Fiscal Policy and Dutch Disease: Antidote or Poison?

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Declaration

I declare that this thesis is my own work and that, to the best of my knowledge, it contains no material that has been published or written by another person(s) except where due acknowledgement has been made. This thesis has not been submitted for award of any other degree or diploma at the University of New South Wales or at any other educational institution. I declare that the intellectual content of this thesis is the product of my own work except to the extent that assistance from others is acknowledged.

Zain Ahmed

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Abstract

This thesis examines the role of fiscal policy in managing declines in learning and output in the non-commodity sector during a transitory or persistent commodity price boom. A New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model is calibrated to the Australian data. Four fiscal rules are imposed on the model: budget balance, taxation rate shock, commodity taxation rule and increased government spending. A key feature of the model is the learning-by-doing (LBD) externality in the production function, which captures the impact of previous period output on current period output. The results find that the success of the fiscal rules hinges on the ability to leverage an improvement in the LBD process. The results conclude that the taxation rate shock provides the best relief to a transitory commodity price boom. Whereas the commodity taxation rule, which allows commodity taxation to adjust to changes in commodity prices and non-commodity output, is the most viable policy to deal with a persistent commodity price boom. Examining the welfare effects of the policies shows preference for budget balance.
1 Introduction

“In Australia, we have about a 20-year uninterrupted growth period; we have nearly record terms of trade, and we’re not prospering. So the settings here are not right... This is not a time when state and federal governments should be becoming more highly indebted, and they are. So that is a weakness of fiscal policy in Australia and it is holding back development and making the so-called Dutch disease risk higher than it need be.”

David Murray, ABC Inside Business, 24/09/2011

Commodity booms can be a mixed blessing. They can significantly improve growth but they equally have an ability to damage other parts of the economy. Dutch Disease describes the process of how a booming tradable sector can contract other parts of the economy. Governments do not have to be complacent when faced with this problem. Governments have the potential to set appropriate fiscal policy settings to stabilise the non-minerals sectors of the economy. However, governments must ensure their response is proportional to the length of the boom. This thesis examines appropriate fiscal policy responses to temporary and persistent commodity price booms that are damaging the learning (or productivity stock) and output of the non-commodity sector.

A New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model is employed to examine the role of fiscal policy to an instance of Dutch Disease. A key feature of the model is the ability to examine the impact of temporary and persistent rises in commodity prices. This is important because the policy responses under both instances can vary significantly. Four fiscal rules are imposed on the model: budget balance, a taxation shock, a commodity taxation rule and a 10 per cent increase in government spending. The performance of the fiscal rules is then examined through welfare analysis.

There is no doubt that in recent years Australia has experienced a record commodities boom. The boom has caused the terms of trade to skyrocket to historical heights (as shown in figure 1). The terms of trade peaked at a hundred and eighteen year high of 106.1 in September 2011, improving by approximately forty per cent in just over two years. This has appreciated the exchange rate to levels not witnessed since the beginning of Australia’s floating exchange rate system.

A key issue is whether this extraordinary rise occurs to the detriment of other sectors. Essentially, the process of Dutch Disease is when a booming tradable sector causes an appreciation of the exchange rate so that the lagging tradable sector contracts. The process works through two channels: by shifting resources from the lagging sector to the booming sector and rising income encouraging the consumption of imports.
The growth in Australia’s mining sector has occurred at the same time as the contraction in the manufacturing sector (as evidenced in figure 2). Although correlation is not causation, the key concern of Dutch Disease is that the commodities boom can cause a permanent, long-term damage to other sectors of the economy. Potential damage of Dutch Disease is explored through a ‘learning-by-doing’ externality. The fundamental idea being that a rise in the minerals sector reduces the stock of productivity in the economy. The reduction in LBD then reduces the economy’s long-term growth prospects.

There is a potential for fiscal policy to intervene to reverse or limit the detrimental effects of Dutch Disease. During the early 2000s resources boom the Commonwealth government witnessed increases in both revenues (receipts) and spending (payments) (as
shown in figure 3). Some have argued poor fiscal policy settings at the time may have compounded the detrimental impacts of the resources boom. The analysis of the four fiscal rules will assist in proving the amount of truth of such feelings. Importantly, the thesis examines the welfare effects of different policy options. Doing so provides information about the best course of action for governments faced with Dutch Disease.

![Australian Commonwealth Government Payments and Receipts](image)

Figure 3: Australian Commonwealth Government Payments and Receipts

This thesis builds upon the existing literature in two ways.

Firstly, it adds to the current movement of the literature of Dutch Disease towards policy options. The literature has experienced three ‘waves’. Early Dutch Disease literature set out the theoretical model. Afterwards, the literature turned focus to modelling the existence and impact of Dutch Disease. Now, with Dutch Disease being well conceptualised, literature has increasingly turned to policy responses to manage and mitigate. Fiscal policy has not been widely examined in the literature. This thesis, by focusing on fiscal policy, fills the existing void. The examination of taxation instruments is a particular area in the literature to which this thesis provides a contribution. Policymakers will be empowered with new information about appropriate fiscal policy settings when faced with instances of Dutch Disease.

Secondly, it provides an examination of Dutch Disease for Australia. Despite, in many senses, Australia providing the ideal economy to examine Dutch Disease the literature has not placed much focus on Australia. Some parts of the literature have examined the rise of the terms of trade in recent years, but it has not correlated this rise with impact
on other sectors. This thesis, by being calibrated to the Australian economy, captures at least some of the effects of Dutch Disease in Australia.

The organisation of this thesis is as follows. Section 2 reviews the relevant literature. Section 3 sets out the model and details the fiscal rules. Section 4 discusses the calibration and data employed. Section 5 analyses the results in the steady state. Section 6 explores the impact of the government sector in the Dutch Disease process. Section 7 examines the dynamic effects of the fiscal rules. Section 8 explores the welfare costs associated with these rules. Section 9 looks at the sensitivity of the results to different parameters. Section 10 concludes.
2 Literature Review

This section provides an overview of the relevant literature. This literature review is split into two sections. Firstly, the literature governing the concept of Dutch Disease is examined (also known as ‘natural resource curse’ or ‘Gregory’s effect’). Initial academic research focused on creating a theoretical model to explain the concept. In 1982, Corden and Neary made an important breakthrough when they analysed Dutch Disease in two effects – the resource movement and spending effect. As the literature grew, attention shifted to creating models to assess the existence and impact of Dutch Disease. Emphasis is placed on papers using Dynamic Stochastic General Equilibrium (DSGE) models, as this is the model employed in this thesis. Secondly, the literature examining the policy implications and responses to Dutch Disease is explored, with an emphasis on fiscal policy. There is significant debate to the role of policy in mitigating and managing Dutch Disease. Some argue policy should play no role and the economy should be left to operate itself. Other sections of the literature place greater concern on the short and long run impacts of a contraction in the non-commodity sector. Policy, especially fiscal policy, is viewed as vital to securing the economy’s prosperity.

2.1 Framework of Dutch Disease

2.1.1 The Process of Dutch Disease

The term Dutch Disease was first used by The Economist in 1977 to describe the experience of the Netherland’s minerals boom. Dutch Disease occurs in two effects – the resource movement effect and the spending effect (Corden & Neary 1982). The resource movement effect describes how a booming tradable sector attracts resources away from a lagging tradable sector. The spending effect accounts for the impact of rising incomes from the booming trade sector being spent on the non-tradable sector and imports.

Corden and Neary (1982) explain that the conditions and circumstances under which the resource movement effect occurs is dependent on the level of factor mobility between the three sectors. When labour is the only mobile sector, a commodity price boom raises demand in the commodity sector. This increases the real wage reducing labour demand and output in other sectors. When capital is mobile between the non-tradable and lagging tradable sectors and labour is mobile across all three sectors, wages rise in the economy due to the commodity boom. The more labour intensive sectors, typically the lagging tradable sector, will experience a contraction. A similar process occurs when capital and labour are fully mobile. Only labour intensive sectors experience a contraction due to
the commodity boom. In light of their findings and with the assumptions of the model of this thesis, the resource movement effect occurs in a situation where the non-commodity sector sheds labour hours or learning after a commodity boom.

The viability of the resource movement effect is dependent on factor intensities and labour supply. The ability for resources to move sectors is limited by the factor intensity of the sector. Ismail (2010) uses a static model to show with international capital mobility (where the domestic interest rate is fixed to the world), the marginal product of capital is fixed. For the tradable sector, the marginal product of capital equals the world level. In the instance of a positive windfall shock, the factor intensities drive the movement of resources. When the lagging tradable sector sheds resources, the non-tradable sector will employ these at its factor intensity. If the sector has low factor intensity, it will not be able to absorb those resources. Decisions regarding labour supply can influence the strength of the resource movement effect (Acosta et al 2009). Acosta et al (2009) use a DSGE to model the Dutch Disease effect of remittances. They consider Greenwood–Hercowitz–Huffman (GHH) style preferences for the consumption function to reduce the impact of the income effect on labour supply decisions. They find that when consumption increases, wages also increase causing an expansion in labour supply in the tradable sector. Tradable productivity falls and the exchange rate appreciates. These forces create the conditions for labour to move to the non-tradable sector. Despite their findings, this thesis will not employ GHH style preferences because the Dutch Disease is better modelled with constant elasticity of substitution (CES) utility (Alcoasta et al 2002, Rees 2013).

However, the dynamics of small open economies are such that the resource movement effect does not occur. Corden (2012) demonstrated this by examining the case of Australia. He argues the resource movement effect does not arise for three reasons. Firstly, labour shortages in the booming sector can be met by the skilled migration program. Second, the minerals sector employs a small amount of labour (especially given its size). Finally, the movement of capital between sectors is limited due to high international capital mobility. Downes et al (2014) completely refute the notion of a trade-off of resources. They, using evidence from Australia, argue that minerals boom assists other sectors by providing additional demand for domestic goods.

The spending effect, as described by Corden (1984, 2012), refers to the impact of extra income from the booming tradable sector on the lagging and non-tradable sectors. When the elasticity of demand for the non-tradable sector is positive, the extra income
from the booming sector causes prices in the non-tradable sector to rise in response to higher consumption. This causes the real exchange rate to appreciate, reducing the international competitiveness and output of the lagging tradable sector. Gregory (1976) finds the spending effect has a similar impact on the lagging tradable sector as tariff reductions. Gregory uses a graphical model to illustrate that the booming tradable sector causes higher inflation and a real exchange rate appreciation. This impacts both the export and import competing sectors, causing both of them to lose competitiveness.

2.1.2 Ramifications of Dutch Disease

There has been significant debate as to whether Dutch Disease is a problem or simply a symptom of an economy allocating resources most efficiently. Generally, the contraction of a sector in response to economic forces is not an issue if neoclassical, competitive conditions exist in the economy (Sachs & Warner 1997). Literature that is dismissive of the issue of Dutch Disease usually fails to account for the negative externalities of a contraction in the lagging tradable sector (Sachs & Warner 1997). Others who are concerned by Dutch Disease, argue that the collapse in productivity in the non-minerals tradable sector during terms of trade booms, can be of such extent and tenure that Dutch Disease can be termed a disease (Van Wijenbergen 1984). They also argue that the booming tradable sector causes significant volatility in economic growth (Sachs & Warner 1997).

The literature has noted that learning by doing externalities (LBD) can propagate the negative consequences of Dutch Disease because of the reduction in welfare (Torvik 2001, Matsuyama 1992). A LBD externality is when second period productivity depends on first period production (Van Wijnbergen 1984). Contributors to the LBD externality could include: labour productivity (Drazen 1985), knowledge spillovers between sectors due to innovations (Jaffe et. al 1993) or external economies of scale (Holmes 1999). With LBD externalities, in any or all sectors, the effects of Dutch Disease are more pronounced. If economic growth is influenced by LBD externalities in the traded sector, a temporary contraction in that sector can destabilise the sector’s viability (Hahn & Matthews 1965). This causes a reduction in productivity, private consumption and economic growth (Torvik 2001, Van per Ploeg 2011). In the long run, the income effect of Dutch Disease causes a further reduction in productivity as the LBD externality worsens and inefficiencies in the lagging sector begin to emerge (Krugman 1987, Hevia et. al 2013). The ability for LBD externalities to propagate the effects of Dutch Disease depends on the level of capital mobility between the traded and non-traded sector (Van per Ploeg 2011). The more mobile capital is between the sector, the greater the impact of Dutch Disease. If Dutch Disease causes exchange rate volatility, as it seems in the
case of many nations, the traded sector experiences significant reductions in investment, which further reduces long run productivity and economic growth (Gylfason et. al 1997). It is important to note, that targeting LBD helps improve labour hours as well. This is because a higher LBD externality, through increasing productivity, increases the social marginal product of labour (Aizenman & Lee 2010). Lama and Medina (2012) directly compare the impact of Dutch Disease with and without a LBD externality on the traded sector. Two reasons are given for the worsening performance of the economy with a LBD externality: a reduction in productivity of the lagging tradable sector due to lower capital as a result of a decline in domestic production and the extra appreciation of the exchange rate driven by the higher domestic price level as a result of lower productivity. They employ a New Keynesian DSGE with the assumptions: that the central bank has full information regarding the length of the resources and the boom is a temporary one with a temporary effect on tradable output.

The overshooting of prices can also propagate the contraction in the non-commodities sector. Models that include money depict a greater short run decline in the lagging tradable sector (Edwards & Aoki 1983). Through comparative dynamics analysis, Edwards and Aoki show that relative prices overshoot because of the additional effect of price elasticity’s in monetary models. Although, their model assumes fixed exchange rates, the authors argue their results translate under flexible exchange rates. Harberger’s (1982) dynamic model concludes similar results, arguing overshooting occurs due to elasticity’s driving different patterns of expenditure for excess money.

2.2 Policy Responses to Dutch Disease

The presence of Dutch Disease presents a dilemma to policymakers. They confront the choice of letting the minerals boom flourish at the expense of other tradable sectors and increased macroeconomic volatility (Lama & Medina 2012) or supporting other tradable sectors at the expense of the minerals boom. Cespedes and Velasco (2014) find evidence that the majority of governments tend to be severely procyclical during times of commodity price booms. By imposing fiscal discipline through fiscal rules, the government will be forced to ensure budget sustainability and counter-cyclical fiscal policy. For this reason, this thesis will explore policy options by examining several fiscal rules. This literature review will consider three options to motivate the choice of fiscal rules: fiscal policy, piecemeal protection and no policy response.
2.2.1 Fiscal Policy

Fiscal policy, the spending and taxation decisions of government, can be set to alleviate the effects of Dutch Disease. A macroeconomic response is more desirable because it assists lagging tradable sectors uniformly and therefore, does not promote inefficiency in resource allocation (Corden 2012). Views regarding the best employment of fiscal policy at a time of Dutch Disease differ amongst the literature. Whilst some hold preference for an active fiscal policy response, other parts of the literature argue against a fiscal response, highlighting its ineffectiveness and welfare loss.

In instances where the demand from a booming sector needs to be contained, fiscal consolidation policies can mitigate the repercussions of Dutch Disease. Corden (2012) argues the government should run fiscal surpluses when faced with Dutch Disease. This will reduce domestic demand, having a deflationary impact on the economy. The lower inflation environment would prompt a reduction in interest rates. In turn, this would lead to a depreciation of the exchange rate due to higher capital outflow. Fiscal expansion aggravates the effects of Dutch Disease as it causes the terms of trade to rise faster making the exchange rate appreciate by a greater margin (Orrego & Vega 2013). The importance of examining fiscal consolidation during Dutch Disease is the reason why this thesis incorporates government borrowings when adding fiscal policy to the Rees (2013) model.

There are four main advantages of employing fiscal consolidation when faced with Dutch Disease. Firstly, it reverses the effects of the exchange rate appreciation. Van der Ploeg (2011) employs a DSGE to conclude that increasing public savings is advisable to ensure the non-traded sector produces enough home grown capital to support infrastructure development and consumption. The exchange rate appreciation is reversed because of the growth in domestic capital. Secondly, it provides a form of national savings that can be relied upon in adverse circumstances (Corden 2012). It may turn out to be beneficial when the mining boom concludes. Thirdly, it imposes more spending restraint on the government (Van der Ploeg 2011). Lastly, if these fiscal surplus are invested in a sovereign wealth fund, then the domestic economy will hold an internationally diversified investment. This reduces risks associated with investing entirely in the domestic economy (Corden 2012).

A contrasting view places no role for fiscal policy in mitigating Dutch Disease. There are many reasons in support of not actively employing fiscal policy. In the long run fiscal policy does not impact the boom. Bruno and Sachs (1982) employ dynamic fore-
sight equilibrium to argue that with perfect foresight, competitive capital markets and infinitely lived households, the choice of fiscal policy is irrelevant. Optimising far-sighted households and government will not consume commodity revenues anticipating a future collapse. The pitfall of such view is failing to account for the lack of information regarding the length, duration and intensity of the boom and long run consequences of a reduction in LBD (Rees 2013). Fiscal policy may also exhibit unwanted and unavoidable consequences after the commodities boom. For example, Arezki and Ismail (2010) argue that fiscal rules in response to Dutch Disease can cause a reduction in capital spending after the boom. Importantly, even if governments wish to use fiscal policy to mitigate Dutch Disease, the stickiness of government spending can sometimes render it unviable. In particular, the political costs of fiscal adjustment inhibits the governments ability to alter policy settings (Arezki and Ismail 2010). Fiscal policy is also viewed as ineffective because it can’t reach the cause of the Dutch Disease problem which is price instability. Rather, Nevia et al. (2013) argue price pressures are better dealt with by monetary policy.

2.2.2 ‘Piecemeal Protection’

The government could also utilise ‘piecemeal protection’ during periods of Dutch Disease. That is, the government would adopt policies to provide financial assistance or competitive advantages to the lagging tradable sector (Corden 2012). The justification for this approach is due to the long term effects of a collapse in productivity in the non-commodity sector (Van Wijnbergen 1984).

Many papers examine this approach in the form of a subsidy. Van Wijnbergen (1984) reasons subsidies are justified if nations spend temporarily high minerals revenues on consumption. A subsidy is needed when revenues are not spent on foreign assets to smooth the current account and when the contraction in the non-commodity sector generates negative externalities that firms, workers and consumers in the sector do not internalise (Rees 2013). This ensures that the non-commodity tradable sector, with a LBD externality, does not experience a reduction in productivity. A problem arises if nations are unsure of the persistence of the commodity boom. The level of information regarding the length of the boom can influence the level of the subsidy (Rees 2013). When the expectation and reality of the boom’s length are not aligned the value of the subsidy is lower than optimally required.

This thesis deviates by considering sectorial taxation as a form of piecemeal protection. Specifically, a commodity taxation rule will be applied to the model. Taxing of natural
resources is a difficult policy decision. On one hand, governments do not wish to blow the blessing of natural resources away. Conversely, much of the public benefit of commodity booms, particularly in the long term, comes from taxation revenue. Resources should be taxed to maximise long term social benefits (Garnaut & Ross 1975). The contraction in the non-commodity sector, especially with an LBD externality, represents a long term social and economic cost of commodity booms (Torvik 2001). Therefore, the commodity tax will account for expansions in the commodity sector and contractions in the non-commodity sector.

The government can also target spending to the lagging tradable sector to shield them against Dutch Disease. Orrego and Vega (2013) employ a real business cycle DSGE to examine the effects of different fiscal rules in propagating or mitigating Dutch Disease. They find, when governments target spending to create positive externalities in the non-tradable or lagging tradable sectors, the effects of Dutch Disease are softened as the appreciation is contained. Such policy approach is effective in restricting Dutch Disease because the investment accumulates capital which can improve productivity in the lagging sectors. This is particularly the case when the government targets expenditure towards investment that eases capacity pressures in the economy that emerge from the boom (Bhattacharyya & Williamson 2011). Targeted government spending can also contain price booms in the growing sector. In instances of monetary models, well planned government spending can help drive down the overshooting of prices (Edwards & Aoki 1983; Harberger 1982).

Imposing piecemeal protection to counteract Dutch Disease has effects on general equilibrium (Corden 2012). Protection reduces imports and through effects on capital inflows can cause an appreciation of the exchange rate. The extra appreciation worsens the impact of Dutch Disease on the lagging tradable sector (Corden 2012). Also in instances of protection, it is likely the government will choose to protect only a small number of industries. Unprotected industries in the lagging tradable sector suffer significantly, they do not receive assistance from the government and must accommodate a higher exchange rate (Corden 2012). For these reasons, this thesis considers a mechanism to support the non-commodity sector by placing a burden on the commodity sector.

2.2.3 Do Nothing

Governments can elect to provide no policy response to Dutch Disease. The appreciation of the exchange rate due to Dutch Disease is simply a flexible economy at work. Flexibility in the economy encourages efficient resource allocation. This reiterates the opinion
of Sachs and Warner (1995), that Dutch Disease is not a disease but merely economics at work. Furthermore, commodity booms can operate to support the entire economy, despite short term disruptions (Stapledon 2013). Stapledon (2013) uses evidence from previous Australian commodity booms to show, despite short term contractions, other industries benefited from the income of resource booms. In fact, some Dutch Disease may even be preferred (Matesen & Torvik 2003). Matesan and Torvik (2003) extend the previous growth literature from a positive to a normative setting and indicate, with LBD externalities present, Dutch Disease is not a concern. The increase in wealth can be consumed to the economy’s benefit. They argue, the pitfall of Dutch Disease is rooted in poor consumption decisions. They suggest consumption in each period needs to be slightly lower to realise the benefits of Dutch Disease.

Crucially, even if the government has no active fiscal policy to manage Dutch Disease, it must ensure policy settings do not propel its impacts. For example, if the government does not exercise spending restraint, this can potentially negatively alter the allocation of capital in the economy (Sachs & Warner 1997).
3 Theoretical Model

The model employed in this thesis is an extension of the New Keynesian DSGE model in Rees (2013). The Rees (2013) model examines the impact of commodity price rises on the non-commodity sector which contains a Learning-by-Doing externality. The model is extended by adding fiscal policy. Fiscal rules are then imposed on the model to examine the role of fiscal policy in confronting Dutch Disease.

3.1 Overview of Model

The model below is based off the standard New Keynesian DSGE framework. The model is solved using Dynare in Matlab. A derivation of this model is provided in Appendix B. Steady state equations are provided in Appendix C.

3.1.1 Indices of International Relative Prices

The relative price of Home goods, $\hat{P}_{H,t}$, and Foreign goods, $\hat{P}_{F,t}$, are:

\[ \hat{P}_{H,t} \equiv \frac{P_{H,t}}{P_t} \quad \hat{P}_{F,t} \equiv \frac{P_{F,t}}{P_t} \] (3.1)

where $P_{H,t}$ is the price of domestically produced goods and $P_{F,t}$ is the price of foreign produced goods. It follows that, $\hat{P}_{H,t} + \hat{P}_{F,t} = 1$.

The bilateral real exchange rate between the Home and Foreign economies, $Q_t$:

\[ Q_t \equiv \frac{\varepsilon_t P_{F,t}}{P_t} \] (3.2)

where $\varepsilon_t$ is the bilateral nominal exchange rate, $P_{F,t}$ is the price of foreign goods and $P_t$ is the overall price of goods in the domestic economy.

By defining the following:

\[ \Pi_t = \frac{P_t}{P_{t-1}} \] (3.3)
\[ \Pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}} \] (3.4)

Producer Price Index (PPI) inflation can be formed through (3.1 - 3.4). This gives PPI inflation in terms of CPI inflation and rate of change of $\hat{P}_{H,t}$:

\[ \Pi_{H,t} = \frac{\hat{P}_{H,t}}{\hat{P}_{H,t-1}} \Pi_t \] (3.5)
Furthermore, the law of one price holds. This implies:

\[
P_{Ft}(j) = \varepsilon_t P^*_F(j) \quad (3.6)
\]

\[
P_{Ht}(j) = \varepsilon_t P^*_H(j) \quad (3.7)
\]

for all \( j \in [0, 1] \)

### 3.1.2 Households

The model consists of a representative household. The representative household either consumes or provides labour. Consumption can consist of home \((C_{H,t})\) or foreign \((C_{F,t})\) goods. Aggregate consumption is a constant elasticity of substitution (CES) of these two goods.

\[
C_t = \left[(1 - \eta)^{\frac{1}{\gamma}}(C_{H,t})^{\frac{\gamma - 1}{\gamma}} + \eta^{\frac{1}{\gamma}}(C_{F,t})^{\frac{\gamma - 1}{\gamma}}\right]^{\frac{\gamma}{\gamma - 1}} \quad (3.8)
\]

The home and foreign goods are CES aggregates as below.

\[
C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\gamma - 1}{\gamma}} dj\right)^{\frac{\gamma}{\gamma - 1}} \quad (3.9)
\]

\[
C_{F,t} = \left(\int_0^1 C_{F,t}(j)^{\frac{\gamma - 1}{\gamma}} dj\right)^{\frac{\gamma}{\gamma - 1}} \quad (3.10)
\]

In equations (3.8 - 3.10), the parameters are as follows. The degree of home bias is measured by \( \eta \). The elasticity between home and foreign produced goods is \( \gamma \). Elasticity between goods in an economy is represented through \( \zeta \).

The objective of the representative household is to maximise expected discounted utility. Utility is a function of both consumption \( C_t \) and labour \( L_t \).

\[
U_t = E_t \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_t^{1-\sigma}}{1-\sigma} - AL_t \frac{L_t^{1+\phi}}{1+\phi} \right] \quad (3.11)
\]

In the utility function, \( \beta \) is the discount factor, \( 1/\sigma \) is the intertemporal elasticity of substitution and \( \phi \) is the Frisch labour supply elasticity.

The household maximises utility (3.11) subject to the household budget constraint (3.12)
for all \( t > 0 \).

\[
\int_0^1 C_{H,t}(j)P_{H,t}(j)dj + \int_0^1 C_{F,t}(j)P_{F,t}(j)dj + \frac{B_{G,t+1}}{1 + r_t} + \frac{\varepsilon_t B_{F,t+1}}{(1 + r^*)\Psi(b_{t+1})} \\
\leq W_t L_t + \Upsilon_t + B_{G,t} + \varepsilon_t B_{F,t} + (1 - \tau_t)\varepsilon_t S_t Y^X \tag{3.12}
\]

Where \( P_{H,t}(j) \) and \( P_{F,t}(j) \) are the domestic prices of home and foreign goods, respectively. \( W_t \) is the nominal wage and \( \Upsilon_t \) are nominal profits. Households assets are comprised of government \( (B_{G,t+1}) \) and foreign \( (B_{F,t+1}) \) bonds. These earn the respective rates of interest of \( r_t \) and \( r^* \). The portfolio adjustment cost is the function \( \Psi(b_{t+1}) = \frac{\psi}{2}(\exp(-B_{F,t+1})\frac{\varepsilon_t}{\Pi_t}) \). \( S_t \) refers to the price of commodities in foreign currency terms. \( Y^X \) is the home economy’s constant commodity endowment. The government tax rate for the commodity sector is \( \tau_c \).

Appendix B.1 contains the derivation for the household optimality conditions.

The household Euler equation is (where \( \Pi_{t+1} = \frac{P_{t+1}}{P_t} \)):

\[
1 = \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{1 + r_t}{\Pi_{t+1}} \right\} \tag{3.13}
\]

The intratemporal optimality condition is:

\[
A_L C_t^\sigma L_t^\phi = \frac{W_t}{P_t} \tag{3.14}
\]

The uncovered interest parity condition (UIP) is:

\[
1 + r_t = (1 + r^*)E_t \left\{ \frac{\varepsilon_{t+1}}{\varepsilon_t} \Psi(b_{t+1}) \right\} \tag{3.15}
\]

3.1.3 Firms

**Production:** Non-commodity home firms produce goods and are subject to government taxation according to:

\[
(1 - \tau_{nc})Y_t(j) = LRN_t(j)^\alpha L_t(j)^{1-\alpha} \tag{3.16}
\]

Where \( Y_t(j) \) refers to output of firm \( j \). The learning-by-doing externality, \( LRN_t(j) \), refers to improvements to productive output that are external to the firm. The government taxation rate for the non-commodity sector is \( \tau_{nc} \). The learning process evolves according to:

\[
LRN_{t+1}(j) = LRN_t(j)^\lambda [(1 - \tau_{nc})Y_t(j)]^{1-\lambda} \tag{3.17}
\]
Rees (2013) defines the value of externality as the marginal product of labour excluding its direct effect on output. Therefore, it evolves as follows:

$$ext_t = \mu_t + \chi(1 - \alpha)(ln_t - h_t) \quad (3.18)$$

Where $\mu_t$ refers to the log deviation in the shadow value of learning from its steady state value. The shadow price is derived in Appendix B.3.

The firm’s real marginal cost is:

$$MC_t(j) = \frac{W_t(j)}{P_{H,t}} \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t(j)}{L_t(j)} \right]^{-1} \quad (3.19)$$

A derivation of this is provided in Appendix B.2.1.

**Price Setting:** Firms set prices according to the Calvo (1983) pricing model. Under the Calvo pricing model, prices are not subject to continuous revisions and prices are changed independent of time. Under this staggered pricing model, firms change prices randomly when they receive signals. Usually, firms will change prices when the expected average price or the state of the market changes. In each period, $(1 - \theta)$ fraction of firms changes prices.

At time $t$, the firm faces the pricing problem (3.20) subject to the demand constraint (3.21):

$$\max_{\check{P}_{H,t}(j)} \left\{ \sum_{k=0}^{\infty} \theta^k \mathbb{E}_t \left\{ \Lambda_{t,t+k}[1 - \tau_{nc})Y_{t+k}(j)(\check{P}_{H,t}(j) - MC_{t+k}(j)P_{H,t+k})] \right\} = 0 \quad (3.20) \right.$$  

$$Y_{t+k}(j) = (1 - \tau_{nc})Y_{t+k} \left( \frac{P_{H,t}(j)}{\check{P}_{H,t+k}} \right)^{-\zeta} \quad (3.21)$$

Where $\check{P}_{H,t}(j)$ is the firm’s reset price at time $t$ and $\Lambda_{t,t+k}$ is the stochastic discount factor between period $t$ and $t + k$.

The firm’s pricing problem optimality condition is:

$$\mathbb{E}_t \left[ \sum_{k=0}^{\infty} \theta^k Q_{t,t+k}(1 - \tau_{nc})Y_{t+k}(j) \left[ \check{P}_{H,t} - \frac{\zeta}{1 - \zeta}MC_{t+k|t}P_{H,t+k} \right] \right] = 0 \quad (3.22)$$

At time $t$, all reset prices will be equal. This allows the optimal pricing condition to be represented as the difference between the reset and average prices for non-commodity...
home goods:

\[
\frac{\tilde{P}_{H,t}}{P_{H,t}} \equiv \Xi_t = \left( \frac{F_t}{J_t} \right)^{\frac{1-\alpha}{1-\alpha + \alpha}} \tag{3.23}
\]

where:

\[
F_t = \frac{\zeta}{1-\zeta}C_t^{-\sigma}(1 - \tau_{nc})Y_tMC_t\tilde{P}_{H,t} + \beta\theta\mathbb{E}_t\left[(\pi_{H,t+1})^{\frac{\zeta}{\zeta-1}}F_{t+1}\right] \tag{3.24}
\]

\[
J_t = \frac{\zeta}{1-\zeta}C_t^{-\sigma}(1 - \tau_{nc})Y_t\tilde{P}_{H,t} + \beta\theta\mathbb{E}_t\left[(\pi_{H,t+1})^{\zeta-1}J_{t+1}\right] \tag{3.25}
\]

The domestic price index can be formulated using these pricing arrangements as:

\[
P_{H,t} = \left[\theta P_{H,t-1}^{1-\zeta} + (1 - \theta)\tilde{P}_{H,t}^{1-\zeta}\right]^\frac{1-\zeta}{1-\alpha} \tag{3.26}
\]

Using (3.26), the home-produced goods inflation rate is:

\[
1 = \theta(\Pi_{H,t})^{\zeta-1} + (1 - \theta)(\Xi_t)^{1-\zeta} \tag{3.27}
\]

Price dispersion, \(\Delta_t\), can be defined as:

\[
\Delta_t = \int_0^1 \left( \frac{P_{H,t}(j)}{\tilde{P}_{H,t}} \right)^{-\frac{\zeta}{1-\alpha}} dj \tag{3.28}
\]

Using (3.27) and (3.28) and applying the law of large numbers:

\[
\Delta_t = \theta\Delta_{t-1}(\Pi_{H,t})^{\frac{\zeta}{1-\alpha}} + (1 - \theta)(\Xi)^{-\frac{\zeta}{1-\alpha}} \tag{3.29}
\]

3.1.4 Commodity Sector

The relative prices of commodities is a function of transitory and persistent shocks to commodity prices.

Transitory Shock: The transitory shock is a temporary shock to commodity prices that decreases overtime. Transitory shocks follow an AR(1) process:

\[
\log(Z_t) = \rho_z \log(Z_{t-1}) + \varepsilon_t^Z \tag{3.30}
\]

Transitory shocks occur when there is a positive increase to \(\varepsilon_t^Z\).

Persistent Shock: The persistent shock increases commodity prices for a number of periods after the shock. Persistent shocks follow an AR(2) process:

\[
\log(V_t) = (1 + \rho_{v1} - \rho_{v2})\log(V_{t-1}) + \rho_{v1}\log(V_{t-2}) + \varepsilon_t^V \tag{3.31}
\]
Persistent shocks occur when there is a positive increase to $\varepsilon_t^V$. Where $\rho_{v1}$ is the AR(1) coefficient and $\rho_{v2}$ is the error correction term.

Relative prices of commodities are a function of the two potential price shocks.

$$S_t = Z_t V_t$$  \hspace{1cm} (3.32)

The constant output of the commodity sector is equal to $Y^X$. The revenue from the commodity sector, in domestic currency terms and accounting for taxation, is equal to:

$$(1 - \tau_{nc})\varepsilon_t S_t Y^X.$$  

### 3.1.5 Government Sector - Fiscal Policy

This subsection explains how the Rees (2013) model is extended to include fiscal policy.

According to Baxter and King (1993), government spending is assumed to affect the utility of the representative household. With the government sector now in the economy, the representative household’s utility function becomes:

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t \left[ C_t^{1-\sigma} - A_L \frac{L_t^{1+\phi}}{1+\phi} \right] + \Gamma[G_t]$$  \hspace{1cm} (3.33)

Where $G_t$ refers to government purchases that use resources without affecting the marginal utilities or products in the economy. $\Gamma(.)$ is non-decreasing in $G_t$ (Baxter & King 1993).

The government taxes all output in the economy. Total taxation ($T_t$) receipts are equal to:

$$T_t = \tau_{nc} Y_t + \tau_e \varepsilon_t S_t Y^X$$  \hspace{1cm} (3.34)

The government is able to meet taxation and government spending differences through borrowing. Borrowing is done through issuing government bonds ($B_{G,t}$). Therefore, the government faces the following budget constraint:

$$T_t + B_{G,t} = (1 + r_t) B_{G,t-1} + G_t$$  \hspace{1cm} (3.35)

### 3.1.6 Foreign Sector

The only foreign shock is the commodity price shock. Preferences between the home and foreign economy are the same. Foreign goods are normalised to equal 1 in foreign currency. Therefore, the price of foreign goods in domestic currency equals $\varepsilon_t$. This
allows equation (3.2) to be re-written as:

\[ Q_t = \varepsilon_t \]  

(3.36)

The absence of foreign shocks permits (3.8) to denoted as:

\[ C_t = \left[ (1 - \eta)\frac{1}{\gamma} (C_{H,t})^{\frac{\gamma - 1}{\gamma}} + \eta \frac{1}{\gamma} (C^*)^{\frac{\gamma - 1}{\gamma}} \right]^{\frac{1}{\gamma - 1}} \]  

(3.37)

where \( C^* \) refers to consumption of foreign goods.

### 3.1.7 Monetary Policy

Monetary policy is set according to the Taylor rule as:

\[
\left( \frac{1 + r_t}{1 + r^*} \right)^{\psi_r} = \left( \frac{\Pi_t}{\Pi} \right)^{\psi_{\Pi}} \left( \frac{\Pi_{H,t}}{\Pi_H} \right)^{\psi_{\Pi_H}} \left( \frac{Y_t}{Y} \right)^{\psi_y} \left( \frac{\varepsilon_t}{\varepsilon_{t-1}} \right)^{\psi_{\varepsilon}} \]  

\( (1 - \psi_r) \)  

(3.38)

Monetary policy will be set using simple rule as in Rees (2013), where monetary policy will only respond to changes in home inflation. As in Rees (2013), \( \psi_{\Pi_H} \) is set to 1.5 and everything else to 0.

### 3.1.8 Aggregation and Market Clearing

The labour demand and supply relationship is:

\[ L_t = \left[ \frac{(1 - \eta)Y_t}{LRN_t^{\alpha}} \right]^{\frac{1}{\alpha}} \Delta_t \]  

(3.39)

where \( Y_t \) is the aggregate GDP level \( Y_t \equiv \int_0^1 \left[ Y_t(j) \left( \frac{1}{\tau_{nc,t}} \right) dj \right]^{\frac{1}{\alpha}} \)

The market clearing condition is:

\[ Y_t = (1 - \eta)(\hat{P}_{H,t})^{-\gamma}C_t + \eta \left( \frac{\hat{P}_{H,t}}{Q_t} \right)^{-\gamma}C^* + G_t \]  

(4.40)

The current account equation is:

\[ C_t + \frac{B_{G,t+1}}{(1 + r^*)\Psi(b_{t+1})} = \hat{P}_{H,t}(1 - \tau_{nc})Y_t + \hat{P}_{H,t}(1 - \tau_c)Q_tS_tX + \frac{Q_t}{Q_{t-1}}B_{G,t} \]  

(3.41)

This is formed by making two assumptions regarding domestic government bonds: they are not traded internationally and they are in zero net supply.
3.1.9 Equilibrium

An equilibrium is a sequence of quantities \( \{C_t, Y_t, L_t, LRN_{t+1}, B_{t+1}, G_t\}_{t=1}^{\infty} \), prices \( \{W_t, \Pi_t, \Pi_{H,t}, Q_t, r_t, \Xi_t, F_t, J_t, \Delta_t\}_{t=1}^{\infty} \) and exogenous processes \( \{S_t, Z_t, V_t\}_{t=1}^{\infty} \) such that households maximise utility (3.13-3.15), firms maximise profits (3.22-3.28) and markets clear (3.39-3.41), subject to the technical conditions (3.2, 3.5, 3.16, 3.17), the exogenous processes (3.30-3.32) and the government budget constraint (3.35).

3.2 Fiscal Rules

Different fiscal rules will be applied to the model. The results will be analysed and the welfare effects calculated to conclude the most suitable policy option. Four fiscal rules will be examined: no government borrowings, taxation increases, commodity sector taxation rule and increases in government spending.

3.2.1 Budget Balance

The first fiscal rule does not permit the government to borrow. Therefore, all government expenditure \( (G_t) \) must be financed entirely by current period taxation \( (T_t) \). The budget constraint becomes:

\[
T_t = G_t
\]

3.2.2 Taxation Shocks

Taxation rates will be subject to a taxation shock. This will be done uniformly across all sectors in the economy. The taxation shock will be imposed so that it is persistent.

\[
\begin{align*}
\tau_{nc,t} &= (1 - \rho_{\tau_{nc}})\tau_{nc} + \rho_{\tau_{nc}} \tau_{nc,t-1} + \varepsilon^T_t \\
\tau_{c,t} &= (1 - \rho_{\tau_c})\tau_c + \rho_{\tau_c} \tau_{c,t-1} + \varepsilon^T_t
\end{align*}
\]

3.2.3 Higher Commodity Sector Taxation

This fiscal rule imposes a mechanism for resource taxation. The commodity sector taxation rate will be set according to the rule:

\[
\tau_{c,t} = \rho_{\tau_{c1}} + \rho_{\tau_{c2}}(S_t - S) - \rho_{\tau_{c3}}(Y_t - Y)
\]

The resource industry will be taxed according increases in commodity pricing and deviations in the steady state value of the non-commodity output. Essentially, this mechanism ensures that commodity taxation is higher during large rises in commodity prices and severe contractions in non-commodity output from its steady state level.
3.2.4 Increase in Government Spending

Governments will be permitted to spend more by increasing the steady state value by 10 percent.
4 Calibration

The model is calibrated to the Australian economy. The sample period is from 1990:Q2 to 2014:Q2. Data sources are provided in Appendix A.

4.1 Borrowed Parameters

Table 1 shows parameters that are borrowed. There are three reasons to borrow parameters: the literature has standard values, to specify aspects of the model or because existing calibrations have been conducted. For the last reason, it would be unwise to attempt a re-calibration when the literature already contains accurately calibrated parameters. In interests of robustness, some of these borrowed parameters are subject to sensitivity analysis in section 9.

Table 1: Borrowed Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta )</td>
<td>0.75</td>
<td>Calvo parameter</td>
</tr>
<tr>
<td>( \phi )</td>
<td>1</td>
<td>Frisch labour supply elasticity</td>
</tr>
<tr>
<td>( \rho_{c1} )</td>
<td>0.86</td>
<td>AR(1) coefficient in persistent commodity price process</td>
</tr>
<tr>
<td>( \rho_{c2} )</td>
<td>( 1 \times 10^{-3} )</td>
<td>Error correction coefficient in persistent commodity price process</td>
</tr>
<tr>
<td>( \rho_{z} )</td>
<td>0.84</td>
<td>AR(1) coefficient in transitory commodity price process</td>
</tr>
<tr>
<td>( \sigma_{v} )</td>
<td>( 2 \times 10^{-3} )</td>
<td>Standard deviation of persistent commodity price shock</td>
</tr>
<tr>
<td>( \sigma_{z} )</td>
<td>( 2 \times 10^{-2} )</td>
<td>Standard deviation of transitory commodity price shock</td>
</tr>
</tbody>
</table>

4.2 Household Parameter Calibration

The value of \( \beta \) must be calibrated for households. The mean value of quarterly inflation from 1990Q2 - 2014Q2 is 0.6442 per cent. The mean interest rate (as defined by the cash rate) in that period is 5.482 per cent. This provides a value for \( \beta \) of 0.9534.

The share of imports in consumption (\( \eta \)) is calibrated to 0.2618. This is determined by dividing imports by the sum of total consumption and imports. The parameter in the Rees (2013) model includes the share of imports in the entire consumption basket. Therefore, consumption across all sectors of the economy is used in this calibration.

The values of \( \sigma \) and \( \phi \) are both set to 1. In the formers case it is to ensure a log
utility function exists. The latter is borrowed from Christiano et. al (2005). Although
the Frisch labour supply elasticity is lower than other DSGE models (particularly real
business cycle DSGEs), Christiano et. al (2005) found their unity value to be inline with
other labour literature.

The elasticity of substitution between domestic and foreign goods (\( \gamma \)) parameter is set
to 1.3 and is borrowed from Jaaskela and Nimark (2011). The elasticity of substitution
between varieties (\( \zeta \)) is set to 6 and borrowed from Gali and Monacelli (2005).

4.3 Firm’s Parameter Calibration

The share of labour to production income is determined by dividing gross domestic pro-
duct by the total compensation of employees for each quarter. The quarter results are
then averaged to provide the labour share of income. In the sample period, this would
suggest a labour share of income of 0.4856. This translates to share of learning equal to
0.5144.

The rate of depreciation (\( \chi \)) for the Learning-by-doing externality is 0.63. It is bor-
rowed from Lama & Medina (2012).

The Calvo parameter (\( \theta \)) is set to 0.75. It is borrowed from Gali and Monacelli (2005).
This value suggests that, on average, there is a one year gap between price adjustments.

4.4 Commodity Sector Calibration

In the Rees (2013) model, the commodity endowment (\( Y^X \)) is equal to the proportion
of commodities in export values divided by total household consumption at the steady
state. The total value of minerals exports is divided by the value of household final con-
sumption. Using ABS data over the sample period, this is determined to be 0.1084.

The commodity price process parameters are borrowed from Rees (2012). They were
estimated using Bayesian methods. For the transitory commodity price shock, the AR(1)
coefficient (\( \rho_z \)) is 0.84 and the standard deviation (\( \sigma_z \)) is \(2 \times 10^{-2}\). The persistent com-
modity price shock, has an AR(1) coefficient (\( \rho_{z1} \)) of 0.86, error correction term (\( \rho_{z2} \)) of
\(1 \times 10^{-3}\) and a standard deviation (\( \sigma_u \)) of \(2 \times 10^{-3}\).
4.5 Government Sector Calibration

The steady state value for government spending as a proportion of GDP \( (\frac{G}{Y}) \) is 0.2469. The steady state value for government taxation \( (\frac{T}{Y}) \) is 0.2391. Both of these are set from the government’s most recent budget position, the value for the 2013-14 financial as reported in the 2014-15 Budget.

The steady state non-commodity taxation rate is set to 0.30, inline with the Australian corporate tax rate. The steady state non-commodity taxation rate is set to 0.17. This is the estimated amount of average taxation for resource companies, sourced from the 2009 Henry taxation review. Commodity sector taxation is difficult to find given commercial-in-confidence considerations and the complexities of the Australian taxation system (which include many concessions for resource companies that make their effective taxation rate lower than the headline rate). Given these limitations, this is the most reliable figure currently available.

4.6 Calibrated Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
<td>0.9534 Intertemporal elasticity of substitution</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>1 Frisch labour supply elasticity</td>
</tr>
<tr>
<td>( \phi )</td>
<td>1 AR(1) coefficient in persistent commodity price process</td>
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<tr>
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<td>0.84 Standard deviation of persistent commodity price shock</td>
</tr>
<tr>
<td>( \sigma_{v} )</td>
<td>( 2 \times 10^{-3} ) Standard deviation of transitory commodity price shock</td>
</tr>
<tr>
<td>( Y^X )</td>
<td>0.1084 Commodity sector share of exports</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>1.3 Elasticity of substitution between domestic and foreign goods</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>0.5143 Learning share of income</td>
</tr>
<tr>
<td>( \chi )</td>
<td>0.63 Rate of depreciation of learning</td>
</tr>
<tr>
<td>( \theta )</td>
<td>0.75 Calvo parameter</td>
</tr>
<tr>
<td>( \eta )</td>
<td>0.2618 Share of imports in consumption</td>
</tr>
<tr>
<td>( \tau_{nc} )</td>
<td>0.3 Steady state non-commodity taxation rate</td>
</tr>
<tr>
<td>( \tau_{c} )</td>
<td>0.17 Steady state commodity taxation rate</td>
</tr>
<tr>
<td>( \frac{G}{Y} )</td>
<td>0.2469 Government spending as a proportion of GDP</td>
</tr>
<tr>
<td>( \frac{T}{Y} )</td>
<td>0.2391 Taxation as a proportion of GDP</td>
</tr>
</tbody>
</table>
5 Steady State Results

In this section, different parameters will be changed to provide an indication of the relationship between the commodity prices and government fiscal policy instruments and, the non-commodity sector. In the tables, the parameterised steady state values are in bold. For convenience, Appendix F provides a legend of the variables.

5.1 Impact of Commodity Prices

Table 3 shows that a rise in commodity prices, causes a contraction in the non-commodity sector. It follows, that learning and labour hours also experiences a contraction as demand and output for non-commodity goods is reduced. This shows evidence for the process of Dutch Disease, where the rise in the commodity prices directly leads to a contraction in the non-commodity sector. In the steady state, where the real exchange rate is assumed constant, the income effect plays no role. Rather, it is the resource movement effect that exerts the process of Dutch Disease (Corden & Neary 1982). Higher commodity prices reduce resources in the non-commodity sector, resulting in the sectors demise.

Table 3: Steady State - Commodity Prices

<table>
<thead>
<tr>
<th>$s$</th>
<th>$Y$</th>
<th>$LRN$</th>
<th>$L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>1.43</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>1.42</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>1.5</td>
<td>1.31</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>2</td>
<td>1.23</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>2.5</td>
<td>1.16</td>
<td>0.96</td>
<td>0.96</td>
</tr>
</tbody>
</table>

5.2 Impact of Fiscal Policies on Non-Commodity Sector

This section examines the impact of the three fiscal policy instruments, on the non-commodity sector in the steady state. Examining the impact of changes of fiscal policy instruments is conducted to inform which direction fiscal policy should be set to reverse contractions in the non-commodity sector that are caused by expansions in commodity prices.

5.2.1 Impact of Government Spending

The impact of different government spending levels on the non-commodity sector is shown in table 4. It can be seen that, in the steady state, an increase in government spending leads to an increase in non-commodity output. This essentially follows the process
outlined in Orrego & Vega (2013), where government spending is targeted to the non-commodity sector to the extent that it breeds positive externalities for that sector. The externalities improve investment (in this model investment changes are captured in the LBD externality) in the non-commodity sector, which improves the sectors output. The increase in non-commodity output is produced by employing more labour and an improvement in the LBD externality.

Table 4: Steady State - Government Spending

<table>
<thead>
<tr>
<th>G/Y</th>
<th>Y</th>
<th>LRN</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1.09</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>0.1625</td>
<td>1.18</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>0.2250</td>
<td>1.28</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>0.2469</td>
<td>1.31</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>0.2875</td>
<td>1.39</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>0.35</td>
<td>1.53</td>
<td>1.07</td>
<td>1.07</td>
</tr>
</tbody>
</table>

5.2.2 Impact of Government Borrowing

Higher government borrowing worsens the position of the non-commodity sector, as depicted in table 5. Although government borrowings can contribute to government spending, they attract a servicing cost which must be repaid in the steady state. This servicing cost, means less of the government’s revenue can be spent. The reduction in government spending in favour of repaying debt reduces non-commodity output. In turn, this reduces the steady state level of labour hours and learning.

Table 5: Steady State - Government Borrowing

<table>
<thead>
<tr>
<th>B/Y</th>
<th>Y</th>
<th>LRN</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>1.296</td>
<td>0.907</td>
<td>0.907</td>
</tr>
<tr>
<td>0.1125</td>
<td>1.290</td>
<td>0.903</td>
<td>0.903</td>
</tr>
<tr>
<td>0.1750</td>
<td>1.285</td>
<td>0.900</td>
<td>0.900</td>
</tr>
<tr>
<td>0.2375</td>
<td>1.280</td>
<td>0.896</td>
<td>0.896</td>
</tr>
<tr>
<td>0.3</td>
<td>1.275</td>
<td>0.892</td>
<td>0.892</td>
</tr>
</tbody>
</table>

5.2.3 Impact of Taxation

The left hand side of table 6, shows the impact of higher non-commodity taxation rates on the non-commodity sector. Higher tax rates improve non-commodity output, labour and learning. In the steady state, higher taxation reduces the governments reliance on
borrowings to finance expenditure. This improves outcomes in the steady state, given borrowings were found to worsen non-commodity output, labour and learning.

The right hand side of table 6, shows the impact of increasing commodity taxation on the steady state value of non-commodity output, learning and labour hours. Essentially, the opposite mechanism to that described in section 5.1 operates here. When commodity taxation is increased, the revenues from the commodity sector that are returned to the economy are reduced. This decreases the contraction that the non-commodity sector experiences. Furthermore, as in the instance of non-commodity taxation, the additional taxation revenue allows the government to forgo the associated costs of borrowing.

<table>
<thead>
<tr>
<th>$\tau_{nc}$</th>
<th>$Y$</th>
<th>$LRN$</th>
<th>$L$</th>
<th>$\tau_c$</th>
<th>$Y$</th>
<th>$LRN$</th>
<th>$L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1.02</td>
<td>0.9176</td>
<td>0.9176</td>
<td>0.1</td>
<td>1.303</td>
<td>0.912</td>
<td>0.912</td>
</tr>
<tr>
<td>0.175</td>
<td>1.11</td>
<td>0.9183</td>
<td>0.9183</td>
<td><strong>0.17</strong></td>
<td><strong>1.314</strong></td>
<td><strong>0.9198</strong></td>
<td><strong>0.9198</strong></td>
</tr>
<tr>
<td>0.25</td>
<td>1.23</td>
<td>0.9191</td>
<td>0.9191</td>
<td>0.175</td>
<td>1.315</td>
<td>0.9203</td>
<td>0.9203</td>
</tr>
<tr>
<td><strong>0.3</strong></td>
<td><strong>1.314</strong></td>
<td><strong>0.9198</strong></td>
<td><strong>0.9198</strong></td>
<td>0.25</td>
<td>1.327</td>
<td>0.9286</td>
<td>0.9286</td>
</tr>
<tr>
<td>0.325</td>
<td>1.36</td>
<td>0.9202</td>
<td>0.9202</td>
<td>0.325</td>
<td>1.339</td>
<td>0.9368</td>
<td>0.9368</td>
</tr>
<tr>
<td>0.4</td>
<td>1.54</td>
<td>0.9214</td>
<td>0.9214</td>
<td>0.4</td>
<td>1.35</td>
<td>0.9450</td>
<td>0.9450</td>
</tr>
</tbody>
</table>
6 Dynamic Results: Impact of Dutch Disease

The theoretical model is compared to the Rees (2013) model (with the parameterisation outlined in Section 4). This allows analysis of the process of Dutch Disease and the impact of the government sector on the Dutch Disease process. In the context of the model outlined in section 3, Dutch Disease is defined as a situation where a rise in commodity prices leads to a contraction in non-commodity output. For convenience, Appendix F provides a legend of the variables.

6.1 Impact of Transitory Price Shock

A transitory price shock results in a 2 per cent increase in commodity prices that tampers off after around five years (twenty quarters). Given that most of this additional revenue is transferred to households, there is a rise in consumption. However, part of the increased consumption is financed through increased household borrowings. The domestic price level increases, furthering the appreciation of the real exchange rate. This real appreciation ensures that despite the rise in domestic prices, the economy’s inflation rate experiences only a minor shock. Under just one year, the economy returns to the steady state inflation rate. This is consistent with Corden and Neary’s (1982) finding of the impact of the income effect. The transitory price boom spurs a reduction in labour hours and the LBD externality, evidence of the resource movement effect (Corden 2012). Both of these contribute to a decline in the non-commodity output. All three of these variables slowly return to steady state values after around twelve years.

6.1.1 The Impact of the Government Sector on Transitory Price Shocks

When the Rees (2013) model is modified and the government sector is added to the model, the economy experiences greater volatility and the propagation mechanism of the transitory price shock changes. The impact to commodity prices from the transitory shock is unchanged, given that as shown in (3.32) the government sector does not feed into the commodity price process. The government worsens the effects of Dutch Disease in the short term but improves them (though not with the same magnitude) in latter periods. This can be evidenced by the initial sharp contraction labour hours, learning and non-commodity output. Subsequently, these move above the steady state with more persistence than the Rees (2013) model. Learning takes one year longer than output and labour hours to do this, due to the lagged learning process. The learning externality plays a crucial role in the path of the non-commodity sector. When non-commodity output is above the steady state, its persistence is driven by the persistence of the learning externality. Labour hours returns to the steady state quickly whilst, learning takes
more time. This is due to the fact that learning follows a lagged process on previous output, causing it to take longer to drive changes in the next periods output. The lagged process of learning is demonstrated by the fact that its highest and lowest points occur after labour hours and non-commodity output. The shadow price helps to highlight the impact of the externality. Initially, the shadow price is significantly higher and labour contracts by more than learning implying a higher value for the externality. However, the improvement in labour and learning causes the externality value to decrease in the longer term; driving non-commodity output back to the steady state.

Interestingly, consumption falls and the real exchange rate appreciates by a greater margin when the government sector is involved in the economy. The reduction in consumption is primarily due to the effect of taxation in redistributing income from households to the government. Consumption is also impacted by the volatility in inflation. Through the New Keynesian Phillips curve, the volatility in the non-commodity sector drives volatility in the home inflation rate. In turn, this determines the path of the domestic inflation rate. The changes in inflation, combined with the greater exchange rate appreciation and the Taylor rule help to form the path of higher interest rates.

The short term buffer against Dutch Disease is driven by government spending. When government spending improves above the steady state level, approximately one year after the price shock, the non-commodity sector begins to expand. The path of government borrowings here is difficult to account for. Government borrowings experience an initial positive shock, above the Rees model, but then return to the steady state with less persistence. This is due to the need to use government bonds to meet the uncovered interest parity condition and to maintain external balance. Given government borrowings contract when government spending rises, bonds are not used to finance government spending. Taxation, which increases as non-commodity output does, is the primary financing mechanism for government spending.
Figure 4: Rees (2013) vs Baseline Model: IRFs for Transitory Price Shock
6.2 Impact of Persistent Price Shock

The persistent commodity price shock results in an immediate 0.2 per cent increase in commodity prices, this slowly rises to peak after five years at 1.2 per cent. Broadly, the impacts of the persistent price shock are similar to that of the transitory. However given the price shock is persistent, the economy experiences the effects of Dutch Disease for a longer period of time. Labour hours, learning and non-commodity output continue to deviate below the steady state value even ten years after the price shock. Similarly, consumption remains persistently above the steady state ten years after the commodity price shock. Two variables experience noteworthy distinctions between the transitory and persistent price shock. Firstly, bond holdings, which contract in the persistent case. This implies that households lend out, rather than borrow, funds during a persistent boom. Bond holdings are used by households to smooth consumption. Secondly, is the path of interest rates. In the persistent case, interest rates experience a greater initial reduction and increase slightly before returning to the steady state value. This is a response to movements in domestic and home produced goods inflation.

6.2.1 The Impact of the Government Sector on Persistent Price Shocks

The government sector can reverse the impacts of Dutch Disease in a persistent price shock, albeit temporarily. This comes at the expense of increased volatility. Learning, labour hours and non-commodity output all improve immediately preceding the commodity price shock. After one year, all three head below the steady state and exhibit poorer performance. The significant contraction in the shadow price, along with greater improvement in labour than learning results in a worsening in the value of the externality with the government sector. As the value of the externality declines, the learning process contributes lesser amounts to the production process. Combined with the lagged nature of learning, this subtracts from the long run improvement in output taking longer for the non-commodity sector to return to the steady state. The government sector causes such changes in these variables. The government changes the course of Dutch Disease in two ways. Firstly, through government spending. Government spending initially experiences a positive shock, but then decreases above the steady state level within a year. The improvement and worsening in the non-commodity sector almost coincides with the changes in government spending. Majority of this increase is funded through taxation, which experiences a similar initial positive shock followed by a period below the steady state. Second, the government provides a buffer against income effect through a lower exchange rate appreciation. This is attributable to the lower domestic prices (which is a result of a smaller difference between home and domestic inflation rates). In the
short term consumption increases as the impact of government spending filters through to households and households borrow to finance consumption. In the longer term, consumption decreases as income is redistributed from households to government.

The response of the government sector to the commodity price shock is slightly peculiar. Both spending and taxation respond positively and fall below the steady state value. They experience their lowest values around six to seven years after the shock. This is surprising for two reasons. Firstly, the positive response occurs immediately after the shock even though government revenues from the commodity sector will take a couple of periods to grow (given persistent commodity shock prices take a number of periods to peak). This may be explained by the fact taxation revenues experience a positive windfall from the initial expansion in the non-commodity sector. Second, is that when commodity prices begin to peak, government spending is at its lowest level. This again is probably due to the fact that the non-commodity sector collapses in such magnitude that the government can’t rely on windfalls from the boom to makeup for the difference.
Figure 5: Rees (2013) vs Baseline Model: IRFs for Persistent Price Shock
7 Dynamic Results: Fiscal Rules

In this section, the four fiscal rules will be imposed. The impact of them will then be compared to the instance in section 6 with the government sector (referred to as the baseline model, henceforth). For convenience, Appendix F provides a legend of the variables.

7.1 Fiscal Rule I: Budget Balance

The first fiscal rule does not permit the government to issue any borrowings to finance the shortfall between spending and revenue. This means the government budget constraint (3.35) changes to:

\[ T_t = G_t \]

7.1.1 Fiscal Rule I: Impact of Transitory Price Shock

Figure 6 shows the impulse response functions for fiscal rule I compared to the baseline case.

**Impact on Households**

Consumption experiences an improvement under the budget balance, due to stronger performance in the non-commodity sector and a lower interest rate. Given the increase in bonds, some of this higher consumption is financed through borrowings. The fact that consumption increases is unexpected. The justification of fiscal consolidation is to contain demand and be deflationary (Corden 2012). Although the rule satisfies the latter, its failure to contain demand is due to the lower interest rate. The lower, less persistent interest rate is a product of, through the Taylor rule, lower home inflation. The damper response of consumption, output and learning contribute to the lower home inflation through the New Keynesian Phillips curve. The lower interest rate could also be accounted for by the fact the government sector is no longer demanding bonds, which puts downward pressure on the interest rate (van der Ploeg 2011). The exchange rate appreciation is limited due to lower domestic prices. This is because the budget balance contains the price pressures from the commodity boom (Orrego & Vela 2013).

**Impact on Home Firms**

Fiscal rule I has mixed effects on non-commodity output. It is able to contain the initial negative shock; with output contracting by just 0.14 percent, one-tenth of the baseline model. However, in the longer term, the fiscal rule prevents output from growing above the steady state as it does in the baseline model. The fact the Dutch Disease process
is dampened is because the two channels through which it manifests itself are lessened. The income effect plays less of a role compared to the baseline as the exchange rate depreciates. Meanwhile, the higher government spending in the non-commodity sector, helps tide the flow in the movement of resources away from it. Labour hours, like output, witnesses a more minor contraction and is prevented from heading above the steady state. The learning input undergoes a dramatic initial improvement but subsequently worsens compared to the baseline. The lower shadow price means that the higher output (from the higher government spending) is the underlying cause of the improvement in learning. This means that although the fiscal rule does reverse the short run output contraction, it does not contribute to an increase in the value of the externality.

**Impact on Government**
The upswing in output, higher consumption and lower appreciation are all attributable to the change of policy position by the government. With the budget balance imposed, the government takes a less active role in mitigating Dutch Disease. Due to smaller taxation and spending shocks, the budget balance rule encourages the non-commodity sector to stand on its own feet. This is in stark contrast to the baseline scenario where the government has a more ‘hands on’ approach to mitigating Dutch Disease. This is because the government can no longer rely on borrowings, so it becomes spending constrained (van der Ploeg 2011). The smaller, more temporary role of government is compounded by the fact most variables return to the steady state in a shorter time span under rule I.
Figure 6: Rule I IRFs for Transitory Price Shock
7.1.2 Fiscal Rule I: Impact of Persistent Price Shock

Figure 7 shows the impulse response functions for fiscal rule I compared to the baseline case during a persistent commodity price shock.

**Impact on Households**
Under rule I consumption experiences a smaller initial positive shock at 0.05 percent, compared to 0.11 percent for baseline case. Consumption rises to peak at 0.12 percent above the steady state after four and half years. It then converges back with more persistence than the baseline case. The source of higher consumption is the higher inflation rate. Inflation contracts to just 0.04 percent below the steady state, 73 percent higher than the baseline model. This is driven by higher domestic inflation and the appreciated exchange rate. The real exchange rate experiences a larger more persistent shock from the persistent commodity price boom, reflecting higher domestic prices. The impact of fiscal rule I is entirely unexpected, as the literature predicts deflation, exchange rate depreciation and demand containing impacts from fiscal consolidation (Corden 2012, van der Ploeg 2011, Orrego & Vega 2013). The fact this does not occur, is because the persistent commodity price boom increases household incomes for a significant period of time encouraging consumption, and because government spending is generally higher. This improves non-commodity output helping to increase incomes from home firms to households. The higher consumption and exchange rate appreciation work together to propagate the income effect.

**Impact on Home Firms**
Non-commodity output has a lower positive shock and is more persistent when it reaches below the steady state level under the fiscal rule. Excluding the first and tenth years after the shocks, non-commodity output is higher; demonstrating that the policy is partially effective. However, in the longer term, when government spending returns to the steady state the non-commodity sector ultimately produces less output. This is because in the persistent commodity boom, commodity prices are still above the steady state. In the latter years, the process of Dutch Disease is occurring without the support of government spending to provide a buffer against it. Compared to the baseline model, labour hours, output and learning all receive smaller initial positive shocks and are then more persistent below the steady state level.

The changing value of the externality helps to drive this volatility in the non-commodity sector. Originally, the shadow price is higher ensuring learning contributes to non-commodity output. However, as learning and output contract, the externality decreases
in size. This reduces the long run prospects for non-commodity output and is partially responsible for the poorer performance in the non-commodity sector. Other than in the initial and final years, the learning input is higher because it reacts to non-commodity output through the lagged process.

**Impact on Government**

Similar to the transitory price shock, the restriction on borrowings limits the government's ability to intervene and assist against Dutch Disease. The smaller role of government means that the economy will behave closer to Rees model from section 6. The impact of persistent shocks to government spending and taxation are minor with both peaking at less than 0.002 per cent. The lower government spending is attributable to the fact that governments no longer have access to borrowings to finance spending (van der Ploeg 2011). Afterwards, government spending is higher as the non-commodity sector experiences higher growth with the budget balance. This gives the government greater revenues which, under the rule, it is forced to spend. Government spending plays a crucial role in supporting the non-commodity sector. As discussed previously, non-commodity output is only higher when the government spending is above steady state. Once this dissipates the non-commodity sector experiences lower growth as the Dutch Disease effects become more apparent. Government spending is less persistent under the fiscal rule as it is constrained by taxation. Taxation revenues hover closer to the steady state given non-commodity output hovers around the steady state. Taxation revenues remain above the steady state, despite the subsequent contraction of non-commodity output below it, because of revenues from the commodity sector.

**7.1.3 Summary of Fiscal Rule I**

According to the literature, forcing budget balances should be an effective catalyst for protecting against Dutch Disease. The exchange rate appreciation should be more subdued, as the government sector places less pressure on foreign exchange markets through borrowings (van der Ploeg 2011), and should contain demand and be deflationary (Corden 2012).

Where the policy is effective, for the transitory case, the results follow the existing literature. In the transitory case, short run non-commodity output and learning contract by significantly less and the exchange rate experiences a lower appreciation. However for the persistent commodity price boom, fiscal rule I does not consistently support the non-commodity sector. It provides some intermediary support but worsens the long run output and the LBD externality.
Figure 7: Rule I IRFs for Persistent Price Shock
7.2 Fiscal Rule II: Taxation Rate Shock

Under Fiscal Rule II, both the non-commodity and commodity taxation rates are shocked.

\[
\begin{align*}
\tau_{nc,t} &= (1 - \rho_{\tau_{nc}})\tau_{nc} + \rho_{\tau_{nc}} \tau_{nc,t-1} + \varepsilon_{t}^{T} \\
\tau_{c,t} &= (1 - \rho_{\tau_{c}})\tau_{c} + \rho_{\tau_{c}} \tau_{c,t-1} + \varepsilon_{t}^{T}
\end{align*}
\]

The taxation processes are defined in such a way that price impacts are persistent, with each taxation shock having a coefficient \((\rho_{\tau_{c}}, \rho_{\tau_{nc}})\) of 0.9. The standard deviation of the taxation shock is 0.01.

The government budget constraint remains the same, but the taxation equation (3.34) changes to:

\[
T_{t} = \tau_{nc,t}Y_{t} + \tau_{c,t}\varepsilon_{t}S_{t}Y^{X}
\]

Given the changes to the non-commodity taxation rate, some aspects (like the New Keynesian Phillips curve) have a slightly altered derivation. Although these derivations are not provided, they are similar to those provided in Appendix B. The log linearised equations for this fiscal rule are provided in Appendix B.4.

7.2.1 Fiscal Rule II: Impact of Transitory Commodity Price Shock

Under a transitory price shock, the impact of a taxation shock compared to the baseline model is shown in figure 8.

Impact on Households
Consumption is higher and more persistent with the taxation rate shock. Both inflation and interest rates are lower, meaning the consumption increase is driven by the income effects of greater persistence in non-commodity output and government spending. The higher taxation revenue increases government spending, boosting output from home firms. This increases profits to households which they can allocate to consumption. The initial shock to the exchange rate is 60 percent lower under the fiscal rule due to lower prices and inflation. Whether the income effect plays a greater role here is difficult to determine, given the lower exchange rate appreciation but higher consumption level.

Impact on Home Firms
The taxation rate shock is able to dampen, but not reverse, the effects of Dutch Disease in the non-commodity sector. Immediately preceding the transitory price shock, non-commodity output declines by just 0.25 percent compared to 1.92 percent for the
baseline. Similar to the baseline case, output grows above the steady state, peaking at 0.71 percent within a year. Non-commodity output also takes longer to return to the steady state. Under the fiscal rule, the non-commodity sector can fight against Dutch Disease because the impacts of the income and resource movement effects are lessened. Most of the improvement in output is produced by learning. For all periods, learning is greater under the fiscal rule than the baseline model. However, a smaller positive shock to the shadow price implies a lower value for the externality. This indicates the improvement in learning is mainly driven by the increasing output, rather than an increase in the value of the externality. The significant improvement in learning, alters the direction of the non-commodity sector as predicted by the literature. The higher learning improves non-commodity output through a productivity improvement (Torvik 2001, Gylfason et al. 1997) and occurs at the time of a lower exchange rate appreciation (Lama & Medina 2012). Labour hours do not contribute to higher output, other than a smaller initial shock, it is virtually indistinguishable between the fiscal rule and baseline. However, given the recovery of learning the social marginal product of labour should increase into the future (Aizenman & Lee 2010).

**Impact on Government Sector**

Taxation experiences a dramatic increase from the fiscal rule due to the increase in taxation rates in both the commodity and non-commodity sectors. Rather than initially contracting, taxation increases. It peaks at 2.8 percent above the steady state, almost 12 times higher than the baseline. Both taxation rates receive initial positive shocks of 20 percent above the steady state. The taxation rate shock is fairly persistent, taking more than ten years to return to the steady state. Essentially, the government uses the extra taxation revenue to increase spending in the economy, with government spending peaking 0.03 percent above the steady state (four times higher than the baseline model). This raises the demand in the non-commodity sector, limiting the resource movement effect that would otherwise be promoted by Dutch Disease (Orrego & Vega 2013). The mechanism for the taxation shock functions by slowing the re-allocation of resources in the economy. The effectiveness of the policy hinges on the fact the increase in taxation revenue (and by extension, spending) coincides with the contraction in non-commodity output that is caused by the commodity price boom.
Figure 8: Rule II IRFs for Transitory Price Shock
7.2.2 Fiscal Rule II: Impact of Persistent Commodity Price Shock

The impact of a taxation rate shock during a persistent commodity price boom compared to the baseline model is shown in figure 9.

**Impact on Households**

The commodity price boom has no immediate impact on consumption. Overtime however, consumption is less persistent under the fiscal rule. Given the fiscal rule has no significant impact on inflation or interest rates, the impact of the government sector is responsible for the longer term consumption difference. In the first instance, the government reduces consumption as higher taxation rates redistribute income from households to the government. Second, the poorer performance of the non-commodity sector in the longer term results in a reduction in income for households so they consume less. The fiscal rule limits the exchange rate appreciation, due to lower domestic prices. Lower domestic prices are a result of a smaller difference between home and domestic inflation. This is because of the deflationary nature of the higher taxation rates.

**Impact on Home Firms**

Overall, the impact of the taxation shock is fairly minor. The initial shock in non-commodity output is almost indistinguishable between the two regimes. For a couple of intermediary years, non-commodity output is higher under the fiscal rule. This reflects the role of higher government spending, which is funded by taxation revenues and borrowings. The non-commodity sector takes some years to improve as the benefits from increased taxation only filter when commodity prices are high. As discussed in section 6.2, commodity prices take around five years to peak in a persistent commodity price shock. The learning input improves between years two and seven, in response to the improvement in output in previous periods. However, as the shadow price does not increase, the value of the externality does not improve. Therefore, when government spending is falling, contracting output, the learning input also declines. Labour hours does not illicit a response from the taxation shock meaning, the temporary improvement in output is driven by productivity gains in the economy. The improvement in learning, from higher output and government spending, is sufficient that labour hours does not need to rise to meet the higher level of non-commodity output.
Figure 9: Rule II IRFs for Persistent Price Shock
Impact on Government Sector
Taxation experiences a positive shock of 1.12 percent above the steady state, 31 percent higher than the fiscal rule. The fiscal rule causes taxation to be more persistent. This is driven by the persistence of the taxation shock as shown by the IRFs for the two taxation rates. Both of these experience an immediate shock of 0.20 percent and take more than ten years to return to their respective steady state values. Government borrowings contract by a smaller margin under the fiscal rule, helping to finance some of the additional spending. The larger taxation revenue permits the government to finance higher government spending. This higher government spending is spent in the non-commodity sector, increasing demand and output (Orrego & Vega 2013). However, the increased government spending dissipates after around seven years, given taxation revenues return back to the steady state. Overall, in this instance, the fiscal rule is ineffective for two reasons. Firstly, the boost to revenue and spending occurs before the impacts of Dutch Disease begin to surface. Relatedly, the taxation rate shocks are not persistent enough to mitigate Dutch Disease.

7.2.3 Summary of Fiscal Rule II
So far, the literature has not placed much emphasis on looking at the impacts of economy wide taxation changes on Dutch Disease. Fiscal Rule II is effective in containing the effects of Dutch Disease. In the transitory case, the rule significantly improves short term outcomes, remaining fairly effective for at least eight years. In the persistent case, the rule is less effective, having a more nuanced impact on the non-commodity sector.

7.3 Fiscal Rule III: Commodity Taxation Rule
Fiscal Rule III imposes a commodity taxation rule on the model. The commodity taxation rate is now time variant with respect to the base commodity taxation rate plus any deviations in commodity prices or output from their steady state level. Commodity taxation will be set according to the rule:

\[
\tau_{c,t} = \rho_{c1} + \rho_{c2}(S_t - S) - \rho_{c3}(Y_t - Y)
\]

where \(\rho_{c1}\) is 0.17 to reflect the Australian commodity taxation rate, \(\rho_{c2}\) and \(\rho_{c3}\) are 0.3.

This means the taxation equation (3.34) is re-written as:

\[
T_t = \tau_{nc}Y_t + \tau_{c,t}\varepsilon_t S_t Y^X
\]
The commodity taxation rule represents a form of piecemeal protection. The government is ‘picking winners’ by electing to create an additional burden on the commodity sector in an attempt to improve outcomes in the non-commodity sector. This is promoted by the fact that the rule adjusts to increase when outcomes improve for the commodity sector (higher commodity prices) and deteriorate for the non-commodity sector (contraction in non-commodity output).

7.3.1 Fiscal Rule III: Impact of Transitory Commodity Price Shock

Figure 10 shows the impact of the commodity taxation rule on the model when it experiences a transitory price shock.

Impact on Households
Under the fiscal rule consumption is slightly less volatile, although the small impact of the shock means consumption does not change significantly. The fact consumption is not significantly altered is because the commodity taxation rule does not function effectively in the transitory case, as will be discussed below. Inflation and interest rates change slightly, but not enough to significantly alter the path of consumption. Lower interest rates are partly attributable to the lower home inflation rate (a product of the Taylor rule). The real exchange rate experiences a noteworthy improvement, appreciating by a smaller amount due to lower domestic produced goods prices. The lower domestic produced goods pricing is a result of lower inflation and home inflation. Inflation is lower as the tampering of commodity price boom caused by the commodity taxation rule, reduces the inflationary circumstances usually associated with commodity booms (Edwards & Aoki 1983). The lower appreciation of the exchange rate provides a buffer against Dutch Disease because it contains the repercussions of the income effect. The fact that the exchange rate appreciates less, counters Corden’s (2012) criticism of piecemeal protection. This adds credibility to a protection mechanism which attacks the commodity sector rather than supporting the non-commodity sector.

Impact on Home Firms
The commodity taxation rule provides only temporary relief to the non-commodity sector. It helps to limit the decline in non-commodity output, with a 20 percent reduction in the initial negative shock. However, in the longer run non-commodity output does not benefit from the commodity taxation rule, as will be discussed below. The increased taxation revenue reduces the performance of the commodity sector and increases the revenues governments can spend on the non-commodity sector. This only occurs in the early periods in the transitory commodity boom.
The initial improvement in output is a result of improvements in labour and the LBD externality. Labour hours also experiences a shock that is 20 percent lower, but doesn’t improve above the baseline subsequent to that. The dampened positive shock to the shadow price shows that the externality is valued less under the fiscal rule. Therefore, the benefit to the externality is not as large as the improvement in the non-commodity sector. This is highlighted by the fact that learning does not expand significantly under the commodity taxation rule. The failure for learning or labour to sustain initial improvements prevents non-commodity output from growing above the baseline model.

**Impact on Government Sector**

Government spending responds with a smaller contraction under the fiscal rule. After a year and half, spending falls back to the steady state with greater haste than the baseline model. Taxation undergoes a more noticeable improvement, which is expected given the additional revenue from higher commodity taxation. Taxation has an initial shock of 0.89 percent below the steady state, a 57 percent improvement from the baseline. The higher government spending is not financed through borrowings, as government borrowings are lower under the fiscal rule. The effectiveness of the commodity taxation rule rests on two grounds. Firstly, the higher taxation revenue allows the government to increase spending in the economy. Second, the commodity taxation rule helps to slow the revenue increase in the commodity sector, by adjusting automatically to improvements in the minerals sector and poor performance in the non-commodity sector. However, the benefits of this rule do not shine through a transitory price shock. The commodity taxation rate only changes temporarily, as commodity prices and non-commodity output are not persistently different from the steady state. Examining the path of commodity taxation, it initially improves by 6.2 percent but then returns to the steady state value after around five years. The lack of persistence means government spending is only higher for the first one and a half years. Subsequently, spending is virtually indistinguishable between the fiscal rule and baseline model. Therefore, the rule plays merely a benign role in the fight against Dutch Disease.
Figure 10: Rule III IRFs for Transitory Price Shock
7.3.2 Fiscal Rule III: Impact of Persistent Commodity Price Shock

Figure 11 shows the impact of the commodity taxation rule on the model when it experiences a persistent commodity price shock.

**Impact on Households**
The commodity tax rule reduces household consumption as households now receive less income from the commodity sector. In addition, consumption is also reduced due to the higher interest rate. The higher interest rate, is a result of higher inflation and lower supply of government bonds. By itself, taxation increases should be deflationary as the reduction in incomes contains demand. However, that does not occur here as the taxation increase prompts an increase in government spending which is inflationary (Orrego & Vega 2013, Corden 2012). The increase in government spending is large enough to counteract the deflationary benefit of reducing commodity sector revenue, as occurred in the transitory commodity price shock. The real exchange rate experiences a smaller appreciation and is far less persistent, given the path of home prices. This neutralises Corden’s (2012) fears of an exchange rate appreciation from piecemeal protection and provides credence to hurting the commodity sector in an attempt to support the non-commodity sector. The lower consumption and exchange rate appreciation help to drive improvements in the non-commodity sector as the income effect is less pronounced.

**Impact on Home Firms**
Overall, non-commodity output is higher and less persistent under the fiscal rule. This is because of the dampening of the commodity price boom as governments poach some of the revenues and the benefits of higher government spending. Non-commodity output worsens then improves as the variables that determine its path - taxation, government spending and the real exchange rate - also worsen before they improve when compared to the baseline model. In essence, these variables all operate to prevent the commodity boom from absorbing resources. Learning, which continues to operate with lag, benefits from the improvement in output. The value of the externality is greater in the fiscal rule, with the shadow price experiencing a smaller negative shock. This shows the firms undervalue labour and therefore, rely more on learning to improve output. The learning input improves above the baseline level after two years. Given labour hours does not significantly change, the non-commodity sector’s improvement hinges on the learning process. The fact that learning externality drives the recovery in non-commodity output means that increasing the stock of productivity is a key benefit of this fiscal rule. The improvement in learning means, future output will be higher, justifying this circumstance of piecemeal protection (van Wijnbergen 1984).
Impact on Government Sector

After one year, taxation is higher under the fiscal rule. The delayed response of taxation is due to the fact that under persistent commodity price booms, there is a lag in the peaking of commodity prices. Government revenue will only grow when commodity prices are higher and non-commodity output is around its lowest value. This can be evidenced by the path of commodity taxation, which peaks at 2.37 percent after 5 years. Government borrowings contract by slightly less under the commodity price rule, meaning the government gives up supply of bonds to finance household consumption. Governments rely less on bond holdings given the increase in taxation revenues, whilst households increase their demand for bonds as they attempt to smooth their consumption following the reduction in commodity windfalls. Therefore, the government is hurting households in two ways: forcing higher borrowing and reducing income. Over the longer term, there is an increase in government spending under the commodity taxation rule. The increased spending is mainly financed through the increased taxation. This extra expenditure helps to improve non-commodity output, as this additional expenditure creates positive externalities in the non-commodity sector (Orrego & Vega 2013, van der Ploeg 2011). Given the manner in which the LBD mechanism is improved under this fiscal rule, the gain to the non-commodity sector is disproportionately larger than the increase in government spending. As spending increases output, this feeds into the learning process which further benefits output over and above the increased level of government spending.

7.3.3 Summary of Fiscal Rule III

The commodity taxation rule is only effective when commodity prices and non-commodity output are significantly different from their steady state values. Therefore, it is effective for persistent commodity shocks but ineffective for transitory commodity price shocks. The policy intervention is justifiable because it meets some of the key conditions identified in the literature. It improves growth in the non-commodity sector and reverses the decline in the externality (Van Wijnbergen 1984, Hahn & Matthews 1965). Furthermore, it doesn’t exhibit the fears articulated by Corden (2012) regarding piecemeal protection such as a higher exchange rate appreciation. This is because it is able to contain some of the price increases brought on by Dutch Disease (Edwards & Aoki 1983).
Figure 11: Rule III IRFs for Persistent Price Shock
7.4 Fiscal Rule IV: Government Spending

Under this fiscal rule, the government increases its spending by increasing the steady state value \( (G_Y) \) by ten percent.

7.4.1 Fiscal Rule IV: Impact of Transitory Commodity Price Shock

The impact of transitory commodity price shocks when government is permitted to increase spending is shown in figure 12.

Impact on Households

Higher government spending comes at an expense to consumption, with consumption being lower than the baseline model for the first six years. This deviates from the idea that government spending should improve consumption by increasing income from home firms. The lower consumption is directly attributable to the higher interest rate, which is caused by a sharper exchange rate appreciation, lower household borrowings and through the Taylor rule, the home inflation level. Lower bond borrowings, at least initially, are because households are consuming less. When the inflation rate is high, government spending is at its highest. This is because government spending contributes to demand and is therefore inflationary (Corden 2012). Domestic prices are higher, resulting in a greater exchange rate appreciation. It is difficult to infer the effects of the income effect in this fiscal rule, given that consumption is lower but the exchange rate appreciates by a greater margin.

Impact on Home Firms

The increased government spending leads to an early aggravation but a subsequent convalescence of Dutch Disease. Immediately preceding the shock, non-commodity output contracts by 0.02 percent, 58 percent greater than the contraction experienced in the baseline model. After one and half years, the benefits of increased government spending dawn on the non-commodity sector and it begins to improve over the baseline model. Output in the commodity sector is more persistent as it moves back to the steady state. The improvement in output is produced by both labour and learning. Both follow a similar path to non-commodity output, initially contracting before improving (learning, as before, operates with a lag). The value of the externality increases, given the shadow price responds more positively, and firms show preference for the LBD externality when compared to labour. However, after around three years the worsening performance of shadow price means that the externality does not sustain its improvement. Learning remains an important input however, given it continues to evolve overtime with output.
The persistence in learning is a significant cause of the persistence in non-commodity output.

**Impact on Government Sector**
The performance of the non-commodity sector is fairly synchronised with movements in the government sector. Government spending decreases when the commodity price shock hits the economy. After one year, it rises above the steady state and shortly after is higher in the fiscal regime. Higher government spending improves output in the non-commodity because it increases demand through the market clearing condition (Orrego & Vega 2013). Government spending contracts as taxation revenues collapse and borrowings are lower as well. Taxation revenues initially decrease to 2.5 percent below the steady state, a contraction that is 61 percent greater than the baseline model. The fact that taxation revenues do not increase immediately after the commodity price shock, could be indicative of the contraction in the non-commodity sector being too large or an ineffective taxation regime for the commodity sector. Taxation peaks slightly later but almost twice as high than the baseline model. This is attributable to the improved performance in the non-commodity sector. Government borrowings do not finance increased expenditure as they are lower in the fiscal rule. Surprisingly, the government does not consistently spend more, even though it is permitted to. This is possibly due to the constraints of taxation, which is the main funding source of government spending. The tax take is mainly contingent on improvements in the non-commodity sector, which is the larger source of taxation revenue. Given the poorer initial performance of the non-commodity sector, the government is constrained in its level of spending due to softer revenues.
Figure 12: Rule IV IRFs for Transitory Price Shock
7.4.2 Fiscal Rule IV: Impact of Persistent Commodity Price Shock

Figure 13 shows the impact of increased government spending during a persistent commodity price shock. **Impact on Households**

Consumption responds positively, but with less persistence, to the persistent commodity price shock. Consumption is higher due to the increased incomes from home firms, as the government spending improves non-commodity output. Consumption becomes less persistent in the fiscal rule as this process occurs in reverse when government spending falls below the steady state. After the initial shock, consumption is also higher due to lower interest rates. Interest rates become lower after around one year, as the reductions in government spending and non-commodity output reduce demand and encourage deflation. Inflation is lower due to the trend of home inflation; which through the New Keynesian Phillips curve is responsive to movements in the non-commodity sector. Therefore, as the non-commodity sector improves and then worsens so does home inflation, inflation and interest rates. The real exchange rate experiences a smaller initial appreciation but after around five years becomes more persistent than the baseline model, following the path of home prices. The impact of the government spending increase on the income effect is equivocal given consumption is higher while the exchange rate is lower.

**Impact on Home Firms**

Non-commodity output receives an initial boost of 1.1 percent, 63 percent higher than the baseline model. After one and half years, the non-commodity sector produces less than the baseline model. This is because government spending begins to contract and subtracts from non-commodity output. Labour hours follow a similar path, initially improving before falling to a level lower than the baseline rule. Learning also contributes to the long run demise of the non-commodity sector. The shadow price has a greater negative shock causing a decline in the value of the externality. This implies the learning externality subtracts from the non-commodity sector, hastening the long run deterioration in output. As output deteriorates, learning deteriorates by a greater margin due to the lagged process. This further contributes to the crumble in the non-commodity sector as contractions in learning reduce consumption, productivity and growth (Gylfason et al 1997, Torvik 2001).

**Impact on Government Sector**

Government spending has an initial shock that is 47 percent greater than the baseline model. This supports non-commodity output through the market clearing condition (Orrego & Vega 2013). However, after one and half years government spending is lower in the fiscal rule, subtracting from non-commodity output. Part of the initial increase in
government spending is met through increased taxation, which has an initial shock of 1.4 percent above the steady state (61 percent higher than the baseline model). Although governments can now spend more, the fact they do not is difficult to account for. A possible source of the volatility in government spending is the rundown of taxation revenues, primarily due to the slowdown in the non-commodity sector. This forces the government to constrain spending.

7.4.3 Summary of Fiscal Rule IV

These results confirm the findings of Orrego & Vega (2013), that Dutch Disease can be prevented by government spending in the lagging sectors. This is principally conducted through a smaller exchange rate appreciation as found in this thesis.

However, neither of these policies lead to a consequential long run improvement to Dutch Disease. The transitory case only exhibits improvements in the medium term, whereas the persistent case only reaps the benefits of this policy in short term. Although, this policy prevents some decline in the LBD externality, it is not persistent enough to improve the long term output of the non-commodity sector.
Figure 13: Rule IV IRFs for Persistent Price Shock
8 Welfare Analysis

In this section, the costs associated with the fiscal rules are considered.

8.1 Welfare Cost

Welfare costs are calculated following the procedure in Dib (2008), who bases his method off Schmitt-Grohe & Uribe (2004). Dib (2008) measures welfare as the unconditional expectation of utility in the deterministic steady state. The model is solved around a second order approximation to allow comparison between the stochastic and deterministic steady states. The welfare gain is measured as the compensating variation - the percentage change in consumption that would give households the same unconditional expected utility in the stochastic economy as the deterministic economy. The Dib (2008) approach of measuring based on consumption change is pertinent for this analysis given the importance of households in the model outlined in section 3.

The utility function with a second-order Taylor expansion:

\[ U(c, l) \approx \log(C) - A_L \frac{L^{1+\phi}}{1+\phi} + \hat{c}_t - A_L L^{1+\phi} \hat{l}_t + \frac{1}{2} A_L L^{1+\phi} \hat{l}^2_t (1 + \phi) \]

A second order approximation, is used as the variances of the shocks affect means and variances of the endogenous variables. Therefore, welfare is calculated as the difference between the level effect (\( \mu_m \), the impact of shocks on expected means) and variance effect (\( \mu_v \), impact of shocks on the variance of endogenous variables).

With the parametrisation of the model, the level and variance effects are equal to:

\[
\begin{align*}
\mu_m &= 0 \\
\mu_v &= \exp \left[ A_L \bar{L}^{\phi+1} \frac{1}{2} \text{Var}[\hat{l}_t^2] (1 + \phi) \right] - 1
\end{align*}
\]

Therefore, the total welfare cost \( \lambda \) is:

\[
\lambda = \mu_m - \mu_v = - \left( \exp \left[ A_L \bar{L}^{\phi+1} \frac{1}{2} \text{Var}[\hat{l}_t^2] (1 + \phi) \right] - 1 \right)
\]

The derivation for welfare cost is provided in Appendix D.

Table 7 shows the welfare cost as measured by changes in the percentage of deterministic steady state consumption. Similar to Dib (2008), the welfare cost for the model is calcu-
lated three times. Once with both the transitory and persistent commodity price shocks, another time with just the transitory commodity price shock and finally with only the persistent commodity price shock.

The fiscal rule with the lowest welfare cost is the government budget balance, which is a reflection of the greater stability the model exhibited and the smaller role for government. By contrast, rule IV has the greatest welfare costs. Combined with its ineffectiveness in mitigating Dutch Disease, this rule should be avoided. Rules II and III have very similar welfare costs, with Rule III having slightly lower welfare costs.

With the exception of fiscal rule I, the welfare costs are higher with the transitory commodity price shock. This reflects the fact that transitory commodity price shocks create greater volatility as they cause a significant immediate spike in commodity prices that dissipates quickly. By contrast, persistent commodity price shocks have a more gradual impact on the economy. The different result for fiscal rule I can be explained by the more volatile behaviour of the government sector during persistent commodity price shocks.

<table>
<thead>
<tr>
<th>Rule</th>
<th>Both</th>
<th>Transitory</th>
<th>Persistent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-0.0090</td>
<td>-0.0683</td>
<td>-0.0214</td>
</tr>
<tr>
<td>Rule 1</td>
<td>-0.0035</td>
<td>-0.0014</td>
<td>-0.0020</td>
</tr>
<tr>
<td>Rule 2</td>
<td>-0.0594</td>
<td>-0.0421</td>
<td>-0.0183</td>
</tr>
<tr>
<td>Rule 3</td>
<td>-0.0559</td>
<td>-0.0428</td>
<td>-0.0130</td>
</tr>
<tr>
<td>Rule 4</td>
<td>-0.1863</td>
<td>-0.1863</td>
<td>-0.0568</td>
</tr>
</tbody>
</table>

Overall, from a welfare perspective, the most to least desirable policies are: rule I, baseline, rule III, rule II and rule IV.

8.2 Macroeconomic Consequences of Fiscal Rules

The viability of the policies is also evaluated on the basis of their macroeconomic performance. Policies that are effective may not be desirable if they encourage volatility in the economy. The volatility of the different fiscal rules is shown in Table 8, as represented by the standard deviation of different variables.

On average, in order of increasing volatility: rule I, rule III, rule II, baseline and rule IV. Rule I, produces the smallest amount of volatility in the non-commodity sector. Its standard deviation is the lowest for non-commodity output, LBD externality and labour
hours. This compares unfavourably to rule IV which produces the most volatility in the non-commodity sector. In the case of non-commodity output and labour hours, rule I is significantly less volatile then the next best option. Rule III is the most stable for consumption volatility, with the other four options a bit less than double that. Rule II followed by rule III have the most stable exchange rate paths, with the other two fairly close together. Finally for inflation, all the the rules perform fairly stably as they all have small standard deviations.

Table 8: Theoretical Data Moments

<table>
<thead>
<tr>
<th>Standard Deviations</th>
<th>Baseline</th>
<th>Rule 1</th>
<th>Rule 2</th>
<th>Rule 3</th>
<th>Rule 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>0.0167</td>
<td>0.0218</td>
<td>0.0271</td>
<td>0.0124</td>
<td>0.0281</td>
</tr>
<tr>
<td>$c$</td>
<td>0.0129</td>
<td>0.0127</td>
<td>0.0134</td>
<td>0.0074</td>
<td>0.0131</td>
</tr>
<tr>
<td>$q$</td>
<td>0.0227</td>
<td>0.0224</td>
<td>0.0142</td>
<td>0.0163</td>
<td>0.0239</td>
</tr>
<tr>
<td>$\text{lrn}$</td>
<td>0.0112</td>
<td>0.0147</td>
<td>0.0127</td>
<td>0.0079</td>
<td>0.0198</td>
</tr>
<tr>
<td>$l$</td>
<td>0.0311</td>
<td>0.0405</td>
<td>0.0243</td>
<td>0.0240</td>
<td>0.0509</td>
</tr>
<tr>
<td>$\pi$</td>
<td>0.0016</td>
<td>0.0019</td>
<td>0.0013</td>
<td>0.0013</td>
<td>0.0023</td>
</tr>
</tbody>
</table>
9 Sensitivity and Robustness Analysis

This section analyses the sensitivity of results and conclusions to different parameter values. Similar to Lama and Medina (2012), key parameters of the model are altered and the impact of the change on the baseline model is examined. The welfare costs of the parameter changes are also considered, the results are presented in table 9.

Table 9: Sensitivity Analysis - Welfare Costs

<table>
<thead>
<tr>
<th>Model Parameters</th>
<th>Baseline</th>
<th>Rule 1</th>
<th>Rule 2</th>
<th>Rule 3</th>
<th>Rule 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha = 0.4$</td>
<td>-0.0090</td>
<td>-0.0035</td>
<td>-0.0594</td>
<td>-0.0559</td>
<td>-0.0568</td>
</tr>
<tr>
<td>$\chi = 0.32$</td>
<td>-0.0129</td>
<td>-0.0127</td>
<td>-0.0134</td>
<td>-0.0074</td>
<td>-0.0131</td>
</tr>
<tr>
<td>$\gamma = 0.85$</td>
<td>-0.0787</td>
<td>-0.0030</td>
<td>-0.0550</td>
<td>-0.0504</td>
<td>-0.0496</td>
</tr>
<tr>
<td>$\theta = 0.5$</td>
<td>-0.1389</td>
<td>-0.0025</td>
<td>-0.0845</td>
<td>-0.0878</td>
<td>-0.0922</td>
</tr>
<tr>
<td>$\sigma = 2$</td>
<td>-0.2290</td>
<td>-0.0024</td>
<td>-0.2676</td>
<td>-0.2516</td>
<td>-0.1122</td>
</tr>
<tr>
<td>$\phi = 5$</td>
<td>-0.1093</td>
<td>-0.0137</td>
<td>-0.0876</td>
<td>-0.0657</td>
<td>-0.1791</td>
</tr>
</tbody>
</table>

9.1 The LBD Externality

A central element to the model is the LBD externality and its ability to propagate the long term issues with Dutch Disease. The sensitivity of the results to changes in parameters governing the evolution of learning will be examined to ensure accuracy of results and conclusions.

9.1.1 Learning Share of Income: $\alpha$

The learning share of income, is parameterised based off Australian data. However, as Gollin (2002) identifies estimating the labour income share of production can be difficult due to the inability to account for income from self-employed and other entrepreneurs. A lower learning share, set at 0.4, is examined to see the sensitivity of results.

Figures 14 and 15 in Appendix E compare the response of transitory and persistent commodity price shocks to key variables with the different learning income shares. In the face of both commodity price shocks, a lower learning share reduces the volatility of labour hours. Through the New Keynesian Phillips curve, changes in labour impact home inflation. This feeds back into inflation, interest rates and consumption. Therefore, consumption is also less volatile with a lower learning share of income. The fact that the LBD externality is not significantly affected by changes in the production share is due to the LBD process. LBD evolves based off previous periods LBD and non-commodity
output. Therefore, it is less affected by fluctuations in share of production as the impact of any changes that affect non-commodity output feed back into the LBD process.

A lower learning share of income does not consistently breed welfare costs (as shown in table 9). Interestingly, the fiscal rules (rules II and III) which performed most strongly in fighting Dutch Disease through improving the learning externality exhibit welfare gains under a lower learning share. For the baseline and rule I, a lower learning share causes higher welfare costs. This result is attributable to the volatility that learning causes in the economy.

Overall, the difference with the lower learning share is not significant. There are minor changes to the short run volatility but they are not dramatic. In the longer term, there is very little difference in outcomes with the differing learning shares.

9.1.2 Rate of Depreciation of Learning: $\chi$

The rate of depreciation of Learning, $\chi$, is borrowed from Lama and Medina (2012) who estimate it based on Canadian data. The rate of depreciation is approximately halved to 0.32 to see the impact on results. A lower depreciation rate, means that the LBD externality evolves more according to previous period LBD than output. It follows, it is expected that instances where the effects of Dutch Disease hit the LBD externality relatively harder, will have greater contractions in the non-commodity sector when the depreciation rate is lower. Therefore, fiscal rules II and III will be most impacted by changes in the depreciation rate.

Figures 16 and 17 in Appendix E show the impact of reducing the depreciation rate on select variables. The overall outcome on non-commodity output does not differ significantly between the two parameters. What is impacted however, is the share of inputs in the production process. Lower depreciation rates cause more volatility in the face of a commodity price shock. Examining the movements in the shadow value of learning explains this. The shadow price experiences greater initial volatility given the impact of consumption and prices. This causes firms to prefer more labour, at least initially, with lower depreciation rates. Eventually, the non-commodity output and inputs are not different between the rates of depreciation. As the impact of the shock wears off and variables return to their steady state levels, the different depreciation rates are inconsequential.

Reducing the rate of depreciation does not have consistent welfare impacts across the
fiscal rules. Fiscal rules that rely on learning to drive output (the taxation rate shock and commodity price rule) have lower welfare costs with lower learning depreciation. This is because they rely on learning proportionately more and can more effectively use the lower depreciation of learning to improve outcomes in the non-commodity sector.

9.2 Elasticity of Substitution between Domestic and Foreign Goods: $\gamma$

The parameter for elasticity of substitution between domestic and foreign goods ($\gamma$) is borrowed from Jaasekela and Nimark (2011), who estimate based on Australian data. Although this is similar to estimations of other comparable economies, empirical estimates have substantial variation. When gamma is less than one, home and foreign goods are complements to utility. This makes commodity price shocks have less of an impact on non-commodity output as additional household income is spent on both home and foreign goods. On the contrary, when gamma is greater than one the opposite occurs as domestic and foreign goods become substitutes.

Figures 18 and 19 in Appendix E compare the impact of a gamma value of 1.3 to 0.85 (from Corsetti et al. (2008)). As described above, the fluctuations in output are contained. However, lower values of gamma are less effective in containing price stability causing volatility in home inflation, interest rates, consumption and the real exchange rate. Therefore, results are sensitive to the parametisation of the elasticity of substitution between domestic and foreign goods.

Lowering the elasticity of substitution between domestic and foreign goods comes at the expense of higher welfare costs, as shown in table 9. In the context of the model, greater reductions in consumption are required to ensure the stochastic expected utility equals that of the deterministic.

9.3 Calvo Parameter: $\theta$

Most macroeconomic literature assumes, as Blinder et al. (1998) found, that firms reset prices once a year. This translates to a Calvo parameter of 0.75. However microeconomic literature, predicts greater frequency in price resetting (Bils & Klenow 2004). A lower Calvo parameter of 0.5 is chosen to test the conclusions of this thesis. The response of this to key variables are shown in Appendix E in figures 20 and 21.

The lower Calvo parameter significantly impacts the conclusions and results, primar-
ily through the impact on home inflation in the New Keynesian Phillips curve. This feeds through the economy and creates volatility in most variables. In some cases the impact of the Calvo parameter is so strong, that the variables behave in a completely different fashion. For example, consumption and home inflation experience much sharper and more dramatic responses with the lower Calvo parameter. Therefore, the results and conclusions are heavily reactive to the selection of the Calvo parameter.

As shown in table 7, a lower Calvo parameter increases welfare costs, with the exception of the case of government budget balance. This implies that household utility suffers when there are more frequent price changes, due to the impact on consumption and home inflation.

9.4 Household Utility

9.4.1 Intertemporal Elasticity of Substitution: $\sigma$

Most of the literature uses a value for the intertemporal elasticity of substitution of 1. However, there has been some movement away towards smaller values of intertemporal elasticity of substitution (implying larger values of sigma), as discussed in Hall (1988). A value for sigma of 2 is considered. The results are shown in figures 22 and 23 in Appendix E. The higher value of sigma implies higher economic cost of fluctuations. In a transitory shock, the only impact is a minor reduction in volatility of consumption. Therefore, the change in sigma has very little impact. In the persistent commodity price shock, changing sigma has a greater impact. Consumption is lower at all times for the first ten years, which is expected given the persistent change in consumption. There is a minor impact on prices which changes inflation and the real exchange rate. This causes output to contract, which worsens the LBD externality (given it is impacted by previous period output). Therefore, changes in the value of sigma may impact the conclusions from persistent commodity price shocks.

The higher value for sigma significantly increases the welfare costs associated with the model, as shown in table 9. So although results may not always be impacted, consumption must decrease to maintain the same expected utility between the deterministic and stochastic states.

9.4.2 Frisch Labour Supply Elasticity: $\phi$

A more elastic labour supply, represented through higher values of $\phi$, has the potential to heighten the resource movement effect as it becomes easier to shed labour hours. Figures
24 and 25 in Appendix E show the impact of changing \( \phi \) to 0.5 and 5. Changes in the value of labour elasticity enter the economy through the New Keynesian Phillips curve, increasing the volatility of home inflation. This filters through to inflation, interests rates and consumption. The LBD externality is vulnerable to changes in labour supply elasticity. The impact of commodity shocks is greater however, the externality becomes less persistent. This is attributable to the impact of labour supply elasticity on the shadow price. By impacting labour supply, labour hours becomes more volatile and the shadow price is lower. This decreases the value of the externality, accounting for the lower persistence of learning.

A change in the labour supply elasticity to 5 has significantly high welfare costs (as shown in table 9), with the welfare costs at least doubling compared to the modelled parameters for most fiscal rules. Combined with the increase in volatility for some variables, allows the conclusion the results are sensitive to the choice of labour supply elasticity.

### 9.5 Effect of Monetary Policy Settings

Much of the previous literature examines the effect of monetary policy settings on Dutch Disease (Lama & Medina 2012, Lartney 2008, Rees 2013). Therefore, it is expected that monetary policy settings will impact results. However given the monetary policy rule is kept consistent among the different fiscal rules, the conclusions regarding fiscal policy in this thesis are upheld.
10 Conclusion

10.1 Discussion of Results

The role fiscal policy can play to manage and mitigate Dutch Disease cannot be under-stated. However, as the fiscal rules employed in this thesis shows, the government must choose its policy approach carefully because not all fiscal settings are desirable. Different fiscal rules are imposed on a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) to test the most advantageous fiscal approach. This model is calibrated, where possible, to Australian quarterly sample data over the period of 1990 to 2014. Importantly, this model incorporates both transitory and persistent commodity price shocks; as the results show the policies required differ according to the persistence of the commodity boom.

In the steady state, higher commodity prices lead to a contraction in the non-commodity sector. The steady state analysis also permits the conclusion that the government levers of spending, taxation and borrowing have significant impact on the non-commodity sector and could potentially be used to support the sector in a situation of Dutch Disease. When government spending and taxation are increased, the non-commodity sector experiences higher output, labour hours and learning. On the other hand, an increase in government borrowing causes a contraction in the non-commodity sector.

The government sector has differing impacts for transitory and persistent commodity price shocks. In the transitory case, the government increases volatility; worsening short term outcomes but slightly improving medium term outcomes. In the persistent case, again the government again encourages significant volatility; but only offers assistance in dealing with Dutch Disease in the short term.

Four fiscal rules are imposed on the model. The first fiscal rule dictates a balanced budget on the government. This policy is found to be effective for short run transitory commodity price boom. The second rule adds taxation rate shocks to the model. Whilst the rule reverses the Dutch Disease process in commodity price shocks, it is more effective for transitory price shocks. The third rule alters commodity taxation in response to changes in commodity prices and non-commodity output. It offers minor improvements in the transitory case and long run improvements in the persistent case. The final rule is a 10 percent increase in government spending. Overall, this fiscal rule is fairly ineffective. It doesn’t offer any significant cure against Dutch Disease other than a minor improvement in short run non-commodity output for a persistent commodity price shock.
The effectiveness of fiscal rules hinged on their ability to support the learning by doing externality process. In the Dutch Disease model, learning captures the long run effects of a decline in output because of its ability to impact future period productivity and output. Policies that supported the learning process, rule III in transitory and IV in persistent, were effective in mitigating Dutch Disease. Learning is critical because of how it impacts the future period output. The ability for policies to improve labour hours was not found to be a condition for their effectiveness.

Altering government policies should not be merely measured on the basis of how they impact the non-commodity sector and in turn, reverse the process of Dutch Disease. Welfare costs with the alternative fiscal rules are considered. This is measured by percentage change in consumption that gives the same expected household utility in the stochastic and deterministic economy. Furthermore, the macroeconomic volatility for each fiscal regime was considered. These found the budget balance to be the policy with the smallest welfare cost.

In total, combining the steady state findings, dynamic results and the conclusions from welfare analysis the most advisable government policy to mitigate and manage Dutch Disease in Australia is: taxation rate increases in transitory commodity price shocks and a commodity tax rule in persistent commodity price shocks. The budget balance rule is also a fairly viable option considering it performs fairly well in the transitory and persistent commodity booms and has the lowest welfare cost.

However, these results are slightly sensitive. In particular, parameters governing the composition of foreign goods and households significantly altered results. Importantly, parameters governing the LBD externality did not significantly impact results, supporting the conclusions regarding the role of LBD in Dutch Disease.

### 10.2 Extensions & Further Research

There are many avenues available to extend this research.

Firstly, instances with ‘noise’ or information asymmetry could be considered. A key assumption in this model is that households, firms and governments are aware of the persistence of the commodity price shock. However, for obvious reasons, the persistence of a commodity price boom is not known at its impact. The impact of information asymmetry was considered in Rees (2013) in the context of monetary policy. Extending the
model to include noise and the impact on fiscal policy settings would be valuable.

Second, the impact of foreign shocks would be a worthwhile addition to the model. The model assumes the only foreign shock is the commodity price shock. This is particularly important as Australia heads towards the end of the mining boom in a period of global economic volatility.

Finally, the model could be extended by further dividing the non-commodity sector into the tradable and non-tradable to better depict the Dutch Disease process outlined by Corden & Neary (1982). This is done in other New Keynesian DSGE models such as Dib (2008) and Orrego & Vega (2013) but, these models do not include transitory and persistent commodity price shocks.

10.3 Concluding Remarks

This thesis explores the impact of fiscal policy in managing and mitigating Dutch Disease. A New Keynesian DSGE is employed and four different fiscal rules applied to it. The thesis contributes by examining the issue of Dutch Disease with a model calibrated to the Australian economy and adding to the policy debate. With regards to the policy debate, this thesis adds to the growing literature on using fiscal policy to deal with Dutch Disease. In particular, the focus on taxation measures is an area of the literature has not explored.

Four fiscal rules are imposed on the model: budget balance, persistent taxation shock, commodity tax rule and an increase in government spending. Not all rules are beneficial in mitigating Dutch Disease, some act as venom to the economy whilst others can heal the economy against Dutch Disease. For the transitory commodity price shock, the taxation rate shock provides the healthiest option. For the persistent commodity price shock, the commodity price rule is the best antidote. These policies are able to extract the poison of Dutch Disease by reversing the contraction in the learning externality.
A  Data

A.1  Data Sources

The data is sourced from the following locations:

Commodity Endowment: ABS Cat No. 5302 - Table 9. ‘Metal ores and minerals’, ‘Coal, coke and briquettes’ and ‘Other minerals fuels’ are summed together. This sum is then divided by the total goods credits. The average is taken to get the commodity endowment. (Section 4.4)

Commodity Taxation Rate: Australia’s Future Tax System: Part One - Overview, pg 47, Chart 6.1. The percentage of profits that resource companies pay in taxation. (Section 4.3)

Company Tax Rate: Australian Taxation Office - Company tax, Tax rates 2014-15. (Section 4.3)

Commonwealth Government Payments & Receipts: 2014-15 Commonwealth Budget Paper No. 1 - Table 10. (Section 1)

Government Expenditure (% of GDP): 2014-15 Commonwealth Budget Paper No. 1 - Table 9. (Section 4.5)

Inflation Rate: ABS Cat No. 6401.0 - Tables 1 & 2. (Section 4.2)

Interest (Cash) Rate: Reserve Bank of Australia - Table A02. (Section 4.2)

Import Share of Consumption: ABS Cat No. 5206 - Table 3. ‘Imports of goods and services’ is divided by the sum of ‘Imports of goods and services’ and ‘All sectors; Final consumption expenditure’. The average is taken to get the import share of consumption. (Section 4.2)

Labour Share of Income: ABS Cat No. 5206 - Table 7. The total compensation of employees is divided by the gross domestic product for each quarter. The quarter results are then averaged to provide the labour share of income. (Section 4.3)

Manufacturing Share: ABS Cat No. 5206 - Table 6. (Section 1)

Minerals Share: ABS Cat No. 5206 - Table 6. (Section 1)

Taxation (% of GDP): 2014-15 Commonwealth Budget Paper No. 1 - Table 9. (Section 4.5)

Terms of Trade: ABS Cat No. 5206 - Table 1. (Section 1)

Trade Weighted Index: Reserve Bank of Australia (RBA). (Section 1)
B Derivation of Model

B.1 Households Utility Maximisation

The representative household maximises utility (3.11) subject to budget constraint (3.12). The variables consumption ($C_t$), labour ($L_t$) and domestic bonds ($B_{G,t+1}$) are maximised using Lagrangian methods.

$$\mathcal{L} = \mathbb{E}_t \left\{ \beta^t \left[ \sum_{t=0}^{\infty} \left[ \frac{C_t^{1-\sigma}}{1-\sigma} - A_L \frac{L_t^{1+\phi}}{1+\phi} \right] \right. \right.$$

$$\left. - \lambda_t \left( W_t L_t + Y_t + B_{H,t} + \varepsilon_t B_{F,t} + (1 - \tau_{ct}) \varepsilon_t S_t Y^X - \int_0^1 C_{H,t}(j) P_{H,t}(j) dj \right) \right.$$

$$\left. - \int_0^1 C_{F,t}(j) P_{F,t}(j) dj - \frac{B_{H,t+1}}{1 + r_t} - \frac{\varepsilon_t B_{F,t+1}}{(1 + r^*) \Psi(b_{F,t+1})} \left. \right] \right\}$$

Solving (B.1) will provide the first order conditions (FOC) are:

$$\lambda_t = -\frac{C_t^{1-\sigma}}{P_t} \quad (B.2)$$

$$\lambda_t = -\frac{A_L L_t^{\phi}}{W_t} \quad (B.3)$$

$$\lambda_t = (1 + r_t) \mathbb{E}_t \{ \lambda_{t+1} \} \quad (B.4)$$

Re-writing equation (B.2) for period $t+1$.

$$\lambda_{t+1} = \mathbb{E}_t \left\{ -\frac{C_{t+1}^{1-\sigma}}{P_{t+1}} \right\} \quad (B.5)$$

Combining equations (B.2), (B.4) and (B.5) gives the household Euler equation, as shown in equation (3.13). Combining equations (B.2) and (B.3) gives the household intratemporal optimality condition, as shown in equation (3.14).

B.2 Firm’s Problems

B.2.1 Marginal Cost

The firm’s production function is presented in equation (3.16). The firm takes wages and LBD as given and chooses labour supply. The firm’s cost minimisation problem is:

$$\min_{L_t} \{ W_t L_t \}$$
subject to:

$$(1 - \tau_{nc,t})Y_t(j) = (1 - \tau_{nc,t})\bar{Y}$$

This is solved using Lagrangian methods:

$$\mathcal{L} = W_t(j)L_t(j) - \lambda_t((1 - \tau_{nc})Y_t(j) - (1 - \tau_{nc})\bar{Y})$$

$$\mathcal{L}_{L_t} = W_t(j) - \lambda_t[(1 - \alpha)LRN_t(j)^a L_t(j)^{-\alpha}]$$

$$= W_t(j) - \lambda_t \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{LRN_t(j)^a L_t(j)^{-\alpha} L_t(j)}{L_t(j)} \right]$$

$$= W_t(j) - \lambda_t \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t(j)}{L_t(j)} \right]$$

$$\lambda_t = W_t(j) \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t(j)}{L_t(j)} \right]^{-1} \quad (B.6)$$

The firm’s cost minimisation problem can also be written in terms of maximising output given a particular cost function. This is shown below:

$$\mathcal{L} = C(Y_t(j)) - \lambda_t(Y_t(j) - Y)$$

where $C(Y_t(j))$ is costs in terms of output. The FOC is:

$$C'(Y_t(j)) = \lambda_t \quad (B.7)$$

Equating (B.6) and (B.7) provides an expression for nominal marginal cost.

$$MC_t(j) = W_t(j) \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t(j)}{L_t(j)} \right]^{-1} \quad (B.8)$$

Dividing equation (B.8) by the home produced goods prices $P_{H,t}$ provides the real marginal cost:

$$MC_t(j) = \frac{W_t(j)}{P_{H,t}} \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t(j)}{L_t(j)} \right]^{-1} \quad (B.9)$$

The average marginal cost is:

$$MC_t = \frac{W_t}{P_{H,t}} \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t}{L_t} \right]^{-1} = \frac{A_t C_t^\phi L_t^\phi}{P_{H,t}} \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y_t}{L_t} \right]^{-1} \quad (B.10)$$

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### B.2.2 Firm Pricing Problem

\[
E_t \left[ \sum_{k=0}^{\infty} \theta^k Q_{t,t+k}(1 - \tau_{nc,t}) Y_{t+k(j)} \left[ \bar{P}^H_t - \frac{\zeta}{1 - \zeta} MC_{t+k|t} P^H_{t+k} \right] \right] = 0 \quad (B.12)
\]

subject to:

\[(1 - \tau_{nc}) Y_{t+k(j)} = (1 - \tau_{nc}) Y_{t+k} \left( \frac{P^H_{t+k}}{P^H_{t(j)}} \right)^{-\zeta} \quad (B.13)\]

\[Q_{t,t+k} = \beta^k C^{-\sigma}_{t+k} \left( \frac{P_t}{P^H_{t+k}} \right) \quad (B.14)\]

Firstly, an expression for marginal costs must be determined. Bring equations (B.9) and (B.10) forward by \( k \) periods. Together with the firm specific demand and production functions, the following expression is formed:

\[MC_{t+k|t} = MC_{t+k} \left( \frac{P^H_t}{P^H_{t+k}} \right)^{-\frac{\mu_{\alpha}}{1-\alpha}} \quad (B.15)\]

Substituting (B.12) \( Y_{t+k(j)} \) into equation (B.11):

\[
E_t \left[ \sum_{k=0}^{\infty} \theta^k Q_{t,t+k}(1 - \tau_{nc}) Y_{t+k} \left( \frac{P^H_{t+k}}{P^H_{t(j)}} \right)^{-\zeta} \left[ \bar{P}^H_t - \frac{\zeta}{1 - \zeta} MC_{t+k|t} P^H_{t+k} \right] \right] = 0
\]

\[
E_t \left[ \sum_{k=0}^{\infty} \theta^k Q_{t,t+k}(1 - \tau_{nc}) Y_{t+k} \left( \frac{P^H_{t+k}}{P^H_{t(j)}} \right)^{-\zeta} \left[ \frac{\zeta}{1 - \zeta} MC_{t+k|t} P^H_{t+k} \right] \right] = 0
\]

\[
E_t \left[ \sum_{k=0}^{\infty} \theta^k Q_{t,t+k}(1 - \tau_{nc}) Y_{t+k} \left( \frac{P^H_{t+k}}{P^H_{t(j)}} \right)^{-\zeta} \left[ \bar{P}^H_t - \frac{\zeta}{1 - \zeta} MC_{t+k|t} P^H_{t+k} \right] \right] = 0
\]

Substituting (B.13) \( Q_{t,t+k} \):

\[
\frac{P^H_t}{P^H_{t+k}} E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C^{-\sigma}_{t+k} \frac{P_t}{P^H_{t+k}} (1 - \tau_{nc}) Y_{t+k} \left( \frac{P^H_{t+k}}{P^H_{t(j)}} \right)^{-\zeta} \right] \frac{P^H_{t+k}}{P^H_{t(j)}} P^H_{t+k}
\]

\[= \frac{\zeta}{1 - \zeta} MC_{t+k|t} \frac{P^H_{t+k}}{P^H_{t(j)}} P^H_{t+k} E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C^{-\sigma}_{t+k} \frac{P_t}{P^H_{t+k}} (1 - \tau_{nc}) Y_{t+k} \left( \frac{P^H_{t+k}}{P^H_{t(j)}} \right)^{-\zeta} \right] \]
\[
\frac{\bar{P}_t^H}{p_t^H} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} (1 - \tau_{nc}) Y_{t+k} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \right] \\
= \frac{\zeta}{1 - \zeta} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} (1 - \tau_{nc}) Y_{t+k} MC_{t+k} \right]
\]

Substituting (B.14) \( MC_{t+k} = MC_{t+k} \left( \frac{\bar{p}_t^H}{p_{t+k}^H} \right)^{-\frac{\alpha \zeta}{1 - \alpha}} : \)

\[
\frac{\bar{P}_t^H}{p_t^H} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} (1 - \tau_{nc}) Y_{t+k} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \right] \\
= \frac{\zeta}{1 - \zeta} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} (1 - \tau_{nc}) Y_{t+k} MC_{t+k} \left( \frac{\bar{P}_t^H}{p_t^H} \right)^{-\frac{\alpha \zeta}{1 - \alpha}} \right]
\]

\[
\left( \frac{\bar{P}_t^H}{p_t^H} \right)^{1+\frac{\alpha \zeta}{1 - \alpha} - \frac{\alpha \zeta}{1 - \alpha}} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} (1 - \tau_{nc}) Y_{t+k} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \right] \\
= \frac{\zeta}{1 - \zeta} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} (1 - \tau_{nc}) Y_{t+k} MC_{t+k} \left( \frac{\bar{P}_t^H}{p_t^H} \right)^{-\frac{\alpha \zeta}{1 - \alpha}} \right]
\]

\[
\left( \frac{\bar{P}_t^H}{p_t^H} \right)^{1-\frac{\alpha + \alpha \zeta}{1 - \alpha}} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} (1 - \tau_{nc}) Y_{t+k} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} \frac{p_{t+k}^H}{p_{t+k}^H} \frac{P_t}{p_{t+k}^H} \right] \\
= \frac{\zeta}{1 - \zeta} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \left( \frac{p_{t+k}^H}{p_{t}^H} \right)^{\zeta} \frac{p_{t+k}^H}{p_{t+k}^H} P_t (1 - \tau_{nc}) Y_{t+k} MC_{t+k} \right]
\]
Dropping $P_t$: 

$\left( \frac{\hat{P}_t}{P_t} \right)^{\frac{1-\alpha + \delta}{1-\alpha}} = E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \left( 1 - \tau_{nc} \right) Y_{t+k} \left( \frac{P_{t+k}^H}{P_{t+j}^H} \right)^{\frac{\zeta}{1-\alpha}} \frac{P_{t+k}^H}{P_{t+k}^P} \right]$

$= \frac{\zeta}{1 - \zeta} E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \left( \frac{P_{t+k}^H}{P_{t+j}^H} \right)^{\frac{\zeta}{1-\alpha}} \frac{P_{t+k}^H}{P_{t+k}^P} \left( 1 - \tau_{nc} \right) Y_{t+k} MC_{t+k} \right]$

Let $J_t = E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \left( 1 - \tau_{nc} \right) Y_{t+k} \left( \frac{P_{t+k}^H}{P_{t+j}^H} \right)^{\frac{\zeta}{1-\alpha}} \frac{P_{t+k}^H}{P_{t+k}^P} \right]$

$= E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \left( 1 - \tau_{nc} \right) Y_{t+k} \left( \frac{P_{t+k}^H}{P_{t+j}^H} \right)^{\frac{\zeta}{1-\alpha}} \frac{P_{t+k}^H}{P_{t+k}^P} \right]$

$= C_t^{-\sigma} \left( 1 - \tau_{nc} \right) Y_t \hat{P}_t^H + \beta \theta E_t \left[ J_{t+1} \left( \Pi_{t+1}^H \right)^{\frac{\zeta}{\alpha}} \right]$

Let $F_t = \frac{\zeta}{1 - \zeta} E_t \left[ \sum_{k=0}^{\infty} (\beta \theta)^k C_{t+k}^{-\sigma} \left( \frac{P_{t+k}^H}{P_{t+j}^H} \right)^{\frac{\zeta}{1-\alpha}} \frac{P_{t+k}^H}{P_{t+k}^P} \left( 1 - \tau_{nc} \right) Y_{t+k} MC_{t+k} \right]$

$= \frac{\zeta}{1 - \zeta} C_t^{-\sigma} \left( 1 - \tau_{nc} \right) Y_t MC_t \hat{P}_t^H + \beta \theta \left[ F_{t+1} \left( \Pi_{t+1}^H \right)^{\frac{\zeta}{\alpha}} \right]$

**B.2.3 New Keynesian Phillips Curve**

The New Keynesian Phillips Curve can be found by combining the linearised firm equations. The linearised firm equations are provided in Appendix (B.3.2).

$\pi_{H,t} = \beta E_t \left\{ \pi_{t+1}^H \right\} + \kappa \left( \phi t + \sigma c_t - \hat{P}_t^H + \frac{\alpha}{1 - \alpha} (y_t - lr t) \right)$

where $\kappa = \frac{(1 - \theta) (1 - \theta)(1 - \alpha)}{\theta(1 - \alpha + \alpha \zeta)}$

**B.3 The Shadow Price ($\mu$) for the Externality**

The shadow price comes from the problem of the social planner. The social planner chooses labour demand to maximise firm profits, taking prices as given.

$\max_{(L_t, LRN_{t+1})} E_0 \beta_t \left[ \frac{P_t^H (1 - \tau_{nc}) LRN_t^a L_t^{1-\alpha}}{L_t} - \frac{W_t L_t}{P_t} \right]$
The optimality conditions are:

\[ P_t = P_{t+1} \]

\[ T_t \]

\[ \mu_t = E_t \left( \mu_{t+1} \right) \]

\[ \pi_{t+1} = \frac{1 - \alpha}{\alpha} (j_t - j) \]

\[ f_t = (1 - \alpha \theta)(1 + \phi) \left( \frac{1 - \alpha}{1 - \alpha \theta} \right) \left( 1 - \alpha \theta \right) \]

\[ j_t = (1 - \beta)(1 + \phi) \left( \frac{1 - \alpha}{1 - \alpha \theta} \right) \left( 1 - \alpha \theta \right) \left( 1 - \alpha \theta \right) \]

B.4 Log Linearised Equations

This section contains the log-linearised equations around the steady state. A lower case letter symbol indicates it is the log deviation from the steady state. A dash over the letter indicates the steady state value. For example:

\[ z_t = \log(Z_t) - \log(Z) \]

B.4.1 Households

\[ c_t = E_t \{ c_{t+1} \} \]

\[ r_t = E_t \{ q_{t+1} \} \]

B.4.2 Home Firms

\[ f_t = (1 - \alpha \theta)(1 + \phi) \left( \frac{1 - \alpha}{1 - \alpha \theta} \right) \left( 1 - \alpha \theta \right) \left( 1 + \phi \right) \]

\[ j_t = (1 - \beta)(1 + \phi) \left( \frac{1 - \alpha}{1 - \alpha \theta} \right) \left( 1 - \alpha \theta \right) \left( 1 + \phi \right) \]

The optimality conditions are:

\[ LRN_{t+1} \bar{X}_{t+1} \]

\[ L_t \]

\[ \mu_{t+1} = \beta E_t \left( \mu_{t+1} \right) \]

\[ \pi_{t+1} = \frac{1 - \alpha}{\alpha} (j_t - j) \]

\[ f_t = (1 - \alpha \theta)(1 + \phi) \left( \frac{1 - \alpha}{1 - \alpha \theta} \right) \left( 1 - \alpha \theta \right) \left( 1 + \phi \right) \]

\[ j_t = (1 - \beta)(1 + \phi) \left( \frac{1 - \alpha}{1 - \alpha \theta} \right) \left( 1 - \alpha \theta \right) \left( 1 + \phi \right) \]
The standard open economy New Keynesian Phillips curve (from Appendix B.2.3):

\[
\pi_{H,t} = \beta \mathbb{E}_t \{ \pi_{H,t+1}^H \} + \kappa \left( \phi l_t + \sigma c_t - \hat{p}_t^H + \frac{\alpha}{1 - \alpha} (y_t - lr n_t) \right)
\]

\[
\kappa = \frac{(1 - \theta)(1 - \beta \theta)(1 - \alpha)}{\theta(1 - \alpha + \alpha \zeta)}
\]

Fiscal Rule II

\[
f_t = (1 - \beta \theta) \left( \left( 1 + \phi \right) l_t - \frac{\tau_{nc,t}^2}{(1 - \tau_{nc,t})^2} \tau_{nc,t}^\cdot \right) + \beta \theta \mathbb{E}_t \left\{ \frac{\zeta}{1 - \alpha} \pi_{H,t+1} + f_{t+1} \right\}
\]

\[
\hat{j}_t = (1 - \beta \theta) \left( y_t - \sigma c_t + \hat{p}_{H,t} - \frac{\tau_{nc,t}}{1 - \tau_{nc,t}} \hat{\tau}_{nc,t}^\cdot \right) + \beta \theta \mathbb{E}_t \{ (\zeta - 1) \pi_{H,t+1} + j_{t+1} \}
\]

The standard open economy New Keynesian Phillips curve (from Appendix B.2.3):

\[
\pi_{H,t} = \beta \mathbb{E}_t \{ \pi_{t+1}^H \} + \kappa \left( \phi l_t + \frac{\tau_{nc,t}}{1 - \tau_{nc,t}} \tau_{nc,t}^\cdot + \sigma c_t - \hat{p}_t^H + \left( \frac{\alpha}{1 - \alpha} \right) (y_t - lr n_t) \right)
\]

\[
\kappa = \frac{(1 - \theta)(1 - \beta \theta)(1 - \alpha)}{\theta(1 - \alpha + \alpha \zeta)}
\]

B.4.3 Commodity Sector

\[
s_t = z_t + v_t
\]

\[
z_t = \rho_z z_{t-1} + \varepsilon_t^z
\]

\[
v_t = (1 + \rho_{v_1} - \rho_{v_2}) v_{t-1} + \rho_{v_1} v_{t-2} + \varepsilon_t^v
\]

B.4.4 Aggregators (International Indicies)

\[
\pi_{H,t} = (\hat{p}_{H,t} - \hat{p}_{H,t-1}) + \pi_t
\]

\[
\hat{p}_{H,t} = -\eta \frac{1}{1 - \eta} q_t
\]

B.4.5 Government Sector

\[
T_{lt} + Bb_{G,t} = G_{gt} + \beta^{-1} Bb_{G,t-1} + (\beta^{-1} - 1) B r_t
\]

Baseline & Fiscal Rules I, IV

\[
T_{lt} = \tau_{nc} Y_{yt} + \tau_c QSY^X (s_t + q_t)
\]
Fiscal Rule II

\[
T_{t|t} = \tau_{nc} Y(y_t + \hat{\tau}_{nc,t}) + \tau_c QSY^X(\hat{\tau}_{c,t} + s_t + q_t)
\]
\[
\hat{\tau}_{c,t} = \rho_{nc} \hat{\tau}_{c,t-1} + \varepsilon_t^T
\]
\[
\hat{\tau}_{nc,t} = \rho_{nc} \hat{\tau}_{nc,t-1} + \varepsilon_t^T
\]

Fiscal Rule III

\[
T_{t|t} = \tau_{nc} Y(y_t + \hat{\tau}_{nc,t}) + \tau_c QSY^X(\hat{\tau}_{c,t} + s_t + q_t)
\]
\[
\tau_c \hat{\tau}_{c,t} = \rho_{\tau_1} + \rho_{\tau_2} S_t + \rho_{\tau_3} Y y_t
\]

B.4.6 Market Clearing Conditions

\[
Y y_t = (1 - \eta)(c_t - \gamma p_t) + \gamma(q_t - p_t)(Y - (1 - \eta)C - G) + Gg_t
\]

Baseline & Fiscal Rules I, IV

\[
y_t = \alpha l r_n_t + (1 - \alpha) l_t
\]
\[
l_{r_n+1} = \chi l r_n_t + (1 - \chi) y_t
\]
\[
c_t + \beta B_{b+1} = (1 - \tau_{nc}) Y(y_t + \hat{p}_{H,t}) + (1 - \tau_c) Y^X(q_t + s_t + \hat{p}_{H,t}) + B_{b_t}
\]

Fiscal Rule II

\[
Y y_t - Y \tau_{nc}(y_t + \tau_{nc}) = LRN^{\alpha} L^{1-\alpha}(\alpha l r_n_t + (1 - \alpha) l_t)
\]
\[
l_{r_n+1} = \chi l r_n_t + (1 - \chi) y_t + \tau_{nc}(\chi - 1) \tau_{nc} \left(1 - \tau_{nc}\right) \frac{Y}{LRN} \right)^{1-\chi}
\]
\[
c_t + \beta B_{b+1} = (1 - \tau_{nc}) Y(y_t + \hat{p}_{H,t}) - \hat{\tau}_{nc,t} \tau_{nc} Y + (1 - \tau_{nc}) Y^X(q_t + s_t + \hat{p}_{H,t}) - \tau_c Y^X \hat{\tau}_{c,t} + B_{b_t}
\]

Fiscal Rule III

\[
y_t = \alpha l r_n_t + (1 - \alpha) l_t
\]
\[
l_{r_n+1} = \chi l r_n_t + (1 - \chi) y_t
\]
\[
c_t + \beta B_{b+1} = (1 - \tau_{nc}) Y(y_t + \hat{p}_{H,t}) + (1 - \tau_c) Y^X(q_t + s_t + \hat{p}_{H,t}) - Y^X \tau_c \hat{\tau}_{c} + B_{b_t}
\]
C  Steady State Results

\[1 = \beta \left[ \frac{1 + r}{\Pi} \right]\]
\[1 + r = (1 + r^e)\Pi \Delta Q\]
\[1 = (1 - \eta) \left( \hat{P}_H \right)^{1 - \gamma} + \eta Q^{1 - \gamma}\]
\[\Pi_H = \Pi\]
\[LRN = (1 - \tau_{nc})Y\]
\[MC = \frac{A_L C^\sigma L^\phi}{\hat{P}_H} \left[ (1 - \alpha)(1 - \tau_{nc}) \frac{Y}{L} \right]\]
\[\Xi = \frac{F}{J}\]
\[F = \frac{\zeta}{\zeta - 1} \frac{C^{-\sigma}(1 - \tau_{nc})Y \hat{P}_H MC}{1 - \beta \theta (\Pi_H)^{\zeta}}\]
\[J = \frac{C^{-\sigma}(1 - \tau_{nc})Y \hat{P}_H}{1 - \beta \theta (\Pi_H)^{1 - \zeta}}\]
\[1 = \theta (\Pi_H)^{\zeta - 1} + (1 - \theta) \Xi^{1 - \zeta}\]
\[\Delta = \frac{(1 - \theta) \Xi - \tau_{nc}}{1 - \theta (\Pi_H)^{\zeta - \tau_{nc}}}\]
\[S = 1\]
\[Y = (1 - \eta)(\hat{P}_H)^{-\gamma}C + \eta \left( \frac{\hat{P}_H}{Q} \right)^{-\gamma} C^* + G\]
\[C = \hat{P}_H Y + Q Y^X\]
\[G = \tau_{ne} Y + \tau_e Y^X - (\beta^{-1} - 1)\]
\[Q = \varepsilon\]
\[T = \tau_{ne} Y + \tau_e Q S Y^X\]
\[D = T - G\]
### Table 10: Steady State Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>$C$</td>
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<td>$\Pi$</td>
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<tr>
<td>$\Pi_H$</td>
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<tr>
<td>$\Delta$</td>
<td>1</td>
</tr>
<tr>
<td>$r$</td>
<td>$\beta^{-1} - 1$</td>
</tr>
<tr>
<td>$r^*$</td>
<td>$\beta^{-1} - 1$</td>
</tr>
<tr>
<td>$\Delta Q$</td>
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</tr>
<tr>
<td>$\hat{P}_H$</td>
<td>1</td>
</tr>
<tr>
<td>$Q$</td>
<td>1</td>
</tr>
<tr>
<td>$Y$</td>
<td>$C - Y^X$</td>
</tr>
<tr>
<td>$\eta C^*$</td>
<td>$(1 - \tau_c)Y - (1 - \eta)C - G$</td>
</tr>
<tr>
<td>$\Xi$</td>
<td>1</td>
</tr>
<tr>
<td>$L$</td>
<td>$(1 - \tau_{nc})Y$</td>
</tr>
<tr>
<td>$F$</td>
<td>$J$</td>
</tr>
</tbody>
</table>
D Derivation of Welfare Cost

A second order linear approximation around steady state \( \bar{C} \)

\[
C_t \approx \bar{C} \left( 1 + x_t + \frac{1}{2} x_t^2 \right)
\]

\[
\frac{C_t - \bar{C}}{\bar{C}} \approx c_t + \frac{1}{2} c_t^2
\]

\[
\left( \frac{C_t - \bar{C}}{\bar{C}} \right)^2 \approx c_t^2
\]

Second order approximation around utility function:

\[
U(c, l) \approx \bar{U} + U_C(c_t - \bar{C}) + \frac{1}{2} U_{CC}(C_t - \bar{C})^2 + U_L(l_t - \bar{L}) + U_{LL}(L_t - \bar{L})^2
\]

\[
+ U_{CL}(C_t - \bar{C})(L_t - \bar{L})
\]

\[
\approx \bar{U} + U_C \bar{C} \left( \frac{C_t - \bar{C}}{\bar{C}} \right) + \frac{1}{2} U_{CC} \bar{C}^2 \left( \frac{C_t - \bar{C}}{\bar{C}} \right)^2 + U_L \bar{L} \left( \frac{L_t - \bar{L}}{\bar{L}} \right) +
\]

\[
\quad \frac{1}{2} U_{LL} \bar{L}^2 \left( \frac{L_t - \bar{L}}{\bar{L}} \right)^2 + \frac{1}{2} U_{CL} \bar{C} \bar{L} \left( \frac{C_t - \bar{C}}{\bar{C}} \right) \left( \frac{L_t - \bar{L}}{\bar{L}} \right)
\]

\[
\approx \bar{U} + U_C \bar{C} \left( c_t + \frac{1}{2} c_t^2 \right) + \frac{1}{2} U_{CC} \bar{C}^2 c_t^2 + U_L \bar{L} \left( l_t + \frac{1}{2} l_t^2 \right) +
\]

\[
\quad \frac{1}{2} U_{LL} \bar{L}^2 l_t^2 + \frac{1}{2} U_{CL} \bar{C} \bar{L} \left( c_t + \frac{1}{2} c_t^2 \right) \left( l_t + \frac{1}{2} l_t^2 \right)
\]

The utility function (3.11), with \( \sigma = 1 \), is:

\[
U(\bar{C}, \bar{L}) = \log(\bar{C}) - A_L \bar{L}^{1+\phi}
\]

\[
U_\bar{C} = \frac{1}{\bar{C}}
\]

\[
U_{CC} = -\frac{1}{\bar{C}^2}
\]

\[
U_L = -A_L \bar{L}^\phi
\]

\[
U_{LL} = -A_L \phi \bar{L}^{\phi-1}
\]

\[
U_{\bar{C}L} = 0
\]
Substituting these values into the second-order approximation:

\[
U(c, l) \approx \log(\bar{C}) - A_L \frac{\bar{L}^{1+\phi}}{1 + \phi} + \frac{1}{C} \bar{C} \left( c_t + \frac{1}{2} c_t^2 \right) - \frac{1}{2} C^2 \bar{C} c_t^2 - A_L \bar{L}^{\phi+1} \left( l_t + \frac{1}{2} l_t^2 \right) \\
- A_L \phi \bar{L}^{\phi-1} \frac{1}{2} \bar{L}^2 l_t^2
\]

\[
\approx \log(\bar{C}) - A_L \frac{\bar{L}^{1+\phi}}{1 + \phi} + c_t + \frac{1}{2} c_t^2 - \frac{1}{2} c_t^2 - A_L \bar{L}^{\phi+1} \left( l_t + \frac{1}{2} l_t^2 \right) \\
- A_L \phi \bar{L}^{\phi-1} \frac{1}{2} \bar{L}^2 l_t^2
\]

\[
\approx \log(\bar{C}) - A_L \frac{\bar{L}^{1+\phi}}{1 + \phi} + c_t - A_L \bar{L}^{\phi+1} l_t - A_L \bar{L}^{\phi+1} \frac{1}{2} l_t^2 (1 + \phi)
\]

The level effect is defined as (Dib 2008):

\[
U[(C, L)] = \mathbb{E}_t[U((1 + \mu_m)c_t, l_t)]
\]

Substituting the second-order approximation into the level effect:

\[
\log(\bar{C}) - A_L \frac{\bar{L}^{1+\phi}}{1 + \phi} = \mathbb{E}_t \left[ \log((1 + \mu_m)\bar{C}) - A_L \frac{\bar{L}^{1+\phi}}{1 + \phi} + c_t - A_L \bar{L}^{\phi+1} l_t \right]
\]

\[
\log(\bar{C}) = \mathbb{E}_t \left[ \log((1 + \mu_m)\bar{C}) + c_t - A_L \bar{L}^{\phi+1} l_t - A_L \bar{L}^{\phi+1} \frac{1}{2} l_t^2 (1 + \phi) \right]
\]

Given that the means are zero, \( \mathbb{E}_t[c_t] = \mathbb{E}_t[l_t] = 0 \)

\[
\log(\bar{C}) = \left[ \log((1 + \mu_m)\bar{C}) \right]
\]

\[
\mu_m = 0
\]

The variance effect is defined as (Dib 2008):

\[
U[(C, L)] = \mathbb{E}_t[U((1 + \mu_v)c_t, l_t)]
\]
Substituting the second-order approximation into the level effect:

\[
\log(\bar{C}) - A_L \frac{L^{1+\phi}}{1 + \phi} = \mathbb{E}_t \left[ \log((1 + \mu_m)\bar{C}) - A_L \frac{L^{1+\phi}}{1 + \phi} - A_L \frac{L^{1+\phi}}{2} l_l^2 (1 + \phi) \right]
\]

\[
\log(\bar{C}) = \mathbb{E}_t \left[ \log((1 + \mu_m)\bar{C}) - A_L L^{\phi+1} \frac{1}{2} l_l^2 (1 + \phi) \right]
\]

\[
\mu_m = \frac{1}{C} \exp \left[ \log(\bar{C}) + A_L L^{\phi+1} \frac{1}{2} \text{Var}[l_l^2](1 + \phi) \right] - 1
\]

\[
\mu_m = \left[ A_L L^{\phi+1} \frac{1}{2} \text{Var}[l_l^2](1 + \phi) \right] - 1
\]

Therefore, the welfare gain is:

\[
\lambda = \mu_m - \mu_v = 0 - \left[ \frac{1}{C} \exp \left( \log(\bar{C}) + A_L L^{\phi+1} \frac{1}{2} \text{Var}[l_l^2](1 + \phi) \right) - 1 \right]
\]

\[
\lambda = - \left[ \exp \left( A_L L^{\phi+1} \frac{1}{2} \text{Var}[l_l^2](1 + \phi) \right) - 1 \right]
\]
E Miscellaneous Figures

Figure 14: Sensitivity Analysis - Transitory Shock: Learning Share of Income

Figure 15: Sensitivity Analysis - Persistent Shock: Learning Share of Income
Figure 16: Sensitivity Analysis - Transitory Shock: Learning Depreciation

Figure 17: Sensitivity Analysis - Persistent Shock: Learning Depreciation
Figure 18: Sensitivity Analysis - Transitory Shock: Elasticity

Figure 19: Sensitivity Analysis - Persistent Shock: Elasticity
Figure 20: Sensitivity Analysis - Transitory Shock: Calvo Parameter

Figure 21: Sensitivity Analysis - Persistent Shock: Calvo Parameter
Figure 22: Sensitivity Analysis - Transitory Shock: Sigma

Figure 23: Sensitivity Analysis - Persistent Shock: Sigma
Figure 24: Sensitivity Analysis - Transitory Shock: Labour Supply Elasticity

Figure 25: Sensitivity Analysis - Persistent Shock: Labour Supply Elasticity
## Legend

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<td>Prices of home goods</td>
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Bibliography


