind the channels by which the economy is affected.

Fifth, the model introduces forward looking behaviour into a number of variables such as consumption and inflation as well as introducing the Taylor monetary policy rule. This is done using a Dynamic Stochastic General Equilibrium (DSGE) framework to construct a hybrid macro model for the Australian economy as another contribution of this study to the existing literature. In fact, this adds to the dynamic features of the model as well as improving its theoretical foundation by, for instance, incorporating expectations about future consumption to the household consumption

equation or including a Taylor type of monetary policy which comprises the variables which are considered to be important for the central bank in defining the interest rate. In addition, the simulation and estimation techniques applied in this study, including Bayesian estimation and stochastic and temporary deterministic shocks used to obtain the empirical results, are other contributions from the complex macroeconomic model developed.

8.3 Discussion and Policy Implications

The model developed in this study was applied in Chapters 6 and 7 for a variety of purposes including analysing the dynamic stability of the model by considering an external stochastic shock and, more importantly, evaluating a number of scenarios of resource taxation policy as well as public expenditure policies for a model characterising the Australian economy faced with a resource price shock. Based on the results obtained for the scenarios in Chapter 7, policy implications for the Australian economy are presented in the next two sections.

8.3.1 Resource tax

A resource price hike in a resource-exporting country presents a challenge for its government to make sure that the additional resource rent generated from this sector is efficiently collected and properly invested. This is important for resource-exporting economies as it contributes to the issue of equity between generations so that the non-renewable natural resource is used in an optimum manner for both current and future generations.

The results discussed in Chapter 7 show that natural resource taxation during a resource boom period generates positive outcomes which can benefit most of the economy. While deteriorating non-resource aggregate supply is always one of the possible negative consequences of a resource boom on the economy, a higher resource tax rate increases non-resource aggregate supply. Additionally, the increase in the non-resource private capital stock following a higher tax rate further benefits non-resource aggregate supply. Of course these reasons are not the only justification for a higher resource tax because the results show that even the private resource capital stock increases as a result of the higher resource tax rate over the resource boom period. The resource tax mechanism was set to be higher following the resource price hike and lower as the resource price declines. This shows another outcome of the structure of the taxation system for the natural resource sector. It highlights that, to achieve the benefits of a resource tax, the resource taxation policy needs to be flexible with regard to the price of the resource itself. It was assumed in a deterministic context in Chapter 7 that the agents, including the government, have perfect foresight and that they can make appropriate and on-time policies for any upcoming event. To have a flexible resource taxation system, the government would require the capability and expertise to monitor the resource market and price fluctuations and also to recognise the threshold price that leads to super profits for resource producing companies.

In this context, following the introduction of the new resource tax in Australia (the MRRT), as discussed in Chapter 3, a mechanism was applied to determine whether an increase in resource price was high enough to create super profits for mining companies and, based on this, whether the government should levy a higher resource

tax on them. However, it appears that the method applied may not have been practically useful in collecting the generated economic rent from the resource-exporting companies during the resource price boom. The poor performance of the taxation procedure in defining a threshold price, for iron ore and coal products most specifically, that creates super profit for resource producers and also the timing issue[62] have been among the reasons why the resource tax decision during the recent resource boom in Australia was not able to collect the expected tax revenue from the resource sector. It also needs to be considered that the administration of the resource tax itself may be very costly for the government because close monitoring of the resource price, which uses high cost expert labour, is required for the resource tax policy to be successful in effectively collecting the generated resource rent.

It is observable from the results that government intervention in the form of increasing the resource tax rate increases financial market fluctuations. Therefore, this suggests that the government needs to be clear about its fiscal policy measures to maintain certainty in financial markets thereby avoiding possible negative impacts such as creating bubbles on the stock exchange.

8.3.2 Expenditure policies

Chapter 7 focused on the role and effects of fiscal expenditure policies under two scenarios relating to the revenues generated from the resource tax policy. The findings from these two scenarios have important implications for public sector expenditure priorities arising from resource tax revenue. As discussed in earlier

[62] This is in relation to the well-known lag involved in fiscal policy which is required for decision making and also implementation as compared to monetary policy.

chapters it is most appropriate for the government to spend the collected funds from the resource sector on productivity-enhancing investments such as infrastructure, human capital and health-enhancing expenditures rather than using the funds for consumption expenditure (Hartwick, 1977; Hannesson, 2001)[63]. The creation of a sovereign wealth fund (SWF) helps the total collected funds (from the resource tax) to be used for investment expenditure (physical, human, financial and real) to benefit the economy as discussed before. The results from this study suggest that even in the absence of an SWF (which is the case in Australia) domestic investment of resource taxes (as the focus of this study) generates more benefits for the whole economy. More interestingly, the simulation results suggest that if the majority of the collected funds are used for consumption expenditure rather than being invested in infrastructure developments and enhancing human capital, the economy is actually better off with the government not increasing the resource tax following a resource price boom. This is one of the key findings of the current study which highlights the importance of allocating funds to productive investments rather than consumption expenditure. It is therefore important for the government to plan for creating an SWF which would facilitate this process by isolating resource tax revenue from general government revenue and then using this for investment purposes. The funds would however need to be actively used in financial investments such as overseas government bonds. In fact an SWF could play a vital regulatory role in providing funds over the appropriate time period and avoiding direct transmission of resource

[63] For a non-renewable resource it is important to invest in future income generating activities that replace lost resource revenue. Another option could be investing in income generating financial or physical assets (e.g. the Norwegian Sovereign Wealth Fund). The latter will lead to capital outflows, constrain the appreciation of the domestic currency and offset Dutch Disease consequences on the non-resource sector.

boom fluctuations into the economy. As discussed previously, Norway is a good example of what can be done with the establishment of an SWF.

Moreover, while the results of this study highlight the importance of replacing consumption expenditure with more investment expenditure and the benefits of this for the economy, more detailed decisions remain for the government in regard to what sub-categories of infrastructure or human capital should be invested in.

8.4 Research Limitations

Like any theoretical modelling and empirical research, this study has been faced with limitations. From a modelling perspective, a lack of macroeconomic models with an endogenous resource producing sector (not only for Australia but in the related literature in general) has been the first and foremost limitation for this study. In fact, in most models, resource production has been considered as an exogenous variable which is a rather vague assumption considering the real world behaviour of the resource sector. For instance, it is very likely that this sector will increase production in response to a higher resource price. It is also expected that resource producers will react to fiscal policies, mainly taxation policy, during a resource boom. If these reactions and responses are important, and this is believed to be so, an exogenous resource sector would hardly reflect this in any macroeconomic model. This study has tried however to adopt some concepts from natural resource producers in firm or industry level studies and to incorporate these in a macroeconomic model to overcome this limitation. Another point is that the model developed in this study is based on having perfect foresight and rational expectation assumptions but it is worth mentioning that this does not necessarily mean that the policy makers are also able to

make appropriate policy decisions or fully efficient policies due to political reasons or other unpredictable real world constraints.

In general, the large number of equations and variables included in the model add to its complexity, therefore, making stability testing, simulations and estimation extremely difficult and time consuming to compile from a technical perspective.

8.5 Extensions for Future Work

There are a number of aspects of this study that can be further developed, both in terms of modelling and simulation scenarios. The resource tax under study was only one type, based on the value of production and paid to the federal government, but royalties which are normally paid to the state governments in Australia were not able to be considered. Application of Computable General Equilibrium (CGE) models in this context would provide an appropriate tool to cover the effects of the state level royalties as well. It would be also interesting to see how far the government could increase the tax rate in order to make sure that they efficiently collect the generated rent from the resource sector.[64]

In addition, the timing considered for the higher resource tax rate was immediately following the resource price hike, but another possibility is to consider a lagged increase in the tax rate following a resource price boom, which would be the case when the government is not able to predict resource price fluctuations in advance.

[64] The maximum change of the resource tax rate by the government in this study was equal to the increase in the resource price.

This may also reflect on the decision-making lag for fiscal policy as mentioned earlier.

Coal and iron ore are used as a proxy for resource products in Australia due to their important role in the recent resource boom. It may be more appropriate for future studies to consider LNG, one of the strategic resource products, as a proxy in a macroeconomic model or to be focused on in CGE models. Based on projections by the Bureau of Resources and Energy Economics (2013) this product is going to be one of the important resource products, along with iron ore, by 2017-2018.

In this research the focus has been on infrastructure and human capital as the major domestic investment expenditures, however it would be interesting to break the investment expenditures down even further; for instance, spending on health and education as part of the human capital enhancing expenditure. This would however require an even more sophisticated model to be able to explain the deep relationships between those variables and the economic dynamics in each sector and between the sectors. This would also create a possible capacity to apply a variety of expenditure policy packages and may lead to an optimum combination for creating a higher rate of economic growth. Furthermore, the capital stocks in the resource and non-resource sectors are important factors for the supply side of the economy and productivity. In a future study it would be good to analyse relative changes in the capital stock in each of these sectors and examine the implications for relative productivity. Overseas investments such as using investing in overseas government bonds as another category for investment could also be incorporated in future studies. This could be

followed with finding the optimum distribution of funds between domestic and overseas investment opportunities to achieve the highest profit.

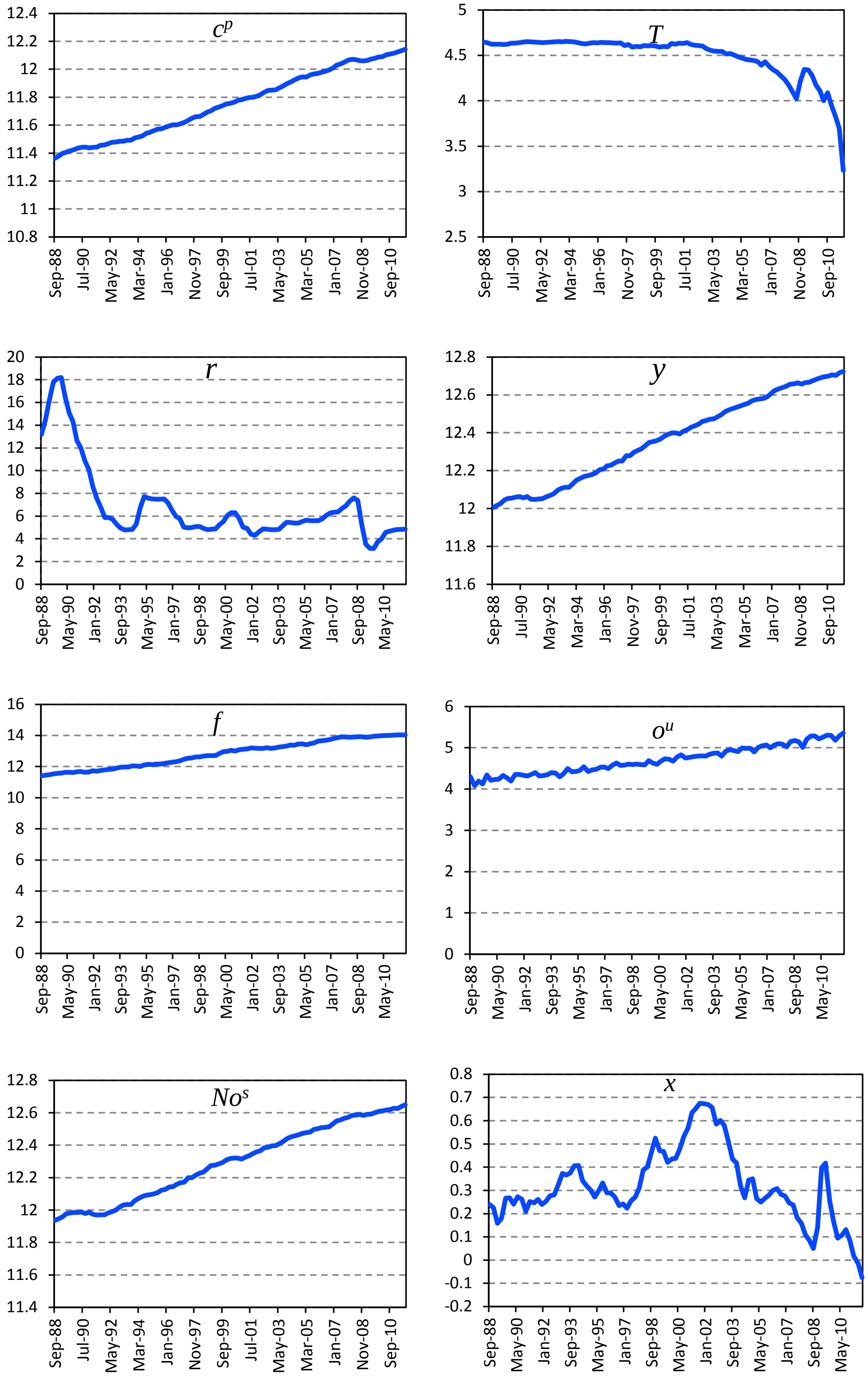
It is considered that the government spends the revenue collected from the resource sector equally on infrastructure and human capital; however, it would be interesting to see the outcome of various proportions of spending on infrastructure and human capital. This would help policy makers to evaluate different policy outcomes. For instance, the Australian Government may want to evaluate the outcome of boosting investment on information technology, such as the National Broadband Network project, or making budget cuts for universities such as deregulating university fees (introduced by the Liberal Government in 2014). Within each investment category it would be up to the policy makers to determine which sub-section is the best place for the investment funds to be directed.

In addition, the increase in investment expenditure has been applied to show the importance of creating an SWF for the Australian economy but an SWF was not specifically applied in the model itself. It would be interesting to include this concept into the theoretical model as it would allow further analysis of the benefits of this fund for the economy. Simulation of possible benefits from an SWF would provide significant insight for policy makers into the process of creating an SWF.

Finally, incorporating other types of tax, such as income tax, to the framework of the model provides an interesting opportunity to see how government could use increased natural resource tax to reduce other taxes such as, for instance, income tax and to then analyse macroeconomic outcomes from adopting this policy.

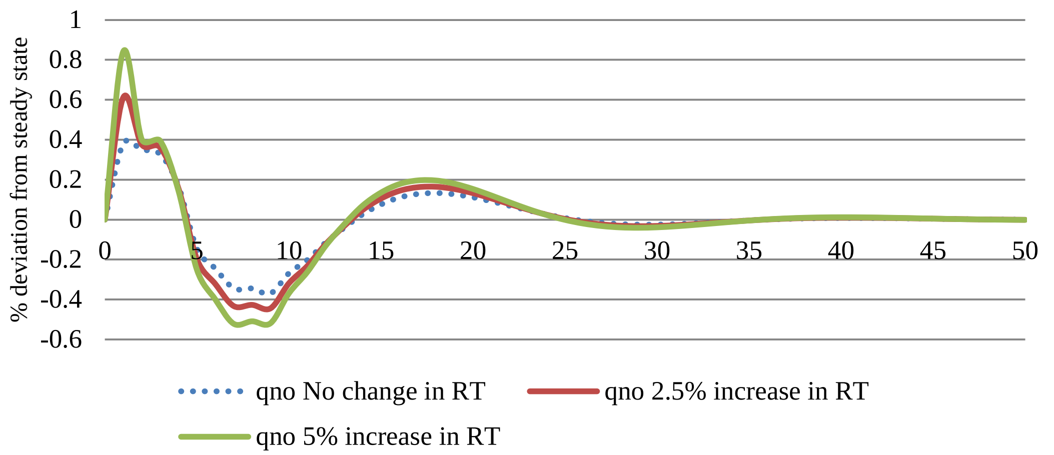
APPENDIX A: TIME SERIES PLOTS FOR THE 8 OBSERVABLE VARIABLES

(for more information on the data see Section 5.2)

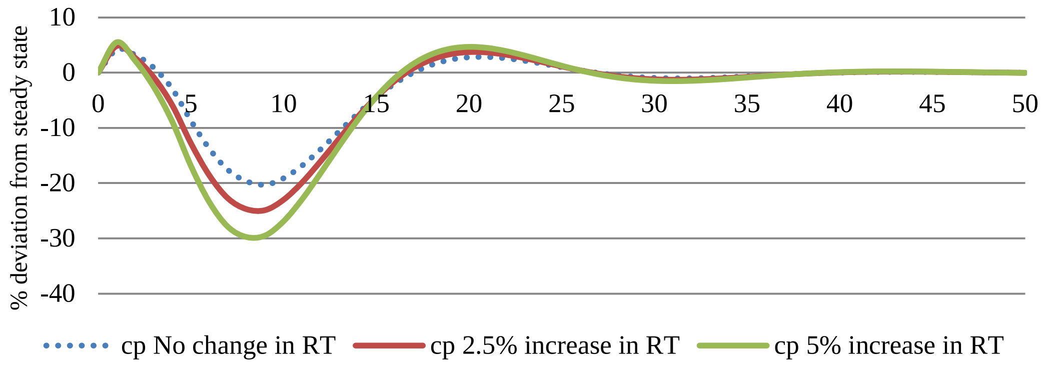


APPENDIX B: IMPULSE RESPONSE FUNCTIONS FOR ADDITIONAL VARIABLES IN SCENARIO 1 & 2

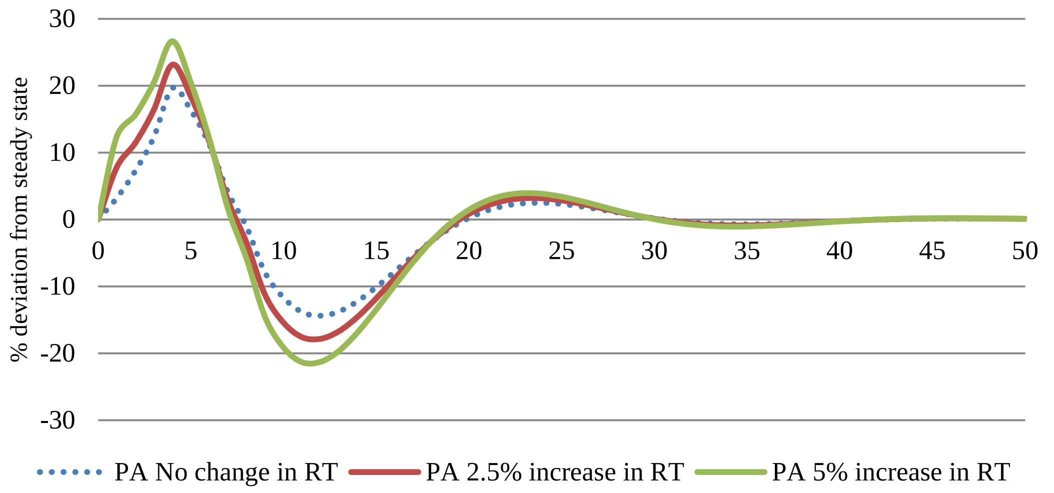
Non-resource *q* ratio (*qno*)- Scenario 1

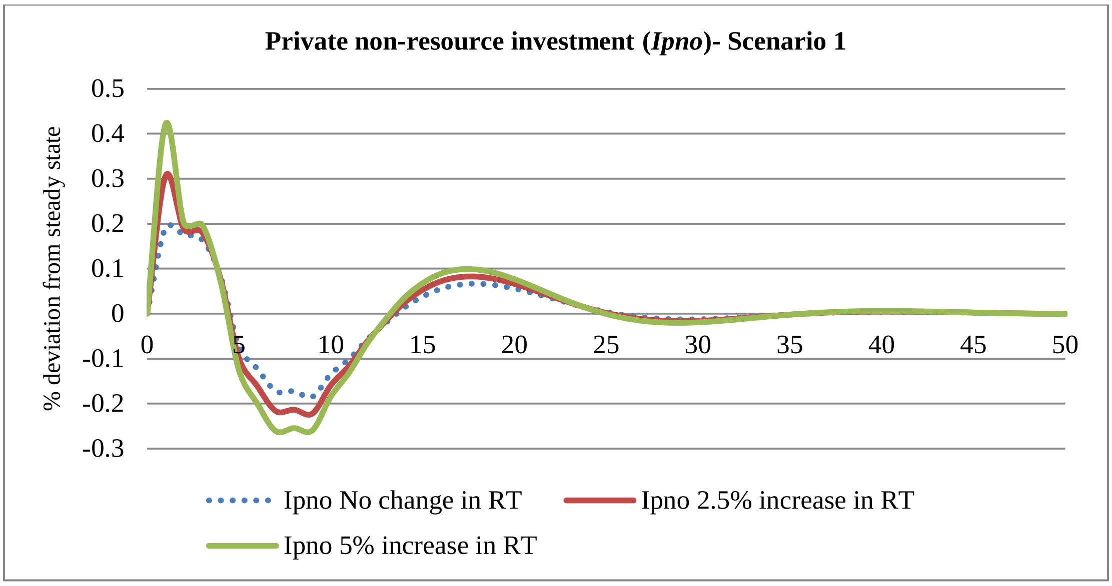


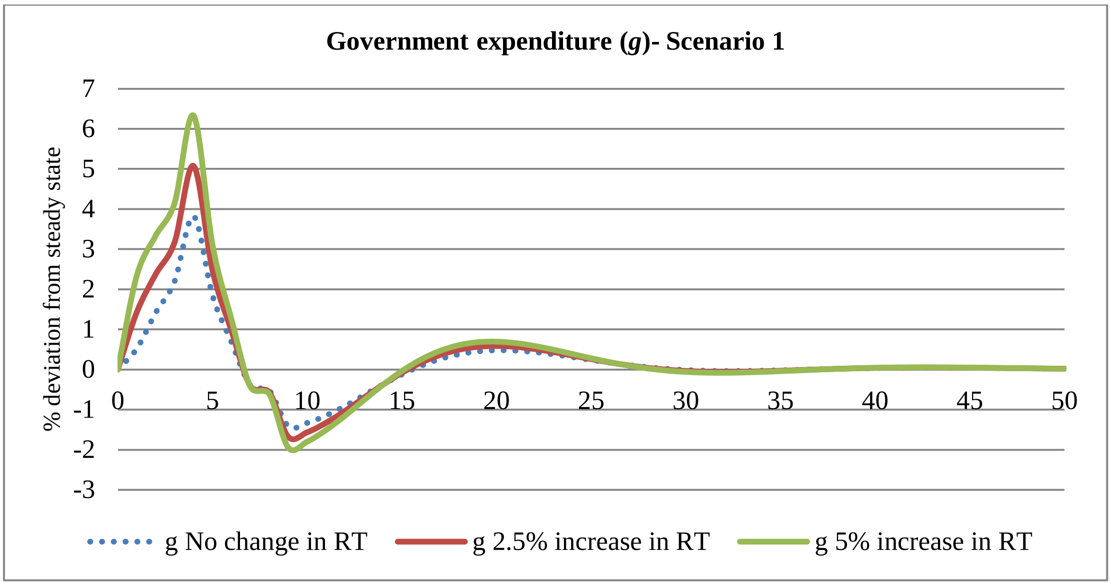
Private consumption (*cp*)- Scenario 1

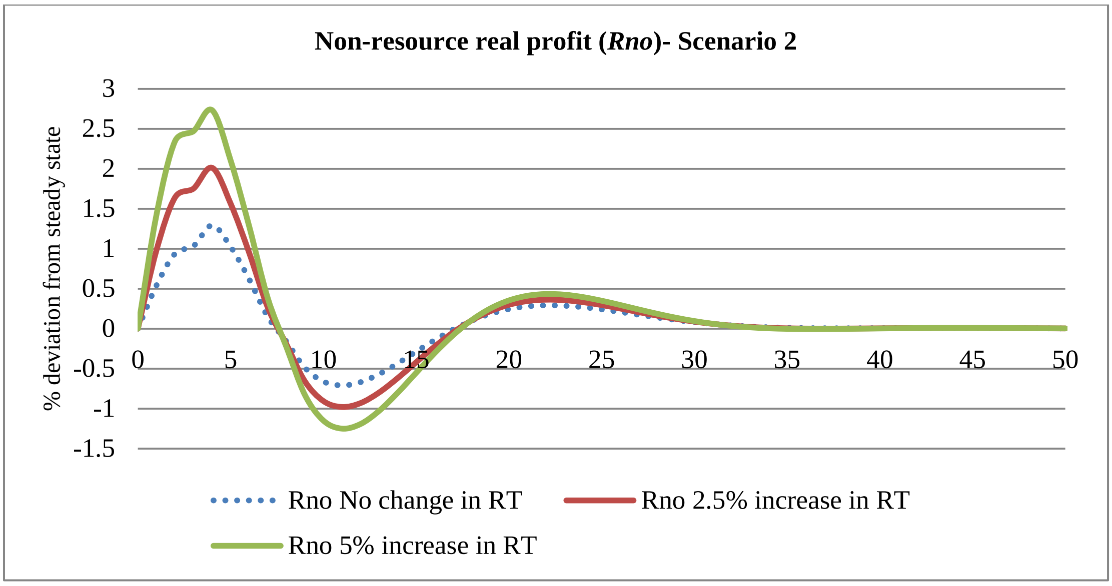


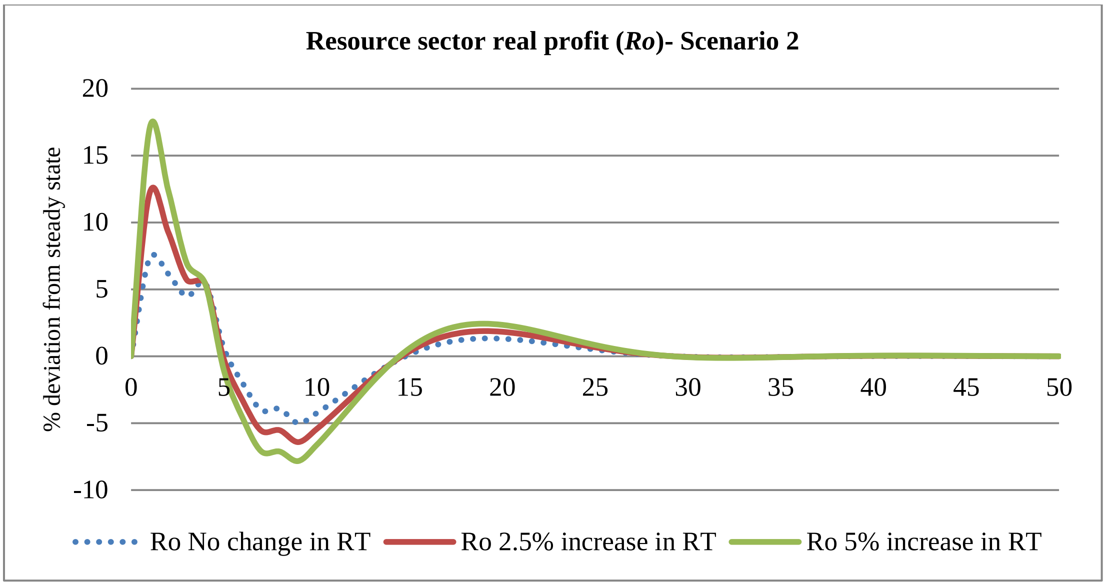
Private asset (*PA*)- Scenario 1



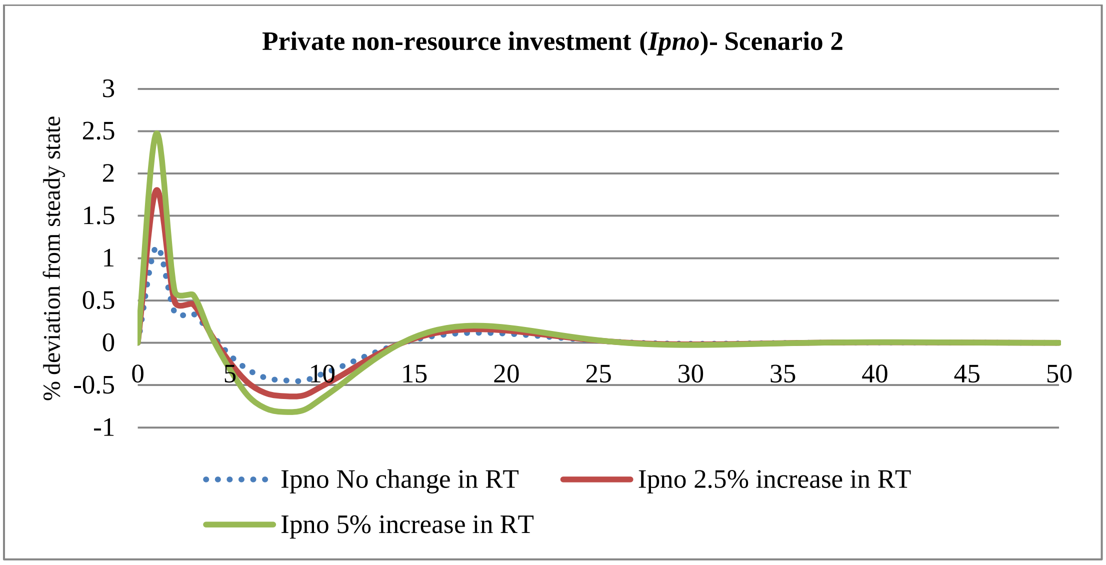

Private non-resource investment (Ipno)- Scenario 1
% deviation from steady state
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0
5
10
15
20
25
30
35
40
45
50
Ipno No change in RT
Ipno 2.5% increase in RT
Ipno 5% increase in RT


Government expenditure (g)- Scenario 1
% deviation from steady state
7
6
5
4
3
2
1
0
-1
-2
-3
0
5
10
15
20
25
30
35
40
45
50
g No change in RT
g 2.5% increase in RT
g 5% increase in RT


Non-resource real profit (Rno)- Scenario 2
% deviation from steady state
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0
5
10
15
20
25
30
35
40
45
50
Rno No change in RT
Rno 2.5% increase in RT
Rno 5% increase in RT



Resource sector real profit (*Ro*)- Scenario 2
% deviation from steady state
20
15
10
5
0
-5
-10
0
5
10
15
20
25
30
35
40
45
50
Ro No change in RT
Ro 2.5% increase in RT
Ro 5% increase in RT



Private non-resource investment (*Ipno*)- Scenario 2
% deviation from steady state
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
5
10
15
20
25
30
35
40
45
50
Ipno No change in RT
Ipno 2.5% increase in RT
Ipno 5% increase in RT

APPENDIX C: CUMULATIVE PERCENTAGE VARIATION FROM BASELINE FOR ADDITIONAL VARIABLES IN SCENARIO 1 & 2

Scenario 1 - Cumulative Percentage Variations from Baseline

		Case A	Case B	Case C
g	Boom period +	9.5642	14.0859	18.6076
	Post-boom period +	-3.8286	-4.0549	-4.2813
	Overall +	7.0795	11.4030	15.7266
qno	Boom period	0.1282	0.0316	-0.0650
	Post-boom period	-0.1546	-0.0841	-0.0136
	Overall	-0.2284	-0.3470	-0.4656
PA	Boom period	71.7654	85.8601	99.9549
	Post-boom period	-97.5491	-117.8695	-138.1898
	Overall	-19.1816	-24.9449	-30.7082
f	Boom period	16.4305	19.7347	23.0389
	Post-boom period	-65.9711	-78.2484	-90.5256
	Overall	-65.3291	-73.9477	-82.5663
ki	Boom period	0.6901	1.0396	1.3890
	Post-boom period	-0.2595	-0.2481	-0.2368
	Overall	0.6933	1.0959	1.4985
kh	Boom period	0.6901	1.0396	1.3890
	Post-boom period	-0.2595	-0.2481	-0.2368
	Overall	0.6933	1.0959	1.4985
Ipno	Boom period	0.0641	0.0158	-0.0325
	Post-boom period	-0.0325	-0.0420	-0.0068
	Overall	-0.1142	-0.1735	-0.2328

Notes: + Boom period (quarters 1-8), Post-boom period (quarters 9-20), Overall (quarters 1-50)

Scenario 2 - Cumulative Percentage Variations from Baseline and Benefits from Increased Public Investment Expenditure (A Comparison of Scenario 1 and 2)*

		Case A	Case B	Case C
Ipno	Boom period +	0.2629	0.3083	0.3537
	Post-boom period +	-0.6943	-0.9534	-1.2124
	Overall +	-0.5705	-0.9153	-1.2600
	Overall- Scenario 1	-0.1142	-0.1735	-0.2328
	Gain from more public investment	-0.4563	-0.7418	-1.0272

Notes: + Boom period (quarters 1-8), Post-boom period (quarters 9-20), Overall (quarters 1-50)

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