Variable GST: A tool for monetary policy in New Zealand? *

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Abstract

This paper argues that a variable goods and services tax (GST) would unlikely be a useful stabilisation tool for monetary policy in New Zealand. It first discusses some of the problems that would arise with the implementation of a variable GST rate. It then develops a stylised model of the New Zealand economy to assess the effects of using a variable GST rate as a monetary policy tool relative to the conventional instrument, an interest rate. The results show that a variable GST rate would be less effective in dampening business cycles than an interest rate. It would lead to larger adjustments in the policy instrument and fluctuations in the real economy and inflation. Moreover, a variable GST rate would lead to greater welfare losses from monetary policy than an interest rate tool.

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1 Introduction

This paper assesses the usefulness of a variable goods and services tax (GST) as a stabilisation tool for monetary policy in New Zealand. It is motivated by a House of Representative inquiry into New Zealand's monetary policy framework. In this inquiry several of the submissions propose a countercyclical use of GST to maintain price stability. This paper examines the potential implications of using a variable GST rate as a stabilisation instrument for monetary policy. It first discusses some of the problems that would arise with the implementation of a variable GST rate system. It then develops a stylised model of the New Zealand economy to assess the effectiveness of a variable GST rate relative to the conventional monetary policy tool, an interest rate.

The paper proceeds as follows. Section 2 discusses the implications of using a variable GST as a stabilisation tool for monetary policy. Section 3 derives the theoretical model. Section 4 describes the adjustment of the economy to shocks. The effectiveness of a variable GST rate in dampening business cycle fluctuations relative to adjusting an interest rate is evaluated in section 5 and the last section summarises and concludes.

2 A variable goods and services tax rate as a monetary policy tool

This section provides a summary overview of New Zealand's monetary policy framework and tax system. It then discusses the potential implications of using a variable goods and services tax as a stabilisation tool for monetary policy.

2.1 Monetary policy framework

The primary objective of monetary policy in New Zealand is to maintain price stability. An explicit inflation target was introduced in 1990. Price stability is defined in the *Policy Targets Agreement* (PTA) – a public contract that is negotiated between the Minister of Finance and the Reserve Bank of New Zealand. The current PTA, signed in 2007, defines price stability as annual increases in the consumer price index (CPI) of between 1 and 3 percent on average over the medium term. In pursuing its price stability objective, the PTA requires the central bank to avoid "unnecessary instability in output, interest rates and the exchange rate".[1]

To achieve the inflation target the Reserve Bank of New Zealand adjusts the official cash rate (OCR).[2] The OCR is the price at which the central bank lends high-powered money to the inter-bank market. Movements in the OCR affect short and longer term interest rates, at which financial intermediaries lend to and borrow from businesses and consumers. Changes in interest rates alter incentives to consume and invest and hence inflation. In an open economy that operates under a floating exchange rate, changes in interest rates also impact on the price of the country's currency. Exchange rate movements have a direct impact on the cost of imports and domestic inflation. In addition, exchange rate movements have an indirect effect on inflation through their impact on the demand and supply of tradeable and non-tradeable goods and services.

Interest and exchange rates move as a result of actions by a relatively small number of financial market participants. Changes in financial prices are then passed on to the household, government and business sectors. Financial prices typically adjust instantaneously in New

[1] See http://www.rbnz.govt.nz/monpol/.

[2] The OCR was introduced in March 1999. Before 1999, the Reserve Bank used a variety of other instruments to control inflation, including influencing the supply of money and open mouth operations.

Zealand in response to changes in monetary policy or expectations of a change in policy (unless securities are highly illiquid). The speed with which financial markets respond suggests relatively low costs of changing financial prices.

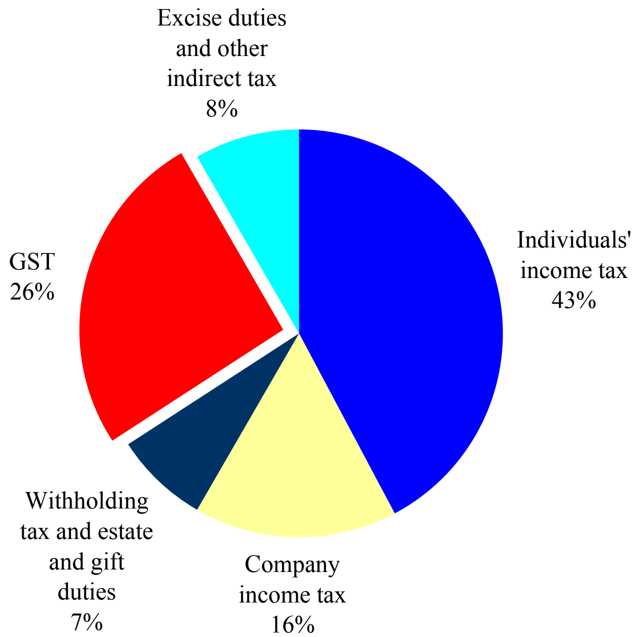
2.2 New Zealand's tax system

The primary purpose of New Zealand's tax system is to raise revenue to fund government expenditure and savings. Tax revenue is collected through income tax payments, a goods and services tax, and excises and duties. The goods and services tax is a comprehensive value added tax and charged at 12.5 percent. It is designed to collect tax revenue from the consumption of goods and services. GST applies at all stages of production, including imports. However, as a value added tax, GST paid on intermediate goods and services can be reclaimed. In theory, New Zealand's GST system does not distort business or export decisions because the tax paid on production inputs and exports is deductible. Moreover, less distortions are likely to arise from the collection of GST than other taxes because of the comprehensive and broad base to which GST applies uniformly at a relatively low rate.

2.3 A variable GST rate as a tool for monetary policy

Recent submissions to a House of Representative inquiry into New Zealand's monetary policy framework have suggested the use of a variable GST rate as a stabilisation tool for monetary policy. For example, the submission by the Reserve Bank of New Zealand notes that "the GST rate could be raised during periods of intense pressures on resources and lowered when inflationary pressures were very weak" (Reserve Bank of New Zealand, 2007). Hall (2007) also

Figure 1: Composition of tax revenue (2007)



Source: The Treasury, "2007 Half year economic and fiscal update".

suggests investigating "a more active countercyclical use of the GST (...) rate".[3]

Introducing a variable GST rate as a monetary policy tool to influence consumer behaviour would deviate from the primary purpose of New Zealand's tax system, which is to raise tax revenue for the government. A comprehensive indirect tax, such as New Zealand's GST, is an important diversifying source of revenue available for the government. GST provides a robust and relatively secure stream of funds for the government to deliver the outcomes for which it was elected to power. In 2007 it contributed about 26 percent to total tax revenue (Figure 1).

Altering the tax policy objectives of GST would have effects on the neutrality and efficiency of New Zealand's tax system. An overarching policy principle is that GST does not distort between current and future consumption, in that GST does not generally affect consumer

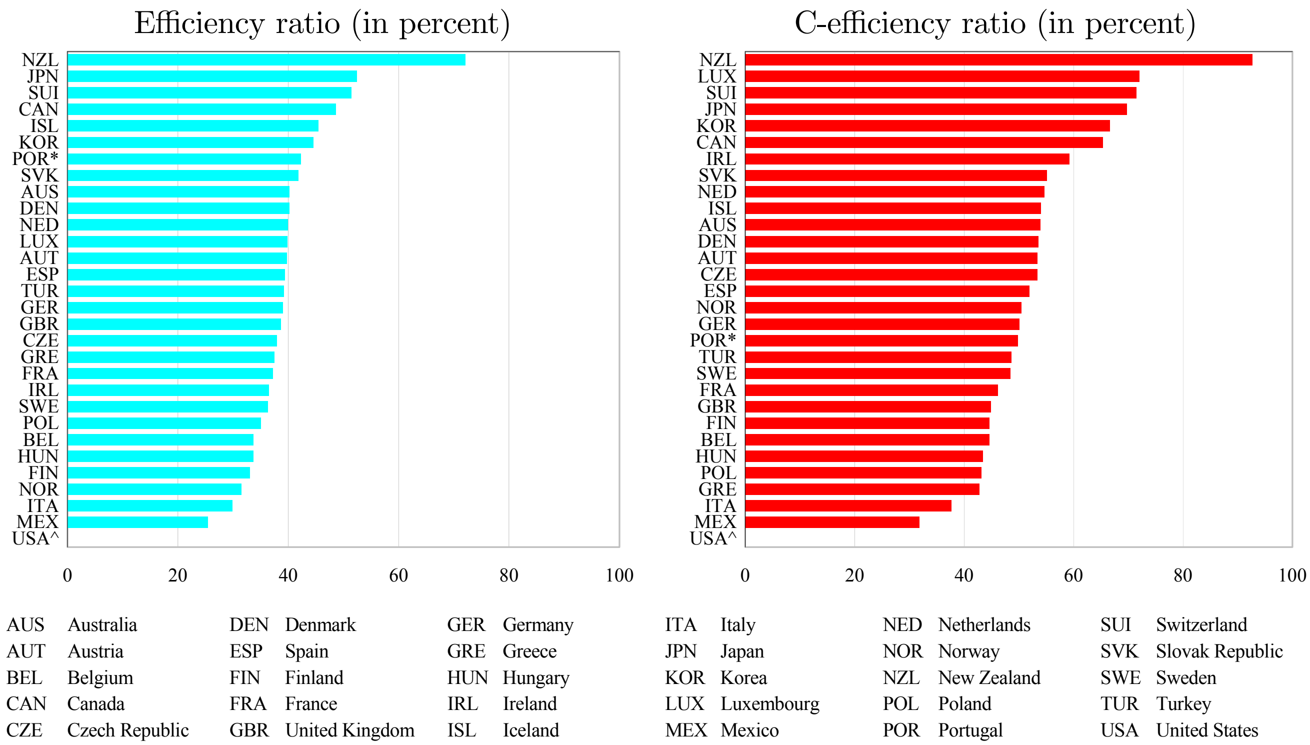
[3] The use of the GST rate as a countercyclical stabilisation instrument for monetary policy was initially proposed by Buiter (2006).

decisions to spend now or spend later (that is, savings). It also assumes that there is a "normative" rate of GST. These principles would be violated with the introduction of a variable GST rate.

2.3.1 Consumer impacts

A variable GST rate would disproportionately affect cash constrained consumers, who do not have the option of deferring consumption expenditure. These consumers tend to be low income households and beneficiaries. To counter the effects of a variable GST rate on low income households and beneficiaries, the government would need to continually revise transfer payments to ensure that tax related consumer price movements would not reduce the value of such transfers. As a result, policymakers may consider a GST system more similar to the value added tax (VAT) systems operating in the European Union that are characterised by variable rates of tax and exemptions. Such policy settings would compromise the efficiency and effectiveness of New Zealand's GST system. Current measures by the Organisation for Economic Co-operation and Development (OECD) of the performance of tax systems consistently rank New Zealand's GST system higher than the VAT/GST systems of other countries (Figure 2). Measures commonly referred to are the efficiency and C-efficiency ratios. The efficiency ratio is calculated as VAT/GST revenues to gross domestic product (GDP) divided by the standard VAT/GST rate (expressed as a percentage). The C-efficiency ratio is calculated as VAT/GST revenues to consumption divided by the standard VAT/GST rate (expressed as a percentage). Low efficiency or C-efficiency ratios are taken as evidence of erosion by exemptions, reduced rates within the tax law or non compliance (Ebrill, Keen, Bodin and Summers, 2001). Figure 2, which plots the efficiency and C-efficiency ratios for 2005, shows that the New Zealand system outperforms that of other countries. A significant

Figure 2: Efficiency ratios (2005)



* Data are for 2004.

^No value added taxes.

Source: Organisation for Economic Co-operation and Development and authors' calculations.

success factor for New Zealand in the OECD's measures of performance is the GST system's broad base and low uniform rate.

Exemptions and reduced rates would impact on the effectiveness of the GST system to manage monetary policy in the manner suggested by submissions. The effectiveness of a variable GST rate as a monetary policy tool would be reduced further if consumers tried to beat the system. Frequent variations could influence "buyer-strikes", whereby consumers stop purchasing certain goods and services until the rate of GST returns to a more normative level, and "panic buying", as illustrated by consumer responses to government budgets in the 1970s and 1980s in connection with increases in the price of tobacco, cigarettes and petrol.

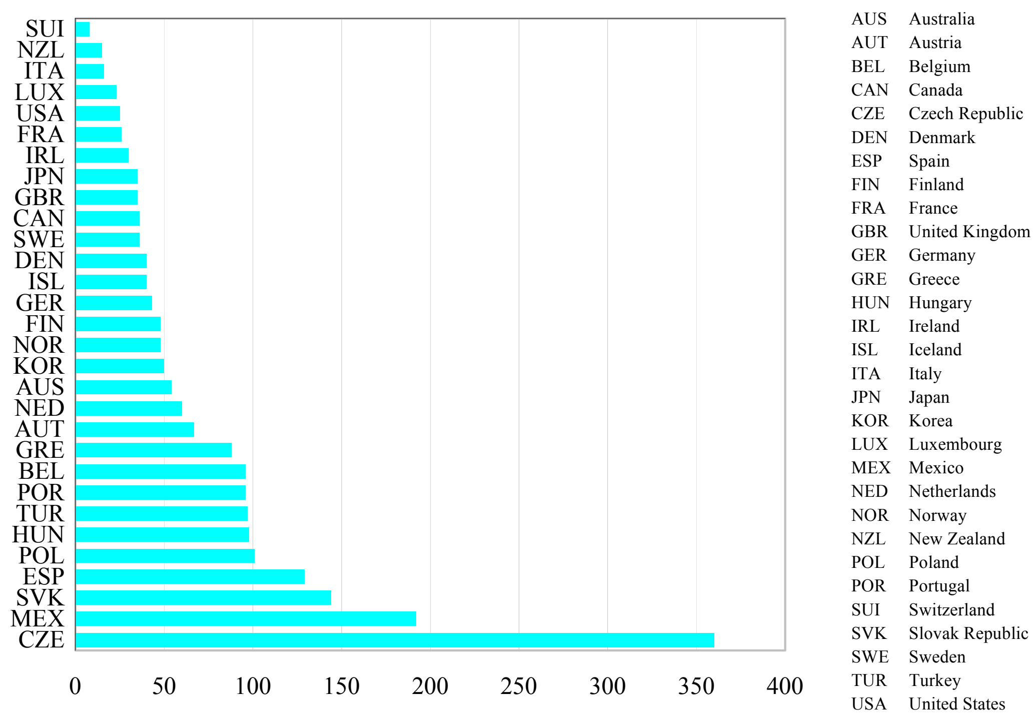
Household finances would become more difficult to manage. GST changes would have an immediate impact on household budgets and may require increased precautionary savings to cope with unexpected GST rate changes. In contrast, under the current operating regime, where the central bank influences wholesale money market interest rates, households can enter into fixed term contracts, which allows them to gradually adjust consumption in response to interest rate changes.

2.3.2 Business impacts

A variable GST rate would shift the burden of implementing monetary policy changes from a relatively small number of financial market participants to more than 600,000 taxpayers currently registered for GST. Moreover, a variable GST rate would lead to production distortions as it would disproportionately affect certain sectors of the economy. For example, changes in the rate of GST for monetary policy purposes would have a material impact for businesses that are unable to deduct GST input tax. For businesses making supplies of exempt goods and services, GST is an irrecoverable cost – a problem typically encountered by the financial services sector. In this respect, frequent movements in the rate of GST could provide incentives for tax planning when transactions cover a number of monetary policy periods. For instance, in the case of long term assets that are used over several taxable periods, taxpayers may be required to apportion GST for non-taxable use. Apportionment can give rise to GST credits and GST liabilities. For businesses that are unable to deduct GST, such as the financial services sector, the rate of GST would materially impact on the timing of those adjustments. Frequent movements in the rate of GST that increase tax planning incentives may reduce compliance.

New Zealand currently ranks second lowest in terms of time to comply with goods and services taxation (Figure 3). A variable GST rate could increase business compliance costs

Figure 3: Time to comply in hours per year: goods and services taxes (2008)



Source: PriceWaterhouseCoopers and The World Bank (2008).

substantially. The design of New Zealand's GST system, such as its comprehensive base and uniform low rate, permits the government to offer a number of simplification techniques that would no longer be able to operate with a variable rate. These simplification techniques include using a tax fraction to calculate GST. Rates of tax that produce simple tax fractions include 5 percent, 6.25 percent, 10 percent, 12.5 percent, 20 percent and 25 percent (respectively 1/21, 1/17, 1/11, 1/9, 1/6 and 1/5). The tax fraction assists in the day-to-day GST bookkeeping, calculating the amount of GST on transactions and establishing the value of input tax deductions.

The use of multiple rates over monetary policy periods (and possibly across different commodities) would create complexities for business taxpayers and the government. Moreover, if those rates frequently varied from period to period it could make the current GST system unworkable for goods and services, such as insurance premiums, telecommunications or power, which are usually invoiced at one point in time but may be supplied over a number of monetary policy periods. This problem could affect other taxpayers more widely in situations where the monetary policy period did not align with the relevant GST return period. Currently, taxpayers return GST on a monthly, two-monthly or six-monthly basis.

A variable GST rate would increase menu costs as businesses would need to change prices more frequently.[4] Businesses would have to conduct physical stock-takes and value work-in-progress to re-price goods and services in response to monetary policy changes. Shifting from GST inclusive pricing to GST exclusive pricing with the tax being collected at the point of sale may partly reduce the costs of adjusting prices. Price adjustments would still be required though to take into account demand changes.

If multiple rates were used over a number of periods, taxpayers would be required to trace payments to the original supply and the relevant rate. These systems would be complex and difficult to manage, especially for small and medium-sized businesses. A more complex and difficult to manage GST system may reduce taxpayer compliance. To maintain government spending and savings, any shortfall in GST collection due to reduced compliance would need to be met with higher tax rates, raising the deadweight cost of taxation and consumer consternation.

2.3.3 Impact on the operation of monetary policy

Accommodating the time necessary for businesses to implement price changes and respond to the practical issues could affect the central bank's operation of monetary policy, such as the

[4] Menu costs are expenses associated with changing prices, including the costs of printing new menus or distributing new catalogs.

time of day when official announcements are made. Advance knowledge of decisions to raise or lower the GST rate would be required by businesses to implement rate changes. Advance knowledge, however, gives rise to opportunities to exploit the situation for personal gain.

Frequently varying the applicable rate of GST would increase price variability and reduce the effectiveness of price signals in allocating resources. It would create uncertainty for businesses and may lead to long run real costs of monetary policy. Moreover, the effectiveness of monetary policy may be reduced over time as transactions may take place outside of the market to avoid the complexities of a variable GST rate system.

Finally, a variable GST rate would make the current consumer price index unsuitable as an inflation target to maintain price stability. Movements in the consumer price index would reflect changes in excess demand (supply) as well changes in monetary policy. That is because consumer prices would increase when the Reserve Bank tightens monetary policy and raises the GST rate to constrain inflation. Conversely, during periods of excess supply and downward pressure on inflation, a monetary easing and decline in the GST rate would lower consumer prices. The consumer price index would need to be modified to remove the GST component. These adjustments would have to take into account multiple effective GST rates during monetary policy periods.

3 A model of the New Zealand economy

Next, we assess whether a variable GST rate would be a more effective monetary policy instrument than an interest rate. This section develops a stylised model of the New Zealand economy to evaluate the effects of using GST as a monetary policy tool compared to an interest rate.

The framework of analysis is a general equilibrium model. There are four agents in the economy: households, firms, a government and a monetary authority.

3.1 Households

Households are infinitely lived and a typical household values streams of consumption and leisure according to

$$E_t \sum_{k=0}^{\infty} \beta^k \left\{ \ln\left(C_{t+k}\right) + \gamma\left(1 - N_{t+k}\right) \right\} \tag{1}$$

where $\gamma > 0$ is a parameter, $\beta \in (0,1)$ is the household's discount factor, E_t is a conditional expectations operator with respect to information available at time t and C_t denotes households' consumption. Households' time endowment is normalised to one. Their labour supply is given by N_t and $(1 - N_t)$ is leisure. Households' period utility function, $U\left(C_t,\ N_t\right)$, is given by

$$U\left(C_t,\ N_t\right) = \ln\left(C_t\right) + \gamma\left(1 - N_t\right) \tag{2}$$

Each household consumes many goods, all of which are domestically produced. C_t is the quantity consumed in period t of an index of these goods with $C_t = \left[\int_0^1 C_t\left(j\right)^{(\theta-1)/\theta} dj\right]^{\theta/(\theta-1)}$, where $C_t\left(j\right)$ denotes the household's period t consumption of good j and $\theta > 0$ is the price elasticity of demand.[5] The price of consumption good j is given by $P_t\left(j\right)$ and the aggregate price level, P_t, is an index given by $P_t = \left[\int_0^1 P_t\left(j\right)^{1-\theta} dj\right]^{1/(1-\theta)}$.

Households earn income from supplying labour, N_t, at wage rate W_t and by renting physical capital, K_{t-1}, accumulated last period, to firms at rate R_t. All physical capital is imported. Moreover, households receive dividend payments, Ω_t, from firms and earn income from holding domestic bonds issued by the government, B_t, and foreign bonds, B_t^*. Domestic bonds, B_t,

[5] The government's consumption index (discussed below) is given accordingly.

earn a nominal return (in terms of domestic currency) of I_t and the nominal rate of interest paid on foreign bonds, B_t^*, is given by I_t^*. Households also hold demand deposits, D_{t-1}, to purchase consumption and capital goods. Demand deposits do not earn any interest. Households pay taxes on their earned income. The tax rate on their wage, rental and interest income is given by τ. Capital gains from exchange rate movements are not taxed. The government also imposes a goods and services tax, τ_t^{GST}. The GST rate is fixed when the nominal interest rate is used as the monetary policy tool. It is variable when GST is the stabilisation tool.

The typical household's budget constraint is given by

$$\begin{aligned}
&(1-\tau) W_t N_t + ((1-\delta) S_t P_t^* + (1-\tau) R_t) K_{t-1} \\
&+ (1 + (1-\tau) I_t) B_t + (1 + (1-\tau) I_t^*) S_t B_t^* + \Omega_t + D_{t-1} \\
&- \left(1 + \tau_t^{GST}\right) P_t C_t - B_{t+1} - S_t B_{t+1}^* - D_t - S_t P_t^* K_t = 0
\end{aligned} \tag{3}$$

where S_t denotes the nominal exchange rate, P_t^* is the foreign price level and $\delta \in (0,1)$ is the economic depreciation rate of capital.[6] The net GST on capital goods is zero as the tax paid on production inputs is deductible.

The household's deposit-in-advance constraint is given by

$$P_t \left(1 + \tau_t^{GST}\right) C_t + S_t P_t^* K_t - (1-\delta) S_t P_t^* K_{t-1} \leq D_{t-1} \tag{4}$$

It holds as an equality at an optimum if $I_t > 0$. Using equation (4), the household's budget

[6] The nominal exchange rate, S_t, is measured as the price of foreign currency in units of domestic currency, i.e. an increase in S_t indicates a depreciation of the domestic currency.

constraint can then be re-written in real terms as

$$
\begin{aligned}
&(1-\tau)\hat{W}_t N_t + (1-\tau)\hat{R}_t K_{t-1} + \tfrac{(1+(1-\tau)I_t)\hat{B}_t}{1+\Pi_t} + \tfrac{(1+(1-\tau)I_t^*)Q_t\hat{B}_t^*}{1+\Pi_t^*} + \hat{\Omega}_t - \hat{B}_{t+1} \\
&-Q_t\hat{B}_{t+1}^* - (1+\Pi_{t+1})\left(\left(1+\tau_{t+1}^{GST}\right)C_{t+1} + Q_{t+1}K_{t+1} - (1-\delta)Q_{t+1}K_t\right) = 0
\end{aligned}
\tag{5}
$$

The real wage and rental rates are given by $\hat{W}_t$ and $\hat{R}_t$, and $\hat{B}_t$, $\hat{B}_t^*$ and $\hat{\Omega}_t$ are the household's domestic and foreign bond holdings and dividend payments from firms in real terms. Q_t denotes the real exchange rate, $Q_t \equiv S_t P_t^*/P_t$. Π_t is the domestic inflation rate with $\Pi_t = P_t/P_{t-1} - 1$ and the foreign inflation rate is given by $\Pi_t^* = P_t^*/P_{t-1}^* - 1$.

The household's optimisation problem consists of choosing $\left\{C_t,\ N_t,\ K_t,\ \hat{B}_{t+1},\ \hat{B}_{t+1}^*\right\}$ for all $t \in [0,\infty)$ to maximise utility (equation (2)) subject to equation (5). Dividends are paid at the end of each period and do not affect households' optimisation problems. Households' first-order conditions are given by

$$
\tfrac{1}{\gamma C_t} - \tfrac{\left(1+\tau_t^{GST}\right)(1+(1-\tau)I_t)}{(1-\tau)\hat{W}_t} = 0 \tag{6}
$$

$$
\tfrac{Q_t}{\left(1+\tau_t^{GST}\right)C_t} - E_t\left[\tfrac{\beta\left((1-\delta)Q_{t+1} + \tfrac{(1-\tau)\hat{R}_{t+1}}{1+(1-\tau)I_{t+1}}\right)}{\left(1+\tau_{t+1}^{GST}\right)C_{t+1}}\right] = 0 \tag{7}
$$

and

$$
E_t\left[\tfrac{Q_{t+1}}{Q_t}\tfrac{1+(1-\tau)I_{t+1}^*}{1+\Pi_{t+1}^*} - \tfrac{1+(1-\tau)I_{t+1}}{1+\Pi_{t+1}}\right] = 0 \tag{8}
$$

At an optimum the marginal rate of substitution between consumption and leisure is equal to the relative price of consumption; that is, the ratio of the after-tax effective price of consumption and the after-tax real wage rate. The effective price of consumption is the sum of its market price (equal to unity) and the opportunity cost of having to hold demand deposits to purchase consumption goods, $(1-\tau)I_t$. Further, the marginal rate of substitution between consumption today and next period is equal to the effective return from accumulating an additional unit of capital. The effective return is given by a unit value of the capital stock net of depreciation plus the after-tax rate of return on capital adjusted for the opportunity cost of having to hold demand deposits to purchase capital. Finally, in equilibrium real rates of return from holding domestic and foreign bonds are equal.

The first-order conditions show how GST and the interest rate affect the real economy. GST alters the effective price of consumption (equation (6)). When GST is the monetary policy tool, i.e. the rate of GST varies over time, it also influences households' investment decisions (equation (7)). Equation (7) thus illustrates how a variable GST rate would violate the overarching policy principle that GST does not distort between current and future consumption. A change in the interest rate alters both incentives to consume and invest (equations (6) and (7)). Moreover, a change in the interest rate impacts on the exchange rate (equation (8)). A change in the real exchange rate in turn affects the price and rate of return of imported capital (equation (7)).

3.2 Firms

Firms are monopolistic competitors and specialise in production. A typical firm produces output of consumption good j, $Y_t(j)$, under a constant elasticity of substitution (CES) technology by hiring labour, $L_t(j)$, and capital, $K_{t-1}(j)$, from households. Firm j's production function is thus given by

$$Y_t(j) = \left[\left(\eta_l \left(Z_t L_t(j)\right)^{\nu} + (1-\eta_l)\left(K_{t-1}(j)\right)^{\nu}\right]^{\frac{1}{\nu}} \tag{9}$$

where $\eta_l \in (0,1]$ is a parameters and $\nu < 1$; that is, the marginal return to each input is diminishing. The elasticity of substitution in production is given by $1/(1-\nu)$ and Z_t denotes aggregate productivity.

Each firm sells their output of consumption good, $Y_t(j)$, to households and the government. Firms also export to the rest of the world.[7] Aggregate exports, EX_t, are a function of the real exchange rate, Q_t, and foreign demand for the domestic country's output, Y_t^*,

$$EX_t = (Q_t)^{\kappa} (Y_t^*)^{\varsigma} \tag{10}$$

where κ, $\varsigma > 0$ are the price and foreign demand elasticities of exports. As is the case in New Zealand, exports are zero rated, i.e. they are not subject to GST.[8] When the central bank uses an interest rate tool, exports are an additional channel through which monetary policy affects the real economy and hence inflation. A change in the interest rate that is transmitted to the real exchange rate affects the price of exports and foreign demand for firms' output.

Each firm chooses $\{P_t(j),\ L_t(j),\ K_{t-1}(j)\}$ to maximise profits subject to its production function (9) and demand function, $Y_t(j) = (P_t(j)/P_t)^{-\theta} Y_t$, i.e.

$$[P_t(j) Y_t(j) - W_t L_t(j) - R_t K_{t-1}(j)] = [P_t(j) - P_t MC_t] \left(\frac{P_t(j)}{P_t}\right)^{-\theta} Y_t \tag{11}$$

[7] With monopolistic competition in the goods market each firm treats the price in domestic currency, $P_t(j)$, of the good j it produces as a choice variable, while taking the domestic aggregate price level, P_t, the nominal exchange rate, S_t, and the foreign price level, P_t^*, as given. Having chosen $P_t(j)$, the firm then produces the quantity of output demanded at that price. Firms may not price discriminate and the price of good j sold to foreign consumers (denominated in foreign currency) is given by $P_t(j)/S_t$. The demand functions for good j are given by $C_t(j) = (P_t(j)/P_t)^{-\theta} C_t$, $G_t(j) = (P_t(j)/P_t)^{-\theta} G_t$ and $EX_t(j) = (P_t(j)/P_t)^{-\theta} EX_t$. $C_t(j)$, $G_t(j)$ and $EX_t(j)$ are the quantity of good j demanded by a typical household, the government and a typical foreign consumer. C_t, G_t and EX_t denote total consumption by households, government consumption and total exports. θ is the price elasticity of demand faced by each monopolistic competitive firm.

[8] New Zealand producers are price takers in world markets. The incidence of a GST on exports would fully fall on domestic producers and distort their export decisions.

where MC_t denotes the real marginal cost. Firm j's first-order conditions are given by

$$P_t\left(j\right) = \tfrac{\theta}{\theta-1} P_t MC_t \tag{12}$$

$$\frac{W_t}{P_t(j)} = \frac{\eta_l (Z_t)^{\nu} \left(\frac{Y_t(j)}{L_t(j)}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} \tag{13}$$

and

$$\frac{R_t}{P_t(j)} = \frac{(1-\eta_l) \left(\frac{Y_t(j)}{K_{t-1}(j)}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} \tag{14}$$

In a symmetric equilibrium, all firms charge the same relative price and hire the same labour and capital. The first-order conditions can then be re-written as

$$MC_t = \frac{1}{\frac{\theta}{\theta-1}} \tag{15}$$

$$\hat{W}_t = \frac{\eta_l (Z_t)^{\nu} \left(\frac{Y_t}{L_t}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} \tag{16}$$

and

$$\hat{R}_t = \frac{(1-\eta_l) \left(\frac{Y_t}{K_{t-1}}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} \tag{17}$$

Equations (16) and (17) show that firms sell their output of consumption goods at a mark-up over production costs and factor prices are below their marginal products. Under price flexibility the mark-up is constant and equal to $\theta/\left(\theta-1\right)$. Under price stickiness it is given by $\xi_t/(\xi_t-1)$. The mark-up gives rise to economic profits of $\left(\xi_t-1\right)Y_t/\xi_t$, which are paid to households as dividends, $\hat{\Omega}_t$, at the end of each period.

3.3 Government

The government collects taxes on households' income and consumption. It uses this revenue to purchase an index of consumption goods, G_t, from firms. For simplicity, the government's budget constraint is assumed to balance in each period

$$\tau\left(\hat{W}_t L_t + \hat{R}_t K_{t-1} + \hat{\Omega}_t + \frac{I_t^* Q_t \hat{B}_t^*}{1+\Pi_t^*}\right) + \tau_t^{GST} C_t - G_t = 0 \tag{18}$$

i.e. there is no debt financing.[9] Note that the GST collected and paid on government consumption nets out.

3.4 Monetary authority

The monetary authority has an explicit consumer price inflation target, Π^T. To maintain this target following a shock to the economy the central bank adjusts its monetary policy tool. Two instruments are considered – the nominal rate of interest paid on domestic bonds, I_t, and the GST rate, τ_t^{GST}. The central bank's reaction function is discussed in more detail in section 4.

To assess the impact of the two monetary policy instruments (GST and interest rate) a measure of welfare is introduced. It is based on the change in consumption that households would require to be as well off as under the absence of a shock and monetary policy response. The welfare measure is obtained by solving equation (19) for $\Delta\bar{C}_t$

$$\bar{U}\left(\bar{C},\ \bar{N}\right) = \ln\left(C_t - \Delta\bar{C}_t\right) + \gamma\left(1 - N_t\right) \tag{19}$$

[9] No debt financing implies that $B_t = 0$ for all t. The assumption does not change the conclusions.

where $\bar{U}\left(\bar{C}, \bar{N}\right)$ is households' utility attained in steady state, and C_t and N_t are consumption and labour following a shock to the economy. Welfare changes are calculated for the GST and interest rate models and expressed as a percent of steady state output, $\bar{Y}$.

3.5 Equilibrium conditions

The labour market clearing condition and the resource constraint are given by

$$L_t = N_t \tag{20}$$

and

$$Y_t = C_t + G_t + EX_t \tag{21}$$

The capital stock obeys the following law of motion

$$IN_t = K_t - (1-\delta)\,K_{t-1} \tag{22}$$

where IN_t denotes investment. All physical capital is imported and the foreign sector clearing condition is given by

$$\tfrac{Q_t(1+I_t^*)\hat{B}_t^*}{1+\Pi_t^*} + EX_t - Q_t\hat{B}_{t+1}^* - Q_t IN_t = 0 \tag{23}$$

Moreover, uncovered interest rate parity holds

$$E_t\left[\tfrac{\left(1+(1-\tau)I_{t+1}^*\right)S_{t+1}}{S_t} - \left(1+(1-\tau)\,I_{t+1}\right)\right] = 0 \tag{24}$$

It implies that households are indifferent between holding domestic and foreign bonds. The real exchange rate is given by $Q_t = S_t P_t^* / P_t$ and evolves according to

$$E_t\left[\frac{Q_{t+1}}{Q_t}\right] = E_t\left[\frac{\frac{S_{t+1}}{S_t}\frac{P_{t+1}^*}{P_t^*}}{\frac{P_{t+1}}{P_t}}\right] \tag{25}$$

The sequences of foreign interest rates, prices, inflation and foreign demand $\{I_t^*, P_t^*, \Pi_t^*, Y_t^*\}$ are given to the small open economy.

3.6 Parameterisation of the model

A period in the model is assumed to correspond to one quarter. Parameter values are chosen so that the steady state of the model is broadly consistent with New Zealand data and/or assumptions made in the literature.[10]

Households' discount rate, β, equals 0.9902 and leads to an annual nominal, steady state domestic interest rate of 6 percent. The coefficient on leisure, γ, in households' utility function is chosen so that their work effort accounts for a third of their time endowment in steady state.

Labour-augmenting productivity, $\bar{Z}$, is normalised to 1 in steady state. The elasticity of substitution between labour and capital, $1/(1-\nu)$, is set to 0.85 in line with estimates for New Zealand by Hall and Scobie (2005). The coefficients on household labour, η_l, and capital, $(1-\eta_l)$, in firms' production function are 0.64 and 0.36. These assumptions are broadly in line with New Zealand input-output data and yield a steady state ratio of imports to output of about 12 percent, the same as in McCallum and Nelson (1999).[11] The capital depreciation rate, δ, equals 8.5 percent per annum, the same as in the Reserve Bank's model and firms' mark-up in steady state is 20 percent ($\theta/(\theta-1) = 1.2$), i.e. $\theta = 6$, the same as in McCallum

[10] The steady state equations are listed in appendix A.

[11] The steady state ratio of imports to output is lower than in the Reserve Bank of New Zealand's macroeconomic model (Black, Cassino, Drew, Hansen, Hunt, Rose and Scott, 1997) because in this model all imports are production inputs whereas in the Reserve Bank's model a proportion of imports is for final demand.

and Nelson (1999).

The annual domestic steady state inflation rate, Π^T, of 2 percent is equal to the mid-point of the Reserve Bank of New Zealand's 1 to 3 percent target band for consumer price inflation. The income tax rate for households, τ, is set to 30 percent, broadly in line with the current average tax rate in New Zealand. The steady state GST rate, $\bar{\tau}^{GST}$, is 12.5 percent, the same as the current rate. The steady state foreign inflation rate, $\bar{\Pi}^*$, and nominal bond rate, $\bar{I}^*$, are assumed to be the same as for the domestic economy and the steady state real exchange rate, $\bar{Q}$, is normalised to 1. The price and foreign demand elasticities of exports, κ and ς, are equal to unity, as in McCallum and Nelson (2000). Foreign demand is chosen to yield a steady state ratio of exports to output of 11 percent, the same as in McCallum and Nelson (1999), leading to a current account deficit of around -1 percent of steady state output.

4 Adjustment of the economy to shocks

To evaluate the effectiveness of a variable GST rate relative to an interest rate as a monetary policy tool, the economy is subjected to a range of exogenous shocks. The adjustment paths and welfare effects of the variable GST rate model are then compared to those of the model, where the central bank uses an interest rate tool. The dynamic responses are derived in terms of logarithmic deviations from steady state (denoted by lower case letters). Analysing the dynamic properties of the GST and interest rate models requires specifying firms' price adjustment, full capacity, flexible price output, the monetary authority's reaction function and the shock processes.

4.1 Price adjustment

The inflation process is derived from firms' optimal price setting. Firms' price adjustment follows Calvo (1983) and is assumed to be sluggish. Each period firms can adjust their prices with a constant probability, φ. The expected time between adjustments is thus given by $1/\varphi$. In the dynamic analysis the probability that firms can adjust prices is set to 0.33; that is, prices remain unchanged on average for three quarters.

Following Rotemberg (1987), the representative firm j sets its price to minimise a quadratic loss function that depends on the difference between the firm's actual price in period t and its target price. The firm's target price, $\tilde{P}_t(j)$, is given by $\tilde{P}_t(j) = \theta/(\theta-1) P_t MC_t$ or in logarithmic deviations from steady state as

$$\tilde{p}_t(j) = p_t + mc_t \tag{26}$$

It is the price that the firm would set in the absence of restrictions of adjusting prices.

Firm j's quadratic loss function is given by[12]

$$\tfrac{1}{2} \sum_{k=0}^{\infty} (1-\varphi)^k \beta^k E_t \left[p_t(j) - \tilde{p}_{t+k}(j)\right]^2 \tag{27}$$

and the first-order condition of equation (27) with respect to $p_t(j)$ is

$$p_t(j) \sum_{k=0}^{\infty} (1-\varphi)^k \beta^k - \sum_{k=0}^{\infty} (1-\varphi)^k \beta^k E_t \left[\tilde{p}_{t+k}(j)\right] = 0 \tag{28}$$

[12] Firms' discount factor, β, is assumed to be the same as for households.

or solving for $p_t(j)$

$$p_t(j) = (1 - (1-\varphi)\beta)\,\tilde{p}_t(j) + (1-\varphi)\,\beta E_t[p_{t+1}(j)] \tag{29}$$

If the number of firms is large, a fraction of firms φ actually adjusts their price each period. Using equation (26) the aggregate price adjustment equation can then be written as

$$\pi_t = \beta E_t[\pi_{t+1}] + \tfrac{\varphi(1-(1-\varphi)\beta)}{(1-\varphi)} mc_t \tag{30}$$

where $\pi_t = p_t - p_{t-1}$ and inflation is a function of expected future inflation and the real marginal cost. Under price stickiness, the marginal cost is equal to the inverse of firms' mark-up, ξ_t, i.e. $MC_t = 1/\xi_t$. Using $\xi_t/(\theta/(\theta-1)) = \xi_t P_t MC_t/(\theta/(\theta-1)\,P_t MC_t) = P_t/\tilde{P}_t(j)$, $\tilde{Y}_t(j) = (\tilde{P}_t(j)/P_t)^{-\theta} Y_t$, and dropping the j's (as all firms charge the same price and produce the same output in a symmetric equilibrium) the log real marginal cost, mc_t, can be derived as

$$mc_t = -\tfrac{1}{\theta}(y_t - \tilde{y}_t) \tag{31}$$

and the inflation adjustment equation is given

$$\pi_t = \beta E_t[\pi_{t+1}] + \varrho\,(y_t - \tilde{y}_t) \tag{32}$$

where $\varrho = \varphi(1-(1-\varphi)\beta)/\theta(1-\varphi)$ and $\tilde{y}_t$ denotes full capacity, flexible price output. Equation (32) thus states that inflation is determined by expected future inflation and the output gap, i.e. deviations of output from flexible price, full capacity output.

4.2 Full capacity, flexible price output

Full capacity, flexible price output, $\tilde{y}_t$, is the total domestic output of consumption goods that would be produced under price flexibility. In that case firms' mark-up is constant and output is given by

$$\tilde{y}_t = \eta_l \left(\frac{\bar{Z}\bar{L}}{\bar{Y}}\right)^{\nu} z_t + \eta_l \left(\frac{\bar{Z}\bar{L}}{\bar{Y}}\right)^{\nu} \tilde{l}_t + (1-\eta_l)\left(\frac{\bar{K}}{\bar{Y}}\right)^{\nu} \tilde{k}_{t-1} \tag{33}$$

where $\tilde{l}_t$ and $\tilde{k}_{t-1}$ denote flexible price household labour and capital. Flexible price household labour, $\tilde{l}_t$, can be derived from households' first-order condition that the marginal utility of leisure is equal to the after-tax real wage rate and firms' first-order condition determining labour demand (equation 16). It is given by $\tilde{l}_t = \tilde{y}_t + \nu/(1-\nu)\, z_t$. Flexible price capital, $\tilde{k}_{t-1}$, is derived from firms' first-order condition (17) and given by $\tilde{k}_{t-1} = \tilde{y}_t - 1/(1-\nu)\, r_t$. Equation (33) can then be re-written as

$$\tilde{y}_t = \frac{1}{1-\nu} z_t - \frac{(1-\eta_l)\left(\frac{\bar{K}}{\bar{Y}}\right)^{\nu}}{\eta_l (1-\nu)\left(\frac{\bar{Z}\bar{L}}{\bar{Y}}\right)^{\nu}} r_t \tag{34}$$

Full capacity, flexible price output is a function of labour-augmenting productivity and the rental rate of capital.

4.3 Monetary authority's reaction function

The monetary authority's reaction function is given by

$$i_t = \mu_1 \pi_t + \mu_2 (y_t - \tilde{y}_t) + \mu_3 i_{t-1} \tag{35}$$

or

$$\check{\tau}_t^{GST} = \mu_1 \pi_t + \mu_2 \left(y_t - \tilde{y}_t \right) + \mu_3 \check{\tau}_{t-1}^{GST} \tag{36}$$

depending on whether the interest rate, i_t, or the GST rate, $\check{\tau}_t^{GST}$, is used as the monetary policy tool. $\check{\tau}_t^{GST}$ denotes logarithmic deviations of the GST rate from steady state. The coefficients on inflation and the output gap are given by $\mu_1 = 1.5$ and $\mu_2 = 0.5$. The choice for μ_1 and μ_2 is based on the parameter values in a Taylor rule (Taylor, 1993).[13] The coefficient μ_3 is set to 0.8, the same as in McCallum and Nelson's (1999) interest rate rule and in line with estimates for New Zealand by Huang, Margaritis and Mayes (2001), who find strong evidence of interest rate smoothing.

5 Business cycle effects

To illustrate the effects of a variable GST rate relative to adjusting an interest rate, two shocks are presented: to aggregate productivity and to foreign demand. The shocks are chosen for two reasons. First, one is a domestic shock and the other is a foreign shock. Second, the two shocks should lead to opposite effects on inflation. The labour-augmenting productivity shock is expected to temporarily lower inflation, while the foreign demand shock should produce upward pressure on prices.

Productivity, z_t, and foreign demand, y_t^*, are univariate exogenous processes with normally distributed errors and evolve according to

$$z_t = \rho_z z_{t-1} + \epsilon_{z,t}, \quad \text{where} \quad \epsilon_{z,t} \sim i.i.d.\ N\left(0; \sigma_z^2\right) \tag{37}$$

[13] The original Taylor rule does not include the lagged interest rate.

$$y_t^* = \rho_{y^*} y_{t-1}^* + \epsilon_{y^*,t}, \quad \text{where} \quad \epsilon_{y^*,t} \sim i.i.d.\ N\left(0; \sigma_{y^*}^2\right) \tag{38}$$

The autocorrelation coefficient of both processes are assumed to be 0.95, i.e. $\rho_{y^*} = \rho_z = 0.95$. The innovation variances are given by $\sigma_z^2 = (0.007)^2$ and $\sigma_{y^*}^2 = (0.02)^2$.

The impulse responses to a positive productivity shock and a positive foreign demand shock are plotted in Figures 4 and 5. They are in percent deviations from steady state unless otherwise indicated.[14] The solid line shows the responses in the interest rate model. The dotted line plots the impulse responses when the GST rate is used as the monetary policy tool. All variables eventually return to steady state.

5.1 Productivity shock

The impulse responses of the variables in the GST and interest rate models to a positive labour-augmenting productivity shock are plotted in Figure 4. In both models, the positive productivity shock raises full capacity, flexible price output. In the interest rate model, the increase in full capacity, flexible price output leads to a negative output gap and downward pressure on inflation. As a result, the central bank eases monetary policy. The interest rate declines and the real exchange rate depreciates.

In the GST rate model, the positive productivity shock also raises full capacity, flexible price output. But the rise is insufficient to meet increased demand and a positive output gap opens up. The positive output gap raises inflation and the central bank tightens monetary policy, i.e. the GST rate increases. The rise in inflation produces a real exchange rate depreciation. The exchange rate depreciates by more than in the interest rate model (due to

[14] The log-linearised model is solved with the method of undetermined coefficients. Uhlig's (1999) procedures for MATLAB are used. The equations are given in appendix B.

the sharp rise in inflation), leading to a larger increase in the cost and rental rate of capital. Also adding to the rise in the rental rate of capital is the increase in the GST rate, which raises the marginal rate of substitution between current and future consumption and the rate of return households demand for the use of their funds. The higher rental rate of capital in turn produces a more subdued rise in full capacity, flexible price output following the positive productivity shock. It also leads to a smaller increase in investment.

In both models, the increase in output following the positive productivity shock raises tax revenue and government consumption. Moreover, the labour-augmenting productivity shock raises households' wage rate and lowers employment. But household labour falls by less in the GST rate model than the interest rate model. This is because of the smaller rise in investment. Also adding to the smaller decline in labour is a higher effective price of consumption due to the rise in the GST rate. Compared to the interest rate model, household consumption increases by less and exports rise by more.

Overall, the smaller increase in consumption and the smaller decline in labour produce a smaller welfare gain following the positive productivity shock in the GST rate model compared to the interest rate model. Furthermore, deviations from steady state of the policy instrument, inflation, output and the exchange rate are substantially larger.

5.2 Foreign demand shock

The impulse responses to a positive foreign demand shock are plotted in Figure 5. In both models, the shock raises exports and output and leads to a positive output gap, upward pressure on inflation and a tightening in monetary policy. But the output gap and inflationary pressures are larger in the GST rate model and the central bank tightens monetary policy by

Figure 4: Impulse responses to a productivity shock (in percent deviations from steady state unless otherwise indicated)

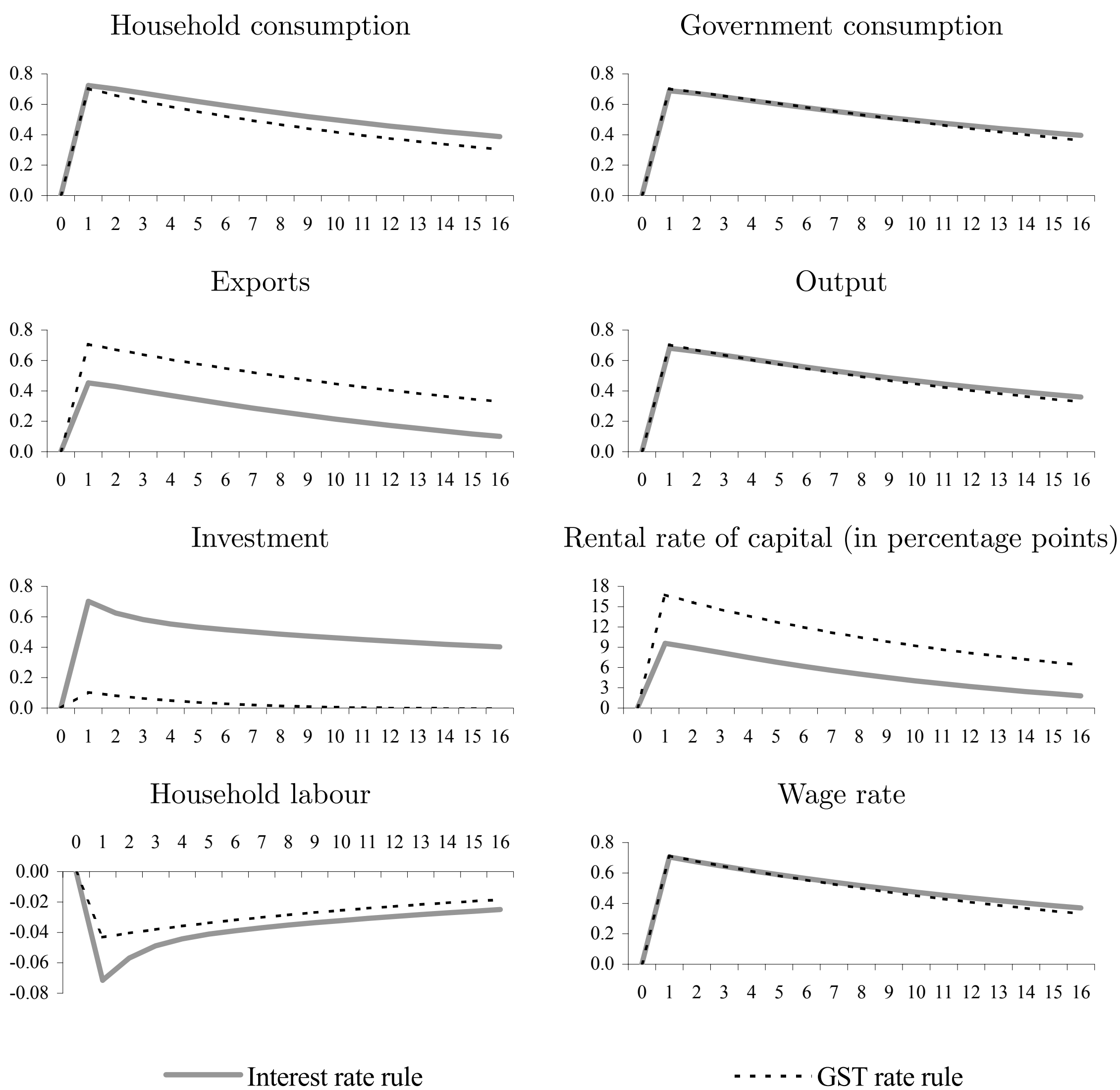
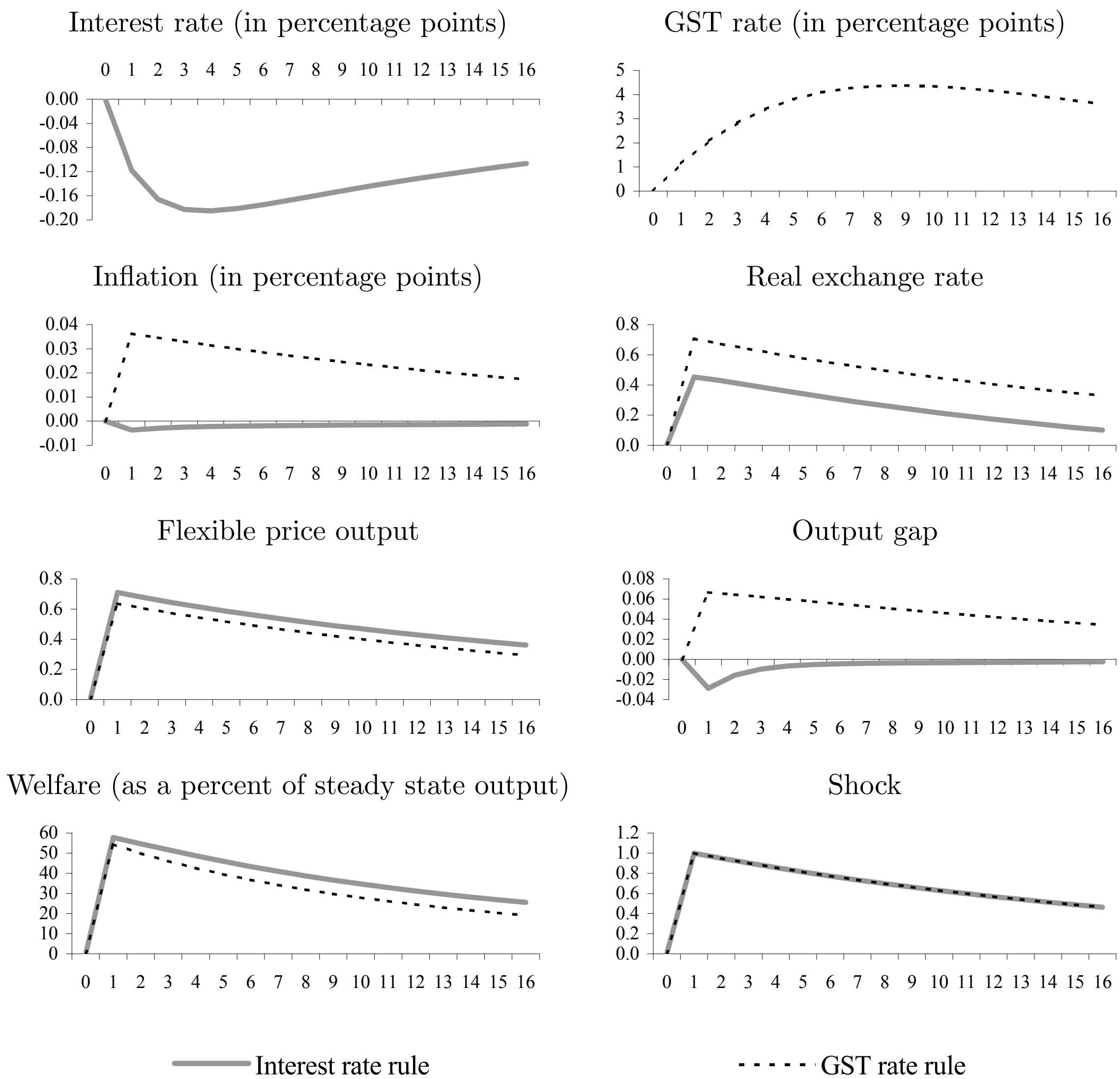


Figure 4 continued



more. The output gap is larger because the real exchange rate appreciates by less, leading to a smaller decline in the cost of imported capital, the rental rate of capital and hence flexible price output. At the same time the smaller real exchange rate appreciation in the GST rate model produces a larger increase in exports and output, adding further to the positive output gap.

In both models, following the foreign demand shock and real exchange rate appreciation, the cost and rental rate of capital fall. In the interest rate model, the decline in the rental rate of capital leads firms to substitute labour for capital. Investment increases by more than household labour and the wage rate falls. In the GST rate model, the rental rate of capital falls by less than in the interest rate model because of a smaller real exchange rate appreciation. Adding to the smaller decline is the rise in the consumption tax rate, which raises the marginal rate of substitution between current and future consumption and the rate of return households demand for the use of their funds. At the same time, the higher consumption tax rate increases the effective price of consumption, leading to a sharp decline in consumption, the growth rate of output and the wage rate. The decline in the wage rate produces to a substitution of capital for labour and investment falls.

A variable GST rate leads to larger fluctuations in tax revenue and government spending. In the interest rate model, the increase in exports and output raises tax revenue and government consumption. Tax revenue and government consumption are also initially higher in the GST rate model but then decline. They fall as the effect of the higher GST rate is more than offset by lower household consumption.

Overall, the tightening in monetary policy following the positive foreign demand shock leads to larger welfare losses in the GST rate model (due to a larger fall in household consumption and a larger rise in household labour) than in the interest rate model. Moreover, as in the case of the productivity shock, the variable GST rate leads to larger adjustments in the policy instrument and fluctuations in the real economy and inflation.

6 Concluding remarks

This paper examined the usefulness of a variable GST rate as a stabilisation tool for monetary policy in New Zealand. It first discussed some of the problems that would arise with the implementation of a variable GST rate. It then developed a stylised model of the New Zealand economy to assess the effectiveness of a variable GST rate relative to the conventional monetary policy tool, an interest rate. The results showed that a variable GST rate would be a less effective monetary policy tool in dampening business cycles than an interest rate. It would lead to larger adjustments in the policy instrument and fluctuations in the real economy and inflation. Moreover, a variable GST rate would reduce welfare. It would result in larger (smaller) welfare losses (gains) from monetary policy compared to using a variable interest rate. We therefore conclude that the goods and services tax would unlikely be a useful stabilisation tool for monetary policy.

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Figure 5: Impulse responses to a foreign demand shock (in percent deviations from steady state unless otherwise indicated)

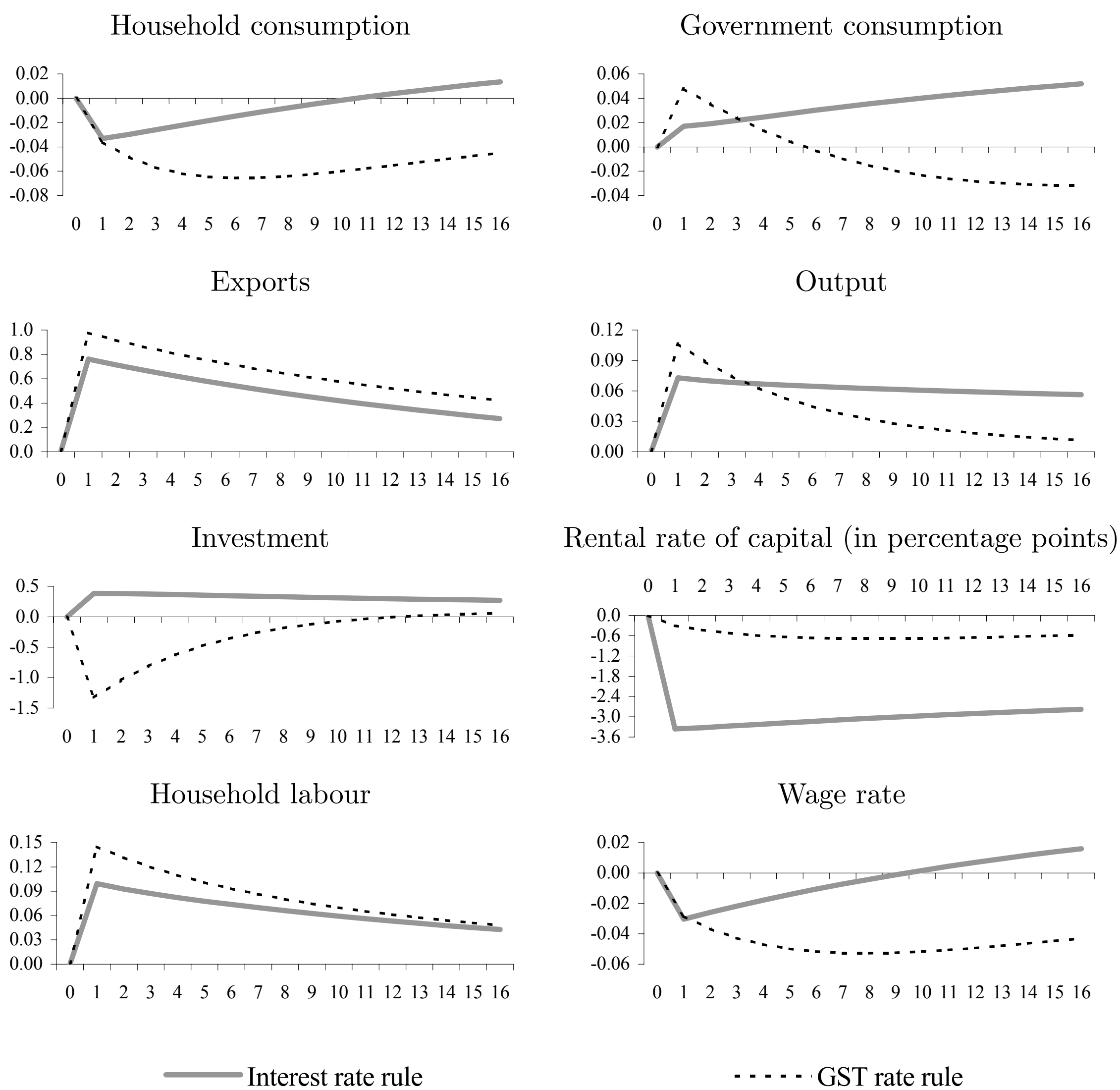
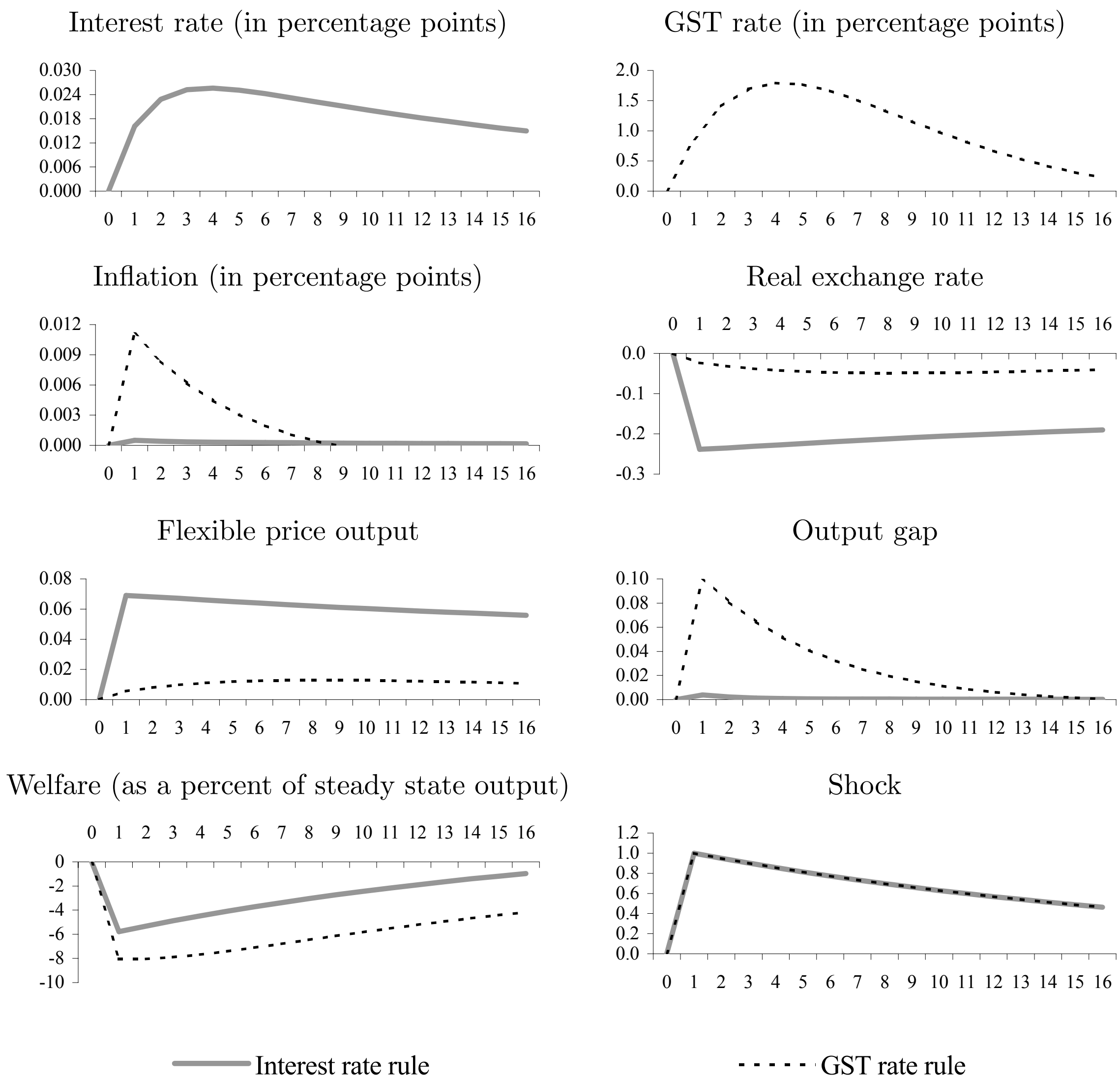


Figure 5 continued



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A Steady state

A residual is calculated to ensure that the model "nearly" solves. The system of steady state equations is given by

$$\begin{aligned}&(1-\tau)\bar{W}\bar{L} + \left((1-\delta)\bar{Q} + (1-\tau)\bar{R}\right)\bar{K} + (1-\tau)\bar{\Omega}\\&+\tfrac{\left(1+(1-\tau)\bar{I}^*\right)\bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} - \bar{Q}\bar{B}^* - \left(1+\bar{\tau}^{GST}\right)\bar{C} - \bar{Q}\bar{K} + residual = 0\end{aligned}$$

$$(1-\tau)\bar{W} - \gamma\left(1+\bar{\tau}^{GST}\right)\bar{C}\left(1+(1-\tau)\bar{I}\right) = 0$$

$$\beta\left(\tfrac{1+(1-\tau)\bar{I}}{1+\bar{\Pi}}\right) - 1 = 0$$

$$\beta\left((1-\delta)\bar{Q} + \tfrac{(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}}\right) - \bar{Q} = 0$$

$$\bar{Y} - \bar{W}\bar{L} - \bar{R}\bar{K} - \bar{\Omega} = 0$$

$$\bar{W} - \frac{\eta_l \left(\bar{Z}\right)^{\nu} \left(\frac{\bar{Y}}{\bar{L}}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} = 0$$

$$\bar{R} - \frac{(1-\eta_l)\left(\frac{\bar{Y}}{\bar{K}}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} = 0$$

$$\bar{Y} - \left((\eta_l \left(\bar{Z}\bar{L}\right)^{\nu} + (1-\eta_l)\,\bar{K}^{\nu}\right)^{\frac{1}{\nu}} = 0$$

$$\frac{\left(1+(1-\tau_*)\bar{I}^*\right)\bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} + \bar{EX} - \bar{Q}\bar{B}^* - \delta\bar{Q}\bar{K} = 0$$

$$\bar{EX} - 0.11 \cdot \bar{Y} = 0$$

$$\bar{Q}\bar{K} - (1-\delta)\,\bar{Q}\bar{K} - \bar{IN} = 0$$

$$\bar{Y} - \bar{C} - \bar{G} - \bar{EX} = 0$$

$$\tau\bar{W}\bar{L} + \tau\bar{R}\bar{K} + \tau\bar{\Omega} + \frac{\tau\bar{I}^*\bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} + \bar{\tau}^{GST}\bar{C} - \bar{G} = 0$$

$$\left(1+(1-\tau)\,\bar{I}^*\right)\bar{\Delta S} - \left(1+(1-\tau)\,\bar{I}\right) = 0$$

$$1 + \bar{\Delta Q} - \frac{\left(1+\bar{\Delta S}\right)\left(1+\bar{\Pi}^*\right)}{1+\bar{\Pi}} = 0$$

B Dynamic model

The dynamic model is described by (32), (34), (35) or (36) and the following equations

$$\eta_l \left(\frac{\bar{Z}\bar{L}}{\bar{Y}}\right)^{\nu} z_t + \eta_l \left(\frac{\bar{Z}\bar{L}}{\bar{Y}}\right)^{\nu} l_t + (1-\eta_l)\left(\frac{\bar{K}}{\bar{Y}}\right)^{\nu} k_{t-1} - y_t = 0$$

$$\bar{W}\bar{L}w_t + \bar{W}\bar{L}l_t + \bar{R}\bar{K}r_t + \bar{R}\bar{K}k_{t-1} + \bar{\Omega}\omega_t - \bar{Y}y_t = 0$$

$$y_t + \frac{1}{\theta}\left(y_t - \bar{y}_t\right) - \omega_t = 0$$

$$(1-\nu)\, y_t - (1-\nu)\, l_t + \nu z_t + \frac{1}{\theta}\left(y_t - \bar{y}_t\right) - w_t = 0$$

$$\frac{(1-\nu)(1-\tau)(1-\eta_l)\left(\frac{\bar{Y}}{\bar{K}}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} y_t - \frac{(1-\nu)(1-\tau)(1-\eta_l)\left(\frac{\bar{Y}}{\bar{K}}\right)^{1-\nu}}{\frac{\theta}{\theta-1}} k_{t-1} + \frac{(1-\tau)(1-\eta_l)\left(\frac{\bar{Y}}{\bar{K}}\right)^{1-\nu}}{\frac{\theta^2}{\theta-1}}\left(y_t - \bar{y}_t\right)$$
$$-\left(1 + (1-\tau)\,\bar{R}\right) r_t + (1-\delta)\,\bar{Q} q_t = 0$$

$$w_t - c_t - \frac{\bar{\tau}^{GST}}{1+\bar{\tau}^{GST}} \check{\tau}_t^{GST} - i_t = 0$$

or

$$w_t - c_t - i_t = 0$$

$$c_t + \frac{\bar{\tau}^{GST}}{1+\bar{\tau}^{GST}} \check{\tau}_t^{GST} - q_t + \frac{\frac{(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}}}{(1-\delta)\bar{Q} + \frac{(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}}} E_t\left[r_{t+1}\right] + \frac{(1-\delta)\bar{Q}}{(1-\delta)\bar{Q} + \frac{(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}}} E_t\left[q_{t+1}\right]$$
$$-\frac{\frac{(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}}}{(1-\delta)\bar{Q} + \frac{(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}}} E_t\left[i_{t+1}\right] - E_t\left[c_{t+1}\right] - \frac{\bar{\tau}^{GST}}{(1+\bar{\tau}^{GST})} E_t\left[\check{\tau}_{t+1}^{GST}\right] = 0$$

or

$$\bar{Q} c_t - \bar{Q} q_t + \frac{\beta(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}} E_t\left[r_{t+1}\right] + \beta\,(1-\delta)\,\bar{Q} E_t\left[q_{t+1}\right] - \frac{\beta(1-\tau)\bar{R}}{1+(1-\tau)\bar{I}} E_t\left[i_{t+1}\right] - \bar{Q} E_t c_{t+1} = 0$$

$$I\bar{N} in_t - \bar{K} k_t + (1-\delta)\,\bar{K} k_{t-1} = 0$$

$$\tau \bar{W}\bar{L} w_t + \tau \bar{W}\bar{L} l_t + \tau \bar{R}\bar{K} r_t + \tau \bar{R}\bar{K} k_{t-1} + \tau \bar{\Omega}\omega_t + \frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} b_t^* + \frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} q_t$$
$$+\frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} i_t^* - \frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} \pi_t^* + \bar{\tau}^{GST}\bar{C} c_t + \bar{\tau}^{GST}\bar{C}\check{\tau}_t^{GST} - \bar{G} g_t = 0$$

or

$$\tau \bar{W}\bar{L} w_t + \tau \bar{W}\bar{L} l_t + \tau \bar{R}\bar{K} r_t + \tau \bar{R}\bar{K} k_{t-1} + \tau \bar{\Omega}\omega_t + \frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} b_t^* + \frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} q_t$$
$$+\frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} i_t^* - \frac{\tau \bar{I}^* \bar{Q}\bar{B}^*}{1+\bar{\Pi}^*} \pi_t^* + \bar{\tau}^{GST}\bar{C} c_t - \bar{G} g_t = 0$$

$$ex_t - q_t - y_t^* = 0$$

$$\bar{C}c_t + \bar{G}g_t + E\bar{X}ex_t - \bar{Y}y_t = 0$$

$$\frac{\left(1+(1-\tau)\bar{I}^*\right)\bar{B}^*}{1+\bar{\Pi}^*}b_t^* + \frac{\left(1+(1-\tau)\bar{I}^*\right)\bar{B}^*}{1+\bar{\Pi}^*}i_t^* - \frac{\left(1+(1-\tau)\bar{I}^*\right)\bar{B}^*}{1+\bar{\Pi}^*}\pi_t^* + \frac{E\bar{X}}{\bar{Q}}ex_t - \frac{E\bar{X}}{\bar{Q}}q_t - I\bar{N}in_t - \bar{B}^*b_{t+1}^* = 0$$

$$E_t\left[i_{t+1}\right] - E_t\left[i_{t+1}^*\right] - E_t\left[s_{t+1}\right] + s_t = 0$$

$$E_t\left[q_{t+1}\right] - q_t - E_t\left[s_{t+1}\right] + s_t - E_t\left[\pi_{t+1}^*\right] + E_t\left[\pi_{t+1}\right] = 0$$