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## Quantifying the role of automatic stabilisers in New Zealand using a macro-simulation approach

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# Quantifying the Role of Automatic Stabilisers in New Zealand Using a Macro-Simulation Approach

Andrew Binning

New Zealand Treasury Working Paper 24/02

April 2024

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# Abstract

Automatic stabilisers are fiscal policy's first line of defence in the face of adverse economic shocks. Automatic stabilisers capture fiscal policy's automatic countercyclical response to the state of the business cycle, and are determined by factors like the progressivity of the tax system, the size of government and the amount of benefit spending that is dependent on recipients' economic circumstances. Built into the system, they do not require legislative action each time they are implemented, meaning they can be deployed relatively quickly. In this paper I investigate the role automatic stabilisers play in stabilising the New Zealand economy across the business cycle. I benchmark current automatic stabilisation policy against different definitions of neutral fiscal policy to determine their contribution to stabilising the economy. I find the standard deviation of GDP could be up to 29% higher in a world without automatic stabilisers. Plausible gains from strengthening automatic stabilisers from current settings are likely to be much smaller. Automatic stabilisers play a larger role when monetary policy is constrained by the lower bound on interest rates or the monetary policy response to inflation and output is weak.

## JEL CLASSIFICATION

H6 National Budget, Deficit and Debt  
H30 Fiscal Policies and Behaviour of Economic Agents:  
General  
E37 Forecasting and Simulation: Models and Applications  
E62 Fiscal Policy

## KEYWORDS

automatic fiscal stabilisers; macro-simulation;  
counter-factual policy simulation;

# Executive Summary

Automatic stabilisers are fiscal policy's first line of defence against adverse economic shocks. Automatic stabilisers capture fiscal policy's automatic countercyclical response to the business cycle, and are determined by factors like the progressivity of the tax system, the size of government and the quantity of transfer payments that are dependent on recipients' economic circumstances. Built into tax codes and the fiscal framework, automatic stabilisers do not require legislative action each time they are implemented. Their timely, temporary and often targeted response means they are preferred by some over countercyclical discretionary fiscal policy, which can be subject to political considerations and implementation lags, resulting in fiscal support that may not arrive where it is needed, when it is needed. Understanding the contribution that automatic stabilisers make to macroeconomic stabilisation and the plausible gains from strengthening them helps improve our understanding of fiscal policy and how it can be used to improve economic outcomes.

Defining what automatic stabilisers are and what they do is key to determining the role they play in macroeconomic stabilisation. There are two main views on what automatic stabilisers are and what they do. Under the first view, automatic stabilisers operate mainly through the progressivity and procyclicality of the tax system and to a lesser extent, the countercyclicality of unemployment benefits. In boom times, wage increases and higher employment expand tax revenues, while lower unemployment reduces unemployment benefit payments. In downturns, workers are less likely to receive wage increases and more likely to lose their jobs, pushing down tax revenue while spending on unemployment benefits increases. Under the second view, automatic stabilisers are mainly driven by the size of government. Government consumption tends to be smooth and relatively acyclical, which is the same for the bulk of transfers spending. Increasing government consumption's share of GDP reduces the volatility of GDP, all else equal, due to a composition effect. Increasing transfer payments reduces the volatility in recipients' after-tax income, reducing the volatility of their consumption and aggregate consumption. The two different views on automatic stabilisers require two definitions of neutral fiscal policy.

In this paper I use an estimated small open economy monetary-fiscal dynamic stochastic general equilibrium (DSGE) model to investigate the contribution made by automatic stabilisers to macroeconomic stabilisation in New Zealand. I carry out macro-simulation exercises where I simulate the model under current policy settings and under two commonly used counterfactual neutral fiscal policy assumptions. Neutral fiscal policy represents a world where automatic stabilisers do not operate. The definition of neutral fiscal policy is determined by the definition of automatic stabilisers. With two definitions of automatic stabilisers, there are two definitions of neutral fiscal policy. I compare the standard deviations of a set of simulated macroeconomic variables under current policy with their counterparts produced under the counterfactual neutral fiscal policies to determine how much more volatile the macroeconomy would be if automatic stabilisers were not operating.

I use the same macro-simulation methodology to determine the potential gains from strengthening automatic stabilisers in New Zealand. More specifically I simulate the model using OECD and European Commission estimates of tax elasticities in the OECD and the euro areas to determine the plausible gains from strengthening automatic stabilisers. The largest elasticities in these regions provide an indication of what the upper bound may be on strengthening automatic stabilisers. I also look at how increasing the share of government consumption and transfer payments, individually and jointly, affects macroeconomic volatility. I calculate the model-implied budgetary semi-elasticity for each of the policies investigated, using the model's parameters. I compare the model implied

budgetary semi-elasticities against OECD and European Commission estimates to gauge the plausibility of the different policies considered. I also look at how increasing the size of government affects macroeconomic stabilisation, and the role that automatic stabilisers play in a low interest rate environment and when monetary policy responds weakly to inflation and output.

I find the standard deviation of GDP would be 16% and 20% higher in a world where automatic stabilisers do not operate, depending on the definition of neutral fiscal policy considered. This increases to 25% and 29% when the effects of automatic stabilisers are isolated from debt stabilisation objectives. The standard deviation of GDP could be 31% larger when interest rates are constrained at the lower bound and automatic stabilisers are not operating. Likewise GDP could be 31% and 42% more volatile in the absence of automatic stabilisers, depending on the definition of neutral fiscal policy, when monetary policy responds weakly to inflation and output. Plausible gains from strengthening automatic stabilisers are likely to be modest at best, in the region of a 4% to 7% reduction in the standard deviation of GDP.

# Contents

<b>Abstract</b> .....	<b>i</b>
<b>Executive Summary</b> .....	<b>ii</b>
<b>1 Introduction</b> .....	<b>1</b>
<b>2 Methodology</b> .....	<b>5</b>
2.1 The Model .....	6
2.2 Automatic Stabilisers, Neutral Fiscal Policy and the Cyclically Adjusted Budget Balance	7
2.3 Fiscal Rules .....	9
2.4 Estimation and Solution Methods .....	13
2.5 Simulation Methodology .....	14
<b>3 Simulation Exercises and Results</b> .....	<b>14</b>
3.1 Simulations With Government Debt .....	17
3.2 Simulations Without Government Debt .....	22
3.3 Monetary Policy .....	29
3.3.1 Low Interest Rate Environment .....	29
3.3.2 Weak Monetary Policy .....	31
<b>4 Conclusion</b> .....	<b>31</b>
<b>A Model Variables and Equations</b> .....	<b>36</b>
A.1 Model Variables .....	36
A.2 Model Equations .....	38
<b>B Data</b> .....	<b>44</b>
<b>C Model Parameterisation</b> .....	<b>46</b>
<b>D Simulation Properties</b> .....	<b>51</b>
<b>E Bootstrapped Residuals</b> .....	<b>55</b>

## List of Tables

Table 1 – Tax Elasticities .....	16
Table 2 – Percentage Change in Volatilities - Simulations with Government Debt .....	18
Table 3 – Relative Steady States .....	19
Table 4 – Percentage Change in Volatilities - Simulations without Government Debt .....	23
Table 5 – Budgetary Semi-Elasticities .....	26
Table 6 – Budgetary Semi-Elasticities: European Commission and OECD Estimates .....	26
Table 7 – Simulations with Low Interest Rates .....	30
Table 8 – Simulations with Weak Monetary Policy .....	30
Table 9 – Model Variables .....	36
Table 10 – Model Data .....	45
Table 11 – Calibrated Parameters .....	46
Table 12 – Great Ratios .....	47
Table 13 – Estimated Parameters .....	48
Table 14 – Estimated Parameters .....	49
Table 15 – Estimated Parameters .....	50
Table 16 – Model vs Data Standard Deviations .....	56
Table 17 – Percentage Change in Volatilities - Simulations with Government Debt .....	57
Table 18 – Percentage Change in Volatilities - Simulations without Government Debt .....	57

## List of Figures

Figure 1 – Budgetary Semi-Elasticities vs Output Gap Volatility .....	28
Figure 2 – Simulations with Government Debt .....	51
Figure 3 – Simulations without Government Debt .....	52
Figure 4 – Simulations in a Low Interest Rate Environment .....	53
Figure 5 – Simulations Under Weak Monetary Policy .....	54
Figure 6 – Budgetary Semi-Elasticities vs Output Gap Volatility .....	58



# Quantifying the Role of Automatic Stabilisers in New Zealand Using a Macro-Simulation Approach

## 1. Introduction

Automatic stabilisers are fiscal policy's first line of defence in economic downturns. Automatic stabilisers capture fiscal policy's automatic countercyclical response to the business cycle, and are determined by factors like the progressivity of the tax system, the average size of government, and the quantity of transfer payments that are dependent on recipients' economic circumstances. Built into the tax code and fiscal system, automatic stabilisers do not require legislative action each time they are deployed. Their timely, temporary and often targeted response is preferred by some over countercyclical discretionary fiscal policy, which, as discussed by Taylor (2000), can be subject to political considerations and implementation lags between the onset of recession and when fiscal support is actually delivered. Quantifying the contribution automatic stabilisers make to macroeconomic stability and the plausible gains from strengthening them improves our understanding of fiscal policy and how it should be implemented to improve economic outcomes.

I use an estimated small open economy, monetary-fiscal, dynamic stochastic general equilibrium (DSGE) model in this paper to carry out a number of macro-simulation exercises that quantify the role of automatic stabilisers in New Zealand, an advanced small open economy. I determine the contribution automatic stabilisers make to macroeconomic stabilisation by comparing the standard deviations of simulated series under current policy settings with their counterparts produced under two commonly used definitions of neutral fiscal policy (a counterfactual where automatic stabilisers are switched off). I use the same macro-simulation methodology, together with OECD and European Commission tax elasticities, to determine the potential and plausible gains from strengthening automatic stabilisers in line with other advanced economies. I find the standard deviation of GDP in New Zealand could be up to 29% higher in a world without automatic stabilisers. Plausible gains from strengthening automatic stabilisers are likely to be smaller, equating to a 7% reduction in the standard deviation of GDP. Automatic stabilisers play a larger stabilisation role when nominal interest rates are constrained at the lower bound and when the monetary policy response to inflation and the output gap is weak.

Using the classification provided by Mohl et al. (2019), research methods used to investigate automatic stabilisers fall into three categories: i) statistical methods, ii) micro-simulation methods, and iii) macro-simulation methods. Statistical methods measure the size of automatic stabilisers by calculating or estimating the elasticity of fiscal variables with respect to the business cycle, usually represented by the output gap. This gives some indication of the proportion of a shock to GDP that is absorbed by fiscal variables, or how much fiscal variables respond to the business cycle. Examples of studies using statistical methods include Ivanova et al. (2009), Price et al. (2015) and Department of Finance (Ireland) (2021). These methods quantify the automatic fiscal response to the business cycle, but not the business cycle's response to automatic stabilisers. As a result, these methods are unable to say anything about how effective automatic stabilisers are in reducing the volatility in GDP and other key macroeconomic aggregates.

Micro-simulation methods are concerned with the static impact of fiscal policy on individuals and households. Automatic stabilisers are calculated as the aggregate pass-through from households' market income to their disposable income following a shock, taking the tax schedules they face and the benefits they receive into account. Tax and transfer payments act to reduce the impact of these shocks by smoothing households' disposable income in relation to their (pre-tax/-transfers) market income. Examples using this methodology include Auerbach & Feenberg (2000) and Dolls et al. (2012). While such analysis enriches our understanding of how automatic stabilisers work at both the household and the aggregate levels, the analysis does not capture behavioural and feedback effects from the shock and the policy response. As a consequence they are unable to say anything about how automatic stabilisers affect households' market income, or the overall reduction in the volatility of key macroeconomic aggregates. Micro-simulation analysis is unable to say anything about the role automatic stabilisers play across the business cycle as they typically only consider a single shock or handful of shocks.

Macro-simulation methods encompass a number of macro modelling approaches that quantify automatic stabilisers' role in moderating the effects of adverse economic shocks. These methods are united by their use of macroeconomic or macroeconometric models that take a simultaneous equations or general equilibrium approach to explaining the relationships between key macroeconomic aggregates. The analysis produced using these methods captures the behavioural responses of economic agents, and incorporates feedback effects, to tell an economy-wide story of the consequences of both current and counterfactual policies. The simulation aspect is broad enough to capture historical counterfactuals (recreating or re-running history under different policy assumptions), scenario analysis (choosing particular sequences of shocks to create a scenario) and stochastic simulation (using the model to produce synthetic data by feeding in long sequences of random shocks).

In an early example using macro-simulation methods, van den Noord (2000) investigates the role automatic stabilisers played in reducing the volatility of GDP in a number of European countries during the 1990s. Using the OECD's INTERLINK model, he carries out counterfactual simulations, re-running history with automatic stabilisers switched off, to determine how much more volatile GDP would have been in their absence. He finds automatic stabilisers contributed to a non-trivial reduction in the volatility of GDP for many of the countries studied. In more recent work, Astarita et al. (2018) use the European Commission's DSGE model, QUEST III, to investigate the role automatic stabilisers play in cushioning the Italian economy in a recession. They create a scenario where output falls due to a combination of supply and demand shocks. Their paper compares the contribution of automatic stabilisers in QUEST III with the European Commission's micro-simulation model, EUROMOD.<sup>1</sup> They find automatic stabilisers contribute to a 5.8% reduction in the fall of GDP. As they mention, these numbers are particularly sensitive to the combination of shocks used to produce the scenario. Using the same model, in 't Veld et al. (2013), find automatic stabilisers reduce the fall in GDP in a global financial crisis (GFC) type scenario (shocks chosen to loosely match stylised responses during the GFC) by 13% and 27% depending on the assumptions made about neutral fiscal policy. The differences in the GDP response between Astarita et al. (2018) and in 't Veld et al. (2013) reflect the different shocks used in the scenarios. In another macro-simulation study, McKay & Reis (2016) investigate the contribution automatic stabilisers make in reducing the volatility of US business cycles using a heterogeneous agent new Keynesian (HANK) DSGE model. In a series of simulations, they calculate the ergodic distributions of key macroeconomic variables, under both current policy settings and a number of counterfactuals where the

<sup>1</sup> The shocks in QUEST III are chosen to make the scenario comparable with the shocks used in EUROMOD.

role of automatic stabilisers is reduced. In particular, they look at the effect of proportional taxes, transfers, and progressive income taxes, on the business cycle, each individually and in combination. Their analysis suggests the reduction in macroeconomic volatility due to automatic stabilisers is small.<sup>2</sup>

Automatic stabilisers and macroeconomic stability are also linked to the average size of government. Galí (1994) and Fatás & Mihov (2001) find a negative relationship between government size (the average ratio of government spending to GDP) and the volatility of GDP, using cross-sectional cross-country data. Debrun et al. (2008) attributes this observed relationship to the presence of liquidity-constrained households that are unable to self-insure against adverse economic outcomes. Government, in comparison, has unrestricted access to capital markets and can borrow to smooth out fluctuations in private agents' income, acting more like an infinitely-lived agent. Fatás & Mihov (2012) explain the link between government size and macroeconomic stability through the budgetary semi-elasticity. The budgetary semi-elasticity is used to remove the effects of automatic stabilisers from the budget balance. Due to the near proportionate relationship between tax revenue and GDP and the acyclicity of government expenditure, the budgetary semi-elasticity will be largely determined by the ratio of government spending to GDP. Government spending tends to be smooth, persistent and acyclical, which means an increase in the steady state government spending to GDP ratio should translate into less volatile GDP by a pure composition effect, all else equal. This is further reinforced by the reduction in the volatility of private consumption that is associated with larger government due to the role transfer payments play. A large share of transfer payments are acyclical, so that an increase in transfer payments to liquidity-constrained households results in smoother after-tax income, which translates into smoother total consumption (see Andres et al. 2008, for example).

Several studies examine the link between the size of government and macroeconomic volatility using structural models. Andres et al. (2008) show increases in the steady state ratio of government spending to GDP in a simple New Keynesian DSGE model leads to less volatile GDP and that rule of thumb consumers are required to match the reduction in the volatility of private consumption associated with larger government. The only source of volatility in the model used by Andres et al. (2008) comes from technology shocks. Collard et al. (2017) use a simple New Keynesian DSGE model to look at the effects of government size (the steady state share ratio of government spending to GDP) on GDP volatility in response to a range of different shocks. They find increasing the size of government reduces the volatility of GDP in response to standard shocks like technology, preference, mark-up and monetary policy shocks, while government expenditure and investment shocks are amplified by increases in the size of government. Collard et al. (2017) also find that the relationship between government size and GDP volatility is not monotone, and beyond some threshold level, increases in government size lead to increases in GDP volatility.

As discussed by in 't Veld et al. (2013), a great deal of the variation between studies looking at automatic stabilisers' contribution to macroeconomic stability can be attributed to the different assumptions made about neutral fiscal policy. This reflects a lack of agreement on what automatic stabilisers are and what they do. As mentioned by in 't Veld et al. (2013), two definitions of automatic stabilisers have dominated the literature. The first definition ties automatic stabilisers to both the response of tax revenues and unemployment benefits to the business cycle. The second definition links automatic

<sup>2</sup> McKay & Reis (2016) report their results as the reduction in the variances of key macroeconomic aggregates. If they reported their results as the reduction in the standard deviation, as is more common, the contribution to the reduction in volatility would be even smaller.

stabilisers to the size of government and government spending, which is largely acyclical.<sup>3</sup> Studying the effectiveness of automatic stabilisers requires a definition of neutral fiscal policy, which serves as the counterfactual that exists in a world where automatic stabilisers do not operate. Automatic stabilisers are then linked to and defined by neutral fiscal policy. Because of the different views on what automatic stabilisers are, there is *no* unique definition of neutral fiscal policy. in 't Veld et al. (2013) propose two definitions of neutral fiscal policy that correspond to the two definitions of automatic stabilisers. These definitions are i) constant tax revenue and government expenditure across the business cycle, and ii) constant ratios of tax revenue and government expenditure to GDP across the business cycle. Due to the near-proportionate response of tax revenue to the business cycle, the counter cyclical response of some benefits and the largely acyclical response of most government spending, the constant tax revenue and government spending counterfactual emphasises the role taxes and, to a lesser extent, unemployment benefits play in stabilising the economy.<sup>4</sup> The same business cycle properties of tax revenue and government spending mean the constant-ratios counterfactual emphasises the role that the size of government, and, to a lesser extent, the progressivity of the tax system play in stabilising the economy.

Of the studies mentioned, van den Noord (2000) makes the constant tax and spending assumption about neutral fiscal policy, while in 't Veld et al. (2013) investigate automatic stabilisers under both assumptions. McKay & Reis (2016) are a notable outlier, using neither the constant tax and spending assumption or the constant ratios assumption for their neutral fiscal policy counterfactual. Instead they opt for a model with what would be considered reduced automatic stabilisers, when compared with the in 't Veld et al. (2013) counterfactuals. McKay & Reis's (2016) counterfactual neutral fiscal policy assumption embodies automatic stabilisers that still provide substantial stabilisation in comparison to the two more commonly used assumptions about neutral fiscal policy, explaining the much smaller contribution of automatic stabilisers to reducing macroeconomic volatility in their paper.

In this paper I carry out a macro-simulation exercise, using an estimated DSGE model to calculate automatic stabilisers' contribution to the reduction of overall macroeconomic volatility in New Zealand. in 't Veld et al. (2013) and Astarita et al. (2018) focus on automatic stabilisers' contribution to reducing GDP's response to a combination of shocks constructed to look like a recession. In contrast, I focus on the role of automatic stabilisers across the business cycle. This means calculating the moments of simulated data produced by a macroeconomic model under current policy settings and counterfactual policy settings. In this regard, my analysis is similar to McKay & Reis (2016) and van den Noord (2000) who also look at the contribution of policy across the business cycle.

I compare the properties of key macroeconomic aggregates simulated under current policy settings with two neutral fiscal policy settings – constant tax revenue and government spending and constant ratios of tax revenue and government spending to GDP, as discussed in in 't Veld et al. (2013). I use a DSGE model based on Leeper et al. (2011), with unemployment, government investment and local currency pricing, following Galí (2011), Baxter & King (1993) and Adolfson et al. (2007), respectively. I produce simulations with and without government debt. The simulations without government debt isolate the impact of automatic stabilisers in the absence of debt stabilisation objectives.

I apply the same macro-simulation methodology to investigate the potential gains from

<sup>3</sup> in 't Veld et al. (2013) provide a list of the studies that fall under each definition.

<sup>4</sup> Unemployment benefits and other cyclically responsive components of benefit and transfer payments are assumed to be small in comparison to total tax revenue.

strengthening automatic stabilisers in New Zealand. To ensure plausibility, I take the largest output gap elasticities for tax revenue estimated by the OECD (see Price et al. 2015) and the European Commission (see Mourre et al. 2019) across a number of different countries as my upper bound for strengthening automatic stabilisers. These should be indicative of the limits of what is possible both economically and politically. I look at the stabilisation gains from increasing the size of government by increasing the steady state ratio of government consumption to GDP, the steady state ratio of transfer payments to GDP, and a combination of both. I also look at the role automatic stabilisers play in a low interest rate environment and in a weak monetary policy environment.

I find in the absence of automatic stabilisers, the standard deviation of GDP would be 16% and 20% larger than under current policy settings, depending on the measure of neutral fiscal policy used. This increases to 25% and 29% when government debt and debt stabilisation is removed from the model. Increasing the tax revenue elasticities with respect to output to match the largest in the OECD would lead to a 7% reduction in the standard deviation of GDP. Keeping the elasticities at their current levels and increasing the ratio of government consumption to GDP from 15% to 25% reduces the standard deviation of GDP by 6%. Likewise, keeping the elasticities at their current levels and increasing transfer payments as a share of GDP from 9% to 25% reduces the standard deviation of GDP by 12%. A combined increase in government consumption and transfer payments as a share of GDP reduces the standard deviation of GDP by 19%. This increases to 29% when the increase in government size is combined with increased tax elasticities. However, policies that involve increasing the share of transfers lead to more volatile consumption for rule of thumb households and implausibly large budgetary semi-elasticities, indicating they are probably not implementable. Policies that reduce the volatility of GDP by 4% to 7% look more plausible, based on the model-implied budgetary semi-elasticities. In a low interest rate environment, the absence of automatic stabilisers would increase the volatility of GDP by up to 31%, which increases to 35% when only considering the periods when the economy is at the lower bound. In a weak monetary policy environment, the absence of automatic stabilisers would increase volatility by 31% and 42%, depending on the measure of neutral fiscal policy used.

The analysis in this paper complements earlier work by Bernstein et al. (2021), who investigate the role of automatic stabilisers in New Zealand using a combination of micro-simulation and statistical methods.<sup>5</sup> Using TAWA, the New Zealand Treasury's micro-simulation model, they find current tax and fiscal policy settings lead to an average income stabilisation coefficient in New Zealand of 33%. This means that a 1% change in market income is moderated by taxes and transfers and leads to only a 0.67% change in disposable income. They also investigate the potential avenues for strengthening automatic stabilisers and reach the same conclusion, that large changes would need to be made to the tax and welfare system to make a significant difference to macroeconomic stabilisation.

The remainder of the paper is structured as follows. Section 2 describes the model, fiscal rules and automatic stabilisers, data, estimation, and the solution and the simulation methodologies. Results from the simulations are presented in Section 3, while Section 4 concludes.

## 2. Methodology

I describe the methodology for calculating the size and effectiveness of automatic stabilisers in New Zealand in this section. This is done through a series of simulation exercises

<sup>5</sup> A final version of this working paper is forthcoming.

using a small open economy DSGE model with a fully fledged fiscal block, parameterised to match New Zealand. The model is simulated under current policy settings, two counterfactual policy settings where automatic stabilisers are switched off (neutral fiscal policy), and under a number of counterfactual policy settings where automatic stabilisers are strengthened. The contribution of automatic stabilisers and the potential gains from strengthening them can be determined by comparing the standard deviations of the simulated series from the different model runs.<sup>6</sup> I start by describing the model, then I define automatic stabilisers and neutral fiscal policy, and how automatic stabilisers are captured through the model's fiscal rules. I finish by describing the data, the estimation and solution methods, and the simulation procedure.

## 2.1 The Model

All analysis in this paper is carried out using a small open economy monetary-fiscal DSGE model based on Leeper et al. (2011). The model is standard in many ways, sharing many features with the benchmark Smets & Wouters (2003) model. It also features a fully fledged fiscal block, with distortionary taxation and government debt. The model has been modified to include unemployment and government investment as specified in Galí (2011) and Baxter & King (1993), respectively. Local currency pricing of imports has also been added, using a similar approach to Adolfson et al. (2007), to better match the relative volatilities of the exchange rate and tradeable inflation.<sup>7</sup> A version of this model has been used by Binning (2024) to look at government consumption multipliers in New Zealand.

The model consists of two types of households, a representative rule of thumb household and a representative Ricardian household. It also consists of a continuum of intermediate goods producers, a continuum of importers, a representative final goods producer, and both fiscal and monetary authorities. The representative Ricardian household supplies labour to intermediate goods producers and receives wages in payment. The Ricardian household can save by either investing in capital or lending to government, and they can borrow from abroad, allowing them to smooth their consumption as dictated by their preferences. The Ricardian household chooses wages, subject to a quadratic adjustment cost on wage changes, to minimise their disutility of working.

Intermediate goods producers, owned by the representative Ricardian household, produce output using both public and private capital, labour, and a common technology. The model allows for increasing returns to scale on public capital to capture the non-rivalrous nature of public goods. Prices on domestically produced and imported goods are chosen by firms to maximise their respective profits, subject to a quadratic adjustment cost on price changes. Interest rates are set by the monetary authority according to a Taylor-type rule in normal times. The fiscal authority buys government consumption goods, installs public capital and redistributes transfers to rule of thumb households.<sup>8</sup> They finance purchases

<sup>6</sup> Many studies that investigate alternative monetary policies use model specific welfare functions as a criteria for ranking policy. Several features of the exercises in this paper complicate welfare analysis. For example government consumption does not appear in the model's utility function. This is important because some of the counterfactual policies shift the relative shares of public and private consumption in the model. If government consumption were added to the utility function, the weighting on private and public consumption would likely drive welfare comparisons. Further assumptions are also required to combine the welfare of the Ricardian and rule of thumb households. I abstract from these complications by focusing on the standard deviation of the simulated series, with a special focus on GDP, as macroeconomic stabilisation policy has tended to focus on output stabilisation as a goal.

<sup>7</sup> The nominal exchange rate cycle is much larger than the tradeable inflation cycle which can be captured in the model by introducing local currency pricing.

<sup>8</sup> The general specification of the model allows for transfers to both the Ricardian and the rule of thumb household. Under the calibration used in this paper, transfer payments are only made to the rule of thumb household. I assume that most transfers are paid to low income, low asset holding households. This assumption serves as an upper bound on transfer payments' impact on the macroeconomy.

and transfers through taxes on capital income, labour income and consumption goods and can borrow from households. Labour tax rates adjust to stabilise government debt around its long-run target. Variations in government spending and taxation are determined by a set of fiscal rules. These rules capture how fiscal policy responds to the business cycle, characterising automatic stabilisers in the model. They will be discussed in more detail in Section 2.3.

The representative rule of thumb household, like the Ricardian household, supplies labour to intermediate goods producers and receives wages as payment. They receive lump-sum transfers from government, pay taxes on consumption and their labour income and consume all their after tax income and transfers. The rule of thumb household proxies for poorer households that have little in assets or wealth, are unable to save, and lack the ability to borrow to smooth their consumption and insulate themselves from economic shocks. The addition of a rule of thumb household adds an extra dimension for breaking Ricardian equivalence and they provide a direct shortcut for capturing Keynesian behaviour. As Andres et al. (2008) and Debrun et al. (2008) highlight, rule of thumb consumers are a crucial for understanding the role automatic stabilisers play in macroeconomic stabilisation.

Some of the simulations are produced using a model without government debt. In the no-debt model, the steady state levels of tax revenue and government expenditure are the same as the version of the model with government debt, and labour tax revenue only responds to the output gap (and not to government debt which is now absent). The difference between tax revenue and government spending, which would usually be used to service debt or would change the level of government debt, is now a lump-sum transfer/tax to the Ricardian household. This is observationally equivalent to retaining government debt in the model and having net lump sum transfers/taxes to the Ricardian household adjust in response to deviations of government debt from target, due to Ricardian equivalence holding along this dimension of the model. More details about this model and the specifics of fiscal policy are discussed in Section 2.3.

A list of the model equations can be found in Appendix A, with their full derivation provided in the online technical appendix to Binning (2024).

## 2.2 Automatic Stabilisers, Neutral Fiscal Policy and the Cyclically Adjusted Budget Balance

Defining what automatic stabilisers are is a key part of determining the contribution they make to macroeconomic stabilisation. Neutral fiscal policy, a hypothetical world where automatic stabilisers do not operate, is determined by the definition of automatic stabilisers. Comparing simulations produced using both current policy and neutral fiscal policy settings determines the contribution current automatic stabilisers make in reducing macroeconomic volatility.

In broad terms, automatic stabilisers measure the change in the budget resulting from a change in economic activity. As noted in in 't Veld et al. (2013), the literature has taken two distinct views on what automatic stabilisers are and the channels through which they work. Under the first view, automatic stabilisers are said to operate mainly through the tax and transfers system. This is primarily driven by the strong procyclical variation in tax revenue. Progressivity in personal income tax rates mean workers climb into higher tax brackets in boom times as their wages increase. When combined with higher employment and increased hours worked, labour tax revenues rise. During downturns workers incomes may stagnate and even fall in real terms. Some workers may lose their jobs and be forced to take lower-paid work or become unemployed, all contributing to a lower tax

take. Corporate income tax revenues can also vary procyclically as a proportion of the tax base due to accelerated capital allowances, depreciation allowances, interest expensing and other accounting practices. Although, it is typically a smaller overall component of the transfers system, unemployment benefits are notably counter cyclical, increasing in recessions as more people become unemployed and decreasing in economic booms as labour demand increases.

Under the second view it is mainly the size of government that plays a stabilising role on the economy. Government consumption spending tends to be acyclical and quite smooth in comparison with other GDP expenditure components. Through a pure compositional effect, increasing government consumption's share of GDP should reduce the overall volatility of GDP, all else equal. Furthermore, recipient numbers for a large component of transfer payments are independent of economic conditions. While transfer payments may be indexed to wage or CPI inflation, these adjustments tend to be made annually using annual inflation rates, reducing any countercyclicality. These factors mean a large proportion of total transfers spending is also acyclical and relatively smooth. For many recipients, transfer payments represent a large proportion of their income, if not their only source of income. An increase in acyclical transfer payments to liquidity-constrained households is likely to lead to a reduction in the volatility of their net after tax income and a reduction in the volatility of their consumption, contributing to a reduction in the volatility of total private consumption.

Because of the different views on what automatic stabilisers are, no single definition of neutral fiscal policy exists. Macroeconomic modelling studies that assess the role of automatic stabilisers, typically make one of two modelling assumptions when defining neutral fiscal policy: i) constant tax revenue and government spending across the business cycle, and ii) constant tax revenue and government spending to GDP across the business cycle.<sup>9</sup> The constant tax revenue and government spending assumption (i) emphasises the role taxes and the unemployment benefit play in stabilising the economy, as these highly cyclical (procyclical in the case of tax revenues and countercyclical in the case of unemployment benefits) elements of fiscal policy will be measured against an acyclical neutral fiscal policy baseline. The constant ratios assumption (ii) emphasises the role the size of government plays in stabilisation policy as the contribution of the relatively smooth (acyclical) government consumption spending and transfer payments are measured against a highly procyclical neutral fiscal policy baseline.<sup>10</sup>

Following in 't Veld et al. (2013), these neutral fiscal policy assumptions can also be motivated through the sensitivity of the budget balance to the business cycle, as captured by the cyclically adjusted budget balance (CAB). The CAB, originally suggested by Blanchard (1990), is used by many fiscal policy agencies to look at the cyclically adjusted stance of fiscal policy. The CAB adjusts the budget balance for the effects of the economic cycle in order to obtain a better measure of the government's structural budget position. Automatic stabilisers are a key component in the calculation of the CAB. Mourre et al. (2013), define the CAB as follows,

$$CAB_t = \left( \frac{T_t - G_t}{Y_t} \right) - \varepsilon_E \left( \frac{Y_t - \bar{Y}_t}{\bar{Y}_t} \right), \quad (1)$$

where  $T_t$  is total tax revenue,  $G_t$  is total government spending, including government investment and transfer payments,  $Y_t$  is GDP,  $\frac{T_t - G_t}{Y_t}$  is the budget balance to GDP ratio,

<sup>9</sup> McKay & Reis (2016) is an exception. Their implied neutral fiscal policy is just an economy with weaker automatic stabilisers, based on the definitions of neutral fiscal policy used in this paper and in 't Veld et al. (2013).

<sup>10</sup> Note that both government spending and taxation are procyclical under this definition of neutral fiscal policy.



$\frac{Y_t - \bar{Y}_t}{\bar{Y}_t}$  is the output gap,  $\bar{Y}_t$  is trend GDP and  $\varepsilon_E$  is a reduced form parameter that measures the strength of the fiscal response to the business cycle or the strength of the automatic stabilisers, where  $E = B, S$ . The combined term,  $\varepsilon_E \left( \frac{Y_t - \bar{Y}_t}{\bar{Y}_t} \right)$ , represents the effects of automatic stabilisers on the budget balance. Two definitions of  $\varepsilon_E$  have typically been used in the calculation of the CAB.

Most institutions that calculate the CAB use the budgetary semi-elasticity, which is defined as follows,

$$\varepsilon_B = (\psi_T - 1) \frac{T}{Y} - (\psi_G - 1) \frac{G}{Y}, \quad (2)$$

where  $\psi_T$  and  $\psi_G$  are the elasticities of government spending and tax revenue with respect to output. Annex II in Mourre et al. (2019) contains a mathematical derivation of the budgetary semi-elasticity. Neutral fiscal policy is consistent with a budgetary semi-elasticity equal to zero, as this would suggest that no cyclical adjustment needs to be made to the budget balance as automatic stabilisers are not operating. This can be achieved by designing fiscal policy such that  $\psi_T = \psi_G = 1$ , which implies a neutral fiscal policy with a constant ratio of tax revenue and government spending to GDP across the business cycle.

Prior to 2013, the European Commission used the budgetary sensitivity when calculating the CAB (see Mourre et al. 2013, for a discussion about the European Commission's adoption of the budgetary semi-elasticity in their CAB calculations). Directorate-General for Economic and Financial Affairs (2006) explains the rationale behind the budgetary sensitivity. The budgetary sensitivity is defined as follows,

$$\varepsilon_S = \psi_T \frac{T}{Y} - \psi_G \frac{G}{Y}. \quad (3)$$

Neutral fiscal policy can be achieved by designing fiscal policy so that  $\psi_T = \psi_G = 0$ , which is consistent with the constant levels definition (i) of neutral fiscal policy, since it implies neither revenue nor expenditure change with the output gap.

## 2.3 Fiscal Rules

Automatic stabilisers are captured in the model through a series of fiscal rules. The fiscal rules characterise, in a reduced form way, how taxes and government expenditure respond to the business cycle and government debt for given fixed policy settings.

The government spending rules I use are standard, with government consumption ( $G_t$ ), government investment ( $G_{I,t}$ ) and transfers spending ( $Z_{N,t}$ ) responding solely to the output gap as follows,

$$G_t = G \left( \frac{Y_t}{Y} \right)^{-\varphi_G} \exp(u_{G,t}), \quad (4)$$

$$G_{I,t} = G_I \left( \frac{Y_t}{Y} \right)^{-\varphi_{G_I}} \exp(u_{G_I,t}), \quad (5)$$

$$Z_{N,t} = Z_N \left( \frac{Y_t}{Y} \right)^{-\varphi_{Z_N}} \exp(u_{Z_N,t}), \quad (6)$$

where  $Y_t$  is output,  $\varphi_j$  is the elasticity of spending with respect to output and  $u_{j,t}$  are shock processes that evolve according to,

$$u_{j,t} = \rho_{u_j} u_{j,t-1} + \varepsilon_{u_j,t}, \quad (7)$$

for  $j = G, G_I, Z_N$ .

The tax rules I use in this paper are not standard. Typically rules for capital, labour and consumption tax are defined in terms of tax rates, which respond to the output and government debt gaps (see Leeper et al. 2010, for example). For the purposes of this paper, I define tax *revenue* rules for capital, labour and consumption taxes, with labour tax revenue responding to both the output gap, to capture automatic stabilisers, and the government debt gap, to ensure dynamic equilibrium.

For  $j = C, K, \ell$ , the tax revenue rules are specified as follows,

$$T_{j,t} = T_j \left( \frac{Y_t}{Y} \right)^{\varphi_j} \left( \frac{B_{t-1}}{B + \rho} \right)^{\gamma_j} \exp(u_{j,t}), \quad (8)$$

for real consumption tax revenue,  $T_{C,t} = \tau_{C,t} C_t$ , real capital tax revenue,  $T_{K,t} = \tau_{K,t} R_{K,t} v_t \bar{K}_{t-1}$  and real labour tax revenue,  $T_{\ell,t} = \tau_{\ell,t} \tilde{W}_t \ell_t$ , where  $C_t$  is aggregate real consumption,  $R_{K,t}$  is the rental rate on capital,  $v_t$  is the utilisation rate,  $\bar{K}_{t-1}$  is last period's capital stock,  $\tilde{W}_t$  is the real wage and  $\ell_t$  is the labour input, and  $\tau_{C,t}$ ,  $\tau_{K,t}$  and  $\tau_{\ell,t}$  are the average tax rates on consumption, capital income and labour income.  $B_{t-1}$  is last period's debt and  $u_{j,t}$  is a shock process that follows,

$$u_{j,t} = \rho_{u_j} u_{j,t-1} + \varepsilon_{u_j,t}, \quad (9)$$

for  $j = C, K, \ell$ . The parameter  $\rho$  allows the switching between a model with government debt and one without, which I will discuss later in this section.  $\varphi_j$  is the elasticity of tax revenue with respect to output and  $\gamma_j$  is the elasticity of tax revenue with respect to government debt. In the baseline model I assume that labour tax revenues are the only fiscal instrument to adjust to stabilise debt.

Alternatively, the tax revenue rules could be rewritten as tax rate rules as follows,

$$\tau_{C,t} = \tau_C \left( \frac{C_t}{C} \right)^{-1} \left( \frac{Y_t}{Y} \right)^{\psi_C} \exp(u_{C,t}), \quad (10)$$

$$\tau_{K,t} = \tau_K \left( \frac{R_{K,t} v_t \bar{K}_{t-1}}{R_K v \bar{K}} \right)^{-1} \left( \frac{Y_t}{Y} \right)^{\psi_K} \exp(u_{K,t}), \quad (11)$$

$$\tau_{\ell,t} = \tau_\ell \left( \frac{\tilde{W}_t \ell_t}{\tilde{W} \ell} \right)^{-1} \left( \frac{Y_t}{Y} \right)^{\varphi_\ell} \left( \frac{B_{t-1}}{B + \rho} \right)^{\gamma_\ell} \exp(u_{\ell,t}). \quad (12)$$

These tax rate rules are observationally equivalent to the tax revenue rules and lead to the same behaviour of tax revenue variables in response to the output and debt gaps.

Using tax revenue rules in place of tax rate rules has two main advantages. First, the elasticities in the tax revenue rules should be comparable with the tax elasticities commonly used in the calculation of the CAB, discussed earlier in this section.<sup>11</sup> The tax elasticities used in the CAB calculations are constructed using a country's tax code, which means that discretionary and structural changes are removed from the cyclical component. Using tax codes avoids the use of econometric tools, which may not be able to distinguish between automatic responses built into the tax and welfare system and discretionary responses that are correlated with the business cycle. The tax elasticities produced by the OECD and the European Commission for a large number of developed countries also give an indication

<sup>11</sup> While I estimate  $\varphi_C$ ,  $\varphi_K$  and  $\varphi_\ell$  in the baseline model, these parameters should be comparable with the elasticities of indirect taxes, corporate income taxes and personal income taxes to the output gap respectively, which are estimated for OECD countries by Price et al. (2015) and for euro area countries by Mourre et al. (2019). While indirect and personal income taxes should closely match consumption and labour income taxes in the model, there will be some discrepancy between corporate income taxes and capital income taxes in the model. This is because the definition of capital income taxes encapsulates other sources of capital income, in addition to corporate income, although corporate income is by far the largest component.

of the maximum feasible tax elasticities, which is useful for gauging the further gains that could be made from strengthening automatic stabilisers in New Zealand.<sup>12,13</sup> For the purposes of this paper, I assume that OECD and European Commission tax elasticities are independent of government size, so that the policies that determine the elasticities do not depend on the size of government.<sup>14</sup>

Second, the tax revenue and government spending rules nest the two common counterfactual neutral fiscal policy assumptions discussed earlier in this section. Under the constant tax and government spending counterfactual, tax revenue and government spending are held constant so that they are invariant to the business cycle as measured by the output gap. This is achieved by setting the output gap elasticity to zero in the tax revenue and government spending rules as follows,

$$T_{\ell,t} = T_{\ell} \left( \frac{B_{t-1}}{B} \right)^{\gamma_{\ell}} \text{ or } T_{\ell,t} = T_{\ell}, \quad (13)$$

$$T_{j,t} = T_j, \quad (14)$$

for  $j = C, K$

$$G_t = G, \quad (15)$$

$$G_{I,t} = G_I, \quad (16)$$

$$Z_t = Z. \quad (17)$$

Because tax revenues tend to move proportionately with GDP, the tax rules in the model imply the countercyclical adjustment of individual tax rates to ensure tax revenues remain constant across the business cycle. When comparing current policy settings with this definition of neutral fiscal policy, most of the stabilisation will occur on the tax side with a smaller contribution made through unemployment benefits, due to their smaller share of government spending.

Under the constant-ratio assumption, tax revenue and government expenditure are assumed to remain constant as a share of GDP across the business cycle. This is achieved by setting the output gap elasticity to 1 in the tax revenue rules and -1 in the spending rules as follows,

$$\frac{T_{\ell,t}}{Y_t} = \frac{T_{\ell}}{Y} \left( \frac{B_{t-1}}{B} \right)^{\gamma_{\ell}} \text{ or } \frac{T_{\ell,t}}{Y_t} = \frac{T_{\ell}}{Y}, \quad (18)$$

$$\frac{T_{j,t}}{Y_t} = \frac{T_j}{Y}, \quad (19)$$

for  $j = C, K$

$$\frac{G_t}{Y_t} = \frac{G}{Y}, \quad (20)$$

$$\frac{G_{I,t}}{Y_t} = \frac{G_I}{Y}, \quad (21)$$

$$\frac{Z_t}{Y_t} = \frac{Z}{Y}. \quad (22)$$

<sup>12</sup> The feasible set of tax elasticities will be constrained by both the structure of the economy and political considerations. Looking at other countries' elasticities gives some indication of the extent to which they could feasibly be strengthened. However, the DSGE model remains silent on how this could be achieved and in practise this would require a careful study of the country in question's tax and welfare systems and related policies, to understand what determines their reduced form elasticities.

<sup>13</sup> Masten & Grdović Gnip (2016) find the CAB does a poor job at identifying the structural stance of simulated data from a monetary-fiscal DSGE model, where the true fiscal stance is known. However, the fiscal rules they use differ from those implied by the CAB framework. The performance of the CAB in this exercise could be improved by using tax revenue and spending rules, like the ones used in this paper.

<sup>14</sup> This may or may not be a reasonable assumption, but it does simplify the analysis.

This implies adjusting tax rates in the model so that tax revenues remain a constant share of GDP across the business cycle. Government expenditure is also adjusted to ensure it remains a constant share across the business cycle. When comparing current policy settings with this counterfactual, most of the stabilisation occurs on the expenditure side, as government expenditure tends to be acyclical, contributing to smoother GDP.

I set the model up to allow for the possibility of running simulations with and without government debt. This allows the study of counterfactuals where tax revenue and government spending respond solely to the the output gap, allowing the contribution of automatic stabilisers to be isolated from debt stabilisation effects. Debt stabilisation can work against the automatic stabilisers as debt tends to rise in recessions, which may trigger a tax increase or spending cut, when government policy follows the simple fiscal rules used in this model. The labour tax revenue response to government debt also increases with the size of government, as steady state labour tax revenue is assumed to increase to pay for higher government spending, which works against the stabilising properties of a larger government.<sup>15</sup> While it is possible to adjust the elasticity of tax revenue with respect to GDP to take into account changes in the size of government, any adjustments would only be locally correct in a non-linear model.

As mentioned earlier in this section when discussing equation (8), I introduce a parameter,  $\varrho$ , that switches government debt on ( $\varrho = 0$ ) and off ( $\varrho = 1$ ) in the model. Under the current calibration of the model, tax revenues need to exceed government expenditure in the steady state in order to cover debt servicing costs. To maintain the same steady state calibration in a model without debt, I introduce a lump-sum transfer to the Ricardian household to ensure that the budget is balanced in all periods. This is observationally equivalent to keeping government debt in the model and having transfers to the Ricardian household adjust solely in response to deviations of government debt from its target, which I discuss at the end of this section.

I augment the model with the condition,

$$\varrho B_t + (1 - \varrho) Z_{R,t} = 0, \quad (23)$$

where  $Z_{R,t}$  is a transfer to Ricardian households. When  $\varrho = 0$ , this transfer will always be set equal to zero and government debt will be positive. When  $\varrho = 1$ , government debt is equal to zero and the transfer payment to the Ricardian household is set according to,

$$Z_{R,t} = \tau_{K,t} R_{K,t} v_t \bar{K}_{t-1} + \tau_{\ell,t} \tilde{W}_t \ell_t + \tau_{C,t} C_t - \tilde{P}_{G,t} G_t - \tilde{P}_{G_I,t} G_{I,t} - Z_t - \Gamma_t. \quad (24)$$

In steady state the transfer payment to the Ricardian household is set according to,

$$Z_{R,t} = -\varrho \frac{B}{Y} Y_t \left( 1 - \frac{R_t}{\pi_t} \right), \quad (25)$$

where  $\frac{B}{Y}$  is the steady state debt to GDP target that is chosen when debt is in the model. Choosing the transfer payment to Ricardian households in this way means the steady state values for the other fiscal variables do not have to change, making the simulations with and without debt comparable.<sup>16</sup>

This is observationally equivalent to a model with government debt, where transfers to the Ricardian household adjust solely to stabilise government debt. In this case the government

<sup>15</sup> This is discussed in more detail in Section 3.

<sup>16</sup> Setting  $Z_{R,t}$  equal to zero in the steady state would require adjusting at least one other fiscal variable, which would add an extra dimension along which the models would differ, making comparisons slightly more difficult.

budget constraint is given by,

$$B_t + \tau_{K,t} R_{K,t} v_t \bar{K}_{t-1} + \tau_{\ell,t} \tilde{W}_t \ell_t + \tau_{C,t} C_t = \frac{R_{t-1}}{\pi_t} B_{t-1} + \tilde{P}_{G,t} G_t + \tilde{P}_{G_I,t} G_{I,t} + \tau_{S,t} \tilde{W}_t \ell_t + Z_t + Z_{R,t} + \Gamma_t, \quad (26)$$

where  $Z_R = 0$  in the steady state and  $Z_{R,t}$  could be determined by the following rule,

$$Z_{R,t} = \left( \frac{B_{t-1}}{B} \right)^{-\gamma Z_R} - 1. \quad (27)$$

## 2.4 Estimation and Solution Methods

I use the model with government debt as my baseline and find its parameters through a combination of estimation and calibration. The estimated parameters are determined using Bayesian methods on data spanning the 1994Q1 to 2019Q4 period. I avoid using data before 1994, because inflation was much higher in the late 1980s and early 1990s, and there were significant policy changes that occurred in the years leading up to 1994, suggesting data before 1994 were generated under a different policy regime. The sample finishes in 2019 to avoid the unprecedented circumstances of the COVID pandemic and its aftermath. I estimate the model using 19 quarterly macroeconomic time series as observable variables. These are real GDP, consumption, investment, government consumption, government investment, exports, interest rates, CPI inflation, wage inflation, the change in the nominal exchange rate, the unemployment rate, transfer payments, labour tax revenue, capital tax revenue, consumption tax revenue, government debt to GDP, foreign GDP, foreign interest rates, and foreign inflation. All levels/log levels variables are Hodrick Prescott filtered, while all inflation rates are de-measured and the foreign interest rate is linearly detrended. A full description of the data used in the estimation can be found in Table 10 in Appendix B.

For the purposes of this paper, I only find parameters at the Posterior mode, which are used in the simulation, I do not sample from the posterior distribution.<sup>17</sup> I calibrate a subset of parameters that are more difficult to estimate, that only affect the model's steady state. The estimated parameters along with their respective priors can be found in Tables 13, 14 and 15, in Appendix C. The calibrated parameters can be found in Table 11 and the great ratios I match as part of the calibration can be found in Table 12, both in Appendix C. Some the parameter estimates are close to their prior means.<sup>18</sup> This could indicate the parameters are not well identified. I leave the investigation of identification for future work.

The model is linearised for estimation purposes, which allows the calculation of the likelihood function using the Kalman filter. I solve the linearised model using an efficient implementation of Chris Sims' GENSYS algorithm developed by Lee & Park (2020), which speeds up estimation. I calculate the role of automatic stabilisers and the gains from strengthening them through a number of simulation exercises. I solve and simulate the model using the extended path algorithm, which is a non-linear solution method that allows the lower bound constraint on the nominal interest rates to be imposed on the simulations. The lower bound constraint implies discontinuities and asymmetries that can only be handled using a non-linear solution method. Non-linear solution methods are also better

<sup>17</sup> I minimise the negative log posterior using the Beegate algorithm in the RISE toolbox, which is a global optimisation routine.

<sup>18</sup> All the parameters differ from their prior means by at least a small amount except for  $\rho_{A_L}$  which has exactly the same value as the prior mean. The corresponding shock standard deviation is estimated to be 0.00001, indicating this shock is not particularly important. The prior I use on the shock standard deviations is designed to push the standard deviation of unimportant shocks towards zero. I estimate the model with 19 observables and 20 shocks so this will not create a stochastic singularity.

able to capture the movements in stock variables like government debt. I use the efficient extended path solution and simulation codes developed by Binning (2022) to solve and simulate the model.

## 2.5 Simulation Methodology

I determine automatic stabilisers' contribution to macroeconomic stability in New Zealand through a series of simulation exercises. Using the extended path algorithm, I create simulations by feeding sequences of random shocks into the model and calculating paths for the macroeconomic variables. I simulate the model under current policy settings and under a number of counterfactual policy settings, using the same sequence of shocks for each simulation. The policy shocks, the public debt shock and the labour elasticity of substitution shock are all switched off for the simulations. The absence of the policy and public debt shocks means policy is determined solely by the fiscal and monetary rules. The labour substitution shock was switched off because it requires substantially more iterations to solve using the extended path algorithm and increases the possibility of finding shock sequences where the model cannot be solved.<sup>19</sup> The model is simulated for 10,500 periods for each policy setting, where the first 500 periods are discarded (burned) to eliminate the effects of the initial condition on the simulated series, to create simulations that are 10,000 periods long. I calculate the contribution of automatic stabilisers and the gains from strengthening them, by comparing the standard deviation of key macroeconomic variables from the counterfactual simulations against the standard deviation of the simulated series under current policy settings. I report the cumulative relative standard deviations for a subset of the reporting variables in Appendix D. These illustrate the convergence of the relative standard deviations as the sample size is increased.

The standard deviations of some of the simulated series from the baseline model produced using independent and identically distributed shocks, drawn from a normal distribution, are quite different from their observed counterparts in the data, as illustrated in Table 16. This is not an uncommon feature of DSGE models that have been estimated using likelihood methods, which don't specifically match first and second data moments.<sup>20</sup> While the data moments are produced using a short sample (104 periods) meaning they could deviate substantially from the population moments, the deviations from the data sample moments may raise questions about the results. To address this issue, I produce a set of simulations using "bootstrapped" shocks (the bootstrapping procedure is discussed in Appendix E), that is more closely able to match some of the data standard deviations. The results for these simulations are presented in Appendix E for comparison and will be discussed in relation to the simulations produced using normally distributed shocks in the next section. Table 16 presents some simulated moments using normally distributed shocks and bootstrapped shocks against their counterparts in the data.

## 3. Simulation Exercises and Results

In this section I present the results from the simulation exercises which I use to determine automatic stabilisers' contribution to macroeconomic stabilisation in New Zealand. I create a baseline by simulating the model under current policy settings. This serves as my

<sup>19</sup> While this issue with the labour substitution shock could be handled by discarding shocks for which the model cannot be solved, doing so creates issues when trying to ensure comparability across model simulations. Shocks occurring in different periods may cause problems for different policy settings, making it harder to find a sequence of random shocks that work for all policy settings. This difficulty is compounded by the time taken to complete the simulations due to the the simulation length.

<sup>20</sup> See for example Warne et al. (2008) where the standard deviation of GDP and consumption are nearly two times larger in the model than they are in the data, and the standard deviation of investment is more than two times larger in the model, than in the data.

reference point when investigating counterfactual policies. I run two counterfactual simulations, each representing an alternative assumption about an economy without automatic stabilisers. The first counterfactual assumes that government expenditure and tax revenue are held constant throughout the simulation. The second counterfactual assumes that the ratios of government expenditure and tax revenue to GDP are held constant throughout the simulation. I then compare the standard deviations of key macroeconomic variables against the baseline to determine how much more volatile these variables would be in the absence of automatic stabilisers. I carry out additional simulations to look at how the stabilisation properties of the economy are strengthened with more elastic tax revenue responses and larger government. These simulations include:

- Setting tax elasticities to the OECD estimates for New Zealand. These elasticities are calculated by the OECD using the tax code so should eliminate any discretionary changes in tax revenues that might be captured in the estimated model.
- Setting tax elasticities to the largest elasticities in the OECD, as estimated by the OECD. These should provide an upper bound on what is feasible when it comes to increasing spending and tax revenue elasticities.<sup>21</sup>
- Setting tax elasticities to the largest elasticities in the euro area, as estimated by the European Commission. These elasticities should provide an upper bound on what is feasible when it comes to increasing spending and tax revenue elasticities.
- Increasing government consumption from 15% of steady state GDP to 25% of steady state GDP. This should provide some understanding to how increasing the size of government consumption could strengthen automatic stabilisers in New Zealand.
- A scenario the same as the previous scenario (government consumption is increased from 15% of steady state GDP to 25% of steady state GDP), but the increase in the size of government is financed by a non-distortionary lump-sum tax on the Ricardian household.
- Increasing transfer payments from 9% of steady state GDP to 25% of steady state GDP. This should provide some understanding for how increasing the size of transfer payments could contribute to strengthening automatic stabilisers in New Zealand.
- Increasing both government consumption and transfer payments to 25% of steady state GDP (this increases the total size of government from 29% of steady state GDP to 55% of steady state GDP). This scenario gives some indication of what a combined increase would mean.
- Increasing both government consumption and transfer payments to 25% of steady state GDP and setting tax elasticities to the largest elasticities in the OECD, as estimated by the OECD.

The increase in government size has been chosen to loosely match the upper bound across OECD countries. France has the largest government in the OECD as a share of GDP. The government consumption to GDP ratio in France has averaged 23% over the 1980 to 2023 period. In line with these numbers, I increase government consumption from 15% of GDP to 25% of GDP.<sup>22</sup> In the last decade the upper bound on cash transfers to GDP

<sup>21</sup> While automatic stabilisers can almost certainly be strengthened in New Zealand, there will be limits as to what is possible, depending on political and economic constraints. Looking at the upper bound of what other developed countries are able to achieve should give some indication of what might be feasible in New Zealand.

<sup>22</sup> These numbers are purely illustrative and I make no suggestions about the likely composition of this additional government consumption.

in the OECD has been about 20% of GDP. In the modelling exercises, I increase transfer payments from 9% to 25% of GDP, which is a bit larger than the OECD upper bound. In the model with government debt, I keep the steady state debt to GDP ratio constant and assume that the tax rate on labour income increases to finance the increase in the size of government. I make the same assumption for the model without government debt, assuming that the ratio of transfers to Ricardian households to GDP remains constant.

Increasing the size of government by increasing government consumption and the tax rate of labour income impacts the economy's stabilisation properties by affecting both the composition of aggregate demand and by increasing the labour tax response to the business cycle. To isolate the impact of an increase in government consumption from changes in distortionary taxation, I include a scenario where the steady state increase in government consumption is funded through an increase in non-distortionary lump-sum taxation on the Ricardian household. This also results in a non-trivial change in the size of GDP, which has implications for the absolute volatility of GDP. I discuss this further later in this section.

I present the OECD's estimates of New Zealand tax elasticities, along with the DSGE estimates for New Zealand and the largest tax elasticities across countries calculated by both the OECD and the European Commission in Table 1. These are the elasticities I use in the simulation exercises.

**Table 1 – Tax Elasticities**

	PIT/Labour Tax	CIT/Capital Tax	Indirect/Consumption Tax
DSGE Estimates for NZ	1.62	2.86	0.90
OECD Estimates for NZ	1.23	2.38	1.22
OECD Maximum Values	2.64 (KOR)	3.70 (DEN)	1.41 (ESP)
European Commission Maximum Values	2.37 (NLD)	3.92 (GBR)	1.10 (ITA)

PIT = Personal income tax, CIT = Corporate income tax.

KOR = South Korea, DEN = Denmark, ESP = Spain, NLD = Netherlands, GBR = United Kingdom, ITA = Italy.

The DSGE estimates for New Zealand are not too different from the OECD's estimates for New Zealand. The estimated labour and capital tax elasticities from the DSGE model are higher than the personal and corporate income tax elasticities calculated by the OECD, but not hugely different. The estimated DSGE consumption tax elasticity is a bit lower than the OECD's estimate for indirect taxes for New Zealand. Denmark and the UK have the highest corporate income tax elasticities as calculated by the OECD and European Commission. South Korea and the Netherlands have the largest personal income tax elasticities. New Zealand tax data is calculated on an accrual basis. While most OECD countries have now transitioned to recording fiscal activity using accrual accounting, tax data for earlier periods may be calculated on a cash basis. This means the OECD estimates for some countries may reflect a spliced approach to data construction.<sup>23</sup>

While I estimate the response of government consumption and government investment to the output gap, these coefficients are set to zero in all the simulations except for the constant-ratio counterfactual, where they are set to -1 to ensure government spending is perfectly procyclical. Transfer payments are also assumed to respond to the business cycle. I set the transfer payments elasticity equal to the estimated value in all simulations except the neutral fiscal policy counterfactuals where it is set to either 0 (constant spending) or -1 (constant spending to GDP ratio).

<sup>23</sup> Price et al. (2015) use OECD tax data for the 1990-2013 period. They do not mention whether their data contains periods where countries used cash accounting. However OECD data descriptions for tax data for some countries over this period would suggest the data has been spliced.



I continue to use the estimated elasticity for transfer payments to the output gap when investigating the gains from strengthening automatic stabilisers. While both the OECD and the European Commission produce estimates of the response of unemployment benefits to the output gap, the model I use does not make the distinction between unemployment benefits and total transfer payments. As a consequence it would take some effort to translate the unemployment benefit elasticities into more general transfers spending elasticities, and these numbers may miss some of the other components of transfers that could also be sensitive to the business cycle. For the purposes of this paper I restrict attention to the gains from increasing the size of the tax elasticities and the size of government.

### **3.1 Simulations With Government Debt**

In the first set of simulations, I include debt in the model and allow labour tax revenue to respond to deviations from target. I then repeat all the simulations without debt in the model. This isolates the impact of automatic stabilisers, from the debt stabilisation response in the fiscal policy rules, which may be working against them.

Results are presented as the relative percentage difference between the counterfactual and the baseline simulation. Relative standard deviations for key macroeconomic aggregates are presented in Table 2 below.

**Table 2 – Percentage Change in Volatilities - Simulations with Government Debt**

Scenario	$Y_t$	$\pi_t^A$	$B_t$	$C_t$	$R_t^A$	$C_{N,t}$	$C_{S,t}$	$I_t$	$\Upsilon_t$	$\log\left(\frac{Y_t}{\bar{Y}}\right)$	$\log\left(\frac{B_t}{\bar{B}}\right)$	$\log\left(\frac{C_t}{\bar{C}}\right)$	$\log\left(\frac{C_{N,t}}{\bar{C}_N}\right)$	$\log\left(\frac{C_{S,t}}{\bar{C}_S}\right)$	$\log\left(\frac{I_t}{\bar{I}}\right)$
Constant Counterfactual	16.03	0.08	-86.68	8.10	0.05	27.39	-2.43	11.45	-0.10	0.73	-27.24	0.42	1.30	-0.17	1.78
Constant-Ratio Counterfactual	19.51	-0.01	-86.35	-3.07	-0.01	44.57	-16.91	3.08	0.43	0.88	-27.14	-0.17	2.10	-1.17	0.49
OECD Elasticities	1.57	0.03	-6.92	-0.53	0.02	-2.75	0.37	2.19	-0.09	0.07	-2.30	-0.03	-0.13	0.03	0.33
Strong OECD Elasticities	-4.70	-0.03	36.96	-1.29	-0.02	0.87	-0.50	-2.42	0.07	-0.21	12.12	-0.07	0.04	-0.03	-0.37
Strong EC Elasticities	-4.37	-0.04	27.24	-0.51	-0.02	2.90	-0.77	-3.33	0.10	-0.20	9.36	-0.03	0.13	-0.05	-0.50
Big Govt. Consumption	1.78	0.07	-19.69	-3.79	0.05	2.24	-6.77	2.90	-0.11	0.08	-6.34	0.74	0.80	0.91	0.26
Big Govt. Consumption*	15.21	-0.02	13.89	1.69	0.02	17.09	-2.80	20.40	-0.18	-0.24	-1.56	0.12	-0.12	0.83	0.24
Big Transfers	4.41	0.15	-1.40	-3.98	0.18	-8.33	2.64	5.15	-0.23	0.24	-1.10	-0.14	-1.61	2.71	0.85
Big GC & Transfers	15.17	0.35	3.30	3.03	0.46	-3.88	7.44	10.09	-0.15	0.79	-1.10	1.35	-1.12	6.76	1.53
Big GC, Transfers & Strong OECD	10.91	0.31	51.55	9.05	0.42	13.09	11.08	4.52	0.46	0.59	10.88	1.76	-0.47	7.35	0.64

Scenario Descriptions:

Constant Counterfactual = constant tax revenue and government spending.

Constant-Ratio Counterfactual = constant ratio of tax revenue and government spending to GDP.

OECD Elasticities = OECD's estimates of New Zealand's tax elasticities.

Strong EC Elasticities = maximum OECD tax elasticities.

Strong EC Elasticities = maximum European Commission tax elasticities.

Big Govt. Consumption = government consumption to GDP set to 25%.

Big Govt. Consumption\* = government consumption to GDP set to 25%, lump sum taxes to Ricardian households increase to finance the increase in government consumption.

Big Transfers = transfers to GDP set to 25%.

Big GC & Transfers = government consumption to GDP set to 25%, transfers to GDP set to 25%.

Big GC, Transfers & Strong OECD = government consumption to GDP set to 25%, transfers to GDP set to 25%, maximum OECD tax elasticities.

Variable Descriptions:

$Y_t$  = GDP.

$\pi_t^A$  = Quarterly gross inflation rate annualised.

$B_t$  = Government debt.

$C_t$  = Private consumption.

$R_t^A$  = Gross nominal interest rate.

$C_{N,t}$  = Rule of thumb consumption.

$C_{S,t}$  = Ricardian consumption.

$I_t$  = Private investment.

$\Upsilon_t$  = Unemployment rate.

Levels variables like GDP ( $Y_t$ ), government debt ( $B_t$ ), consumption ( $C_t$ ), rule of thumb consumption ( $C_{N,t}$ ), Ricardian consumption ( $C_{S,t}$ ) and private investment ( $I_t$ ) are reported as the percentage difference between the counterfactual and the baseline according to,

$$s = 100 \times \left( \frac{\sigma_c}{\sigma_b} - 1 \right),$$

where  $\sigma_c$  is the standard deviation of the variable of interest from the counterfactual simulation and  $\sigma_b$  is the standard deviation for the same variable simulated under current policy settings. Percentage variables like annualised inflation ( $\pi_t^A$ ), the annualised nominal interest rate ( $R_t^A$ ), the unemployment rate ( $\Upsilon_t$ ), the output gap ( $\log\left(\frac{Y_t}{\bar{Y}}\right)$ ), the government debt gap ( $\log\left(\frac{B_t}{\bar{B}}\right)$ ), the consumption gap ( $\log\left(\frac{C_t}{\bar{C}}\right)$ ), the rule of thumb consumption gap ( $\log\left(\frac{C_{N,t}}{\bar{C}_N}\right)$ ), the Ricardian consumption gap ( $\log\left(\frac{C_{S,t}}{\bar{C}_S}\right)$ ), and the investment gap ( $\log\left(\frac{I_t}{\bar{I}}\right)$ ), are reported as the difference between the counterfactual and the baseline according to,

$$s = 100 \times (\sigma_c - \sigma_b).$$

I present both levels and gap variables for output, government debt, consumption, rule of thumb consumption, Ricardian consumption and investment. By presenting both I illustrate the absolute and relative changes in the volatility attributed to these policy changes. This has no impact on the overall results when only fiscal elasticities are changed, and the size of government remains the same. This is because the elasticities do not affect the steady state model. However, this distinction becomes more important when the size of government changes. To make this point I report the steady state values of these variables for each scenario relative to the baseline model in Table 3.

**Table 3 – Relative Steady States**

Scenario	$Y_t$	$B_t$	$C_t$	$C_{N,t}$	$C_{S,t}$	$I_t$
Constant Counterfactual	1.00	1.00	1.00	1.00	1.00	1.00
Constant Ratio Counterfactual	1.00	1.00	1.00	1.00	1.00	1.00
OECD Elasticities	1.00	1.00	1.00	1.00	1.00	1.00
Strong OECD Elasticities	1.00	1.00	1.00	1.00	1.00	1.00
Strong EC Elasticities	1.00	1.00	1.00	1.00	1.00	1.00
Big Govt. Consumption	1.00	1.01	0.84	0.87	0.82	1.01
Big Govt. Consumption*	1.21	1.19	0.99	1.20	0.87	1.18
Big Transfers	0.99	0.99	0.99	1.40	0.75	0.99
Big GC & Transfers	0.99	0.99	0.83	1.27	0.57	1.00
Big GC, Transfers & Strong OECD	0.99	0.99	0.83	1.27	0.57	1.00

As expected the relative steady states are 1 for all variables when only the elasticities are changed and the size of government remains the same. The changes in the tax and spending elasticities do not affect the steady state. When the size of government is increased, the steady states can change. When labour taxes are increased to fund the expansion in government, there is only a 1% reduction in steady state GDP. However, consumption falls relative to the baseline. When the increase in the size of government is funded by lump sum taxes on Ricardian households, the level of GDP increases by more than 20% relative to the baseline. This is because lump sum taxes to Ricardian households are not distortionary and lead to large positive permanent government consumption multipliers (see Baxter & King 1993, for a more detailed discussion of permanent fiscal multipliers financed through lump sum taxation). Changing the level of a variable while keeping the relative volatility fixed changes the absolute volatility. Simulation studies by Andres et al. (2008) and McKay & Reis (2016) report standard deviations and variances

from levels variables, while studies by Galí (1994) and Collard et al. (2017) report standard deviations from gap variables. I report both in this paper for completeness.

I plot the cumulative relative standard deviations (ie the standard deviations relative to the baseline) for a subset of the simulated variables in Figure 1 to check for convergence. These plots illustrate the convergence of the relative standard deviations as the simulation horizon and the sample size increase. The relative standard deviations appear to converge after 2000 periods when the size of government does not change. When the size of government is increased, the relative standard deviations take much longer to converge, with some of the relative standard deviations still moving after 9000 periods, although this movement is quite small. The slower convergence in these simulations is likely to be due to the larger tax response to government debt which introduces more irregular dynamics into the model.

With labour tax revenue stabilising government debt, the standard deviation of GDP would be 16% to 20% higher without automatic stabilisers, depending on which neutral fiscal policy definition current policy settings are measured against. Under the constant government spending and tax revenues counterfactual, private investment and rule of thumb consumption are both more volatile. In the case of rule of thumb consumption, higher volatility occurs because the rule of thumb consumer is one of the largest beneficiaries of automatic stabilisation policy. They cannot smooth consumption by themselves, as they do not own any assets and they are unable to borrow. Holding tax revenues constant requires countercyclical changes in average tax rates. This is particularly destabilising for investment, which is sensitive to changes in the tax rate on capital income.

Shifting from current fiscal policy to the constant ratios counterfactual, would see a larger increase in the volatility of rule of thumb consumption as transfers spending becomes procyclical under this counterfactual, amplifying the boom/bust nature of the business cycle faced by the rule of thumb household. The increase in the volatility of investment is much smaller because the constant ratios counterfactual implies procyclical tax revenue, which is not too different from current policy settings. Ricardian consumption is much less volatile under the constant ratios counterfactual because government consumption is strongly procyclical. This causes Ricardian consumption to be crowded-out in booms and crowded-in during recessions, reducing its overall cyclical nature. Under both neutral fiscal policy counterfactuals, government debt is much less volatile, indicating that much of the current volatility in debt is due to the automatic response of fiscal policy to the business cycle. These results are broadly similar when the simulations are produced using bootstrapped shocks as illustrated in Table 17 in Appendix E.

The differences in the volatility of inflation, nominal interest rates and unemployment between the baseline and neutral counterfactuals are generally smaller by comparison. In the case of inflation, it is comprised of a high frequency component, largely driven by cost push shocks, which drives most of the variation, and a low frequency component, driven by variation in the real marginal cost gap. Changes in fiscal policy affect the dynamics of inflation through the real marginal cost channel, which has a smaller impact on the volatility of inflation. While interest rates respond to the output gap in the model, the relative weighting is small in comparison to the weight placed on inflation. This is further offset by interest rate smoothing, which means the central bank looks through some of the short run volatility in inflation and the output gap when setting interest rates. Following Galí (2011), unemployment is defined as the difference between employment set under monopolistically competitive households, subject to a quadratic adjustment cost on changing nominal wages, and the level of employment that would prevail at that wage rate in the absence of monopolistic competition. Many of the features that affect the

household's chosen level of employment, also affect the hypothetical perfectly competitive level of employment, reducing the overall impact on unemployment. The standard deviation of inflation for the three models with higher steady state transfers spending are a bit larger than the other models. This is primarily due to the increased volatility in the stochastic discount factor coming from more volatile Ricardian consumption and consumption tax rates. Likewise, interest rates are also more volatile for these models.

I re-run the simulations using the OECD's estimated tax elasticities for New Zealand. The OECD's elasticities are calculated through a mix of econometric methods and by inspecting the tax codes for the respective countries. This has the advantage of removing cyclical aspects of discretionary fiscal policy that may contaminate the estimation of the elasticities in the DSGE model. The OECD's elasticities do not differ too much from the estimates in the model. Simulating the model under the OECD's tax elasticities leads to GDP that is slightly more volatile, consumption that is slightly less volatile and investment that slightly more volatile. However, the results are not significantly different from the baseline simulation under current policy.

I run five counterfactual simulations where the size of government is increased, either from an increase in the steady state share of transfers, an increase in the steady state share of government consumption, or both. In all five cases GDP is more volatile than the baseline under current fiscal policy. This runs counter to the empirical results in Fatás & Mihov (2001) and Galí (1994) that support a negative relationship between government size and GDP volatility. Andres et al. (2008) are also able to replicate this result in a simple New Keynesian DSGE model. The discrepancy between the results presented in this paper and Andres et al. (2008) can be explained by how debt is stabilised in each of the models. In Andres et al. (2008) government debt is stabilised through adjustments to transfer payments to both Ricardian and rule of thumb households, where the adjustment parameter is set at a small value. Ratto et al. (2009) make the same assumption in the European Commission's QUEST III model, used by 't Veld et al. (2013) to investigate automatic stabilisers, with only transfer payments gradually adjusting to stabilise government debt.

In contrast, in this model, labour tax revenue responds to deviations of government debt from its target, in addition to the business cycle. Increasing the size of government, which is funded through higher taxes on labour income, results in a larger response to deviations of debt from its target. This can be demonstrated by taking the derivative of equation (8) with respect to debt,

$$\frac{\partial T_{\ell,t}}{\partial B_{t-1}} = \gamma_{\ell} \frac{T_{\ell}}{B_{t-1}} \left( \frac{Y_t}{Y} \right)^{\varphi_{\ell}} \left( \frac{B_{t-1}}{B} \right)^{\gamma_{\ell}} \exp(u_{\ell,t}) = \gamma_{\ell} \frac{T_{\ell,t}}{B_{t-1}}, \quad (28)$$

which illustrates how a given change in debt will lead to a bigger tax response when government is larger, for the same debt elasticity. In dynamic equilibrium, the debt response dominates the increased GDP stabilisation that comes from a larger government and larger automatic stabilisers. van den Noord (2000) notes, when looking at OECD countries, that discretionary fiscal policy and fiscal consolidation have offset automatic stabilisers in many countries.

Note that in the case where the increase in steady state government consumption is funded through non-distortionary lump-sum taxation on the Ricardian household, the increase in absolute GDP volatility is due to the increase in GDP level. When comparing the change in the volatility of the output gap, the standard deviation is lower relative to the baseline scenario, consistent with the stabilising properties of larger government. This is because the overall labour tax response to debt is less affected by changes in the size of government in this model. The change in the steady state labour tax revenue between

the baseline scenario and the counterfactual with higher government consumption funded through lump-sum taxation is almost but not quite proportional to the change in GDP.

Table 17 presents the same simulations constructed using bootstrapped shocks. The simulations with bootstrapped shocks are more closely able to match some of moments in the data. The general pattern in the results is broadly similar to the simulations produced using normally distributed shocks. GDP could be 18% or 22% higher in a world without automatic stabilisers, depending on the definition of neutral fiscal policy. Stronger tax elasticities reduce the standard deviation of GDP by 4% to 5%. Increasing the size of government increases the volatility of GDP as the tax response dominates the stabilisation effects. The pattern in other variables is broadly similar, although the changes in the volatilities of the consumption variables is noticeably smaller. The changes in the relative volatilities (the gap variables) are also smaller due to the reduction in absolute volatility when bootstrapped shocks are used.

### 3.2 Simulations Without Government Debt

In order to isolate the effects of automatic stabilisers from the impacts of fiscal consolidation and debt stabilisation, especially when changing the size of government, I re-run the simulations without government debt in the model. In this model the budget is balanced through a lump-sum tax/transfer to the Ricardian household. This is observationally equivalent to a model with government debt where lump-sum taxes/transfers to the Ricardian household adjust to stabilise government debt. The results from the simulations in the model without government debt are presented in Table 4.

**Table 4 – Percentage Change in Volatilities - Simulations without Government Debt**

Scenario	$Y_t$	$\pi_t^4$	$C_t$	$R_t^4$	$C_{N,t}$	$C_{S,t}$	$I_t$	$\Upsilon_t$	$\log\left(\frac{Y_t}{\bar{Y}}\right)$	$\log\left(\frac{C_t}{\bar{C}}\right)$	$\log\left(\frac{C_{N,t}}{C_N}\right)$	$\log\left(\frac{C_{S,t}}{C_S}\right)$	$\log\left(\frac{I_t}{\bar{I}}\right)$
Constant Counterfactual	24.94	0.15	20.16	0.11	56.07	-0.86	11.08	-0.10	1.06	0.95	2.18	-0.05	1.74
Constant-Ratio Counterfactual	28.58	0.06	7.70	0.05	76.60	-15.53	2.73	0.42	1.21	0.36	2.97	-1.05	0.45
OECD Elasticities	1.71	0.03	-0.04	0.02	-0.91	0.34	1.97	-0.09	0.07	0.00	-0.03	0.02	0.30
Strong OECD Elasticities	-6.67	-0.04	-4.80	-0.03	-6.71	-0.92	-1.83	0.07	-0.28	-0.22	-0.25	-0.06	-0.28
Strong EC Elasticities	-5.60	-0.04	-3.12	-0.03	-3.74	-1.02	-2.76	0.10	-0.24	-0.15	-0.14	-0.07	-0.42
Big Govt. Consumption	-6.33	0.00	-13.27	-0.03	-11.34	-10.53	3.10	-0.10	-0.27	0.13	0.06	0.56	0.28
Big Govt. Consumption*	15.13	-0.01	-0.67	0.02	17.73	-3.05	20.40	-0.18	-0.22	0.00	-0.08	0.80	0.24
Big Transfers	-12.49	0.00	-22.92	-0.01	-1.66	-10.35	5.38	-0.23	-0.50	-1.05	-1.14	1.38	0.86
Big GC & Transfers	-19.47	-0.01	-35.09	-0.05	1.37	-24.76	8.91	-0.26	-0.78	-1.04	-0.76	2.17	1.25
Big GC, Transfers & Strong OECD	-29.25	-0.07	-36.90	-0.11	19.83	-27.41	6.84	0.20	-1.20	-1.14	-0.18	1.84	0.93

Automatic stabilisers have a larger impact on the volatility of GDP when government debt is absent from the model. In the counterfactual simulations without automatic stabilisers, GDP is 25% and 29% more volatile (depending on the measure of neutral fiscal policy considered), compared with 16% and 20% in the simulations with government debt. This indicates how debt stabilisation can work against automatic stabilisers and the important role labour taxes play in stabilising the economy when not constrained by government debt considerations. Again, under the constant spending and tax revenue counterfactual, total consumption, driven by rule of thumb consumption, is more volatile, as is investment. This is because tax rates need to respond countercyclically to keep tax revenues constant and investment is particularly sensitive to changes in the capital income tax rate. Likewise, the representative rule of thumb consumer is not able to save, so their consumption will be more sensitive to labour income taxes, which now respond countercyclically to keep tax revenues constant. Under the constant-ratio counterfactual, rule of thumb consumption is even more volatile, as transfers spending becomes pro-cyclical. These numbers are a similar order of magnitude to the income stabilisation elasticity estimated by Bernstein et al. (2021) although it is not clear how comparable these concepts are.<sup>24</sup> These numbers are also broadly consistent when the same simulations are carried out using bootstrapped shocks, as presented in Table 18 in Appendix E.

As was the case with the model with government debt, the OECD tax elasticities give almost identical results to the estimated elasticities. This is not surprising given the similarities between the OECD and DSGE estimates for New Zealand.

Strengthening the automatic stabilisers, so that the tax elasticities are equal to the largest elasticities estimated by the OECD and the European Commission results in a reduction in the volatility of GDP of 7% and 6% respectively. This is slightly larger than the 5% and 4% reduction in the model with government debt, but on the whole is still quite small, especially given the additional policy changes required to increase the elasticities to these levels could be quite large.

Increasing the size of government by increasing government consumption's share from 15% of steady state GDP to 25% results in a 6% reduction in the standard deviation of GDP. Increasing the size of transfers from 9% of GDP to 25% of GDP results in a 12% reduction in the standard deviation of GDP. While the increase in the steady state level of transfers reduces the steady state level of total consumption by less than 1%, there is a shift in the relative proportions of Ricardian and rule of thumb consumption. In particular, the increase in transfer payments to the rule of thumb household raises the share of rule of thumb consumption, which is less volatile in relative terms. This lowers the volatility of total consumption and GDP. Increasing both the share of transfers and government consumption would reduce the standard deviation of GDP by more than 19%, although rule of thumb consumption would be slightly more volatile and Ricardian consumption would be 25% less volatile, due to the fall in the steady state level of Ricardian consumption. Increasing the steady state share of both transfers and government consumption and increasing the tax elasticities to the largest values in the OECD leads to a 29% reduction in the volatility of GDP. However, rule of thumb consumption is now 20% more volatile, due to the increase in its steady state level.

I also run a simulation with increased steady state government consumption funded by a lump tax on the Ricardian household. This simulation allows the effects of an increase in the size of government to be separated from changes in distortionary taxation. In this

<sup>24</sup> Mohl et al. (2019) regress the income stabilisation coefficients for the euro area countries against their respective budgetary semi-elasticities and find there is a positive relationship between them, although it is not especially tight.



scenario GDP is 15% more volatile due to the 21% increase in steady state GDP relative to the baseline. The standard deviation of the output gap is 0.22% lower than the baseline simulation. This is smaller than the 0.27% reduction in the standard deviation of the output gap when larger government is funded through labour taxes, suggesting that some of the reduction in the volatility from larger government is also due to the increased absolute response of labour taxes to the business cycle which is the result of higher labour taxes as a share of GDP.<sup>25</sup>

For comparison, I re-run the simulations using bootstrapped shocks, which produces simulated series with standard deviations closer to their counterparts in the data. The results are presented in Table 18. The general pattern in these simulations is broadly similar to the simulations produced using normally distributed shocks. GDP would be 22% and 27% more volatile in a world without automatic stabilisers, depending on the definition of neutral fiscal policy used. Strengthening the tax elasticities to match the largest in the OECD and the euro area would only reduce the volatility in GDP by 6% and 5% respectively. Increasing the steady state share of government consumption to 25% of GDP would reduce the volatility of GDP by 7%. Increasing the steady state share of transfers paid to the rule of thumb household to 25% of GDP would reduce the volatility of GDP by 13%. Increasing the share of both government consumption and transfers reduces the volatility of GDP by 19%. This change in volatilities increases to 28% when combined with the largest tax elasticities in the OECD. The change in the volatilities of other variables is quite similar to the results produced using normally distributed shocks, although the change in the volatility of consumption is smaller. The volatilities of the gap variables are also smaller, because the simulations with bootstrapped shocks are less volatile than the simulations produced using normally distributed shocks.

In keeping with the theme of wanting to explore feasible policies, I calculate the model-implied budgetary semi-elasticities, evaluated at the steady state, for all the counterfactual policies where automatic stabilisers are strengthened and compare them against OECD and European Commission estimates for a number of OECD and euro area countries. Looking at other countries' budgetary semi-elasticities should provide some indication about the feasible gains from strengthening automatic stabilisers. As discussed earlier in this paper, the budgetary semi-elasticity is a key coefficient in the calculation of the cyclically adjusted budget balance. It determines the sensitivity of the budget balance to the business cycle, measured by the output gap, and provides a measure of the overall impact of automatic stabilisers on the budget balance. Estimates of the semi-elasticity are readily available, produced by the OECD and the European Commission for a number of developed countries.<sup>26</sup> The budgetary semi-elasticity is the difference between the derivative of the tax revenue to GDP ratio and the government expenditure to GDP ratio, both taken with respect to output, evaluated at the steady state. While I have used the upper bound of observed elasticities and government sizes in my calculations, the budgetary semi-elasticity provides a measure of how feasible it would be to combine "upper bound" policies into a single policy.<sup>27</sup> The tax and expenditure components in the model

<sup>25</sup> The absolute labour tax response to output is given by:

$$\frac{\partial T_{\ell,t}}{\partial Y_t} = \varphi_\ell \frac{T_\ell}{Y_t} \left( \frac{Y_t}{Y} \right)^{\varphi_\ell} \exp(u_{\ell,t}) = \varphi_\ell \frac{T_{\ell,t}}{Y_t},$$

which is increasing in the ratio of labour tax revenue to output.

<sup>26</sup> It is also possible to calculate a model-implied budgetary sensitivity, although I do not do that here. The results shouldn't be too different from the budgetary semi-elasticity.

<sup>27</sup> OECD and European Commission estimates would suggest that countries with larger tax elasticities for a particular category do not necessarily have larger tax elasticities elsewhere, or a larger size of government.

can be weighted as follows to determine the model-implied budgetary semi-elasticity,

$$\begin{aligned}\varepsilon_B &= (\psi_{TAX} - 1) \frac{TAX}{\tilde{P}_{HY}} - (\psi_{\mathcal{E}} - 1) \frac{\mathcal{E}}{\tilde{P}_{HY}} \\ &= \left( \psi_C \frac{T_C}{TAX} + \psi_{T_\ell} \frac{T_\ell}{TAX} + \psi_K \frac{T_K}{TAX} - 1 \right) \frac{TAX}{\tilde{P}_{HY}} \dots \\ &\quad \dots - \left( \psi_G \frac{\tilde{P}_G G}{\mathcal{E}} + \psi_{G_I} \frac{\tilde{P}_{G_I} G_I}{\mathcal{E}} + \psi_{Z_N} (1 - \mu) \frac{Z_N}{\mathcal{E}} - 1 \right) \frac{\mathcal{E}}{\tilde{P}_{HY}},\end{aligned}\tag{29}$$

where  $\varepsilon_B$  is the model-implied budgetary semi-elasticity and  $TAX = T_C + T_\ell + T_K$  and  $\mathcal{E} = \tilde{P}_G G + \tilde{P}_{G_I} G_I + (1 - \mu) Z_N$  are the steady state levels of total tax and the components of total expenditure that respond to the business cycle, respectively. The OECD and European Commission measures are not entirely comparable with the model because they use a wider measure of government spending and revenue (in New Zealand's case total crown government spending and revenue) which is larger than that implied by the National Accounts measures used to calibrate the ratios in this model. However, they should still give some indication of how easy or difficult it would be to strengthen automatic stabilisers and what the plausible potential gains are. I use equation (29) to calculate the model-implied semi-elasticities for all policies investigated. The budgetary semi-elasticities are reported along with the relative changes in GDP and the output gap in Table 5.

**Table 5 – Budgetary Semi-Elasticities**

Scenario	Budgetary Semi-Elasticity	GDP % Diff Std Dev	Output Gap % Diff Std Dev
Estimated Coefficients (Current Policy)	0.61	0.00	0.00
Constant Counterfactual	-0.01	24.94	1.06
Constant-Ratio Counterfactual	0.00	28.58	1.21
OECD Elasticities	0.55	1.71	0.07
Strong OECD Elasticities	0.85	-6.67	-0.28
Strong European Commission Elasticities	0.81	-5.60	-0.24
Big Govt. Consumption	0.78	-6.33	-0.27
Big Govt. Consumption*	0.72	15.13	-0.22
Big Transfers	1.01	-12.49	-0.50
Big GC & Transfers	1.18	-19.47	-0.78
Big GC, Transfers & Strong OECD	1.70	-29.25	-1.20

For comparison I list the OECD's and the European Commission's estimates of the maximum and minimum budgetary semi-elasticities, along with the OECD's estimate for New Zealand in Table 6.

**Table 6 – Budgetary Semi-Elasticities: European Commission and OECD Estimates**

Country	Budgetary Semi-Elasticity
OECD New Zealand	0.51
OECD Average	0.50
OECD Maximum (Belgium, Denmark, Sweden)	0.66
OECD Minimum (Mexico)	0.21
European Commission Average (euro area)	0.55
European Commission Maximum (France)	0.63
European Commission Minimum (Bulgaria)	0.29

Source: Price et al. (2015) and Mourre et al. (2019)

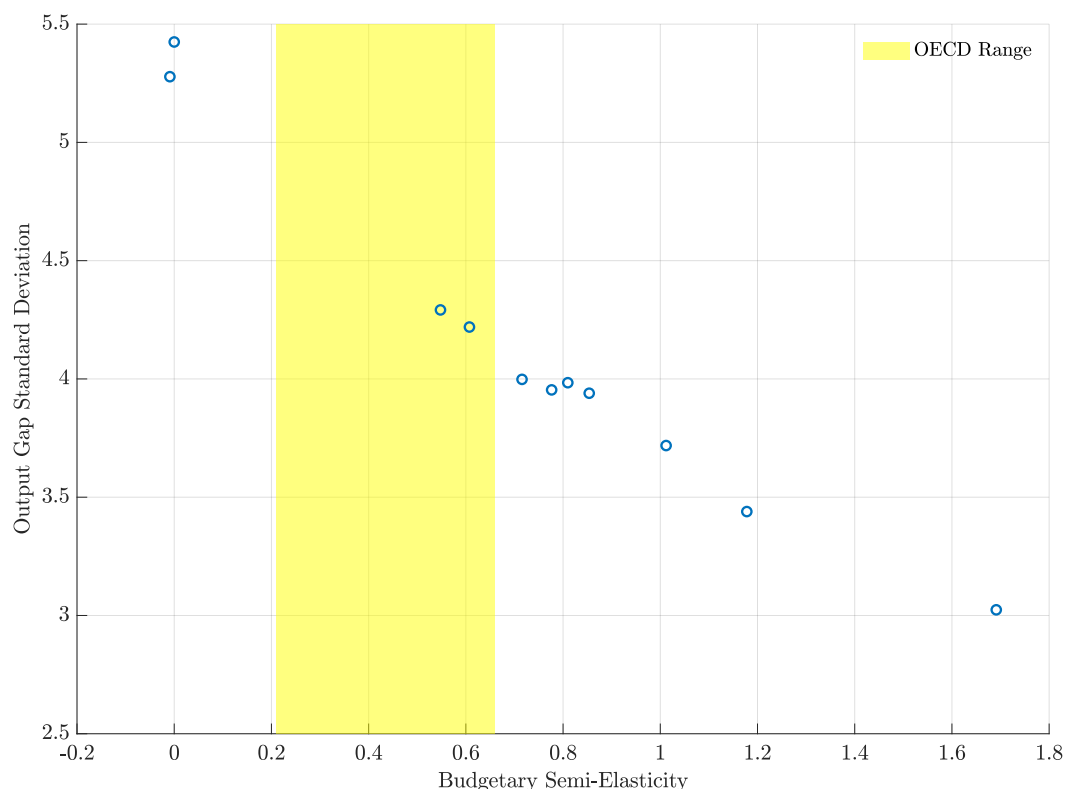
Using the estimated coefficients, the DSGE implied semi-elasticity is 0.61, which is slightly higher than the OECD's estimate of 0.51 for New Zealand. However, when I use the OECD's coefficients for New Zealand, this number falls to 0.55, which is closer to the OECD number. The differences between the OECD's estimate of the budgetary semi-elasticity are due to the slightly smaller OECD elasticities and the slightly larger size of government used by the OECD. The OECD uses a wider definition of government, which implies a larger size of government, although this is offset by the smaller tax elasticities they use. Despite these discrepancies, the numbers are close enough that the range of OECD budgetary semi-elasticities should provide some guidance on which combination of policies is feasible.

The results in Table 5 show the budgetary semi-elasticity increases to 0.85 and 0.81, when the largest OECD and European Commission elasticities are used. This is in comparison with the largest budgetary semi-elasticity estimated by the OECD, which is 0.66 for Belgium, Denmark and Sweden. Increasing the size of government, by raising government consumption's share to 25% of steady state GDP, increases the budgetary semi-elasticity to 0.78. Each of these improvements, while reasonably substantial would only lead to a reduction of between 6% and 7% in the standard deviation of GDP.

An increase in the share of transfers from 9% to 25% would see the budgetary semi-elasticity increase to 1.01. This is much larger than the upper bound of the OECD countries, raising questions about the feasibility of such a policy. In the modelling exercise the same transfers elasticity is applied to all transfers, including the additional transfer payments made when the size of government is increased. It may not be reasonable to apply this elasticity to all of this spending, as some of the increase in transfers may have to go to areas that are not sensitive to the business cycle. Likewise the other policies with larger transfer payments also result in implausibly large budgetary semi-elasticities, calling into question the ability to implement these policies.

I plot the standard deviation of the output gap for all the simulations against their respective implied budgetary semi-elasticities in Figure 1.

**Figure 1 – Budgetary Semi-Elasticities vs Output Gap Volatility**



The yellow highlighted region represents the range of budgetary semi-elasticities across the OECD, based on OECD calculations.

The relationship between the model-implied budgetary semi-elasticities and the volatility of the output gap is remarkably close to being linear. Generalising this relationship, it would appear that the model-implied budgetary semi-elasticity is a reasonably good indicator of the strength of automatic stabilisers in the model and that output elasticities are somewhat substitutable with the size of government when considering the design of fiscal policies. Figure 6 in Appendix E shows the same relationship between the simulations with bootstrapped shocks and the model-implied budgetary semi-elasticities.

Before moving to the next section, I discuss how my results relate to the findings of McKay & Reis (2016). McKay & Reis (2016) carry out a number of simulation exercises in a heterogeneous agent New Keynesian (HANK) DSGE model to understand the role automatic stabilisers play in macroeconomic stabilisation in the US. Most notably they find automatic stabilisers play a very small role in stabilising the US economy. Their results are further obscured by comparing the variances of the macroeconomic series rather than the standard deviations.<sup>28</sup> As in 't Veld et al. (2013) note, much of the variation between the results from different macro-simulation exercises looking at the role of automatic stabilisers can be attributed to the definition of automatic stabilisers and correspondingly the definition of neutral fiscal policy. In the case of McKay & Reis (2016) their definition of neutral fiscal policy looks like a world with weaker automatic stabilisers, when compared with the definitions used in 't Veld et al. (2013) and this paper. This explains in part (maybe even in large part) why the role of automatic stabilisers in macroeconomic stabilisation are much larger in this paper and much smaller in their paper.

<sup>28</sup> The magnitude of their results would be even smaller if they calculated standard deviations rather than variances.

## 3.3 Monetary Policy

In this subsection I look at how different assumptions about monetary policy affect automatic stabilisers' role in macroeconomic stabilisation. In particular I look at the role of automatic stabilisers in a low interest rate environment, and when the monetary authority sets interest rates according to a "weak" Taylor-type rule.<sup>29</sup>

### 3.3.1 Low Interest Rate Environment

To understand the role that automatic stabilisers play in a low interest rate environment, I simulate the model again under current policy settings and under the counterfactual neutral fiscal policies previously mentioned, but this time I increase the discount factor and lower the inflation target, so that the steady state annual inflation rate is 0.5% and the steady state nominal interest rate is 1%. The baseline current policy simulation is re-run in this low interest rate environment so that the impact of current automatic stabilisers can be measured at the lower bound. Simulating the model under these settings with the same sequence of shocks will lead to the economy hitting the lower bound more often. All simulations are produced using the model without government debt. Note that I do not consider the effects of unconventional monetary policy (e.g quantitative easing, policies that lower the effective lower bound, forward guidance, etc.) when the economy is at the lower bound. These unconventional monetary policies may have implications for the role of fiscal policy at the lower bound. The results from these simulations are presented in Table 7.

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<sup>29</sup> The coefficients in the "weak" Taylor-type rule are chosen so that the Taylor principle only just holds.

**Table 7 – Simulations with Low Interest Rates**

Scenario	$Y_t$	$\pi_t^A$	$C_t$	$R_t^A$	$C_{N,t}$	$C_{S,t}$	$I_t$	$\Upsilon_t$	$\log\left(\frac{Y_t}{Y}\right)$	$\log\left(\frac{C_t}{C}\right)$	$\log\left(\frac{C_{N,t}}{C_N}\right)$	$\log\left(\frac{C_{S,t}}{C_S}\right)$	$\log\left(\frac{I_t}{I}\right)$
<b>Entire Simulation</b>													
Constant Counterfactual	22.85	0.15	25.18	0.11	53.27	-0.36	7.13	-0.07	0.98	1.04	2.22	-0.02	1.14
Constant-Ratio Counterfactual	31.31	0.06	19.07	0.05	79.69	-11.93	1.39	0.58	1.33	0.78	3.32	-0.71	0.19
<b>At the ELB</b>													
Constant Counterfactual	21.13	0.08	25.58	0.00	53.35	1.70	5.06	-0.07	0.89	1.06	2.39	0.10	0.62
Constant-Ratio Counterfactual	35.08	0.05	24.44	0.00	82.09	-6.93	1.25	0.69	1.49	1.01	3.66	-0.35	0.12
<b>Away from the ELB</b>													
Constant Counterfactual	23.60	0.10	25.37	0.09	55.69	-0.47	7.02	-0.10	1.00	1.00	2.14	-0.03	1.27
Constant-Ratio Counterfactual	28.21	0.04	15.78	0.05	79.85	-13.35	1.04	0.46	1.18	0.61	3.03	-0.80	0.18

Entire Simulation = standard deviations are calculated using simulated data from the entire simulation.  
 At the ELB = standard deviations are only calculated on data when the model is at the ELB.  
 Away from the ELB = standard deviations are only calculated on data when the model is not at the ELB.

**Table 8 – Simulations with Weak Monetary Policy**

Scenario	$Y_t$	$\pi_t^A$	$C_t$	$R_t^A$	$C_{N,t}$	$C_{S,t}$	$I_t$	$\Upsilon_t$	$\log\left(\frac{Y_t}{Y}\right)$	$\log\left(\frac{C_t}{C}\right)$	$\log\left(\frac{C_{N,t}}{C_N}\right)$	$\log\left(\frac{C_{S,t}}{C_S}\right)$	$\log\left(\frac{I_t}{I}\right)$
Constant Counterfactual	30.54	-0.05	30.47	-0.04	63.64	5.65	15.83	-0.06	1.42	1.52	2.95	0.38	2.57
Constant-Ratio Counterfactual	42.27	-0.17	25.15	-0.21	93.95	-8.19	8.89	0.76	1.96	1.25	4.35	-0.55	1.51

GDP is more volatile in the constant-ratio counterfactual in a low interest rate environment, than in the normal interest rate environment. In the new baseline simulation, interest rates are at the lower bound in 4,696 periods out of 10,000 simulation periods. This compares with 1,027 periods in the normal interest rate environment. In the low interest rate environment GDP is 31% more volatile than the current policy baseline across the entire simulation, which compares with 29% in normal times. This increases to 35% when only looking at periods where the lower bound is binding and reduces to 28% in the periods away from the lower bound. Under this counterfactual, automatic stabilisers play a larger role when the economy is at the lower bound, which is consistent with the results from McKay & Reis (2016).

When comparing the increase in volatility between the baseline and the constant level counterfactual, the increase is smaller in the low interest rate environment, than in the normal interest rate environment. This reflects the interaction between the lower bound on interest rates and the countercyclical tax rates required to keep tax revenues constant across the business cycle. It is generally the case that demand shocks are amplified at the lower bound and supply shocks are moderated due to their respective impacts on inflation expectations and the real interest rate. In extreme cases, tax increases at the lower bound have been found to be stimulatory in the simple New Keynesian DSGE model. This has been described as the paradox of toil by Eggertsson (2010). With tax rates moving countercyclically to keep tax revenues constant, the negative effects on GDP from raising tax rates during a recession are going to be reduced at the lower bound due to the additional inflation that is created and the impact this has lowering the real interest rate.

### 3.3.2 Weak Monetary Policy

To understand the role that monetary policy plays in determining the effectiveness of automatic stabilisers, I re-run the baseline and counterfactual neutral fiscal policy simulations with a very weak monetary policy rule. In this case I set the coefficient on the response to inflation equal to 1.001 (compared to 2.25, which is the estimated coefficient) and the response to the output gap equal to 0 (the estimated coefficient is 0.12) so that the Taylor principle barely holds. The results from these simulations are presented in Table 8.

When monetary policy is weak, simulations without automatic stabilisers result in GDP that is 31% and 42% more volatile, depending on the counterfactual neutral fiscal policy used. This is largely driven by increases in the volatility of rule of thumb consumption, which benefits more from stabilisation policies carried out by government when monetary policy is weak. This is consistent with the results from McKay & Reis (2016) who find that the impact of automatic stabilisers is larger when monetary policy is weaker.

## 4. Conclusion

I carry out a number of macro-simulation exercises using an estimated small open economy monetary-fiscal DSGE model, to determine the contribution automatic stabilisers make to macroeconomic stabilisation in New Zealand. More precisely, I compare the standard deviation of a set of key macroeconomic aggregates under current policy settings with their corresponding standard deviations produced under two commonly used counterfactual neutral fiscal policy assumptions, in which automatic stabilisers are not operating. Using the same simulation methodology, I investigate the potential gains from strengthening automatic stabilisers in New Zealand. In particular, I use OECD and European Commission estimates of tax revenue elasticities to determine the potential reduction in the standard deviations of key macroeconomic aggregates that could be achieved if the New Zealand economy could be restructured and fiscal policy set in a way to obtain these elasticities. I

look at the potential stabilisation gains from increasing the size of government, through increases in the steady state shares of government consumption and transfer payments. I also look at how the contribution of automatic stabilisers changes in a low interest rate environment and in a weak monetary policy environment.

My analysis suggests that in a world without automatic stabilisers, the standard deviation of GDP would be about 16% and 20% higher than under current policy settings, depending on the measure of neutral fiscal policy used. The standard deviation of GDP increases by 25% and 29% when the business cycle stabilisation effects of fiscal policy are isolated from the debt stabilisation effects, as government debt stabilisation tends to work against automatic stabilisers. When ignoring debt stabilisation in fiscal policy rules, I find strengthening automatic stabilisers by increasing the responsiveness of tax revenue to GDP to match the largest tax elasticities in the OECD and euro area reduces the standard deviation of GDP by between 6% and 7% (this is 4% and 5% for the model with government debt). Increasing the GDP share of government consumption from 15% to 25% would result in a reduction in the standard deviation of GDP of about 6%, while increasing transfer payments from 9% to 25% of GDP would result in a reduction in the standard deviation of GDP of about 12%. Combining a larger government with higher tax elasticities could see a reduction in the standard deviation of GDP of about 29%. Comparing the model-implied budgetary semi-elasticities with actual budgetary semi-elasticities indicates a likely upper bound on the extent to which automatic stabilisers can be strengthened and the feasible gains from doing so. Ignoring the more implausible policies suggests that the reduction in the standard deviation of GDP from strengthening automatic stabilisers is likely to be modest at best, in the 4% to 7% range.

While the modelling analysis highlights some of the potential gains from strengthening automatic stabilisers, it is silent on how this can be achieved in practice, treating the tax elasticities as reduced form coefficients. A more detailed investigation of the tax systems and fiscal policies in countries with larger tax elasticities is required to understand why their fiscal policy is more responsive to the business cycle. Furthermore, countries do not usually choose the size of their respective governments for stabilisation purposes. Improved stabilisation tends to be an unintended consequence of larger government or policies designed to increase redistribution or reallocation. While the analysis in this paper has looked at the stabilisation gains from strengthening automatic stabilisers, it has not looked at the loss in efficiency that may occur from expanding the size of government or restructuring fiscal policy to make it more responsive to the business cycle. Given the plausible stabilisation gains from increasing both the tax elasticities and the size of government are relatively small, and the difficulties faced from changing these policies in a way that is likely to improve the stabilisation properties of the economy, the plausible gains from strengthening automatic stabilisers could easily be more than offset by the efficiency losses in doing so. Investigating this question is left for future research.



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# A. Model Variables and Equations

## A.1 Model Variables

Table 9 lists the 74 model variables along with a short description.

**Table 9 – Model Variables**

Variable	Description
<b>Real Variables</b>	
$Y_t$ ,	Output
$C_{S,t}$ ,	Ricardian consumption
$C_{N,t}$ ,	Rule of thumb consumption
$C_t$ ,	Total private consumption
$I_t$ ,	Total private investment
$\ell_t$ ,	Total employed
$L_t$ ,	Total labour force
$\Upsilon_t$ ,	Unemployment rate
$M_t$ ,	Imports
$F_t$ ,	Net foreign debt
$C_{S,t}^*$ ,	Effective consumption
$M_t^*$ ,	Exports
$v_t$ ,	Variable capacity utilisation
$\bar{K}_t$ ,	Physical capital stock
$K_t$ ,	Effective capital stock
$D_t$ ,	Profits
<b>Relative Prices</b>	
$\tilde{P}_{H,t}$ ,	Relative price of domestically produced goods
$\tilde{P}_{F,t}$ ,	The relative price of imported goods
$T_t$ ,	Terms of trade
$Q_t$ ,	Real exchange rate
$\tilde{P}_{I,t}$ ,	Relative price of private investment
$\tilde{P}_{G,t}$ ,	Relative price of government consumption goods
$\tilde{P}_{G_I,t}$ ,	The relative price of government investment goods
$Q_t$ ,	Price of new capital goods
$R_{K,t}$ ,	Real rental rate on capital goods
$\tilde{W}_t$ ,	Real wage
$\lambda_t$ ,	The marginal utility of consumption
$\Omega_t$ ,	The real marginal cost
<b>Domestic Inflation and Interest Rates</b>	
$\pi_t$ ,	Consumer price inflation
$\pi_{H,t}$ ,	Home price inflation
$\tilde{\pi}_{H,t}$ ,	Home price inflation index
$\pi_{W,t}$ ,	Nominal wage inflation
$\tilde{\pi}_{W,t}$ ,	Nominal wage inflation index
$\pi_{F,t}$ ,	Import inflation
$\tilde{\pi}_{F,t}$ ,	Import inflation indexation
$R_t$ ,	Nominal interest rates
$R_t^*$ ,	Shadow interest rate
$\mathfrak{R}_t$ ,	Real interest rate
$\frac{S_t}{S_{t-1}}$ ,	Change in the nominal exchange rate

Variable	Description
<b>Fiscal variables</b>	
$Z_t$ ,	Total transfers
$Z_{N,t}$ ,	Transfers to the rule of thumb household
$Z_{S,t}$ ,	Transfers to the Ricardian household
$G_t$ ,	Government consumption
$B_t$ ,	Government debt
$\tau_{C,t}$ ,	Tax rate on consumption
$\tau_{K,t}$ ,	Tax rate on capital income
$\tau_{\ell,t}$ ,	Tax rate on labour income
$K_{G,t}$ ,	Public capital stock
$G_{I,t}$ ,	Government investment
$T_{C,t}$ ,	Consumption tax revenue
$T_{K,t}$ ,	Capital income tax revenue
$T_{\ell,t}$ ,	Labour income tax revenue
<b>Foreign Variables</b>	
$Y_t^*$ ,	Foreign GDP
$R_t^*$ ,	Foreign nominal interest rate
$\pi_t^*$ ,	Foreign inflation rate
<b>Shock Processes</b>	
$A_t$ ,	Total factor productivity
$u_{C,t}$ ,	Consumption tax shock process
$u_{K,t}$ ,	Capital income tax shock process
$u_{\ell,t}$ ,	Labour income tax shock process
$u_{Z_N,t}$ ,	Transfers shock process (rule of thumb household)
$u_{Z_S,t}$ ,	Transfers shock process (Ricardian household)
$u_{G,t}$ ,	Government consumption shock process
$u_{G_I,t}$ ,	Government investment shock process
$A_{I,t}$ ,	Investment efficiency
$\kappa_t$ ,	Labour preferences shock process
$A_{B,t}$ ,	Risk premium shock process
$A_{S,t}$ ,	Foreign risk premium shock process
$A_{T,t}$ ,	Stochastic subsidy on imported goods
$A_{P,t}$ ,	Stochastic subsidy on domestically produced goods
$A_{SFA,t}$ ,	Stock/flow adjustment shock on government debt
$A_X,t$ ,	Export shock process
$A_L,t$ ,	Labour demand shock
$\eta_t$ ,	Unemployment shock

## A.2 Model Equations

The 74 model equations are listed as follows:

$$\begin{aligned} \mu(1 + \tau_{C,t})C_{S,t} + \tilde{P}_{I,t}I_t + B_t + F_t &= \frac{R_{t-1}}{\pi_t}B_{t-1} \dots \\ \dots + \frac{R_{t-1}}{\pi_t}F_{t-1} + \mu(1 - \tau_{\ell,t})\tilde{W}_t\ell_t \dots \\ \dots + (1 - \tau_{K,t})R_{K,t}v_t\bar{K}_{t-1} + \mu Z_{S,t} + Z_{R,t} + D_t, \end{aligned} \quad (30)$$

$$D_t = \tilde{P}_{H,t}Y_t - R_{K,t}K_t - \tilde{W}_t\ell_t + \tilde{P}_{F,t}M_t - Q_t \left( M_t + A_t^{\frac{1}{1-\alpha}}\psi_M \right), \quad (31)$$

$$\bar{K}_t = (1 - \delta)\bar{K}_{t-1} + A_{I,t} \left[ 1 - \frac{\phi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 \right] I_t, \quad (32)$$

$$K_{G,t} = (1 - \delta_G)K_{G,t-1} + G_{I,t}, \quad (33)$$

$$\lambda_t = \frac{\left( C_{S,t}^* - \theta C_{S,t-1}^* \right)^{-\gamma}}{1 + \tau_{C,t}}, \quad (34)$$

$$C_{S,t}^* = C_{S,t} + \varphi_G G_t + \varphi_I G_{I,t}, \quad (35)$$

$$\begin{aligned} \left( \frac{\phi_W}{\eta - 1} \right) \pi_{W,t} [\pi_{W,t} - \tilde{\pi}_{W,t}] &= \left( \frac{\eta}{\eta - 1} \right) \kappa_t \left( \frac{\ell_t^\xi}{\lambda_t \tilde{W}_t} \right) - 1 + \tau_{\ell,t} \dots \\ \dots + E_t \left\{ \left( \frac{\phi_W}{\eta - 1} \right) \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{\pi_{W,t+1}^2}{\pi_{t+1}} \frac{\ell_{t+1}}{\ell_t} [\pi_{W,t+1} - \tilde{\pi}_{W,t+1}] \right\}, \end{aligned} \quad (36)$$

$$(1 - \tau_{\ell,t})\tilde{W}_t = \kappa_t \frac{L_t^\xi}{\lambda_t}, \quad (37)$$

$$\Upsilon_t = 1 - \frac{\ell_t}{L_t}, \quad (38)$$

$$\begin{aligned} \tilde{P}_{I,t} &= Q_t A_{I,t} \left( 1 - \frac{\phi_I}{2} \left( \frac{I_t}{I_{t-1}} - 1 \right)^2 - \phi_I \left( \frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} \right) \dots \\ \dots + E_t \left\{ \beta \frac{\lambda_{t+1}}{\lambda_t} Q_{t+1} A_{I,t+1} \phi_I \left( \frac{I_{t+1}}{I_t} - 1 \right) \left( \frac{I_{t+1}}{I_t} \right)^2 \right\}, \end{aligned} \quad (39)$$

$$\lambda_t = E_t \left\{ \beta \lambda_{t+1} \frac{R_t}{\pi_{t+1}} \exp(A_{B,t}) \right\}, \quad (40)$$

$$R_t = E_t \left\{ \frac{S_{t+1}}{S_t} R_t^* \exp \left( -\phi_F \left( \frac{F_t}{P_{H,t} Y_t} - \frac{F}{P_H Y} \right) + A_{S,t} \right) \right\}, \quad (41)$$

$$\lambda_t Q_t = E_t \left\{ \beta \lambda_{t+1} \left( \begin{aligned} &(1 - \tau_{K,t+1}) R_{K,t+1} v_{t+1} \dots \\ &\dots - \tilde{P}_{I,t+1} \left[ \psi_1 (v_{t+1} - 1) + \frac{\psi_2}{2} (v_{t+1} - 1)^2 \right] + Q_{t+1} (1 - \delta) \end{aligned} \right) \right\}, \quad (42)$$

$$(1 - \tau_{K,t}) R_{K,t} = \tilde{P}_{I,t} [\psi_1 + \psi_2 (v_t - 1)], \quad (43)$$

$$(1 + \tau_{C,t}) C_{N,t} = (1 - \tau_{\ell,t}) \tilde{W}_t \ell_t + Z_{N,t}, \quad (44)$$

$$C_t = \mu C_{S,t} + (1 - \mu) C_{N,t}, \quad (45)$$

$$Z_t = \mu Z_{S,t} + (1 - \mu) Z_{N,t}, \quad (46)$$

$$Y_t = A_t K_t^\alpha \ell_t^{1-\alpha} K_{G,t-1}^{\alpha_G} - A_t^{\frac{1}{1-\alpha}} \psi_H, \quad (47)$$

$$R_{K,t} = \Omega_t \alpha A_t K_t^{\alpha-1} \ell_t^{1-\alpha} K_{G,t-1}^{\alpha_G}, \quad (48)$$

$$\tilde{W}_t = A_{L,t} \Omega_t (1 - \alpha) A_t K_t^\alpha \ell_t^{-\alpha} K_{G,t-1}^{\alpha_G}, \quad (49)$$

$$\begin{aligned} \left( \frac{\phi_P}{\varepsilon - 1} \right) \pi_{H,t} [\pi_{H,t} - \tilde{\pi}_{H,t}] &= \left( \frac{\varepsilon}{\varepsilon - 1} \right) \frac{\Omega_t}{\tilde{P}_{H,t}} - \exp(A_{P,t}) \dots \\ &\dots + E_t \left\{ \left( \frac{\phi_P}{\varepsilon - 1} \right) \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{\pi_{H,t+1}^2}{\pi_{t+1}} \frac{Y_{t+1}}{Y_t} [\pi_{H,t+1} - \tilde{\pi}_{H,t+1}] \right\}, \end{aligned} \quad (50)$$

$$\begin{aligned} \left( \frac{\phi_F}{\varepsilon - 1} \right) \pi_{F,t} [\pi_{F,t} - \tilde{\pi}_{F,t}] &= \left( \frac{\varepsilon}{\varepsilon - 1} \right) \frac{Q_t}{\tilde{P}_{F,t}} - \exp(A_{T,t}) \dots \\ &\dots + E_t \left\{ \left( \frac{\phi_F}{\varepsilon - 1} \right) \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{\pi_{F,t+1}^2}{\pi_{t+1}} \frac{M_{t+1}}{M_t} [\pi_{F,t+1} - \tilde{\pi}_{F,t+1}] \right\}, \end{aligned} \quad (51)$$

$$\tilde{P}_{H,t} = \left[ (1 - \nu_C) + \nu_C T_t^{1-\mu_C} \right]^{\frac{1}{\mu_C-1}}, \quad (52)$$

$$\frac{\tilde{P}_{I,t}}{\tilde{P}_{H,t}} = \left[ (1 - \nu_I) + \nu_I T_t^{1-\mu_I} \right]^{\frac{1}{1-\mu_I}}, \quad (53)$$

$$\frac{\tilde{P}_{G,t}}{\tilde{P}_{H,t}} = \left[ (1 - \nu_G) + \nu_G T_t^{1-\mu_G} \right]^{\frac{1}{1-\mu_G}}, \quad (54)$$

$$\frac{\tilde{P}_{G_I,t}}{\tilde{P}_{H,t}} = \left[ (1 - \nu_{G_I}) + \nu_{G_I} T_t^{1-\mu_{G_I}} \right]^{\frac{1}{1-\mu_{G_I}}}, \quad (55)$$

$$\begin{aligned} Y_t = & (1 - \nu_C) \tilde{P}_{H,t}^{-\mu_C} C_t + (1 - \nu_I) \left( \frac{\tilde{P}_{H,t}}{\tilde{P}_{I,t}} \right)^{-\mu_I} I_t \dots \\ & \dots + (1 - \nu_G) \left( \frac{\tilde{P}_{H,t}}{\tilde{P}_{G,t}} \right)^{-\mu_G} G_t + (1 - \nu_{G_I}) \left( \frac{\tilde{P}_{H,t}}{\tilde{P}_{G_I,t}} \right)^{-\mu_{G_I}} G_{I,t} + M_t^*, \end{aligned} \quad (56)$$

$$\frac{\tilde{P}_{H,t}}{Q_t} = (\nu^*)^{\frac{1}{\mu^*}} \left( \frac{Y_t^*}{M_t^*} \right)^{\frac{1}{\mu^*}} \left( 1 - \frac{\phi_M^*}{2} \left( \frac{M_t^*}{M_{t-1}^*} - 1 \right)^2 \right)^{\frac{-1}{\mu^*}} \left[ \begin{array}{l} 1 - \frac{\phi_M^*}{2} \left( \frac{M_t^*}{M_{t-1}^*} - 1 \right)^2 \dots \\ \dots - \phi_M^* \left( \frac{M_t^*}{M_{t-1}^*} - 1 \right) \left( \frac{M_t^*}{M_{t-1}^*} \right) \end{array} \right], \quad (57)$$

$$M_t = \nu_C \tilde{P}_{F,t}^{-\mu_C} C_t + \nu_I \left( \frac{\tilde{P}_{F,t}}{\tilde{P}_{I,t}} \right)^{-\mu_I} I_t + \nu_G \left( \frac{\tilde{P}_{F,t}}{\tilde{P}_{G,t}} \right)^{-\mu_G} G_t + \nu_{G_I} \left( \frac{\tilde{P}_{F,t}}{\tilde{P}_{G_I,t}} \right)^{-\mu_{G_I}} G_{I,t}, \quad (58)$$

$$K_t = \nu_t \bar{K}_{t-1}, \quad (59)$$

$$\tilde{P}_{H,t} = \frac{\pi_{H,t}}{\pi_t} \tilde{P}_{H,t-1}, \quad (60)$$

$$\tilde{P}_{F,t} = \frac{\pi_{F,t}}{\pi_t} \tilde{P}_{F,t-1}, \quad (61)$$

$$\tilde{W}_t = \frac{\pi_{W,t}}{\pi_t} \tilde{W}_{t-1}, \quad (62)$$

$$Q_t = \frac{S_t}{S_{t-1}} \frac{\pi_t^*}{\pi_t} Q_{t-1}, \quad (63)$$



$$T_t = \frac{\tilde{P}_{F,t}}{\tilde{P}_{H,t}}, \quad (64)$$

$$\tilde{\pi}_{F,t} = \pi_{F,t-1}^{\iota_F} \pi_F^{1-\iota_F}, \quad (65)$$

$$\tilde{\pi}_{H,t} = \pi_{H,t-1}^{\iota_H} \pi_H^{1-\iota_H}, \quad (66)$$

$$\tilde{\pi}_{W,t} = \pi_{W,t-1}^{\iota_W} \pi_F^{1-\iota_W}, \quad (67)$$

$$B_t + \tau_{K,t} R_{K,t} v_t \bar{K}_{t-1} + \tau_{\ell,t} \tilde{W}_t \ell_t + \tau_{C,t} C_t = \dots \\ \dots \frac{R_{t-1}}{\pi_t} B_{t-1} + \tilde{P}_{G,t} G_t + \tilde{P}_{G_I,t} G_{I,t} + \tau_{S,t} \tilde{W}_t \ell_t + Z_t + Z_{R,t} + A_{SFA,t}, \quad (68)$$

$$\varrho B_t + (1 - \varrho) Z_{R,t} = 0, \quad (69)$$

$$R_t^* = (R_{t-1}^*)^{\rho_R} \left( R \left( \frac{\pi_t}{\pi} \right)^{\kappa_\pi} \left( \frac{Y_t}{Y} \right)^{\kappa_Y} \right)^{1-\rho_R} \exp(\varepsilon_{R,t}), \quad (70)$$

$$R_t = \mathbf{Z}_t R_t^* + (1 - \mathbf{Z}_t) R_{ELB}, \quad (71)$$

where  $\mathbf{Z}_t = \begin{cases} 0 & \text{if } R_t^* \leq R_{ELB} \\ 1 & \text{if } R_t^* > R_{ELB} \end{cases}$ . Note that this specification implies  $R_t = \max(R_t^*, R_{ELB})$ .

$$T_{C,t} = \tau_{C,t} C_t, \quad (72)$$

$$T_{\ell,t} = \tau_{\ell,t} \tilde{W}_t \ell_t, \quad (73)$$

$$T_{K,t} = \tau_{K,t} R_{K,t} v_t \bar{K}_{t-1}, \quad (74)$$

$$T_{C,t} = T_C \left( \frac{Y_t}{Y} \right)^{\psi_C} \exp(u_{C,t}), \quad (75)$$

$$T_{\ell,t} = T_\ell \left( \frac{Y_t}{Y} \right)^{\psi_\ell} \left( \frac{B_{t-1}}{B} \right)^{\gamma_\ell} \exp(u_{\ell,t}), \quad (76)$$

$$T_{K,t} = T_K \left( \frac{Y_t}{Y} \right)^{\psi_K} \exp(u_{K,t}), \quad (77)$$

$$G_t = G \left( \frac{Y_t}{Y} \right)^{-\varphi_G} \exp(u_{G,t}), \quad (78)$$

$$G_{I,t} = G_I \left( \frac{Y_t}{Y} \right)^{-\varphi_{G_I}} \exp(u_{G_I,t}), \quad (79)$$

$$Z_{N,t} = Z_N \left( \frac{Y_t}{Y} \right)^{-\varphi_{Z_N}} \exp(u_{Z_N,t}), \quad (80)$$

$$Z_{S,t} = Z_S \left( \frac{Y_t}{Y} \right)^{-\varphi_{Z_S}} \exp(u_{Z_S,t}), \quad (81)$$

$$\mathfrak{R}_t = E_t \left\{ \frac{R_t}{\pi_{t+1}} \right\}, \quad (82)$$

$$u_{C,t} = \rho_{u_C} u_{C,t-1} + \varepsilon_{u_C,t}, \quad (83)$$

$$u_{K,t} = \rho_{u_K} u_{K,t-1} + \varepsilon_{u_K,t}, \quad (84)$$

$$u_{\ell,t} = \rho_{u_\ell} u_{\ell,t-1} + \varepsilon_{u_\ell,t}, \quad (85)$$

$$u_{Z_N,t} = \rho_{u_{Z_N}} u_{Z_N,t-1} + \varepsilon_{u_{Z_N},t}, \quad (86)$$

$$u_{Z_S,t} = \rho_{u_{Z_S}} u_{Z_S,t-1} + \varepsilon_{u_{Z_S},t}, \quad (87)$$

$$u_{G,t} = \rho_{u_G} u_{G,t-1} + \varepsilon_{u_G,t}, \quad (88)$$

$$u_{G_I,t} = \rho_{u_{G_I}} u_{G_I,t-1} + \varepsilon_{u_{G_I},t}, \quad (89)$$

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{A,t}, \quad (90)$$

$$Y_t^* = (Y^*)^{1-\rho_{Y^*}} (Y_{t-1}^*)^{\rho_{Y^*}} \exp(\varepsilon_{Y^*,t}), \quad (91)$$

$$R_t^* = (R^*)^{1-\rho_{R^*}} (R_{t-1}^*)^{\rho_{R^*}} \exp(\varepsilon_{R^*,t}), \quad (92)$$

$$\pi_t^* = (\pi^*)^{1-\rho_{\pi^*}} (\pi_{t-1}^*)^{\rho_{\pi^*}} \exp(\varepsilon_{\pi^*,t}), \quad (93)$$

$$A_{I,t} = A_{I,t-1}^{\rho_{A_I}} A_I^{1-\rho_{A_I}} \exp(\varepsilon_{A_I,t}), \quad (94)$$

$$\kappa_t = \kappa_{t-1}^{\rho_{\kappa}} \kappa^{1-\rho_{\kappa}} \exp(\varepsilon_{\kappa,t}), \quad (95)$$

$$A_{B,t} = \rho_{A_B} A_{B,t-1} + \varepsilon_{A_B,t}, \quad (96)$$

$$A_{S,t} = \rho_{A_S} A_{S,t-1} + \varepsilon_{A_S,t}, \quad (97)$$

$$A_{T,t} = \rho_{A_T} A_{T,t-1} + \varepsilon_{A_T,t}, \quad (98)$$

$$A_{P,t} = \rho_{A_P} A_{P,t-1} + \varepsilon_{A_P,t}, \quad (99)$$

$$A_{SFA,t} = \rho_{SFA} A_{SFA,t-1} + \varepsilon_{SFA,t}, \quad (100)$$

$$A_{M^*,t} = A_{M^*,t-1}^{\rho_{A_{M^*}}} A_{M^*}^{1-\rho_{A_{M^*}}} \exp(\varepsilon_{A_{M^*},t}), \quad (101)$$

$$A_{L,t} = A_{L,t-1}^{\rho_{A_L}} A_L^{1-\rho_{A_L}} \exp(\varepsilon_{A_L,t}), \quad (102)$$

$$\eta_t = \eta_{t-1}^{\rho_{\eta}} \eta^{1-\rho_{\eta}} \exp(\varepsilon_{\eta,t}), \quad (103)$$

## B. Data

I estimate the model using 19 quarterly time series variables that span the 1994Q1 to 2019Q4 period. The variables, descriptions and data descriptions are listed in Table 10. The transfers and tax revenue data are all nominal and highly seasonal, so I divide them by the consumers price index and seasonally adjust them using the x13 filter.<sup>30</sup> Net core Crown debt is annual, so I interpolate it to make it quarterly. I assume that the foreign economy is 80% US and 20% Australia, so the foreign output variable, inflation and the interest rate are all constructed using these weights. I use the TWI exchange rate which has a 0.92 correlation with an 80 20 USD/NZD AUD/NZD weighted exchange rate. All variables are Hodrick Prescott filtered to produce gaps except for domestic inflation, wage inflation, foreign inflation and the foreign interest rate. I use a smoothing parameter of 100,000 in the Hodrick Prescott filter. Quarterly domestic inflation, wage inflation and foreign inflation are demeaned. The foreign interest rate is linearly detrended. I transform the domestic and foreign interest rates into quarterly series by dividing by 4 and this is what I match with the model's measurement equations.

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<sup>30</sup> Nominal taxes and transfers are divided by the CPI because the consumption deflator is the numeraire in the model although using the GDP deflator in place of the CPI wouldn't make a large difference as these series track each other closely over the sample period.

**Table 10 – Model Data**

Variable	Description	Data Description	Treasury/Stats NZ data identifiers
$\hat{Y}_t$	Output gap	Gross Domestic Product - expenditure measure	NGDP_ZQ/SNEQ.SG02RSC00B15
$\hat{R}_t$	Nominal interest rate gap	New Zealand: Bank Bill Yields: 90-Days (Percent)	R90D11AMQ
$\hat{\pi}_t$	Inflation gap	Consumers Price Index: All groups	PCPIQ/CPIQ.SE9A
$\hat{\pi}_{W,t}$	Wage inflation gap	Average hourly earnings; Ordinary time; By sector: Private Sector	LQHOPRZQ
$\hat{Y}_t$	Unemployment gap	Unemployed; Total both sexes; New Zealand: Unemployment Rate	LHURZQ/HLFQ.S1F3S
$\hat{I}_t$	Investment gap	Gross Fixed Capital Formation - Total Market and Non-Market - Private	NIP_ZQ/SNEQ.SG02RSC01P51T1
$\hat{C}_t$	Consumption gap	Final Consumption Expenditure - Private Non Profit Organisations and Households Combined	NCP_ZQ/SNEQ.SG02RSC30P30G
$\hat{M}_t^*$	Export gap	Exports of Goods and Services	NZ_ZQ/SNEQ.SG06RSC00P60
$\hat{G}_t$	Government consumption gap	Final Consumption Expenditure - General Government	NGG_ZQ/SNEQ.SG02RSC30P30C
$\hat{G}_{I,t}$	Government investment gap	Gross Fixed Capital Formation - Total Market and Non-Market - General Government	NIG_ZQ/SNEQ.SG02RSC01P51T5
$\hat{Z}_t$	Transfers gap	Treasury calculations, Consumers Price Index: All groups	PCPIQ/CPIQ.SE9A
$\hat{T}_{C,t}$	Consumption tax revenue gap	GST revenue, Consumers Price Index: All groups	FTGSTM, PCPIQ/CPIQ.SE9A
$\hat{T}_{\ell,t}$	Labour tax revenue gap	Individual tax revenue, Consumers Price Index: All groups	FTINDVLM, PCPIQ/CPIQ.SE9A
$\hat{T}_{K,t}$	Capital tax revenue gap	Corporates, Residents interest, Residents dividends, Consumers Price Index: All groups	FTCPM, FTRWTM, FTTDWTM, PCPIQ/CPIQ.SE9A
$\frac{\hat{B}_t}{\hat{Y}_t}$	Government debt to GDP gap	Core Crown net debt, Gross Domestic Product - expenditure measure	FANDIFRSA, NGDP_ZQ/SNEQ.SG02RSC00B15
$\frac{\hat{S}_t}{\hat{S}_{t-1}}$	Exchange rate growth rate gap	New Zealand: Trade-Weighted Exchange Rate Index	RTWI11AMQ
$\hat{Y}_t^*$	Foreign GDP gap	Real Gross Domestic Product	IUSGDP_ZQ, IAUGDP_ZQ
$\hat{\pi}_t^*$	Foreign inflation gap	CPI-U: All Items, Consumer Price Index	IUSCPIQ, IAUCPIQ
$\hat{R}_t^*$	Foreign interest rate gap	Federal Funds Effective Rate, Percent, Quarterly, Not Seasonally Adjusted, 3-Month or 90-day Rates and Yields: Bank Bills for Australia, Percent, Quarterly, Not Seasonally Adjusted	FEDFUNDS, IR3TBB01AUM156N

## C. Model Parameterisation

The calibration is identical to Binning (2024), except for  $\beta$ , which is chosen to give a steady state real interest of 3%, close to the average real interest rate over the sample. Binning (2024) discusses how the other parameters are set.

**Table 11 – Calibrated Parameters**

Parameter	Description	Value
$\alpha$	Capital's share of income	0.3
$\alpha_G$	The elasticity of output with respect to public capital	0.07
$\beta$	The discount factor	0.9926
$\delta$	The depreciation rate for private capital	0.025
$\delta_G$	The depreciation rate for public capital	0.025
$\varepsilon$	The elasticity of substitution between intermediate goods	6
$\eta$	The elasticity of substitution between labour varieties	6.0113
$\gamma$	The inverse of the intertemporal elasticity of substitution	1
$\gamma_G$	Government consumption's response to debt	0
$\gamma_{G_I}$	Government investment's response to debt	0
$\gamma_K$	Capital tax's response to debt	0
$\gamma_{Z_N}$	Rule of thumb transfers response to debt	0
$\gamma_{Z_S}$	Ricardian transfers response to debt	0
$\mu$	Ricardian household's share	0.7
$\nu^*$	Domestic bias in foreign production	0.3
$\nu_C$	Import bias in consumption	0.25
$\nu_G$	Import bias in government consumption	0.12
$\nu_{G_I}$	Import bias in government investment	0.4
$\nu_I$	Import bias in investment	0.4
$\psi_1$	Weight on capacity utilisation adjustment cost	0.0275
$\tau_C$	Average tax rate on consumption expenditure	0.15
$\tau_K$	Average tax rate on capital income	0.28
$\tau_\ell$	Average tax rate on labour income	0.18
$\phi_S$	Net foreign debt elasticity in risk premium	0.01
$\rho_{SFA}$	Persistence of public debt shock process	0
$\rho_\kappa$	Persistence of labour preferences shock process	0
$\rho_{Z_S}$	Persistence of transfers to the Ricardian household	0
$\sigma_\kappa$	Shock standard deviation labour preferences	0
$\sigma_{Z_S}$	Shock standard deviation for transfers to the Ricardian household	0

**Table 12 – Great Ratios**

Ratio	Description	Calibrated Value	Data
$\frac{C}{Y}$	Consumption to GDP	0.60	0.58
$\frac{I}{Y}$	Investment to GDP	0.20	0.17
$\frac{G}{Y}$	Government consumption to GDP	0.15	0.18
$\frac{G_I}{Y}$	Government investment to GDP	0.05	0.05
$\frac{M}{Y}$	Imports to GDP	0.27	0.28
$\frac{X}{Y}$	Exports to GDP	0.27	0.29
$\frac{Z}{Y}$	Transfers to GDP	0.10	0.10
$\frac{B}{4 \times Y}$	Government debt to GDP	0.3	
$\frac{F}{4 \times Y}$	Net foreign debt to GDP	-0.7	-0.67
$\mathfrak{R}$	Quarterly gross real interest rate	1.0025	
$\pi$	Quarterly gross CPI inflation rate	1.005	
$\Upsilon$	Unemployment rate	0.05	
$\frac{T_K}{Y}$	Capital income tax revenue to GDP	0.08	0.06
$\frac{T_L}{Y}$	Labour income tax revenue to GDP	0.13	0.13
$\frac{T_C}{Y}$	Consumption tax revenue to GDP	0.09	0.09

**Table 13 – Estimated Parameters**

Parameter	Description	Prior*	Prior Mean	Prior Std	Post Mode
$\chi$	Elasticity of capacity utilisation costs	$\mathcal{N}$	2.00	0.50	2.427
$\xi$	Inverse of the Frisch labour supply elasticity	$\mathcal{N}$	2.00	0.25	3.263
$\phi_I$	Weight on investment adjustment costs	$\Gamma$	6.00	1.00	6.444
$\phi_X$	Weight on export adjustment costs	$\mathcal{N}$	2.00	0.25	1.934
$\theta$	Weight on habit formation	$\beta$	0.50	0.10	0.122
$\phi_W$	Weight on wage adjustment costs	$\Gamma$	200.00	20.00	178.265
$\phi_P$	Weight on domestic price adjustment costs	$\Gamma$	200.00	20.00	194.881
$\phi_F$	Weight on imported price adjustment costs	$\Gamma$	200.00	20.00	194.950
$\iota_W$	Weight on wage indexation	$\beta$	0.50	0.10	0.244
$\iota_P$	Weight on domestic price indexation	$\beta$	0.50	0.10	0.296
$\iota_F$	Weight on imported price indexation	$\beta$	0.50	0.10	0.188
$\mu_C$	EoS between domestic and imported goods in consumption	$\beta$	1.50	0.25	2.441
$\mu_I$	EoS between domestic and imported goods in investment	$\beta$	1.50	0.25	1.828
$\mu_G$	EoS between domestic and imported goods in government consumption	$\beta$	1.50	0.25	1.630
$\mu^*$	EoS between foreign and exported goods in foreign final goods	$\beta$	1.50	0.25	1.334
$\mu_{G_I}$	EoS between domestic and imported goods in government investment	$\beta$	1.50	0.25	1.598
$\kappa_\pi$	Weight on inflation in the Taylor-type rule	$\mathcal{N}$	1.50	0.50	2.246
$\kappa_y$	Weight on the output gap in the Taylor-type rule	$\mathcal{N}$	0.12	0.01	0.117
$\rho_R$	Weight on interest rate smoothing in the Taylor-type rule	$\beta$	0.50	0.10	0.871
$\psi_\ell$	Labour tax response to the output gap	$\Gamma$	1.00	0.75	1.618
$\psi_K$	Capital tax response to the output gap	$\Gamma$	1.00	0.75	2.857
$\psi_G$	Government consumption response to the output gap	$\Gamma$	1.00	0.75	0.134
$\psi_{G_I}$	Government investment response to the output gap	$\Gamma$	1.00	0.75	0.354
$\psi_{Z_N}$	RoT transfers response to the output gap	$\Gamma$	1.00	0.75	0.964
$\gamma_\ell$	Labour tax response to public debt	$\Gamma$	0.50	0.12	0.231

\* Key:  $\mathcal{N}$  = normal distribution,  $\Gamma$  = gamma distribution,  $\beta$  = beta distribution. EoS = Elasticity of substitution, RoT = Rule of thumb.



**Table 14 – Estimated Parameters**

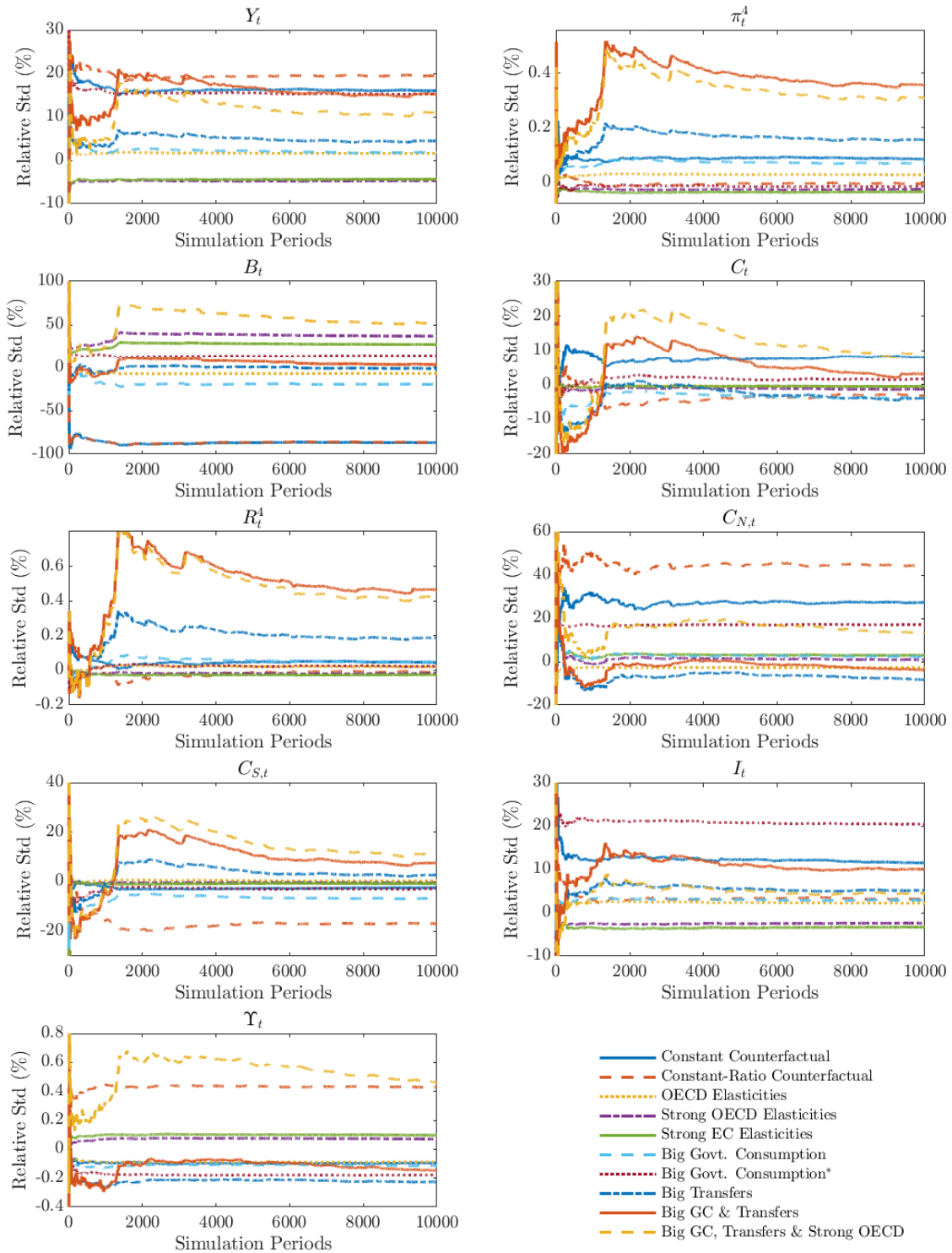
Parameter	Description	Prior	Prior Mean	Prior Std	Post Mode
$\rho_A$	Technology shock	$\beta$	0.50	0.10	0.908
$\rho_{A_I}$	Investment efficiency shock	$\beta$	0.50	0.10	0.259
$\rho_{A_P}$	Stochastic subsidy in domestic production	$\beta$	0.50	0.10	0.371
$\rho_{A_T}$	Stochastic subsidy in imported goods	$\beta$	0.50	0.10	0.210
$\rho_{A_S}$	External risk premium shock	$\beta$	0.50	0.10	0.867
$\rho_{M^*}$	Export demand shock	$\beta$	0.50	0.10	0.706
$\rho_{A_B}$	Risk premium shock	$\beta$	0.50	0.10	0.809
$\rho_{A_L}$	Labour demand shock	$\beta$	0.50	0.10	0.500
$\rho_\eta$	Elasticity of differentiated labour shock	$\beta$	0.50	0.10	0.246
$\rho_{u_C}$	Consumption tax shock	$\beta$	0.50	0.10	0.470
$\rho_{u_\ell}$	Labour tax shock	$\beta$	0.50	0.10	0.785
$\rho_{u_K}$	Capital tax shock	$\beta$	0.50	0.10	0.505
$\rho_{u_G}$	Government consumption shock	$\beta$	0.50	0.10	0.816
$\rho_{u_{Z_N}}$	Rule of thumb transfers shock	$\beta$	0.50	0.10	0.461
$\rho_{u_{G_I}}$	Government investment shock	$\beta$	0.50	0.10	0.526
$\rho_{Y^*}$	Foreign GDP shock	$\beta$	0.50	0.10	0.889
$\rho_{\pi^*}$	Foreign inflation shock	$\beta$	0.50	0.10	0.341
$\rho_{R^*}$	Foreign interest rate shock	$\beta$	0.50	0.10	0.879

**Table 15 – Estimated Parameters**

Parameter	Description	Prior	Prior Mean	Prior Std	Post Mode
$\sigma_A$	Technology shock	$\mathcal{N}$	0.00	0.40	0.01740
$\sigma_{AI}$	Investment efficiency shock	$\mathcal{N}$	0.00	0.40	0.22623
$\sigma_{uC}$	Consumption tax shock	$\mathcal{N}$	0.00	0.40	0.02972
$\sigma_{u\ell}$	Labour tax shock	$\mathcal{N}$	0.00	0.40	0.03216
$\sigma_{uK}$	Capital tax shock	$\mathcal{N}$	0.00	0.40	0.08468
$\sigma_{uG}$	Government consumption shock	$\mathcal{N}$	0.00	0.40	0.01274
$\sigma_{uGI}$	Government investment shock	$\mathcal{N}$	0.00	0.40	0.08959
$\sigma_{uZN}$	Rule of thumb transfers shock	$\mathcal{N}$	0.00	0.40	0.03716
$\sigma_R$	Monetary policy shock	$\mathcal{N}$	0.00	0.40	0.00166
$\sigma_{AP}$	Stochastic subsidy in domestic production shock	$\mathcal{N}$	0.00	0.40	0.25037
$\sigma_{AS}$	External risk premium shock	$\mathcal{N}$	0.00	0.40	0.00606
$\sigma_{AT}$	Stochastic subsidy in imported goods	$\mathcal{N}$	0.00	0.40	0.58549
$\sigma_{AB}$	Risk premium shock	$\mathcal{N}$	0.00	0.40	0.00615
$\sigma_{AL}$	Labour demand shock	$\mathcal{N}$	0.00	0.40	0.00001
$\sigma_\eta$	Elasticity of differentiated labour shock	$\mathcal{N}$	0.00	0.40	1.06459
$\sigma_{SFA}$	Public debt shock	$\mathcal{N}$	0.00	0.40	0.01122
$\sigma_{M^*}$	Export shock	$\mathcal{N}$	0.00	0.40	0.07789
$\sigma_{Y^*}$	Foreign GDP shock	$\mathcal{N}$	0.00	0.40	0.00708
$\sigma_{\pi^*}$	Foreign inflation shock	$\mathcal{N}$	0.00	0.40	0.00539
$\sigma_{R^*}$	Foreign interest rate shock	$\mathcal{N}$	0.00	0.40	0.00096

## D. Simulation Properties

Figure 2 – Simulations with Government Debt



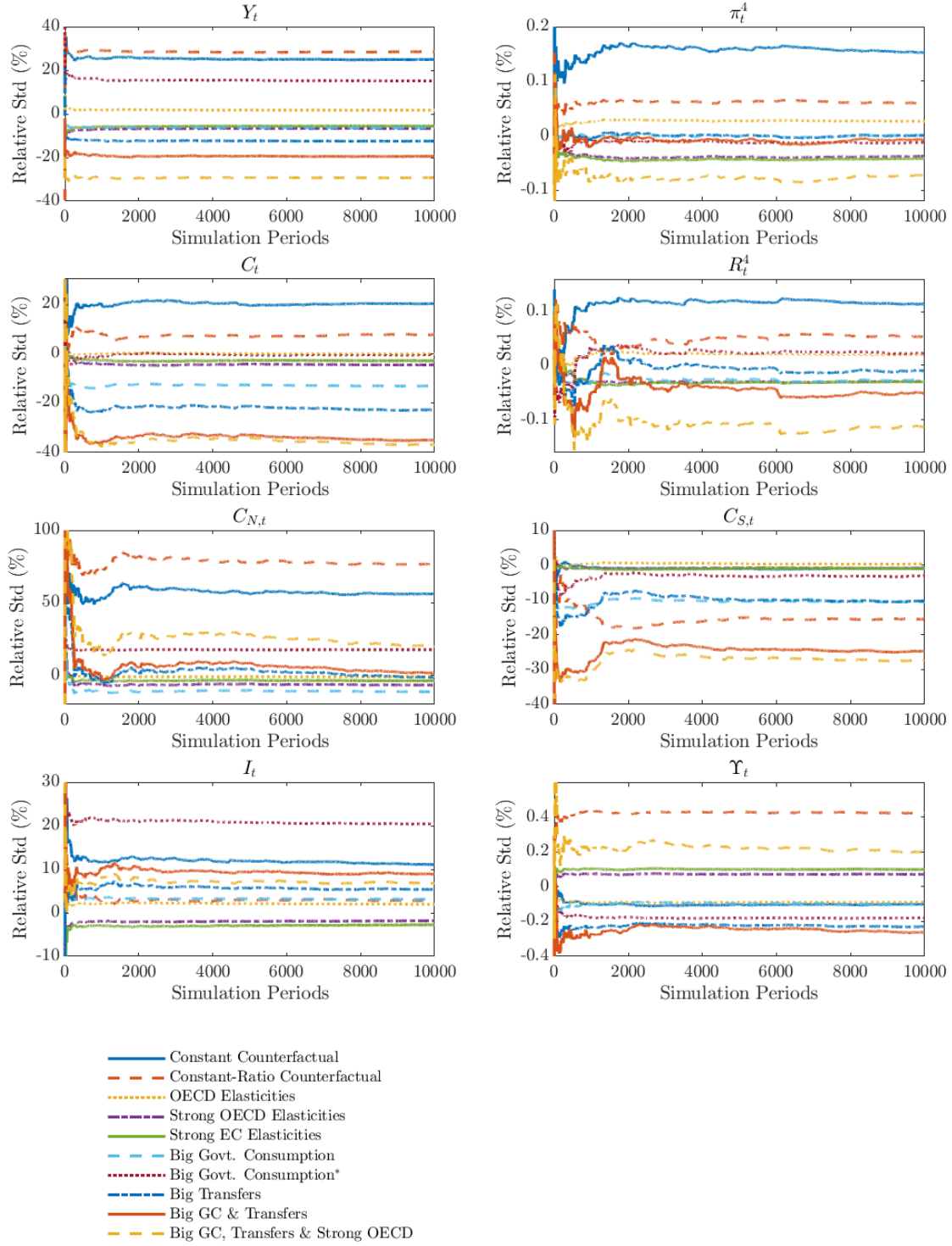
These plots contain the cumulative relative standard deviations for subset reporting variables.

The cumulative relative standard deviation is defined as:  $\Gamma_t = 100 \times \left( \frac{\sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}}}{\sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}}} - 1 \right)$

or  $\Gamma_t = 100 \times \left( \sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}} - \sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}} \right)$  where  $\bar{X}_{j,t} = \frac{1}{t} \sum_{k=1}^t X_{j,k}$  for  $j = b, c$ , and

$X = Y, \pi^A, B, C, R^A, C_N, C_S, I, \Upsilon$ .

**Figure 3 – Simulations without Government Debt**

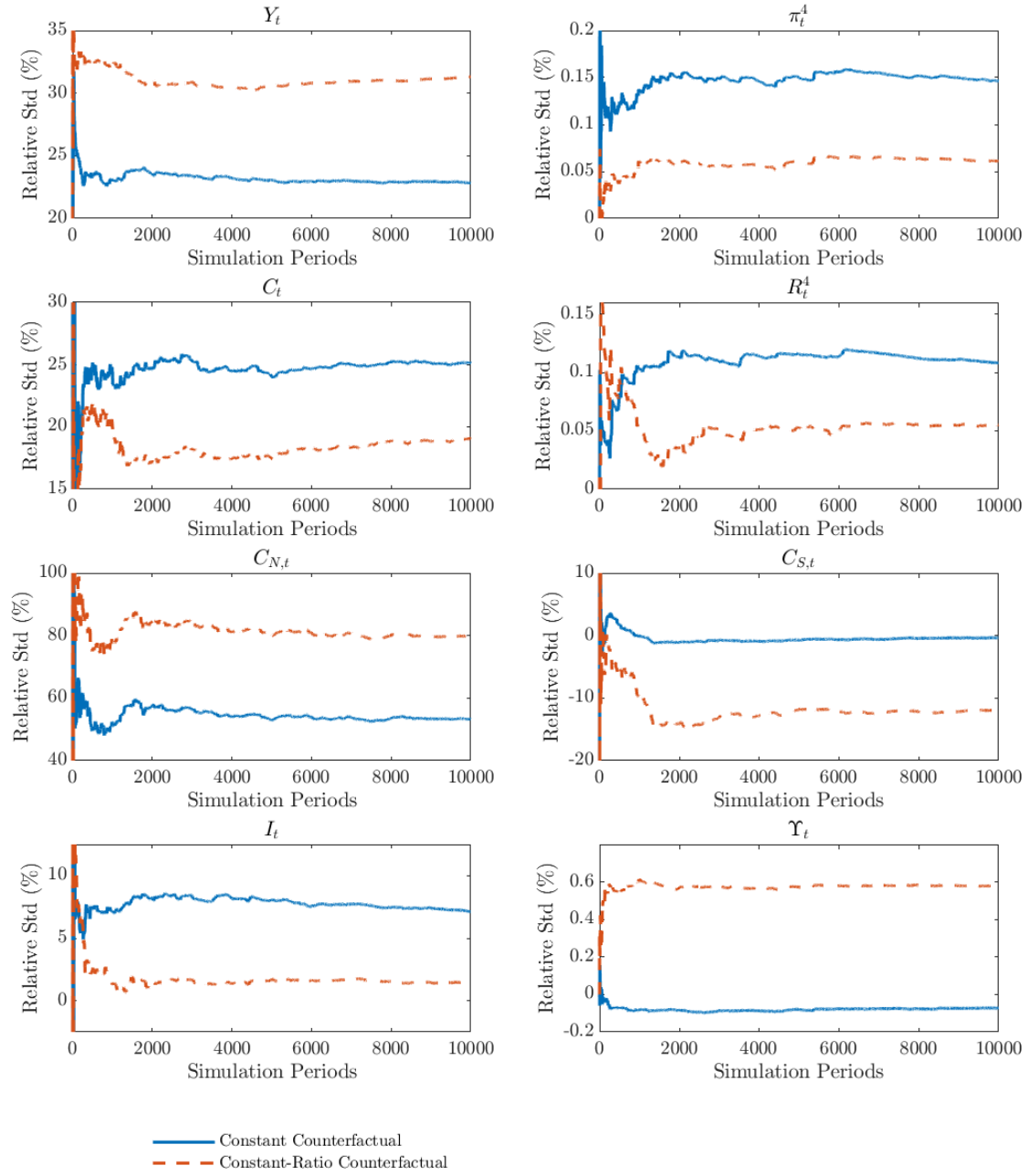


These plots contain the cumulative relative standard deviations for subset reporting variables.

The cumulative relative standard deviation is defined as:  $\Gamma_t = 100 \times \left( \frac{\sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}}}{\sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}}} - 1 \right)$

or  $\Gamma_t = 100 \times \left( \sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}} - \sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}} \right)$  where  $\bar{X}_{j,t} = \frac{1}{t} \sum_{k=1}^t X_{j,k}$  for  $j = b, c$ , and  $X = Y, \pi^A, C, R^A, C_N, C_S, I, \Upsilon$ .

**Figure 4 – Simulations in a Low Interest Rate Environment**

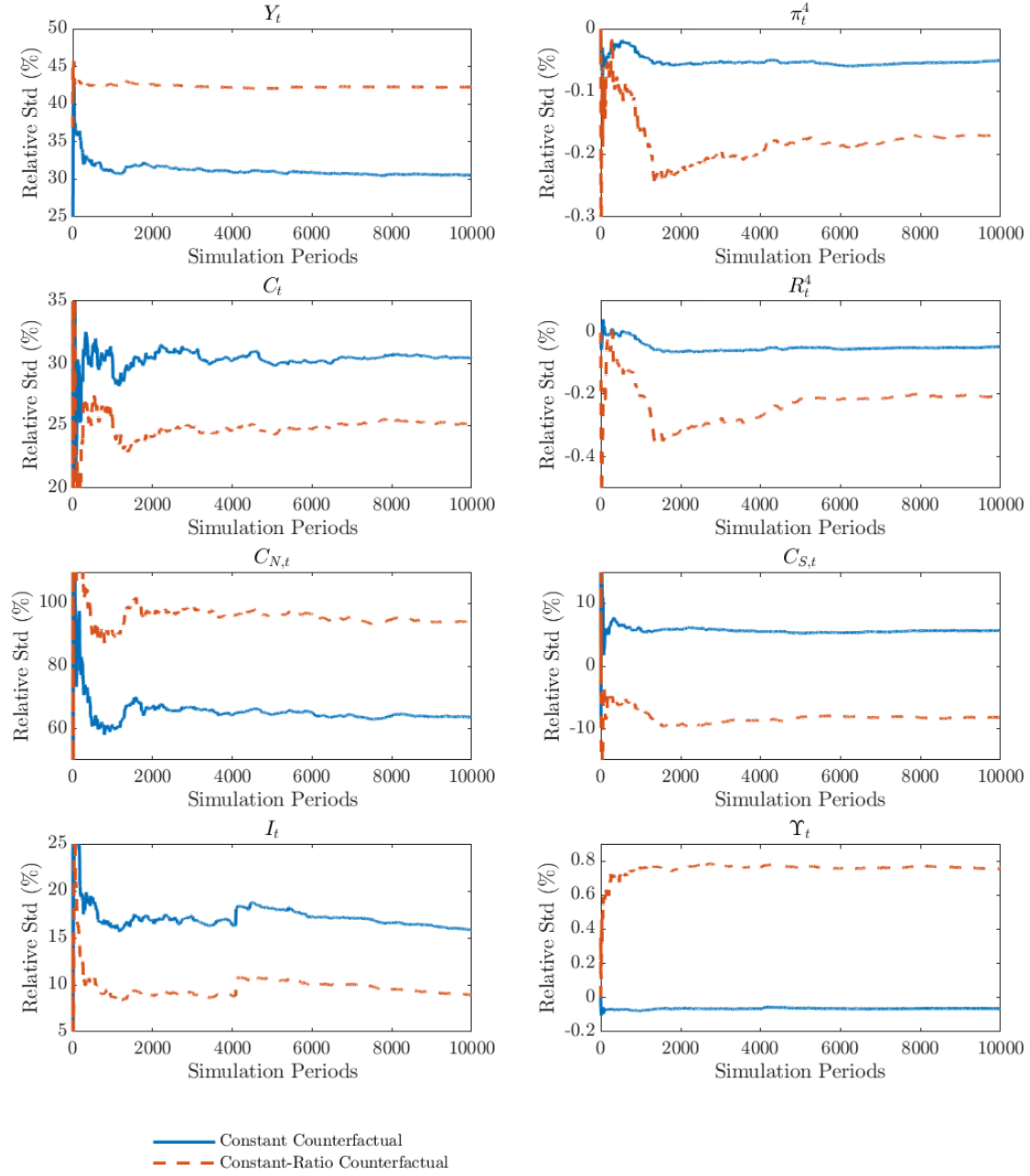


These plots contain the cumulative relative standard deviations for subset reporting variables.

The cumulative relative standard deviation is defined as:  $\Gamma_t = 100 \times \left( \frac{\sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}}}{\sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}}} - 1 \right)$

or  $\Gamma_t = 100 \times \left( \sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}} - \sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}} \right)$  where  $\bar{X}_{j,t} = \frac{1}{t} \sum_{k=1}^t X_{j,k}$  for  $j = b, c$ , and  $X = Y, \pi^A, C, R^A, C_N, C_S, I, \Upsilon$ .

**Figure 5 – Simulations Under Weak Monetary Policy**



These plots contain the cumulative relative standard deviations for subset reporting variables.

The cumulative relative standard deviation is defined as:  $\Gamma_t = 100 \times \left( \frac{\sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}}}{\sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}}} - 1 \right)$

or  $\Gamma_t = 100 \times \left( \sqrt{\sum_{i=1}^t \frac{(X_{c,i} - \bar{X}_{c,i})^2}{t}} - \sqrt{\sum_{i=1}^t \frac{(X_{b,i} - \bar{X}_{b,i})^2}{t}} \right)$  where  $\bar{X}_{j,t} = \frac{1}{t} \sum_{k=1}^t X_{j,k}$  for  $j = b, c$ , and  $X = Y, \pi^A, C, R^A, C_N, C_S, I, \Upsilon$ .

## E. Bootstrapped Residuals

The estimated shocks over the sample period are not independent, identically and normally distributed. Instead they are cross correlated and exhibit some minor heteroscedasticity. This is due to a combination of the relatively short estimation sample and model misspecification. This has consequences for the model's properties when calculated under the standard assumption of independent, identically and normally distributed shocks. While the linearised model is able to match the properties of the observed data when the model is simulated using the estimated shocks in their chronological order, this is not the case when random normally distributed shocks are used in model simulations, or when the asymptotic analytical properties of the model are calculated. It may be desirable for the properties of the simulated series to more closely match the actual data.

There are a number of approaches for more closely aligning the model's simulated properties with their counterparts in the data. Del Negro & Schorfheide (2008), Christiano et al. (2011) and Beneš & Andrle (2013) have proposed endogenous priors, also known as system priors, as a way of addressing this problem during the estimation stage. This involves imposing additional priors, based on the model's moments, on the estimation objective function. These priors nudge the model towards matching the sample properties of the data. However, these priors may be in conflict with the restrictions the model imposes and the parameter regions that match the data in the absence of these additional restrictions. This is further complicated when there are a large number of observed variables and the aim is to impose moment matching priors on all of them.

Bootstrapping simulation procedures can also be used to more closely align the model's simulated properties with the data. This is achieved by recycling the fitted shocks from the estimated model, which are able to match the moments exactly, to create new shock sequences that can be used in model simulations. Several papers have used bootstrapping procedures in structural models to produce more realistic fan charts (see Andrle & Hunt 2020, for example). However, conventional bootstrapping methods are less likely to produce downturns that look like recessions because this requires particular shock groupings. Gonzalez-Astudillo & Vilan (2019) develop a bootstrapping procedure that is able to produce recessions. They partition history into normal times and recessions. They simulate a two state Markov-switching process, one state representing normal times and the other recessions. When the Markov-switching process is in recession, they draw shocks from historical recessions. When the Markov-switching process is in normal times, they draw shocks from normal periods over history. Their method is dependent on having enough recession periods over history to draw shocks from.

Bootstrapping methods can be further refined by using a balanced sampling procedure. Balanced bootstrapping has been proposed by Davison et al. (1986) as a way of reducing sampling inefficiency. It involves sampling without replacement so that each historical shock appears  $n$  times for a synthetic series of length  $n.T$ , where  $T$  is the length of the historical shock series. Balanced bootstrapping also ensures that the cross sectional moments of the shock series are preserved, which helps when trying to match the model's moments with their counterparts in the data.

In this paper, I propose a balanced bootstrapping procedure for producing simulations. The sampling and simulation procedure is described as follows:

1. Recover the historical shocks using the linearised model and the Kalman filter/smoothener.
2. Divide the sample into blocks. I used a block size of 10, which corresponds to 11

blocks when using a historical sample of length  $T = 104$ .

3. Draw time periods within each block without replacement until each time period has been drawn. This is equivalent to rearranging the order of dates in the block, while preserving the cross sectional dependencies.
4. Repeat this  $n = 101$  times to generate a time series of shocks of length  $n.T = 10,504$ .
5. Add “jitter” to the shock time series. This is done by weighting the sum of the bootstrapped series and white noise normally distributed shocks. I use a 75% weight on the bootstrapped shocks and a 25% weight on the iid normal shocks.
6. Simulate the non-linear model using the sequence of shocks.
7. Burn the first 500 periods to remove the impact of the initial condition on the results and keep the next 10,000 periods. I calculate moments and distributions using the second half of the sample.

By sampling without replacement, I ensure the sampling procedure is balanced and the shocks cross-sectional moments match their historical counterparts. Sampling within blocks preserves some of the heteroscedasticity, which is key to producing simulated moments that are not too different from the original data. This also ensures that recession and normal time shocks are preserved. Adding jitter gets around some of the small sample issues and adds some randomness to the simulations, while maintaining the underlying bootstrapping procedure. I use the same sequence of bootstrapped shocks for each of the model simulations that I run. I do not use any of the policy shocks, the debt shock or the labour substitution shock to produce the simulations.

**Table 16 – Model vs Data Standard Deviations**

Variable	Model: Normal Shocks	Model: Bootstrapped Shocks	Data
$100 \times \log \left( \frac{Y_t}{\bar{Y}} \right)$	4.54	2.12	2.20
$100 \times \log \left( \frac{R_t}{\bar{R}} \right)$	0.72	0.41	0.36
$100 \times \log \left( \frac{\pi_t}{\bar{\pi}} \right)$	1.02	0.56	0.49
$100 \times \log \left( \frac{\pi_{W,t}}{\bar{\pi}_W} \right)$	0.83	0.34	0.49
$100 \times \Upsilon_t$	3.16	1.35	0.89
$100 \times \left( \frac{I_t}{\bar{I}} \right)$	14.62	9.64	9.66
$100 \times \left( \frac{C_t}{\bar{C}} \right)$	5.17	2.90	2.43
$100 \times \left( \frac{B_t}{4 \times P_{H,t} Y_t} - \frac{B}{4 \times P_H \bar{Y}} \right)$	10.44	3.48	4.35
$100 \times \left( \frac{S_t}{S_{t-1}} - 1 \right)$	3.95	2.84	3.41
$100 \times \log \left( \frac{Y_t^*}{\bar{Y}^*} \right)$	1.53	1.42	2.35
$100 \times \log \left( \frac{R_t^*}{\bar{R}^*} \right)$	0.21	0.20	0.32
$100 \times \log \left( \frac{\pi_t^*}{\bar{\pi}^*} \right)$	0.58	0.45	0.55



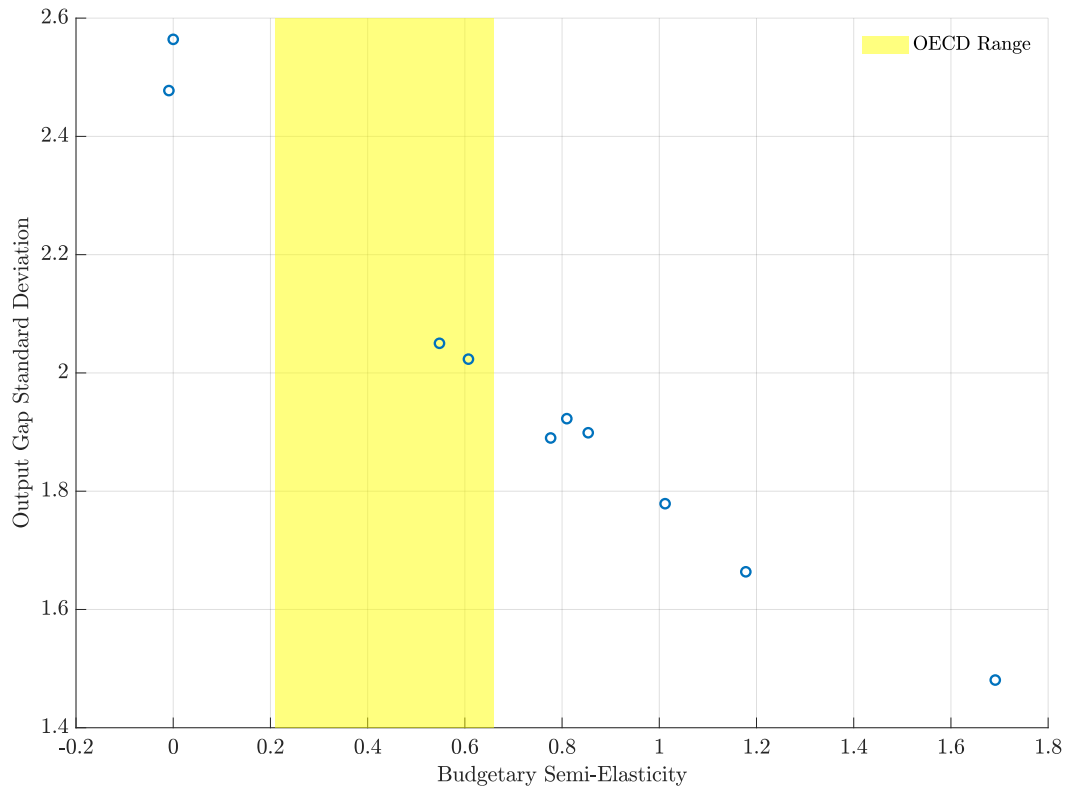
**Table 17 – Percentage Change in Volatilities - Simulations with Government Debt**

Scenario	$Y_t$	$\pi_t^4$	$B_t$	$C_t$	$R_t^4$	$C_{N,t}$	$C_{S,t}$	$I_t$	$\Upsilon_t$	$\log\left(\frac{Y_t}{\bar{Y}}\right)$	$\log\left(\frac{B_t}{\bar{B}}\right)$	$\log\left(\frac{C_t}{\bar{C}}\right)$	$\log\left(\frac{C_{N,t}}{C_N}\right)$	$\log\left(\frac{C_{S,t}}{C_S}\right)$	$\log\left(\frac{I_t}{\bar{I}}\right)$
Constant Counterfactual	17.53	0.04	-80.24	6.79	0.03	24.25	-3.36	11.22	-0.04	0.37	-9.20	0.21	0.59	-0.15	1.10
Constant-Ratio Counterfactual	21.64	0.01	-80.15	-2.14	0.02	39.32	-12.07	4.12	0.17	0.46	-9.19	-0.05	0.96	-0.54	0.42
OECD Elasticities	1.25	0.01	-6.76	-0.42	0.00	-1.27	-0.02	1.81	-0.04	0.03	-0.80	-0.01	-0.03	0.00	0.17
Strong OECD Elasticities	-5.02	-0.01	31.04	-1.17	-0.01	-0.15	0.20	-2.26	0.03	-0.11	3.90	-0.04	-0.01	0.01	-0.22
Strong EC Elasticities	-4.29	-0.01	24.45	-0.39	-0.01	0.66	0.15	-2.96	0.04	-0.09	3.04	-0.01	0.01	0.01	-0.28
Big Govt. Consumption	0.21	0.02	-8.02	-9.35	0.00	1.82	-10.90	1.95	-0.02	0.01	-1.35	0.21	0.39	0.35	0.07
Big Transfers	0.44	0.04	7.88	-13.01	0.02	3.16	-9.66	3.02	-0.04	0.02	0.61	-0.37	-0.63	0.92	0.29
Big GC & Transfers	7.56	0.07	9.32	-18.03	0.04	5.06	-17.21	5.33	0.13	0.18	0.71	-0.07	-0.42	1.95	0.40
Big GC, Transfers & Strong OECD	2.82	0.05	48.60	-14.51	0.03	19.30	-15.44	1.35	0.39	0.08	5.30	0.05	-0.15	2.08	0.02

**Table 18 – Percentage Change in Volatilities - Simulations without Government Debt**

Scenario	$Y_t$	$\pi_t^4$	$C_t$	$R_t^4$	$C_{N,t}$	$C_{S,t}$	$I_t$	$\Upsilon_t$	$\log\left(\frac{Y_t}{\bar{Y}}\right)$	$\log\left(\frac{C_t}{\bar{C}}\right)$	$\log\left(\frac{C_{N,t}}{C_N}\right)$	$\log\left(\frac{C_{S,t}}{C_S}\right)$	$\log\left(\frac{I_t}{\bar{I}}\right)$
Constant Counterfactual	22.48	0.05	12.51	0.01	27.54	-2.15	11.09	-0.04	0.45	0.35	0.64	-0.10	1.09
Constant-Ratio Counterfactual	26.73	0.02	3.16	0.01	42.70	-10.97	3.95	0.17	0.54	0.09	1.00	-0.48	0.40
OECD Elasticities	1.34	0.01	-0.05	0.00	-0.74	0.06	1.64	-0.04	0.03	0.00	-0.02	0.00	0.16
Strong OECD Elasticities	-6.17	-0.01	-2.96	0.00	-0.65	-0.33	-1.80	0.03	-0.12	-0.08	-0.01	-0.01	-0.18
Strong EC Elasticities	-5.00	-0.01	-1.83	0.00	-0.28	-0.28	-2.50	0.04	-0.10	-0.05	0.00	-0.01	-0.24
Big Govt. Consumption	-6.65	0.01	-15.76	0.01	-2.94	-13.37	2.17	-0.02	-0.13	-0.01	0.26	0.22	0.10
Big Transfers	-12.70	0.01	-24.05	0.02	9.72	-16.75	3.65	-0.06	-0.24	-0.65	-0.51	0.50	0.38
Big GC & Transfers	-18.81	0.02	-38.43	0.03	11.18	-32.81	6.04	0.04	-0.36	-0.73	-0.29	0.77	0.52
Big GC, Transfers & Strong OECD	-27.77	0.00	-38.57	0.03	25.22	-34.48	4.42	0.24	-0.54	-0.73	-0.03	0.64	0.37

**Figure 6 – Budgetary Semi-Elasticities vs Output Gap Volatility**



The yellow highlighted region represents the range of budgetary semi-elasticities across the OECD, based on OECD calculations.