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Government Spending Multipliers in Times of Tight and Loose Monetary Policy: Evidence for New Zealand*

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We investigate the cumulative government spending multiplier in times of tight and loose monetary policy for New Zealand. Using local projections with instrumental variables, we find the spending multiplier peaks at 0.54 under loose monetary policy, while remaining statistically insignificant when monetary policy is tight. Splitting government spending into two components leads to different results. The government consumption multiplier does not depend on the stance of monetary policy and peaks at a value of 1.57. On the other hand, the government investment multiplier peaks at 1.10 when monetary policy is loose, but is not statistically significant when it is tight.

JEL Classifications: E62, E63, H50.

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1 Introduction

When the recent global financial crisis (GFC) unfolded, interest rates in many developed nations fell close to the zero lower bound (ZLB) and alternative policies in the form of fiscal stimulus packages were considered to avoid a depression (Ramey, 2019). Since then, discretionary monetary and fiscal policies have been used in conjunction to provide economic support in times of distress, including during the current COVID-19 pandemic (Capano et al., 2020). Parallel to this, researchers have shown a renewed interest in quantifying fiscal multipliers to understand the impact of policy decisions.

Initial research focused on 'average' multipliers, estimated without considering the state of the economy over the business cycle. While this provided some insight, improved methodologies have allowed for a change of focus. Researchers are now interested in how fiscal multipliers change with the state of the economy. Comparing multipliers of normal times to those at the ZLB (Bonam et al., 2020; Crafts and Mills, 2013; Miyamoto et al., 2018; Ramey, 2011), in times of economic slack (Auerbach and Gorodnichenko, 2012; Fazzari et al., 2015; Owyang et al., 2013; Ramey and Zubairy, 2018), and in times of high private debt overhang (Bernardini and Peersman, 2018) has been of particular interest. Research after the GFC primarily estimates spending multipliers above one (Auerbach and Gorodnichenko, 2012; Fazzari et al., 2015). However, more recent analysis has revealed these initial estimates are likely to be positively biased by their econometric methodology (Ramey, 2011, 2019; Ramey and Zubairy, 2018).

This paper adds to the current literature on fiscal policy in New Zealand. It extends the studies of Claus et al. (2006), Dungey and Fry (2009), Parkyn and Vehbi (2014), and Hamer-Adams and Wong (2018) by analysing whether the government spending multiplier depends on the state of monetary policy. We estimate the spending multiplier in times of tight and loose monetary policy to determine whether there is a statistically significant difference between multipliers in each state. The New Zealand economy is particularly useful for analysing spending multipliers in this context. Unlike other OECD economies[1], New Zealand's economy has not experienced negative interest rates, nor rates near the ZLB for the vast majority of our sample period. We not only add to the current literature by estimating the government spending multiplier across states of monetary policy, we also add to the growing literature on spending multipliers in small open economies.

We follow the local projection-instrumental variable (LP-IV) method of Ramey and Zubairy (2018) and compare a non-linear empirical model to its linear version, building on previous New

[1] Krippner (2021) calculates short-term shadow rates for several countries based on estimates of the term structure of interest rates. These rates are suggested as a proxy for the stance of monetary policy in unconventional times (Krippner, 2020). Shadow rates for New Zealand only reach the ZLB, in the literature assumed to be generally a rate below 1%, in 2019Q3 and go negative in 2020Q2 (Krippner, 2021). In our sample, which ends in 2019Q4, there are only two quarters of interest rates near the ZLB. Therefore, the ZLB is not relevant for our study with New Zealand data.

Zealand studies. The linear model assumes the spending multiplier does not depend on the stance of monetary policy while the non-linear model estimates the spending multiplier in times of tight and loose monetary policy. We empirically establish whether (i) the government spending multiplier is dependent on the state of monetary policy and (ii) if it is, its value in each state.

The remainder of our paper is laid out as follows: Section 2 reviews recent literature and the methodological advancements over the last 10 years. Section 3 outlines our methodology. Section 4 presents our baseline model and Section 5 discusses our robustness checks. Section 6 concludes.

2 Literature Review

Research published in recent years focuses on quantifying fiscal multipliers and understanding how they vary with the state of the economy. Despite numerous studies on the topic, there is no consensus on the empirical size of these multipliers (Ramey, 2019). Most research focuses on the US and UK economies with limited research on small open economies, such as New Zealand. Our review begins by introducing the seminal work of Blanchard and Perotti (2002) before discussing the government spending multiplier: its estimates, state dependence, and the methodological improvements made in recent years. We then focus on research relating to New Zealand.

2.1 Blanchard and Perotti (2002)

Published before the GFC, Blanchard and Perotti's (2002) seminal research forms the foundation for most subsequent studies on fiscal multipliers. Post-WWII US data is used to investigate the impact of fiscal shocks by estimating both the tax and government spending multipliers. Fiscal shocks are identified by imposing externally calculated elasticities for the automatic response of tax revenue and by using the time lags of responses of fiscal variables due to institutional factors. They use a linear structural vector autoregression (SVAR) to construct iterative impulse response functions (IRFs) and multipliers in the form of elasticities. The variables included in their baseline model are real government spending, taxes and GDP with results dependent on whether the time trend in the SVAR is either deterministic or stochastic. Under a deterministic trend the spending multiplier is estimated to peak at 1.29, 20 quarters after the fiscal shock. However, when using a stochastic trend, the estimate never exceeds unity with a peak value of 0.9 on impact. Similar discrepancies are found for the tax multiplier.

Aside from trend specification, these contradictory results could also possibly be explained by Blanchard and Perotti's (2002) use of a linear SVAR model that inherently assumes the economy remains in a single state rather than varying between states over the business cycle. Post-GFC studies often relax this assumption by using non-linear models to consider different states of the economy. Furthermore, Mertens and Ravn (2014) show that Blanchard and Perotti's (2002) results critically depend on the values of the fiscal elasticities calculated and imposed from outside the SVAR model.

2.2 The Government Spending Multiplier

Since the linear SVAR approach of Blanchard and Perotti (2002) numerous researchers have developed non-linear models to analyse the state-dependence of the government spending multiplier. The state of the economy is captured in different ways, with consideration given to the ZLB, economic slack, and private debt overhang. We briefly discuss the estimates reported and methods used.

2.2.1 Zero Lower Bound

A theoretical study by Woodford (2011) analyses the size of the US spending multiplier using neoclassical and New Keynesian models. The neoclassical model with perfectly flexible wages and prices suggests government expenditure leads to a spending multiplier below unity, as government spending crowds out private investment. However, the New Keynesian model with sticky prices and wages indicates a much larger spending multiplier, with its size dependent on monetary policy. Woodford (2011) also indicates that the US spending multiplier when interest rates are at the ZLB is much larger than in normal times, with a value above one possible.

Eggertsson (2011) agrees with Woodford (2011), however, suggests the US spending multiplier at the ZLB could reach a value of two, while below unity during normal times. Cogan et al. (2010) disagree with these estimates, indicating the US spending multiplier at the ZLB is approximately unity on impact and declines thereafter. Both Eggertsson (2011) and Cogan et al. (2010) use a New Keynesian dynamic stochastic general equilibrium (DSGE) model with a government spending shock equivalent to 1% of GDP. However, a key difference in their methods may explain their opposing conclusions. Cogan et al. (2010) assume increased government spending continues beyond the ZLB while Eggertsson (2011) assumes government spending only increases while at the ZLB. Further empirical work by Christiano et al. (2011) agrees with Woodford (2011) and Eggertsson (2011), suggesting the US spending multiplier is higher than unity when interest rates are at the ZLB. In contrast, Ramey's (2011) empirical research finds no evidence that the spending multiplier is greater when interest rates are at the ZLB or that it is above unity at or beyond the ZLB, compared to normal times. Ramey (2011) constructs IRFs iteratively and uses historic military events and related large military spending in the US to construct a narrative *news* variable to define unexpected fiscal shocks.

Recent studies use improved econometric methods to estimate fiscal multipliers. Ramey and Zubairy (2018) employ historical US data from 1890Q1 to 2015Q4 to estimate the government spending multiplier in normal times, at the ZLB, and in times of high and low economic slack. Unlike the research discussed so far, Ramey and Zubairy (2018) construct IRFs and spending multipliers using local projections (LP; Jordà, 2005; Montiel Olea et al., 2020) at each impulse horizon. Unlike standard IRFs that are based on iterative methods and assume the economy does not change its state over the IRF horizon, this local projections method incorporates changes to the state of the economy. Furthermore, Ramey and Zubairy (2018) use government spending shocks as instrumental variables (IVs) in local projections in order to estimate the cumulative government spending multiplier directly at various horizons. They apply the LP-IV method on both linear and non-linear models. The linear model assumes the multiplier does not depend on the state of the economy such that it represents an average multiplier over the business cycle. The non-linear model estimates a separate spending multiplier for each of the two states, high and low economic slack. Real GDP and government spending are included in the baseline version of each model, with both military news shocks and Blanchard-Perotti government spending shocks used for comparison. Government spending is defined as government consumption plus government investment.

When using the full sample and a military news shock the government spending multiplier is greater in normal times than at the ZLB with estimates of 0.78 and 0.66, respectively. The opposite is true under a Blanchard-Perotti shock for which the spending multiplier is estimated to be greater at the ZLB than in normal times (0.63 and 0.16, respectively). While these results appear conflicting, we should note the multiplier estimates across states are not statistically significantly different from each other following the military news shock but are following the Blanchard-Perotti shock.

Interestingly, when the rationing period of WWII is excluded from the sample, results for each type of shock indicate the government spending multiplier is greater at the ZLB than in normal times. Following a military news shock the spending multipliers at the ZLB and in normal states are 1.40 and 0.63 respectively, after two years. Under a Blanchard-Perotti shock these values are 1.08 and 0.10, respectively. In each case the government spending multiplier is statistically significantly different between states. This second set of results is in line with Eggertsson (2011) and Woodford (2011).

Miyamoto et al. (2017) also compare the government spending multiplier at the ZLB to normal times. They use a method similar to Ramey and Zubairy (2018) with Blanchard-Perotti government spending shocks for Japanese data from 1980Q1 to 2014Q4. They estimate a spending multiplier of 1.54 on impact when at the ZLB, more than double that of normal times when it is estimated as 0.61.

Bonam et al. (2020) put a twist on previous research by using a panel VAR model for 17 developed nations.[2] They investigate the impact of disaggregated public spending shocks (government

[2] These do not include New Zealand.

consumption and investment spending) when interest rates are persistently low. Countries are considered to be in the ZLB state when interest rates are below 1% for four consecutive quarters. With a similar method to the previous two studies, the government consumption multiplier is estimated to peak at 2.0 and 0.3 for the ZLB and normal states, respectively. The government investment multiplier peaks at 1.1 and 0.8 for the ZLB and for normal states, respectively. This study suggests the spending multiplier varies with the type of government spending.

2.2.2 Economic Slack

Auerbach and Gorodnichenko (2012) offer a seminal piece of research on fiscal multipliers when the economy is in a recession. They use a non-linear SVAR model with a smooth transition logistic two-regime switching function and US data to estimate the spending multiplier in recessions and expansions.[3] In their baseline model, following a Blanchard and Perotti shock, the government spending multiplier is estimated to be 2.24 in a recession, and -0.33 in an expansion after five years. However, the latter result is not statistically significant at the 5% level.

Auerbach and Gorodnichenko (2012) disaggregate government spending shocks in two ways, into defence and non-defence spending, and into investment and consumption spending. Following a defence spending shock, the spending multiplier is estimated to be 1.67 in a recession and -0.43 in an expansion, with the latter result statistically insignificant at the 5% level. Interestingly, the spending multiplier is very similar across states following a non-defence spending shock with estimates of 1.09 and 1.03 for recessions and expansions, respectively. Under a government consumption shock, the spending multiplier is estimated to be 1.47 in a recession and -0.25 in an expansion. These estimates are much lower than following a government investment shock for which estimates of the spending multiplier are 3.42 in a recession and 2.27 in an expansion. Overall, Auerbach and Gorodnichenko's (2012) results suggest the spending multiplier is greater in times of recession than expansion, however, the exact value depends on the type of government spending shock. After considering alternative model specifications and taking the US economic history into account, they state their *"preferred"* spending multiplier estimates are 1.0 to 1.5 in a recession and 0.0 to 0.5 in an expansion.[4]

Using a related discrete-change (non-smooth) threshold SVAR, Fazzari et al. (2015) also find that the US government spending multiplier is greater in times of economic slack.[5] A structural VAR

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[3] A seven-quarter centred moving average of the real GDP growth rate is used as an indicator that triggers regime transition. See also Caggiano et al. (2015) for a similar approach with particular attention to fiscal expectations.

[4] Subsequently, Ramey and Zubairy (2018) implement Jordà's (2005) local projections method on Auerbach and Gorodnichenko's (2012) data and baseline specification. In doing so they estimate the spending multiplier as 0.84 after five years, more in line with their own estimates.

[5] They point out that Auerbach and Gorodnichenko (2012) impose parameters on the smooth transition function, instead of estimating them as they do in their discrete transition model.

identification with several alternative variables is used to measure the amount of slack in the economy. The peak spending multiplier for the states of high and low utilisation capacity are estimated as 1.6 and 0.8, respectively, two years after the shock.

As mentioned previously, Ramey and Zubairy (2018) also investigate the US economy in states of high and low economic slack, defined using an unemployment rate threshold of 6.5% for the baseline regressions.[6] Whether using a military news or Blanchard-Perotti shock, the government spending multiplier remains below unity in each state, a contrast to previous results. After a military news shock the spending multiplier is almost identical across states with estimates of 0.60 and 0.59, in times of high and low economic slack, respectively, two years after the shock. Furthermore, the difference in estimates across states is not statistically significant, indicating the spending multiplier is not dependent on slack in the economy. Interestingly, estimates are statistically different between states of unemployment when using a Blanchard-Perotti shock, with estimates of the spending multiplier of 0.68 and 0.3 in times of high and low unemployment, respectively, two years after the shock.

2.2.3 Private Debt Overhang

A final, and new area of interest is understanding the impact of private debt overhang on the government spending multiplier. Bernardini and Peersman (2018) introduce research to this area using data from the US economy and follow the method of Ramey and Zubairy (2018). They define high private debt as two consecutive quarters with a debt-to-GDP ratio larger than the Hodrick-Prescott (HP) stochastic trend value (Hodrick and Prescott, 1997) of the same variable. Two years after a Blanchard-Perotti shock, the spending multiplier in states of low and high private debt is estimated as 0.93 and 1.57, respectively. Following a military news shock these estimates increase to 0.8 and 2.3, respectively. These results suggest the spending multiplier is greater in times of high private debt than low private debt. These results are robust when controlling for business cycles, public debt overhang, the ZLB and financial crises.

2.3 Fiscal Shocks in the New Zealand Economy

Research on the impact of fiscal shocks on the macroeconomy has been largely focused on the US and other large economies. We now turn to research which relates directly to New Zealand. To date, this research has focused on the average effect of fiscal shocks, estimated using linear VARs.

[6] See also Owyang et al. (2013), who include Canada besides the US.

Claus et al. (2006) investigate the spending and tax multipliers in New Zealand using data from 1982Q2 to 2004Q3.[7] They use the same SVAR model specification and identification strategy as Blanchard and Perotti (2002), imposing externally calculated elasticities for New Zealand. Claus et al. (2006) find the impact government spending multiplier under a deterministic and stochastic time trend to be 0.14 and 0.13, respectively. These multipliers are below unity and much smaller than equivalent spending multiplier estimates of Blanchard and Perotti (2002) with US data of 0.84 and 0.9, respectively. Despite their low value, each of the estimates reported in Claus et al. (2006) are statistically significant at the 5% level.

Dungey and Fry (2009) present a new methodology to disentangle temporary and permanent shocks in a SVAR framework. Their method combines identification via sign restrictions, cointegration and exclusion restrictions, and explicitly models stationary and non-stationary variables. They do not calculate fiscal multipliers, however, the IRF for a positive government spending shock shows higher output in the economy. Also, historical shock decompositions reveal government spending shocks are approximately counter-cyclical. While they make positive contributions to output prior to March 2003, they act negatively on output since then.

Further research for New Zealand came after the GFC. Parkyn and Vehbi (2014) use data from 1983Q1 to 2010Q2. Their SVAR model builds on the three-variable linear SVAR of Blanchard and Perotti (2002) and Claus et al. (2006) to include interest rates and inflation in addition, while also taking the public debt-to-GDP ratio into consideration. Alongside the government spending multiplier Parkyn and Vehbi (2014) estimate the tax multiplier, identified by imposing external elasticities similar to Claus et al. (2006) and Blanchard and Perotti (2002). However, because Parkyn and Vehbi (2014) include additional variables in their SVAR model, more externally imposed elasticities are required. In addition to the elasticities of government spending and taxes to GDP (as used in Blanchard and Perotti, 2002), they also use the elasticities of government spending and taxes each with respect to interest rates and inflation. Keeping our focus on spending multipliers, Parkyn and Vehbi (2014) find a government spending shock equivalent to 1% of GDP results in a spending multiplier of 0.25 on impact and 0.46 (in terms of percentage changes in output) after one year. This indicates a small but positive response much like Claus et al. (2006).

Hamer-Adams and Wong (2018) provide a further adaptation to the linear SVAR model of Parkyn and Vehbi (2014) while using the same identification strategy and method to quantify shocks. Much like Parkyn and Vehbi (2014), Hamer-Adams and Wong (2018) estimate tax and spending multipliers. However, they take their estimation of the spending multiplier one step further by also

[7] Their sample covers periods with and without inflation targeting, which was introduced in New Zealand in 1990.

disaggregating government spending and estimating its value following shocks to government consumption and investment separately. Following a shock to total government spending the spending multiplier is estimated as 0.43 on impact and 0.24 after one year. However, results are not statistically significant after the first quarter. When government spending is disaggregated, the spending multiplier following a shock to government consumption and investment is estimated as 0.82 and -0.59, respectively after the first year. While the negative multiplier is surprising, Hamer-Adams and Wong (2018) acknowledge this value is sensitive to model specification. Furthermore, all spending multiplier estimates from the disaggregated models are not statistically significant at the 5% level. Although research on fiscal multipliers in the New Zealand economy is limited, results generally match those of developed nations. Hamer-Adams and Wong (2018) note the next step is to consider state-dependent spending multipliers in New Zealand using a non-linear model.

3 Methodology

We largely follow the SVAR-based LP-IV approach of Ramey and Zubairy (2018) to estimate government spending multipliers.[8] To estimate IRFs, we use local projections (Jordà, 2005) for each impulse horizon instead of the conventional iterative approach. Rather than using VAR parameters estimated once over the full sample, the local projections method re-estimates parameters at each horizon. Monte Carlo studies have shown that this method is generally more robust to misspecification than standard IRFs and successfully accommodates non-linear models (Jordà, 2005).

Following Ramey and Zubairy (2018), we use Blanchard-Perotti government spending shocks as an instrument for the estimation of cumulative multipliers. We use New Zealand data, building on and extending the studies of Hamer-Adams and Wong (2018), Parkyn and Vehbi (2014), and Claus et al. (2006). However, unlike these New Zealand studies, we do not identify tax shocks. Mertens and Ravn (2014) show how tax multipliers used for identification crucially depend on externally calculated elasticities imposed on SVARs of the type used by the Blanchard and Perotti (2002). The key elasticity is the elasticity of tax revenue with respect to output. Auerbach and Gorodnichenko (2012) point out that this elasticity likely changes over the business cycle and is not constant as usually assumed. Hence, some researchers have moved to narratively identified tax revenue changes.[9] Information on the timing, motivation, and quantitative effects on tax revenue of enacted tax changes is not publicly available for New Zealand and a narrative tax analysis would be beyond the scope of this paper.

[8] An advantage over DSGE models is that structural VARs impose less economic theory. See Pagan and Wickens (2019) on advantages and disadvantages of each, and how they relate to each other.

[9] The narrative approach to identify tax revenue shocks due to tax law changes was pioneered by Romer and Romer (2010) for the US. For as survey on tax multipliers, see Ramey (2019).

3.1 Data, Multipliers, IRF Estimation and Inference, and Baseline Model Specification

3.1.1 Data Description

We use data for the New Zealand economy from 1991Q1 to 2019Q4 (116 quarterly observations) in all models and all robustness checks. This range is determined by two important economic events. The start date was chosen to encompass the Reserve Bank of New Zealand's (RBNZ) current monetary policy regime, inflation targeting, which began in 1990 (McDermott and Williams, 2018). We exclude 1990Q2 to 1990Q4 in order to allow an adjustment period at the start of the regime and also to accommodate the start of the census-based population series in 1991Q1 from the Infoshare data base of Statistics New Zealand. The final quarter was selected to maximise the sample while excluding data for the COVID-19 pandemic period.[10]

Variables used across all models, including robustness checks, are level measures of real GDP, real government spending, real government consumption, real government investment, the ratio of nominal tax receipts to nominal GDP, inflation, the 90-day bank bill rate (90BBR), nominal and real trade weighted indices, and the 5-year secondary market government bond yield (5YBR). Variables are seasonally adjusted, where appropriate, with further details available in Appendix A.

We use the 90BBR[11] to reflect the stance of monetary policy, following Dungey and Fry (2009), and tax receipts rather than tax revenue. According to the Treasury[12], tax revenue measures the tax payments due in a given month and is partially calculated using estimates from taxpayers and tax-paying entities. Although tax revenue data are audited yearly, tax receipts are a measure of tax collected, rather than an estimation of what is to be collected. The Treasury also acknowledges that tax revenue is harder to measure and often more erratic than tax receipts. Considering these factors we chose to use tax receipts, hereafter referred to as 'tax'.[13]

3.1.2 Definition of the Spending Multiplier

Mountford and Uhlig (2009), among others, argue that the government spending multiplier should be calculated using integrals, taking the ratio of the integral of the GDP response to the integral of the government spending change. This multiplier represents the cumulative gain in GDP in relation to the cumulative response of government spending for an initial government spending shock. Multipliers

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[10] The first case of COVID-19 in New Zealand was recorded on 28 February 2020 (Ministry of Health, 2020). When this project began only one quarter of data from the pandemic was available and we were concerned its use would skew results.
[11] Studies with New Zealand data generally use the 90BBR to represent the short term interest rate.
[12] https://www.treasury.govt.nz/publications/tax-outturn-data/tax-outturn-data-may-2020
[13] We use tax as a control variable only and follow Ramey and Zubairy (2018) by not subtracting transfer payments.

calculated in this manner are of particular interest to policy makers, who want to understand the total impact of government spending shocks over a given time period.

A further problem in estimating multipliers arises when using the logarithmic rather than level measures of variables. Most researchers use the log of macroeconomic variables, however, this results in IRFs depicting elasticities rather than multipliers that give the dollar change in GDP for a one dollar increase in government spending. In such cases a second step must then be taken to convert these elasticities to dollar amounts. This is generally done using the ratio of the sample average of GDP to the sample average of government spending as a conversion factor (Ramey, 2019). Ramey and Zubairy (2018) highlight a problem with this method. The ratio used to transform elasticities can vary greatly over time and is sensitive to the length of the time series. To overcome any such bias, Ramey and Zubairy (2018) implement Gordon and Krenn's (2010) transformation on GDP and government spending. Rather than using logarithms, the level measure of each variable is divided by the trend of GDP. This ensures variables are in the same units and allows the cumulative spending multiplier to be read directly from the IRFs at each horizon (Ramey, 2019). We follow Ramey and Zubairy's (2018) method and use the Gordon-Krenn transformation.

3.1.3 Shock Identification

The Blanchard-Perotti government spending shocks are constructed under the identifying assumption that government spending does not react to other variables within the quarter, i.e., government spending does not respond contemporaneously to any shock other than its own while lagged responses are unrestricted. Researchers, including Ramey (2011), Ramey and Zubairy (2018), and Bernardini and Peersman (2018) often use military spending news shocks parallel to Blanchard-Perotti shocks in order to assert the robustness of their empirical findings to different government spending shock identification procedures. For military spending shocks, it is argued large government spending increases occur due to war rather than the business cycle, and such shocks can hence be treated as exogenous events. However, this method does not often translate well to other countries, which do not experience large shocks to military spending, such as New Zealand. Therefore, we exclusively use Blanchard-Perotti government spending shocks.

3.1.4 Local Projections

Jordà's (2005) local projection method involves estimating a regression at every horizon, h, following a shock at time t. The linear model is:

$$y_{t+h} = \alpha_h + \psi_h(L)z_{t-1} + \beta_h shock_t + \varepsilon_{t+h}, \quad h = 0, 1, \ldots, 12 \qquad (1)$$

where y_{t+h} is real GDP in our case, α is the intercept, $\psi(L)$ is the lag polynomial, set to four lags, and z_{t-1} is the vector of lagged control variables. The variable $shock_t$ is the Blanchard-Perotti government spending shock, orthogonal to government spending at time t, denoted g_t, and hence uncorrelated with the error term ε_{t+h}. The coefficient β_h is the response of the variable of interest y_{t+h} at time $t+h$ to the shock at time t. That is, it is the *impact* multiplier for $shock_t$ on y_{t+h}.

Estimating parameters at each horizon sets Jordà's (2005) method apart from the standard conventional method of calculating IRFs. The conventional method would instead estimate parameters only once at horizon zero and iterate forward to derive the effects on y_{t+h}. The local projections method is easily adapted to estimate IRFs for the non-linear model, hereafter referred to as the 'state-dependent' model. The response of GDP to a government spending shock at time t for each state[14] is determined by:

$$y_{t+h} = I_{t-1}\left[\alpha_{A,h} + \psi_{A,h}(L)z_{t-1} + \beta_{A,h}shock_t\right] + (1 - I_{t-1})\left[\alpha_{B,h} + \psi_{B,h}(L)z_{t-1} + \beta_{B,h}shock_t\right] + \varepsilon_{t+h}, \quad h = 0, 1, \dots, 12 \tag{2}$$

where the indicator variable, I_{t-1}, indicates the state of the economy at time t-1 with a value of 0 for periods with loose monetary policy and a value of 1 for periods with tight monetary policy. The subscripts *A* and *B* refer to each state of the economy such that $\beta_{A,h}$ and $\beta_{B,h}$ are the non-cumulative responses of real GDP to the government spending shock for tight and loose monetary policy, respectively. All coefficients are allowed to vary between states.

3.1.5 Calculating the Cumulative Spending Multiplier

In this paper, we focus on the cumulative government spending multiplier. All IRF graphs depict cumulative multipliers, the values of which are presented in the tables. We follow Ramey and Zubairy (2018) and directly estimate the cumulative government spending multiplier using LP-IV estimation. For the linear model we use:

$$\sum_{j=0}^{h} y_{t+j} = \gamma_h + \phi_h(L)z_{t-1} + m_h \sum_{j=0}^{h} g_{t+j} + \omega_{t+h}, \quad h = 0, 1, \dots, 12 \tag{3}$$

where $shock_t$ is used as an instrument for $\sum_{j=0}^{h} g_{t+j}$, the cumulative path of the government spending variable from t to $t+h$. Likewise, $\sum_{j=0}^{h} y_{t+j}$ is the cumulative response of GDP from t to $t+h$. γ_h is the intercept and $\phi_h(L)$ is the lag polynomial, set again to four lags. The error term is ω_{t+h} and the

[14] Following Bernardini and Peersman (2018) and Ramey and Zubairy (2018), the state is determined by the state in the period before the shock hits. This avoids contemporaneous feedback from government policy to the state of the economy.

coefficient m_h is the cumulative spending multiplier estimate at horizon h. This can be extended to the non-linear state-dependent model using:

$$\sum_{j=0}^{h} y_{t+j} = I_{t-1}\left[\gamma_{A,h} + \phi_{A,h}(L)z_{t-1} + m_{A,h}\sum_{j=0}^{h} g_{t+j}\right] + (1 - I_{t-1})\left[\gamma_{B,h} + \phi_{B,h}(L)z_{t-1} + m_{B,h}\sum_{j=0}^{h} g_{t+j}\right] + \omega_{t+h}, \quad h = 0, 1, \dots, 12 \tag{4}$$

where $I_{t-1}shock_t$ and $(1 - I_{t-1})shock_t$ are used as the IVs for cumulative government spending in the corresponding state. The coefficients $m_{A,h}$ and $m_{B,h}$ are the estimated cumulative spending multiplier at horizon h for state *A* and *B* of the economy.

The advantage of this IV method is that the cumulative multipliers and their standard errors are estimated directly from equations (3) and (4) for horizons 0 to 12.[15] All regressions are run with the LP-IV method. Montiel Olea and Plagborg-Møller (2021) prove the robustness of inference in lag-augmented LP-based IRFs over a wide range of response horizons and explain the LP advantages over VARs for IRF inference. Also, they recommend using heteroskedasticity-robust standard errors for lag-augmented LPs, based on the Eicker–Huber–White adjustment.[16] They show that lag augmentations in the LP regressions make it unnecessary to correct standard errors for serial correlation. A remaining concern is the potential presence of nonstationary variables that could lead to spurious regression results. However, Montiel Olea and Plagborg-Møller (2021) show that inference in lag-augmented linear LP-based IRFs is valid with stationary and non-stationary data.[17]

3.1.6 Baseline Model Specification

The vector of control variables, z_{t-1}, in the baseline model includes the ratio of real GDP per capita to the real GDP per capita trend, the ratio of real government spending per capita to the real GDP per capita trend, the ratio of nominal tax per capita to nominal GDP per capita, inflation, and the 90-day bank bill rate (90BBR). Following Ramey and Zubairy (2018), we divide real per capita GDP

[15] IV estimation is not feasible at horizon 0, because the instrument (shock) is perfectly co-linear to g_t.
[16] Two-stage least-squares LP-IV regressions were run using the Stata command *ivreg2* (Baum et al., 2010). The options *bw*(1) and *robust* were selected to calculate heteroskedasticity robust variance estimates, based on standard Eicker–Huber–White corrections. (The bandwidth "*bw*(*m*)" uses lags equal to *m*-1 to construct the kernel estimates, i.e., none in our case).
[17] Linear LP-based and conventional IRFs are the same in VAR models with *unrestricted* lag structures (Plagborg-Møller and Wolf, 2021). A Monte Carlo study by Gospodinov et al. (2013) with pre-tests for unit roots and cointegration finds that when the exact magnitude of roots is unknown or unclear, conventional VAR-based impulse responses estimated from a model with variables in levels are more robust than those from a model inaccurately restricted on the basis of unit root and cointegration pre-tests. This provides an additional argument for using variables in levels for LP-based IRFs.

and government spending by the real GDP per capita stochastic trend, calculated using the HP filter.[18] Ramey and Zubairy's (2018) baseline model for US data only includes real GDP and real government spending measures mentioned above, with tax considered in their robustness check as nominal tax divided by nominal GDP. However, we choose to include tax along with a short-term interest rate (90BBR) and inflation in our baseline model in order to remain consistent with previous research on the New Zealand economy (Hamer-Adams and Wong, 2018; Parkyn and Vehbi, 2014). The lag polynomial, $\psi(L)$, is run with four lags following Ramey and Zubairy (2018) and the recommendation by Kilian and Lütkepohl (2017) for estimating impulse repsonse functions in small sample settings.

We implement a positive Blanchard-Perotti government spending shock following Ramey and Zubairy (2018) and Bernardini and Peersman (2018), among others. The identifying assumption that government spending does not respond contemporaneously to other structural shocks is justified for two reasons. Firstly, unlike tax, there are no automatic stabilisers affecting government purchases, and secondly, government spending changes are lagged due to the process of making and implementing policy decisions. Government spending policy is backward-looking and follows the equation:

$$g_t = \psi(L)z_{t-1} + shock_t, \tag{5}$$

where the purchase of goods and services by the government is determined by the set of lagged control variables, z_{t-1}, and an orthogonal shock of autonomous changes to government spending.

3.1.7 Instrument Relevance and Hypothesis Testing

Following Ramey and Zubairy (2018) we test the relevance of the instruments used to calculate the cumulative multipliers using the first stage Kleibergen-Paap rk F-statistic (Kleibergen and Paap, 2006). This F-statistic is calculated for the cumulative multiplier of each state and horizon. Testing the IV strength is important as results estimated using weak IVs may be biased and unreliable (Andrews, Stock, and Sun, 2019).

A threshold F-statistic value is used to determine whether the instrument is relevant. As a rule of thumb for linear IV regressions, F-statistics below 10 indicate a weak instrument (Staiger and Stock, 1997; Stock and Yogo, 2005). However, Montiel Olea and Pflueger (2013) suggest a more stringent threshold for a linear model with one single endogenous regressor, when the first stage regression errors are heteroskedastic and serially correlated.[19] We note the value of this second threshold which has a 10 % significance value of 19.75.[20] Following Mertens and Montiel Olea (2018) we use both

[18] The smoothing parameter λ is set to 1600.
[19] See also Montiel Olea et al. (2020).
[20] The 10% significance level was chosen because of our relatively small sample size. The Montiel Olea and Pflueger (2013) threshold value was generated through Stata's user written command *weakivtest* (Pflueger and Wang, 2013, 2015) where $\tau = 10\%$.

Stock and Yogo (2005) and Montiel Olea and Pflueger (2013) threshold values when considering instrument relevance. We choose an F-statistic of 10 or above as an indication an instrument is not weak, and results should be reliable, whereas a value of 19.75 or above indicates a particularly strong instrument. We report heteroskedastic-robust standard errors with the Eicker–Huber–White adjustment for the multiplier estimates, using lag-augmented LP regressions, however, when instruments are weak we also consider the Anderson and Rubin (1949) AR-based weak-instrument-robust standard errors in our analysis of the results.[21]

For the state-dependent model, we test whether the cumulative multiplier is statistically significantly different across states. We test the null hypothesis that the cumulative multiplier is the same in each state for a given horizon, against the alternative that they are different. We report both heteroskedasticity consistent (Eicker-Huber-White) and Anderson and Rubin (1949) (AR) p-values to test our hypothesis, with the latter statistic again robust to weak instruments but likely less powerful than the former. The AR-based p-values will be reported along the F-statistics but are of particular interest only when either or both states have an F-statistic value below 10, i.e. the instrument used is a weak instrument. We determine the outcomes of these tests at the 10% significance level.

3.2 Defining Tight and Loose Monetary Policy

In the baseline model, the states of tight and loose monetary policy are defined using the 5YBR in relation to its stochastic trend, estimated using the HP filter.[22] For a given quarter, we define the state of tight monetary policy as a 5YBR value greater than its stochastic trend value and loose monetary policy as a 5YBR value equal to, or below its stochastic trend value. Defining states using a variable in relation to its stochastic trend has been done in previous studies on the state-dependence of the government spending multiplier (Bernardini and Peersman, 2018). An alternative would be to use a threshold value of the 5YBR, akin to Ramey and Zubairy’s (2018) definition of economic slack as the unemployment rate being above its median value. However, this alternative is not suitable for our research because the 5YBR slowly declines over our sample period, rather than continually fluctuating around a given point. Our definition also allows for a surprisingly even number of observations in each state, 59 for tight monetary policy and 57 for loose monetary policy.

We considered a number of alternative variables as candidates for the indicator variable before selecting 5YBR. The 90-day bank bill rate (90BBR), being a short-term interest rate, can be sensitive

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[21] In order to conserve space we do not include in the tables AR standard errors for the coefficient estimates, but these are available from the authors on request.

[22] It is chosen for consistency with the stochastic trend we use for the Gordon-Krenn transformation, again with λ=1600.

to small and temporary fluctuations in the macroeconomy. A longer-term interest rate such as the 5YBR is less likely to be affected by noisy fluctuations and, therefore, provides a better signal for the stance of monetary policy. We also considered the 10-year government bond rate that, compared to the typical length of the business cycle in New Zealand of 8.1 years (Hall and McDermott, 2014), is unlikely to capture the stance of monetary policy changes over the New Zealand business cycle. This is evident because it led to less than a third of all observations in the loose monetary policy state.

Further options considered to define the state of monetary policy were firstly inflation in relation to its target with monetary policy, defining tight monetary policy when inflation is above its target and loose if it is at, or below its target. This definition was not used because inflation targets in New Zealand have changed over time and, more importantly, there is a fluctuating lag between the RBNZ announcing the official cash rate (OCR; Reserve Bank of New Zealand, 2020) and the inflation rate reacting. Secondly, we considered the difference between the OCR and 90BBR, defining tight monetary policy when the OCR is above the 90BBR and loose monetary policy when the OCR is at, or below the 90BBR. This was also unviable because the OCR has been changed very infrequently and often these changes were anticipated before the official announcement. Data for the OCR are also unavailable prior to 1999. After considering all options we chose to define monetary policy using the 5YBR in relation to its stochastic trend.

4 Results

In this section we discuss the results of our baseline model and our model using disaggregated government spending for both the linear and non-linear specifications. We focus our discussion on the cumulative government spending multipliers, the estimates for m_h from equation (3), and, $m_{A,h}$ and $m_{B,h}$ from equation (4) for the linear and state-dependent models, respectively. We discuss instrument relevance and for equation (4), test the null hypothesis that the cumulative spending multiplier is the same in each state at every horizon, against the alternative that they are different.

4.1 Baseline Model

The IRFs and cumulative multiplier estimates for the baseline model are presented in Figure 1 and Table 1. Under the linear model the cumulative multiplier is statistically significant at the 10% level two and four quarters after a positive government spending shock with values of 0.26 and 0.18, respectively. In other words, a $1 increase in real government spending leads to a $0.26 increase in real GDP two quarters after the impact and to a $0.18 increase four quarters after the impact of the spending shock. Although, both are cases of only borderline significance. The cumulative spending multiplier for all other horizons is statistically insignificant, however, the F-statistic remains above 10 for all horizons. This indicates all cumulative multiplier estimates are based on strong instruments.

We now focus on the state-dependent model in which the model can change between two states of the economy, tight and loose monetary policy. Under tight monetary policy the cumulative spending multiplier is statistically insignificant for all 12 quarters after the government spending shock. In this state the F-statistic is above 10 for the first three quarters, indicating the multipliers from horizon four onwards are estimated using weak instruments. This is not concerning as the estimated multiplier is statistically insignificant at each quarter with standard errors considerably larger than the multiplier estimate at each horizon, for both Eicker-Huber-White and weak-instrument-robust AR standard errors. In summary, we find the cumulative spending multiplier, in times of tight monetary policy, is statistically insignificant following a shock to government spending.

In times of loose monetary policy, we find the cumulative multiplier is statistically significant from one to six, and 12 quarters after the spending shock. The cumulative multiplier peaks two quarters after the shock with a value of 0.54 before declining thereafter with the F-statistic above 10 until horizon 6 (inclusive) and below thereafter. The cumulative multiplier at horizon 12 is negative but not statistically significant based on the weak-instrument-robust AR-based standard error. Also, we note that the accuracy of cumulative multiplier estimates is reduced at longer horizons (e.g., Haug and Smith, 2012).

The results of our hypothesis tests indicate the spending multipliers in each state are statistically different from horizons two to six. At these horizons the spending multiplier for loose monetary policy remains statistically significant and ranges from 0.25 to 0.54. This result suggests the government spending multiplier is dependent on the state of monetary policy and is greater in times of loose monetary than in times of tight monetary policy.

4.2 Disaggregated government spending: government consumption and government investment

We modify the baseline model to separate government consumption from government investment shocks. For government policy it is of particular interest to assess the effects of government consumption of goods and services separately from those of government investment. Related recent research by Boehm (2020) with OECD panel data indicates the government investment multiplier is "*near zero*", whereas the government consumption multiplier is approximately 0.8. Boehm (2020) points out that this contrasts many conventional macroeconomic models that predict the opposite. Boehm argues public investment may be an intertemporal substitute for private investment. The conventional view is instead that a higher stock of public capital is a complement to private investment and raises productivity and output.[23]

4.2.1 Government Consumption

Table 2 and Figure 2 report results for the effects of a positive shock to government consumption on real GDP. For the linear model, the cumulative multiplier peaks after one quarter with a value of 1.57 and then tapers off to below 1.0 after four quarters, becoming statistically insignificant from the ninth quarter onwards. The F-statistic value is above 33 at every horizon, well above the more stringent threshold value of 19.75 suggested by Montiel Olea and Pflueger (2013). This indicates each multiplier was estimated using a particularly strong instrument.

Our results suggest the linear model, rather than the state-dependent model, is suitable for government consumption shocks as multipliers are not statistically significantly different across the states of tight and loose monetary policy. In the state-dependent results the relevant p-value at each horizon, expect horizon zero (impact) indicates there is no statistical difference between the cumulative multiplier estimate for each horizon. At horizon zero the relevant Eicker-Huber-White p-value is 0.08, a borderline situation at the 10% level of significance. We stop our discussion of the state-dependent model here in favour of the linear model in this circumstance.

We find fiscal spending in the form of government consumption is not dependent on the stance of monetary policy. The linear model suggests that a $1 increase in real government consumption translates to a $1.57 increase in real GDP at the peak of the effect, which occurs one quarter after the positive shock to government consumption. Government consumption is therefore an effective fiscal policy tool for New Zealand because the increase in GDP is greater than the increase in government spending at its peak impact.

4.2.2 Government Investment

Table 3 and Figure 3 present results for the effect of a positive shock to real government investment on real GDP. Under the linear model, the multiplier estimates are statistically significant at the 10% level over horizons two to six, peaking at a value of 0.42 at horizon two and tapering off to 0.22 at horizon six. The F-statistics for the linear model are all above 19.75, indicating the use of particularly strong instruments, except for horizon eight (19.05).

[23] On the role of public capital, see Bom and Ligthart (2014) for a meta-analysis. They show that the productivity effects vary with the time horizon, the type of capital, and central, regional and local capital. See also Aschauer (1989).

Results for the state-dependent model indicate tight monetary policy makes government investment ineffective in the terms of real GDP; the multiplier is not statistically significantly different from zero at any horizon.[24] However, the scenario is very different for loose monetary policy. The multiplier in this state is significantly different from zero for one to eight horizons after the shock. It peaks at quarter four with a value of 1.10 and tapers off to 0.29 at quarter eight, after which the state-dependent model is no longer statistically distinct from the linear one and the linear multipliers are not significantly different from zero at quarters nine to 12.

A possible explanation for these results is that during times of tight monetary policy government investment crowds out private investment, with the overall effect leaving real GDP unchanged. In contrast, during times of loose monetary policy government investment does not lead to crowding out and instead a $1 increase in public investment increases real GDP by more than $1, by $1.10. In comparison to government consumption, the multiplier takes longer to peak for government investment and it is smaller, comparing the peak of 1.10 here to 1.57 for government consumption.

In regard to F-statistics, in the state of tight monetary policy F-statistics are above 10 for the first three horizons and then drop below this threshold thereafter. On the other hand, F-statistics for the state of loose monetary policy remain above 10 for all horizons, except for horizon 12. In contrast to the government consumption multiplier, the relevant p-values for the null hypothesis indicate the multiplier estimates in each state are statistically different until horizon 8. This result indicates the state-dependent model is preferable when government investment is included in the model.

5 Robustness Checks

5.1 Additional Variable: Real Trade Weighted Index (TWI)

The five-variables in our vector of control variables, z_{t-1}, for our baseline model were chosen for consistency with previous research on the New Zealand economy. However, this model may fail to capture some aspects of the impact of global economic events in a timely manner. This is important when researching New Zealand's small open economy, which relies heavily on international trade. Our first robustness check takes this into consideration by including the real TWI[25] in our vector of control variables, z_{t-1}. We report results for this extended model in Table B.1 and Figure B.1.

When real TWI is added to the baseline model, the IRFs are similar to those for the baseline model. Under the linear model, the cumulative multiplier is statistically insignificant for all horizons

[24] This is also the case when weak-instrument-robust AR-based standard errors are used.
[25] TWI is a weighted index, which captures the value of the New Zealand dollar in relation to the currencies of New Zealand's 17 largest trading partners.

after the spending shock, which is slightly different from the baseline results where there was borderline statistical significance at quarters two and four. The F-statistic remains above 10 for all horizons. Under the state-dependent model we find the cumulative multiplier in times of tight monetary policy is again statistically insignificant for all horizons after the shock. The F-statistic remains above 10 until horizon two, dropping below this threshold thereafter, earlier than in the baseline model for which the F-statistic remained above 10 until horizon four. In times of loose monetary policy, we find the cumulative multiplier is statistically significant for horizons one to seven, one quarter longer than in the baseline model. The multiplier still peaks at horizon two with a value of 0.71 rather than 0.54 as in the baseline model. In other words we find that when real TWI is included in the model a $1 increase in real government spending increases real GDP by $0.71. In this state the F-statistic remains above 10 until horizon six, as in the baseline model. Our results also indicate that the state-dependent model is the appropriate specification for this extended model with the cumulative multiplier in each state statistically different across states from horizons one to seven with relevant p-values below 0.10.

The over-arching features of these results, including horizons of statistical significance and the quarter of the peak multiplier, are similar to those of the baseline model. This suggests our baseline model is robust to the addition of real TWI. While we acknowledge the importance of including an exchange rate for a small open economy like New Zealand, we favour our baseline model which produces similar results with less variables and more degrees of freedom. For further reassurance we also replace the real TWI with the nominal TWI and find fairly identical results.[26]

5.2 Alternative Filters: Hamilton's (2018) Filter

We used the HP filter in the baseline model to identify the state of monetary policy.[27] In our second robustness check we use Hamilton's (2018) filter to define the state of monetary policy rather than the HP filter. Hamilton (2018) shows that the HP filter could introduce spurious dynamic relations that are not present in the underlying data generating process of a time series.[28] Hamilton instead suggests a regression of the variable at date t on its four most recent values as of date t – h, where h=8 for quarterly data, in order to filter out the cycle. This filter "*achieves all the objectives sought by users of the HP filter with none of its drawbacks*" (Hamilton, 2018, p. 831). We define the stochastic trend as the remainder after removing the cycle.[29]

[26] Detailed results are available from the authors on request.
[27] We do not use the values of any filtered series directly in our regressions.
[28] See also the subsequent response by Hodrick (2020).
[29] Hamilton's filter removes from the cycle both the long-run trend as well as any seasonal components, however, we use seasonally adjusted data and thus should get a reasonable approximation of the trend by using the remainder.

In a similar manner to the baseline model, for a given quarter we define the state of tight monetary policy as a 5YBR value greater than the stochastic trend defined by the Hamilton filter. Loose monetary policy is defined as a 5YBR value equal to, or below, this stochastic trend. Results for this robustness check are presented in Table B.2 and Figure B.2. As we are only changing only the way the state of monetary policy is defined, rather than changing the variables included in the model, the results on the linear model are identical to those for the baseline linear model.

For the state-dependent model, in times of tight monetary policy we find the cumulative spending multiplier is statistically significant from horizon seven to nine after the government spending shock, based on standard errors using Eicker-Huber-White adjustments. AR-based standard errors show no statistical significance in line with the baseline model using the HP filter. However, we would like to note that the F-statistic in this state is particularly low from horizons seven to nine and therefore results may be biased. Compared to the baseline model, the F-statistics for this state drop below 10 one quarter earlier, after the first two horizons. In the state of loose monetary policy, the cumulative multiplier is statistically significant and positive from quarter two to eight and statistically significant but negative from quarters 10 to 12 with the F-statistics above 10 for all horizons.[30] This is similar to the baseline model for which the multiplier was significant and positive from horizons two to six. Nevertheless, the cumulative multiplier again peaks in the second quarter with a value of 0.55, very similar to the 0.54 of the baseline model. Lastly, the hypothesis test for this robustness check indicates the cumulative multipliers in each state are statistically different from each other at most horizons (horizons two to eight and 10 to 12) This indicates it is preferable to use a state-dependent model.

5.3 Alternative Filters: Kamber et al.'s (2018) BN Filter

Kamber et al. (2018) propose a filter based on the Beveridge-Nelson (BN) trend-cycle decomposition that imposes a reduced signal-to-noise ratio on the BN decomposition for an autoregressive process. This provides a better description of the log of the real US business cycle in terms of amplitude and persistence than a standard unmodified BN decomposition. For our last robustness check we use Kamber et al.'s (2018) BN filter to define the state of monetary policy. Again, tight monetary policy is defined as a quarter with a 5YBR value greater than the stochastic trend calculated by Kamber et al.'s (2018) BN filter. Loose monetary policy is defined when a quarter has a 5YBR value equal to, or below Kamber et al.'s (2018) BN stochastic trend. Our results are presented in Table B.3 and Figure B.3 with all results of the linear model identical to those of the baseline model.

[30] The F-statistic values taper off as the horizon increase and are just above 10 (10.55) at h=12. Inference on weak-instrument-robust AR-based standard errors show no statistical significance at quarters 10 to 12.

In times of tight monetary policy, the cumulative multiplier is statistically significant and negative from quarters six to nine. This is different to the baseline model for which the multiplier was insignificant for all quarters after the shock. However, we should note that the F-statistic drops below 10 from quarter three onwards (as in the baseline model) and using the AR-based standard errors, instead of the Eicker-Huber-White ones, renders all these multiplier estimates statistically insignificant. In times of loose monetary policy, the cumulative spending multiplier is statistically significant and positive from quarters zero (impact) to five and significant but negative from quarters nine to 12. Compared to the baseline model, the window of statistically significant positive estimates after the shock appears slightly shorter and earlier, from quarters zero to five rather than one to seven. However, the peak still occurs in the second quarter after the shock, this time with a value of 0.65. For the multiplier estimates in this state, the F-statistic drops below the threshold of 10 from quarter nine onwards. Again, AR-based standard errors for quarters nine to 12 lead to statistically insignificant multipliers for these horizons. Lastly, the hypothesis test indicates the multiplier estimates in each state are statistically different from each other until quarter nine. This is also different to the baseline model and suggests the state-dependent model is the appropriate model at shorter horizons, loosing relevance at longer horizons when the state is defined using Kamber et al.'s (2018) BN filter.

6 Conclusion

This paper analyses the government spending multiplier in times of tight and loose monetary policy for the New Zealand economy. Using data from 1991Q1 to 2019Q4, we follow Ramey and Zubairy's (2018) local projection-instrumental variables methodology. We use linear and non-linear (state-dependent) models to estimate the cumulative spending multipliers for up to 12 quarters after a government spending shock. We find that the spending multiplier is dependent on the state of monetary policy and is greater in times of loose monetary policy than in times of tight monetary policy when it not statistically significantly different from zero. This is in line with economic theory suggesting the increase in GDP, following a positive government spending shock, is larger in times of loose monetary policy, defined as times when interest rates are below their stochastic trend.

We found that the spending multiplier is statistically significant in times of loose monetary policy from one to six quarters after a positive shock to government spending, ranging from 0.25 to 0.54. The peak impact occurs at horizon two and indicates a $1 increase in real government spending leads to a cumulative $0.54 increase in real GDP. These spending multiplier estimates are comparable to those in the related literature, which uses similar methodology for US data (Ramey and Zubairy, 2018; Bernardini and Peersman, 2018).

Furthermore, we found the differences in the spending multipliers across monetary policy states to be statistically significant at each horizon from horizons two to six after the shock. Our results suggest that a government spending increase does not increase real GDP when the economy is in a state of tight monetary policy, while it increases real GDP in times of loose monetary policy. This is likely due to government spending crowding out private spending in times of tight monetary policy.

To gain insights into the behaviour of government spending components, we split government spending shocks into government consumption and government investment shocks. For government consumption, our analysis supports the linear model with no statistically significant difference of multipliers across tight and loose monetary policy. The cumulative consumption multipliers peaks one quarter after the shock with a value of 1.57 and then tapers off to below 1.0 at quarter 5 and becomes statistically insignificant after quarter nine. On the other hand, the government investment multiplier differs across tight and loose monetary policy. Under tight monetary policy, it is not statistically significantly different from zero, again likely because of crowding out. Under loose monetary policy, however, it peaks in quarter four with a value of 1.10. After its peak, it tapers off to 0.29 eight quarters after the positive shock to government investment. In other words, positive real government consumption shocks increase real GDP regardless of the stance of monetary policy. On the other hand, government investment policy has multiplier effects only when monetary policy is loose.

We undertake a number of robustness checks, which consider additional variables in the model and different methods to define the state of monetary policy. We separately added the real and nominal TWI to the baseline model to account more directly for global economic fluctuations but find that our results are mostly robust to these additions. Similarly, we find that the results of the baseline model hold up when we use alternative filters to the HP filter in order to extract the stochastic trend of interest rates that we use to determine the stance of monetary policy as tight or loose: Hamilton's (2018) filter and Kamber et al.'s (2018) BN filter.

This paper adds to the current literature in two important ways. First, we show that the government spending multiplier is dependent on the state of monetary policy, an area previously not explored for New Zealand. Second, we provide estimates of the spending multiplier for a small, open economy, unlike most research in this area that tends to focus on the US and UK. Third, we find that government consumption and government investment shocks have very different effects from the aggregate of the two. A potential limitation of our study is that government investment shocks in our model are one-time, short-lived shocks rather than government investment that is sustained over several quarters and will hence likely lead to different multipliers. Also, we do not capture the long-run growth effects of government investment beyond three years (12 quarters). For future research it would be of interest to explore long-run multipliers of government investment within an economic growth model.

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Table 1: Baseline Model

Horizon (h)	Linear Model		State-Dependent Model				p-value for the hypothesis test*
			Tight Monetary Policy		Loose Monetary Policy		
	Multiplier	F-statistic	Multiplier	F-statistic	Multiplier	F-statistic	
2	0.26	37.03	-0.07	22.30	0.54	17.46	^EHW = 0.052
	(0.149)		(0.199)		(0.242)		AR = 0.066
4	0.18	18.04	-0.05	8.08	0.53	15.50	EHW = 0.020
	(0.103)		(0.157)		(0.191)		^AR = 0.024
6	0.07	14.98	-0.02	5.35	0.25	12.15	EHW = 0.072
	(0.057)		(0.108)		(0.102)		^AR = 0.081
8	-0.02	14.47	-0.04	4.66	0.06	9.61	EHW = 0.349
	(0.044)		(0.086)		(0.059)		^AR = 0.364
10	-0.05	16.41	-0.07	5.94	-0.07	8.11	EHW = 0.979
	(0.044)		(0.096)		(0.061)		^AR = 0.979
12	-0.02	15.94	0.03	5.41	-0.13	6.30	EHW = 0.149
	(0.042)		(0.077)		(0.078)		^AR = 0.162

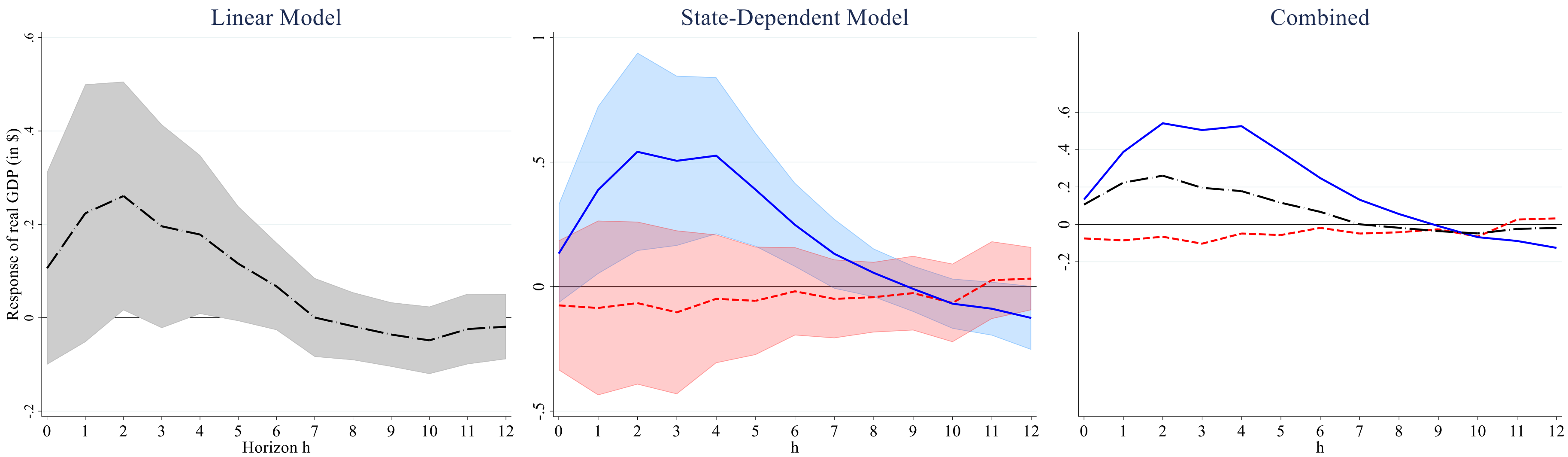
Notes: All multipliers are cumulative multipliers. Standard errors based on Eicker-Huber-White adjustments are given in parentheses. 'F-statistic' is the first stage Kleibergen-Paap rk F-statistic statistic for instrument relevance. Weak instruments are identified by an F-statistic below 10 (Staiger and Stock, 1997). The * indicates testing the null hypothesis that multipliers across states are equal. EHW represents Eicker-Huber-White p-values and AR represents the Anderson-Rubin p-values, robust to weak instruments. An ^ indicates the relevant p-value for the given horizon based on the weak-instrument F-statistic threshold at the 10% significance level, using AR results if it is below 10 for either or both states.

Table 2: Disaggregated Government Spending

Horizon (h)	Linear Model		State-Dependent Model				p-value for the hypothesis test*
			Tight Monetary Policy		Loose Monetary Policy		
	Multiplier	F-statistic	Multiplier	F-statistic	Multiplier	F-statistic	
Panel A: Government Consumption							
2	1.47	63.96	1.80	25.49	2.37	11.64	^ EHW = 0.464
	(0.269)		(0.497)		(0.601)		AR = 0.473
4	1.19	45.01	1.27	11.97	2.21	11.22	^ EHW = 0.079
	(0.197)		(0.280)		(0.458)		AR = 0.096
6	0.69	38.82	0.93	8.57	1.20	7.82	EHW = 0.478
	(0.134)		(0.220)		(0.299)		^AR = 0.490
8	0.30	34.71	0.53	9.52	0.52	4.46	EHW = 0.982
	(0.102)		(0.147)		(0.206)		^AR = 0.982
10	0.01	33.37	0.07	7.50	0.21	2.77	EHW = 0.511
	(0.088)		(0.147)		(0.160)		^AR = 0.531
12	0.02	33.78	-0.09	7.55	0.02	2.17	EHW = 0.619
	(0.071)		(0.110)		(0.192)		^AR = 0.643
Panel B: Government Investment							
2	0.42	64.91	-0.21	40.78	0.98	11.59	^ EHW = 0.002
	(0.209)		(0.240)		(0.287)		AR = 0.007
4	0.34	33.10	-0.36	9.05	1.10	17.08	EHW = 0.000
	(0.176)		(0.292)		(0.256)		^AR = 0.001
6	0.22	23.19	-0.37	3.31	0.69	22.97	EHW = 0.001
	(0.100)		(0.297)		(0.124)		^AR = 0.000
8	0.05	19.05	-0.27	2.77	0.29	16.22	EHW = 0.014
	(0.084)		(0.218)		(0.074)		^AR = 0.013
10	-0.06	24.27	-0.24	5.26	-0.02	13.12	EHW = 0.388
	(0.092)		(0.244)		(0.083)		^AR = 0.329
12	-0.07	20.80	0.04	5.05	-0.27	6.71	EHW = 0.137
	(0.108)		(0.154)		(0.140)		^AR = 0.208

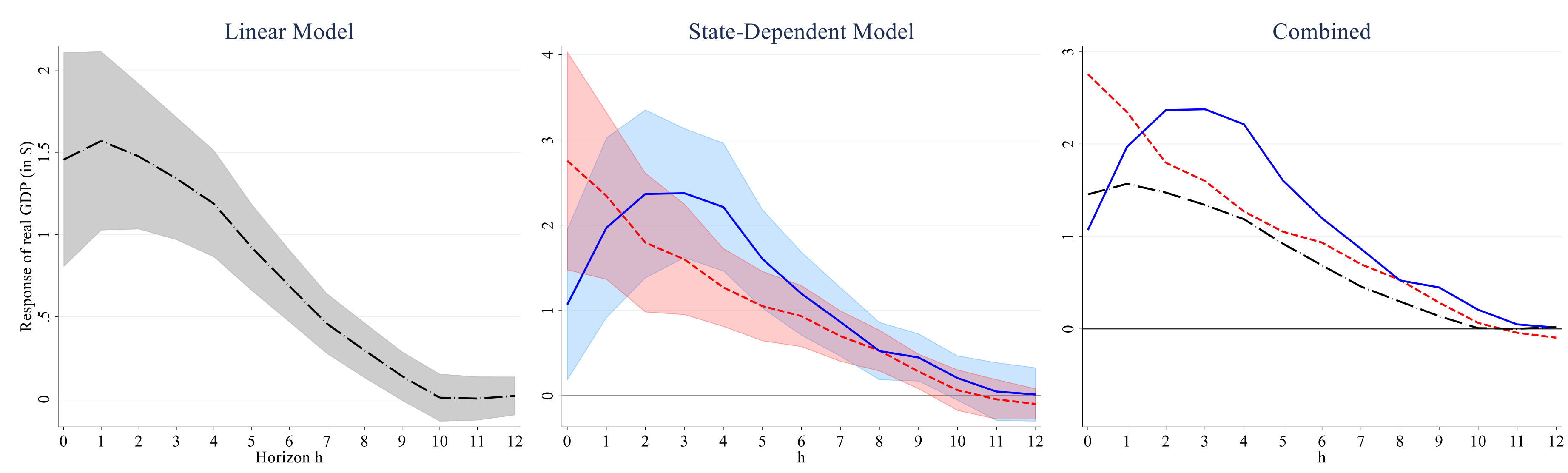
Notes: See table 1

Figure 1: Baseline IRFs of GDP to a Government Spending Shock for the Linear and State-Dependent Models



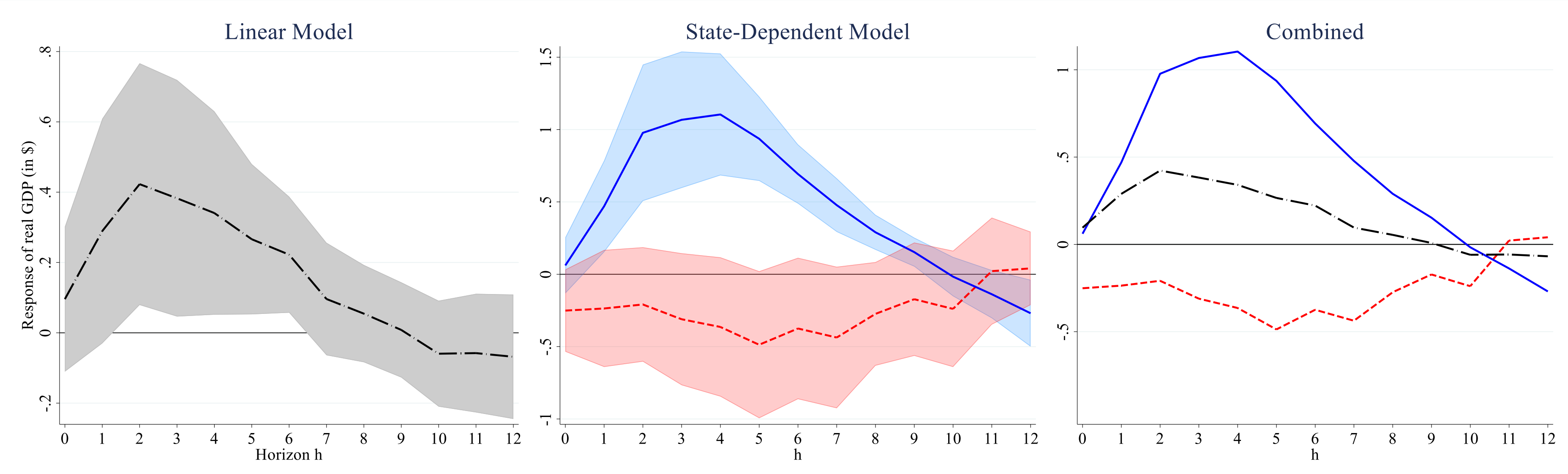
Notes: This figure presents the cumlative IRFs of real GDP for the linear and state-dependent models. The first two coloums are presented with a 90% confidence interval based on the Eicker-Huber-White standard errors. The third column displays the IRFs from each model, for comparative purposes. The blue (solid) line depicts the loose monetary policy state and the red (broken) line the tight monetary policy state.

Figure 2: IRFs of GDP to a Government Consumption Shock for the Linear and State-Dependent Models



Notes: See Figure 1.

Figure 3: IRFs of GDP to a Government Investment Shock for the Linear and State-Dependent Models



Notes: See Figure 1.

Appendix A: Data

We collect data for the New Zealand economy as quarterly measures from 1991Q1 to 2019Q4, unless otherwise stated. Below, we list each variable used in our empirical analysis, the sources of the untransformed data and briefly describe the construction of each series, as far as relevant.

GDP Deflator and GDP

The GDP deflator is collected from the OECD National Accounts B1_GE dataset, seasonally adjusted with a base of 100 in 2015Q3 (https://stats.oecd.org, last accessed 24 August 2020). Seasonally adjusted nominal GDP is retrieved from the RBNZ M5 dataset, collected using the expenditure approach (https://www.rbnz.govt.nz/statistics/m5, last accessed 27 August 2020). Real GDP is calculated by taking the ratio of nominal GDP to the GDP deflator, multiplied by 100.

Government Spending

We calculate nominal government spending as the sum of government consumption and government gross capital formation. Seasonally adjusted measures of these variables are collected from the OECD National Accounts P3S13 and P51S13 datasets, respectively (https://stats.oecd.org, last accessed 23 August 2020). We construct real government spending by taking the ratio of nominal government spending to the GDP deflator, multiplied by 100.

Tax Receipts

We use tax receipt data from monthly tax outturn data from the New Zealand Treasury. We use fully consolidated tax receipts (FCTR), net of Crown and government department tax payments. However, this variable is only available from July 2002, while total tax receipts, which do not deduct public tax payments, are available from July 1990 onwards. Therefore, we construct a seasonally adjusted FCTR dataset from 1990Q3 to 2019Q4 using both tax measures (https://www.treasury.govt.nz/publications/tax-outturn-data/tax-outturn-data-may-2020, last accessed 30 October 2020). Total tax receipt data from July 1990 to June 2003, and FCTR data from July 2002 to December 2019 are seasonally adjusted in EViews 11, using X-12.[31] Next, we transform each set of tax data to quarterly data, taking the average of the monthly values in each quarter. Lastly, we take the average ratio of FCTR to total tax receipts for the four quarters of overlap (2002Q3 to 2003Q2) and multiply this value to tax receipts back to 1990Q3.[32]

[31] Ramey and Zubairy (2018) use the same method to seasonally adjust data.
[32] The average ratio is 0.926.

Inflation

Following Ramey and Zubairy (2018), we calculate inflation as the first difference in the log of the GDP deflator, multiplied by 400.

Interest Rates

Percentage values of monthly the 90-day bank bill rate, and the 5- and 10-year secondary market government bond yields are collected from the RBNZ B2 dataset, (https://www.rbnz.govt.nz/statistics/b2, 27 August 2020). We collect data from July 1986 to December 2019 to ensure the up to 4-year quarterly rolling average for each variable can be calculated from 1991Q1 onwards. Prior to calculating rolling averages, we transform monthly data to quarterly measures using the average of the monthly values in each quarter.

Real and Nominal Trade Weighted Index (TWI)

Monthly, real TWI and nominal TWI data are collected from the RBNZ B1 dataset (https://www.rbnz.govt.nz/statistics/b1, last accessed 27 August 2020). Again, we construct quarterly data by averaging the monthly values in each quarter. See Steenkamp (2014) on details for the construction of these series.

Population

Estimated, census-based resident population data are collected from 1991Q1 to 2019Q4 from Statistics New Zealand's Infoshare database, dataset DPE059AA (http://archive.stats.govt.nz/infoshare, last accessed 27 October 2020). See Statistics New Zealand (2014) for details.

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Appendix B: Robustness Checks

Table B.1: Extended Baseline Model with the Real TWI

Horizon (h)	Linear Model		State-Dependent Model				p-value for the hypothesis test*
			Tight Monetary Policy		Loose Monetary Policy		
	Multiplier	F-statistic	Multiplier	F-statistic	Multiplier	F-statistic	
2	0.24	36.72	-0.28	19.35	0.71	13.86	EHW = 0.011^
	(0.164)		(0.225)		(0.320)		AR = 0.017
4	0.16	18.04	-0.25	5.30	0.64	14.02	EHW = 0.005
	(0.119)		(0.227)		(0.218)		AR = 0.006^
6	0.08	15.43	-0.16	2.30	0.31	10.49	EHW = 0.037
	(0.067)		(0.200)		(0.101)		AR = 0.023^
8	0.00	15.23	-0.09	2.11	0.07	7.44	EHW = 0.235
	(0.050)		(0.127)		(0.062)		AR = 0.243^
10	-0.03	17.88	-0.04	2.54	-0.09	5.56	EHW = 0.740
	(0.048)		(0.122)		(0.077)		AR = 0.736^
12	0.00	16.44	0.06	2.66	-0.17	2.83	EHW = 0.128
	(0.042)		(0.094)		(0.115)		AR = 0.079^

Notes: See Table 1.

Table B.2: Baseline Model with Hamilton's (2018) Filter

Horizon (h)	Linear Model		State-Dependent Model				p-value for the hypothesis test*
			Tight Monetary Policy		Loose Monetary Policy		
	Multiplier	F-statistic	Multiplier	F-statistic	Multiplier	F-statistic	
2	0.26	37.03	-0.09	15.31	0.55	30.39	^EHW = 0.062
	(0.149)		(0.260)		(0.227)		AR = 0.077
4	0.18	18.04	-0.17	5.13	0.37	36.73	EHW = 0.075
	(0.103)		(0.246)		(0.168)		^AR = 0.067
6	0.07	14.98	-0.15	5.11	0.22	33.62	EHW = 0.006
	(0.057)		(0.115)		(0.068)		^AR = 0.006
8	-0.02	14.47	-0.19	4.84	0.10	23.03	EHW = 0.001
	(0.044)		(0.076)		(0.037)		^AR = 0.004
10	-0.05	16.41	-0.03	6.59	-0.09	15.63	EHW = 0.576
	(0.044)		(0.087)		(0.040)		^AR = 0.566
12	-0.02	15.94	0.08	7.50	-0.16	10.55	EHW = 0.057
	(0.042)		(0.076)		(0.074)		^AR = 0.057

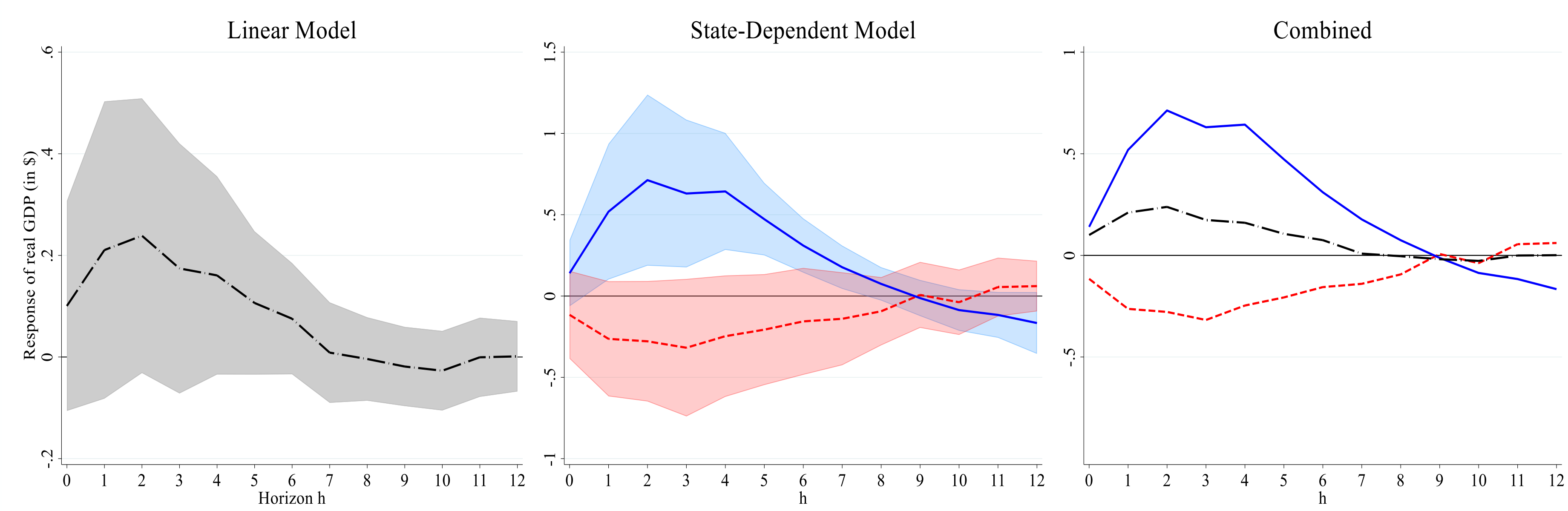
Notes: See Table 1.

Table B.3: Baseline Model with Kamber et al.'s (2018) BN Filter

Horizon (h)	Linear Model		State-Dependent Model				p-value for the hypothesis test*
			Tight Monetary Policy		Loose Monetary Policy		
	Multiplier	F-statistic	Multiplier	F-statistic	Multiplier	F-statistic	
2	0.26	37.03	-0.10	13.11	0.65	22.08	^EHW = 0.014
	(0.149)		(0.234)		(0.195)		AR = 0.025
4	0.18	18.04	-0.11	6.02	0.43	18.36	EHW = 0.027
	(0.103)		(0.180)		(0.163)		^AR = 0.042
6	0.07	14.98	-0.18	6.07	0.17	13.13	EHW = 0.017
	(0.057)		(0.101)		(0.107)		^AR = 0.039
8	-0.02	14.47	-0.22	5.80	-0.04	10.23	EHW = 0.060
	(0.044)		(0.078)		(0.062)		^AR = 0.081
10	-0.05	16.41	-0.17	7.63	-0.11	8.23	EHW = 0.658
	(0.044)		(0.109)		(0.062)		^AR = 0.651
12	-0.02	15.94	-0.05	8.32	-0.09	6.96	EHW = 0.696
	(0.042)		(0.072)		(0.070)		^AR = 0.699

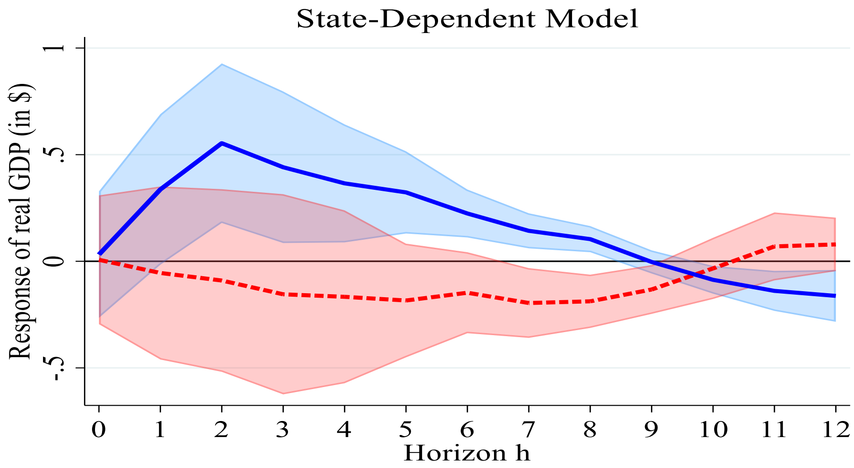
Notes: See Table 1.

Figure B.1: IRFs of GDP for the Extended Baseline Model with the Real TWI



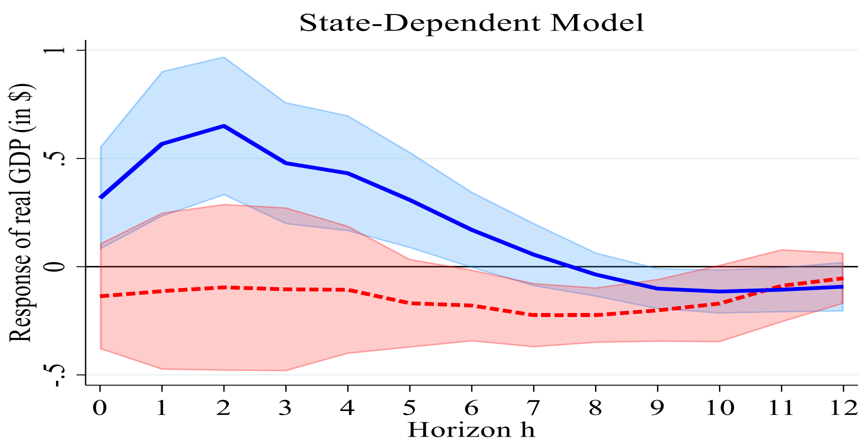
Notes: See Figure 1.

Figure B.2: IRFs of GDP for the Baseline Model with Hamilton's (2018) Filter



Notes: See Figure 1.

Figure B.3: IRFs of GDP for the Baseline Model with Kamber et al.'s (2018) BN Filter



Notes: See Figure 1.

Online Appendix: Additional Results

Robustness Check with an Additional Variable: Nominal TWI

In an additional robustness check we add nominal TWI to our baseline vector of control variables, z_{t-1}. Results, which are almost identical to the robustness check which included real TWI, are presented in Table OA.1 and Figure OA.1. Under the linear model, the cumulative spending multiplier is statistically insignificant for all horizons with the F-statistic remaining above 10 for each quarter. These results are slightly different to the baseline model for which there was slight statistical significance in the spending multiplier at quarters two and four and 12, but identical to the robustness check which included real TWI.

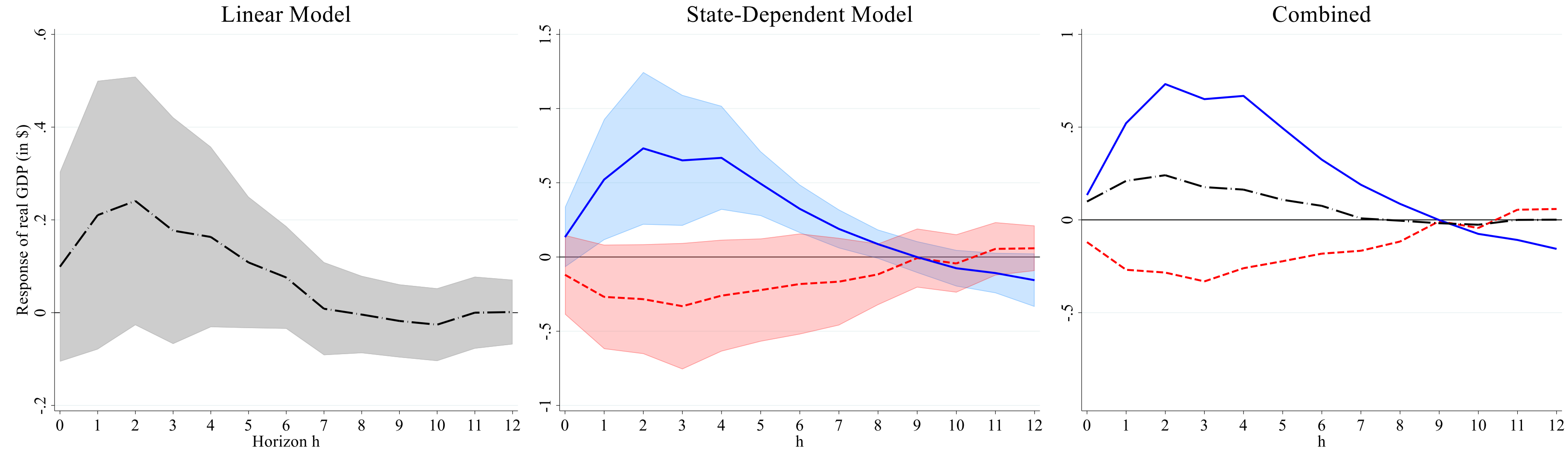
For the state-dependent model we find the cumulative multiplier in times of tight monetary policy is again statistically insignificant for all horizons after the spending shock. In this state, the F-statistic remains above 10 for the until horizon two, one quarter less than in the baseline model. In times of loose monetary policy, we find the spending multiplier is statistically significant from quarters one to seven, a slightly longer window than in the baseline model but that same for when real TWI is included in the model. The cumulative multiplier of this robustness check still peaks at quarter two but with a value of 0.73, higher than for the baseline model. The F-statistic in this state remains above 10 until horizon 7, one extra quarter than in the baseline model, but the same as the robustness check with real TWI. This robustness check found the cumulative multipliers in times of tight and loose monetary policy were statistically different from each other at the 10% significance level for horizons one to seven, suggesting it is correct to use a state-dependent model.

Table OA.1: Extended Baseline Model with the Nominal TWI

Horizon (h)	Linear Model		State-Dependent Model				p-value for the hypothesis test*
			Tight Monetary Policy		Loose Monetary Policy		
	Multiplier	F-statistic	Multiplier	F-statistic	Multiplier	F-statistic	
2	0.24	36.85	-0.28	19.56	0.73	13.92	EHW = 0.008^
	(0.163)		(0.225)		(0.312)		AR = 0.014
4	0.16	18.28	-0.26	5.30	0.67	14.12	EHW = 0.003
	(0.118)		(0.229)		(0.212)		AR = 0.004^
6	0.08	15.62	-0.18	2.31	0.32	10.55	EHW = 0.027
	(0.067)		(0.206)		(0.099)		AR = 0.015^
8	0.00	15.35	-0.12	2.08	0.09	7.58	EHW = 0.144
	(0.051)		(0.126)		(0.059)		AR = 0.151^
10	-0.03	18.17	-0.04	2.46	-0.08	5.72	EHW = 0.820
	(0.048)		(0.119)		(0.074)		AR = 0.818^
12	0.00	16.72	0.06	2.56	-0.16	3.01	EHW = 0.133
	(0.042)		(0.093)		(0.109)		AR = 0.092^

Notes: See Table 1.

Figure OA.1: IRFs of GDP for the Extended Baseline Model with the Nominal TWI



Notes: See Figure 1.