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TAXATION AND FINANCE CONSTRAINED FIRMS

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This paper develops an open economy model to assess the long-run effects of taxation when firms are finance constrained. Finance constraints arise because of imperfect information between borrowers and lenders. Only borrowers (firms) can costlessly observe actual returns from production. Imperfect information and finance constraints magnify the effects of taxation. A reduction (rise) in income taxation increases (lowers) firms' internal funds and their ability to access external finance to expand production. The findings thus underline the importance of incorporating access to finance into models that assess the impact of taxation.

JEL classification: H2, E44, F41

Keywords: Taxation, finance constraint, asymmetric information, open economy, general equilibrium model

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I. INTRODUCTION

This paper develops an open economy model to assess the long-run effects of taxation when firms are finance constrained. It is motivated by empirical evidence that taxation may inhibit the start-up and growth of small firms.[1] The model in this paper provides a theoretical basis for the empirical finding.

Small firms typically face finance constraints when starting up or expanding a business because of imperfect information between borrowers and lenders and reduced economies of scale with respect to acquiring information about small firms. Information asymmetry arises because borrowers (firms) generally know more about their production processes and investment projects than lenders (financial intermediaries and households). Imperfect information and finance constraints magnify the effects of taxation and may be more pronounced in a small open economy. Small economies tend to have fewer large firms and relatively more small firms, while in open economies there may be additional information asymmetries between domestic and foreign borrowers and lenders.

The paper proceeds as follows. Section II develops a theoretical model with finance constrained firms that is calibrated to the small open economy of New Zealand. The parameterisation of the model is discussed in section III. Section IV assesses the long-run effects of taxation when firms are finance constrained and sensitivity analysis is presented in section V. The last section summarises and concludes.

[1] See, for example, Carroll, Holtz-Eakin, Rider and Rosen [2001], Gentry and Hubbard [2004] and Bruce and Gurley [2005].

II. THEORETICAL MODEL

There are six agents in the economy: households, firms, entrepreneurs, financial intermediaries, a government and a monetary authority. Entrepreneurs own firms and provide financing (internal funds) to firms. Firms are monopolistic competitors and produce output of goods. To pay for production inputs they use entrepreneurs' internal funds. They also obtain external financing from households via financial intermediaries. Firms face a finance constraint because of limited supply of internal funds and because of information asymmetry between borrowers and lenders. The information asymmetry arises because only firms/entrepreneurs can costlessly observe actual returns from production.[2] The imperfect information leads to a moral hazard problem and lowers the probability that a loan is repaid. Financial intermediaries help overcome this information asymmetry.

II.A. Financial Intermediaries

The primary role of financial intermediaries is to channel funds from households to entrepreneurs (firms).[3] Firms obtain external financing from households to pay for production inputs. In addition to external financing firms also use entrepreneurs' net worth (internal funds) consisting of their wage earnings and capital.

Financial intermediaries reduce the cost of moving funds between borrowers (firms/ entrepreneurs) and lenders (households) because they enhance risk diversification and help overcome information asymmetry. By taking advantage of economies of scale financial intermediaries can promise households a higher payoff relative to the non-intermediated case,

[2] "Firms" and "entrepreneurs" are used interchangeably.

[3] Financial intermediaries also hold households' demand deposits and issue domestic bonds (discussed further below).

resulting in a more efficient allocation of resources. Information asymmetry arises because firms must use external financing to produce output and because their production is subject to idiosyncratic technology shocks. This leads to agency costs because the technology shocks can only be observed costlessly by entrepreneurs (firms). Agency costs arise because agents (borrowers) have an incentive not to perform in the best interest of principals (lenders). To resolve the imperfect information problem financial intermediaries lend to entrepreneurs via a debt contract, an agreement by the borrower to pay the lender a fixed amount, and monitor entrepreneurs who default on their debt. Debt contracts are negotiated at the beginning of each period and resolved by the end of the period.

The set-up for financial intermediaries follows Carlstrom and Fuerst [1998]. Each entrepreneur i borrows $(A_t(i) - NW_t(i))$, where $A_t(i)$ is firm i's production input bill and $NW_t(i)$ is entrepreneur i's net worth or internal funds. Each firm i's production function is subject to an idiosyncratic technology shock, $\omega_t(i)$, which is only observed by firms and entrepreneurs after production commences. The random variable $\omega_t(i)$ is assumed to be lognormally distributed across time and firms (entrepreneurs), i.e. $\ln(\omega_t(i)) \sim N\left(\tilde{\mu},\ \tilde{\sigma}^2\right)$, with a mean of unity and a standard deviation of σ. The distribution function and density of $\omega_t(i)$ are given by $\Phi(\omega_t(i))$ and $\phi(\omega_t(i))$.

Agency costs arise because lenders can only observe $\omega_t(i)$ at a monitoring cost of $\alpha A_t(i)$ of output, i.e. there is costly state verification [Townsend 1979]. The information asymmetry creates a moral hazard problem because entrepreneurs have an incentive to underreport their true value of $\omega_t(i)$. The optimal debt contract is structured so that entrepreneur i always truthfully reports the value of $\omega_t(i)$. The optimal contract is risky debt and characterised

by the size of firm i's input bill, $A_t(i)$, and a critical $\omega_t(i)$ that triggers bankruptcy, denoted by $\varpi_t(i)$. If the realisation of the technology shock $\omega_t(i)$ is below the critical $\varpi_t(i)$, the entrepreneur becomes bankrupt and defaults on the debt contract. In the event of default, the financial intermediary monitors the entrepreneur, as in Williamson [1986], confiscates all returns from production and absorbs any losses.

To derive the optimal project size $A_t(i)$ and the critical $\varpi_t(i)$ that triggers bankruptcy two functions, $f(\varpi)$ and $g(\varpi)$, are defined. They are the fractions of the expected output received by the entrepreneur and lender. Time and entrepreneur subscripts have been dropped for simplicity. The functions are given by $f(\varpi) = \int_{\varpi}^{\infty}(\omega - \varpi)\, d\Phi(\omega) = \int_{\varpi}^{\infty}\omega d\Phi(\omega) - [1 - \Phi(\varpi)]\varpi$ and $g(\varpi) = \int_{0}^{\varpi}\omega d\Phi(\omega) - \alpha\Phi(\varpi) + [1 - \Phi(\varpi)]\varpi$, where $f(\varpi)$ integrates only over values of ω in excess of ϖ and $g(\varpi)$ integrates over 0 to ϖ. Moreover, $f(\varpi)$ and $g(\varpi)$ do not sum to one because of expected bankruptcy and monitoring costs, i.e. $f(\varpi) + g(\varpi) = 1 - \alpha\Phi(\varpi)$. The expected bankruptcy and monitoring costs (and assumption of constant returns to scale in production, see equation 14 below) imply that output sells at a mark-up. Financial intermediaries can reduce this mark-up, Ψ_t, by pooling funds in the economy and risk sharing. The expected output received by the entrepreneur and lender from firm i's production is then given by $f(\varpi_t(i))\Psi_t A_t(i)$ and $g(\varpi_t(i))\Psi_t A_t(i)$.

The optimal contract between the lender and entrepreneur is given by the pair $(A_t(i), \varpi_t(i))$ that maximises the entrepreneur's output subject to the lender being indifferent between loaning the funds to the entrepreneur and retaining them, i.e.

$$\max f(\varpi_t(i))\Psi_t A_t(i) \tag{1}$$

subject to[4]

$$g\left(\varpi_t\left(i\right)\right)\Psi_t A_t\left(i\right) \geq A_t\left(i\right) - NW_t\left(i\right) \tag{2}$$

The first-order conditions of the optimisation problem are given by

$$\frac{f(\varpi_t(i))}{f'(\varpi_t(i))} = \frac{g(\varpi_t(i))\Psi_t - 1}{g'(\varpi_t(i))\Psi_t} \tag{3}$$

which can be re-written as

$$\Psi_t\left(1 - \alpha\Phi\left(\varpi_t\left(i\right)\right) + \frac{\alpha\phi(\varpi_t(i))f(\varpi_t(i))}{f'(\varpi_t(i))}\right) = 1 \tag{4}$$

and

$$A_t\left(i\right) = \frac{NW_t(i)}{1 - g(\varpi_t(i))\Psi_t} \tag{5}$$

Equation (4) determines the critical $\varpi_t\left(i\right)$ as a function of the mark-up, Ψ_t, the distribution of the stochastic technology shock, $\omega_t\left(i\right)$, and the monitoring cost, α. The critical $\varpi_t\left(i\right)$ is independent of i; that is, all entrepreneurs receive the same basic terms on their debt contract. Contracts only differ in terms of size – entrepreneurs with larger net worth receive a proportionately larger loan (equation 5). This result is important as it overcomes the heterogeneity problem with firms that arises from the idiosyncratic technology shock. The result follows from the assumption of linear monitoring costs and a constant returns to scale production technology. Variables specific to i can henceforth be interpreted as averages.

[4] At an optimum equation (2) holds as an equality.

The gross expected return to internal funds, $1 + IR_t$, is given by

$$1 + IR_t = \frac{f(\varpi_t)\Psi_t A_t}{NW_t} = \frac{f(\varpi_t)\Psi_t}{1 - g(\varpi_t)\Psi_t} \tag{6}$$

where $\left(f\left(\varpi_t\right)\Psi_t A_t\right)/NW_t$ denotes the expected output received by entrepreneurs per unit of leveraged net worth.

II.B. Households

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

$$E_t \sum_{k=0}^{\infty} \beta^k \left\{\ln\left(C_{t+k}^h\right) + \gamma\left(1 - N_{t+k}^h\right)\right\} \tag{7}$$

where E_t is the conditional expectations operator with respect to information available at time t, where $\gamma > 0$ is a parameter, $\beta \in (0,1)$ denotes the household's discount factor and C_t^h is an index of household consumption in period t. Each household consumes many goods, each of which is domestically produced by a monopolistic competitive firm.[5] Households' time endowment is normalised to one. Their labour supply is given by N_t^h and $\left(1 - N_t^h\right)$ is leisure. Households' utility function implies an intertemporal elasticity of substitution between consumption and leisure of unity.

Households earn income from supplying labour, N_t^h, at wage rate W_t^h and by renting

[5] C_t^h is the quantity consumed in period t of an index of these goods with $C_t^h = \left[\int_0^1 C_t^h\left(j\right)^{(\theta-1)/\theta} dj\right]^{\theta/(\theta-1)}$, where $\theta > 0$ is the price elasticity of demand and $C_t^h\left(j\right)$ denotes the household's period t consumption of good j [see Dixit and Stiglitz 1977]. 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 $P_t = \left[\int_0^1 P_t\left(j\right)^{1-\theta} dj\right]^{\theta/(\theta-1)}$. Entrepreneurs' and the government's consumption indexes (discussed below) are given accordingly.

capital, K^h_{t-1}, which they accumulated last period, to firms at rate R_t. Households also earn income from holding domestic and foreign bonds, B^h_{t-1} and B^{h*}_{t-1}. Domestic bonds, B^h_{t-1}, earn a nominal return (in terms of domestic currency) of I_t and the nominal rate of interest paid on foreign bonds, B^{h*}_{t-1}, is given by I^*_t. Households also hold demand deposits, D^h_{t-1}, to purchase consumption and capital goods. Demand deposits do not earn any interest.

Households pay taxes on their earned income. The tax rates on wage, rental and domestic interest income are given by τ_L, τ_K and τ_B, while the tax rate on foreign interest income is a function of the tax rate on domestic interest income, τ_B, and the foreign tax rate, τ_*. The assumption that foreign interest income is taxed at the domestic and foreign tax rate reflects that a proportion of foreign earned income is double taxed in New Zealand (and other countries). Capital gains from exchange rate movements are not taxed and capital depreciation can be fully deducted. The government also imposes a consumption tax of τ_C. The typical household's budget constraint is thus given by

$$\begin{aligned}
&(1-\tau_L)\, W^h_t N^h_t + ((1-\delta) + (1-\tau_K)\, R_t + \tau_K \delta)\, P_t K^h_{t-1} \\
&+ (1 + (1-\tau_B)\, I_t)\, B^h_{t-1} + (1 + (1-\tau_B)\,(1-\tau_*)\, I^*_t)\, S_t B^{h*}_{t-1} + D^h_{t-1} \\
&- P_t\,(1+\tau_C)\, C^h_t - B^h_t - S_t B^{h*}_t - D^h_t - P_t K^h_t = 0
\end{aligned} \tag{8}$$

where S_t denotes the nominal exchange rate, δ is the depreciation rate of capital and $\tau_K \delta P_t K^h_{t-1}$ represents the depreciation allowance.[6]

[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.

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

$$P_t\left(\left(1+\tau_C\right)C_t^h + K_t^h - \left(1-\delta\right)K_{t-1}^h\right) \leq D_{t-1}^h \tag{9}$$

and holds as an equality at an optimum if $I_t > 0$. Using equation (9) the household's budget constraint can then be re-written in real terms as

$$\begin{aligned}&\left(1-\tau_L\right)\hat{W}_t^h N_t^h + \left(1-\tau_K\right)R_t K_{t-1}^h + \tfrac{(1+(1-\tau_B)I_t)\hat{B}_{t-1}^h}{1+\Pi_t} + \tfrac{(1+(1-\tau_B)(1-\tau_*)I_t^*)Q_t\hat{B}_{t-1}^{h*}}{1+\Pi_t^*}\\ &-\hat{B}_t^h - Q_t\hat{B}_t^{h*} - \left(1+\Pi_{t+1}\right)\left(\left(1+\tau_C\right)C_{t+1}^h + K_{t+1}^h - \left(1-\delta\left(1-\tau_K\right)\right)K_t^h\right)\\ &= 0\end{aligned} \tag{10}$$

where the real wage rate is given by $\hat{W}_t^h$, and $\hat{B}_t^h$ and $\hat{B}_t^{h*}$ are the household's domestic and foreign bond holdings in real terms. Q_t denotes the real exchange rate, $Q_t \equiv S_t P_t^*/P_t$, and Π_t is the domestic inflation rate with $\Pi_t = P_t/P_{t-1} - 1$. The foreign inflation rate is given by $\Pi_t^* = P_t^*/P_{t-1}^* - 1$, where P_t^* is the aggregate foreign price level.

The household's optimisation problem consists of choosing $\{C_t^h,\ N_t^h,\ K_t^h,\ \hat{B}_t^h,\ \hat{B}_t^{h*}\}$ for all $t \in [0,\infty)$ to maximise lifetime utility (equation 7) subject to equation (10). Households' first-order conditions are given by

$$\tfrac{1-N_t^h}{\gamma C_t^h} - \tfrac{(1+\tau_C)(1+(1-\tau_B)I_t)}{(1-\tau_L)\hat{W}_t^h} = 0 \tag{11}$$

$$\tfrac{1}{C_t^h} - E_t\left[\frac{\beta\left((1-\delta(1-\tau_K)) + \frac{(1-\tau_K)R_{t+1}}{1+(1-\tau_B)I_{t+1}}\right)}{C_{t+1}^h}\right] = 0 \tag{12}$$

and

$$E_t\left[\frac{Q_{t+1}}{Q_t}\frac{1+(1-\tau_B)(1-\tau_*)I^*_{t+1}}{1+\Pi^*_{t+1}}-\frac{1+(1-\tau_B)I_{t+1}}{1+\Pi_{t+1}}\right]=0 \tag{13}$$

Equation (11) indicates that 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, $(1-\tau_B)\,I_t$. Equation (12) implies that 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 allowance plus the after-tax rate of return on capital adjusted for the opportunity cost of having to hold demand deposits to purchase capital goods. Equation (13) indicates that the real, after-tax rates of return from holding domestic and foreign bonds are equal and households are indifferent between holding domestic or foreign bonds.

The first-order conditions show that the distortionary effect of capital income taxation is larger than that of labour income and consumption taxation. This is because the distortionary impact accumulates over time. The tax rate on capital income influences households' intertemporal decisions to save and invest, whereas the labour income and consumption tax rates affect consumption and leisure at time t only. The tax rate on interest income influences both consumption and leisure choices and decisions to save and invest. It also impacts on the real exchange rate.

II.C. Firms

Firms are monopolistic competitors and specialise in production. A typical firm produces output of good i, $Y_t(i)$, under a constant elasticity of substitution (CES) technology by employing household and entrepreneurial labour, $L_t^h(i)$ and $L_t^e(i)$, using capital, $K_{t-1}(i)$, and commodity inputs, $IM_t(j)$. Production inputs are purchased in competitive factor markets. Firms rent the capital from households and entrepreneurs and import the commodity inputs at the beginning of each period. Firm i's production function is given by

$$\begin{aligned} Y_t(i) &= \omega_t(i) Z_t[(\eta_l \left(L_t^h(i)\right)^{\nu} + \eta_k \left(K_{t-1}(i)\right)^{\nu} \\ &+\eta_{im} \left(IM_t(i)\right)^{\nu} + (1-\eta_l-\eta_k-\eta_{im}) \left(L_t^e(i)\right)^{\nu}]^{\frac{1}{\nu}} \end{aligned} \tag{14}$$

where η_l, η_k, $\eta_{im} \in (0,1]$ are parameters, the elasticity of substitution between production inputs is given by $1/(1-\nu)$, $\omega_t(i)$ denotes an idiosyncratic technology shock and Z_t is aggregate productivity.

Each firm sells their output of good, $Y_t(i)$, to domestic households and entrepreneurs 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

[7] With monopolistic competition in the goods market each firm treats the price in domestic currency, $P_t(i)$, of the good i 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 $P_t(i)$, the firm then produces the quantity of output demanded at that price. Firms may not price discriminate and the price of good i sold to foreign consumers (denominated in foreign currency) is given by $P_t(i)/S_t$. The demand functions for good i of the typical household and entrepreneur and the government are given by $C_t^h(i) = (P_t(i)/P_t)^{-\theta} C_t^h$, $C_t^e(i) = (P_t(i)/P_t)^{-\theta} C_t^e$ and $G_t(i) = (P_t(i)/P_t)^{-\theta} G_t$. $C_t^h(i)$, $C_t^e(i)$, $EX_t(i)$ and $G_t(i)$ are the quantity of good i demanded by a typical household and entrepreneur, a typical foreign consumer and the government, C_t^h, C_t^e and G_t denote total consumption by households, entrepreneurs and the government, and θ is the price elasticity of demand faced by each monopolistic competitive firm. Foreign demand for good j is given by $EX_t(j) = (P_t(j)/P_t)^{-\theta} EX_t$, where EX_t denotes total exports.

output, Y_t^*, and given by

$$EX_t = \left(\frac{S_t P_t^*}{P_t}\right)^{\kappa} (Y_t^*)^{\varsigma} \tag{15}$$

where κ, $\varsigma > 0$ are the price and foreign demand elasticities of exports.

In a symmetric equilibrium, all firms charge the same relative price, employ the same labour and use the same capital and commodity inputs. They choose the optimal value of inputs $\{L_t^h,\ L_t^e,\ IM_t,\ K_t\}$ to maximise profits. This leads to the following first-order conditions for the typical firm

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

$$\hat{W}_t^e = \frac{(1-\eta_l-\eta_k-\eta_{im}) \left(\frac{Y_t}{L_t^e}\right)^{1-\nu}}{\Psi_t \frac{\xi_t}{\xi_t - 1}} \tag{17}$$

$$R_t = \frac{\eta_k \left(\frac{Y_t}{K_{t-1}}\right)^{1-\nu}}{\Psi_t \frac{\xi_t}{\xi_t - 1}} \tag{18}$$

and

$$Q_t = \frac{\eta_{im} \left(\frac{Y_t}{IM_t}\right)^{1-\nu}}{\Psi_t \frac{\xi_t}{\xi_t - 1}} \tag{19}$$

where $\hat{W}_t^h$ and $\hat{W}_t^e$ denote the real wage rates for household and entrepreneurial labour. The first-order conditions (16) to (19) show that firms sell their output of goods at a mark-up, $\Psi_t \xi_t / (\xi_t - 1)$, over production costs and factor prices are below their marginal products. The mark-up arises because idiosyncratic technology shocks lead to agency costs and because of imperfect competition in the goods market.[8] The mark-up gives rise to economic profits of $(\xi_t - 1)\, Y_t / \xi_t \Psi_t$, which are paid to entrepreneurs as dividends, Ω_t, at the end of each period.

[8] Under price flexibility the mark-up from monopolistic competition, $\xi_t / (\xi_t - 1)$, is constant and equal to $\theta / (\theta - 1)$, where θ is the price elasticity of demand faced by each monopolistic competitive firm.

II.D. Entrepreneurs

Entrepreneurs are infinitely lived. They own firms and provide internal funds, given by their net worth, to pay for production inputs, $A_t = \hat{W}_t^h L_t^h + \hat{W}_t^e L_t^e + R_t K_{t-1} + Q_t IM_t$. Entrepreneurs also obtain debt financing from households via financial intermediaries. Entrepreneurs' net worth, NW_t, consists of their after-tax wage and dividend incomes, domestic and foreign bond holdings and the value of their capital stock

$$\begin{aligned} NW_t = (1-\tau_L)\,\hat{W}_t^e N_t^e + (1-\tau_\Omega)\,\Omega_t + \frac{(1+(1-\tau_B)I_t)\hat{B}_{t-1}^e}{1+\Pi_t} \\ + \frac{(1+(1-\tau_{B^*})I_t^*)Q_t\hat{B}_{t-1}^{e*}}{1+\Pi_t^*} + ((1-\delta)+(1-\tau_K)\,R_t + \tau_K\delta)\,K_{t-1}^e \end{aligned} \tag{20}$$

N_t^e is entrepreneurs' labour supply and $\hat{B}_{t-1}^e$, $\hat{B}_{t-1}^{e*}$ and K_{t-1}^e denote entrepreneurs' domestic and foreign bond holdings and capital stock in real terms. As in the case of households, capital depreciation is fully deductible. The tax rate paid on dividend income is given by τ_Ω.[9] The assumption of entrepreneurial labour income ensures that entrepreneurs always have a nonzero level of net worth. Entrepreneurs' net worth earns an expected return to internal funds of $f(\varpi_t)\,\Psi_t/(1-g(\varpi_t)\,\Psi_t)$ (see equation 6) and is affected by the tax rates on capital, labour, dividend and interest income.

After production of output commences firms' idiosyncratic technology shock, ω_t, is realised. Entrepreneurs whose firm is subject to an adverse shock become bankrupt and default on their debt contract. Entrepreneurs, who are still solvent after the shock occurs, repay their loans and make their consumption and leisure decisions. The typical entrepreneur's

[9] For simplicity, equities are assumed non-tradeable.

utility function is given by

$$E_t \sum_{k=0}^{\infty} (\zeta\beta)^k \left\{ \ln\left(C^e_{t+k}\right) + \vartheta\left(1 - N^e_{t+k}\right)\right\} \tag{21}$$

where C^e_t is an index of consumption, the entrepreneur's labour supply is given by N^e_t and $(1 - N^e_t)$ is leisure. $\vartheta > 0$ is a parameter and $\zeta \in (0, 1)$ is an additional discount factor. Entrepreneurs are assumed to discount the future more heavily than households to ensure that they use external financing. Agency costs imply that the return to internal funds is greater than the return to external funds and entrepreneurs have an incentive to postpone all consumption and accumulate internal funds to self-finance. With no external financing, agency costs and the finance constraint disappear. The additional discount factor avoids this outcome.

Entrepreneurs, like households, hold demand deposits that earn no interest to purchase consumption and capital goods. The typical entrepreneur's budget constraint in real terms is thus given by

$$\begin{aligned}
&\left(\left(1 - \tau_L\right)\hat{W}^e_t N^e_t + \left(1 - \tau_\Omega\right)\Omega_t + \tfrac{\left(1+\left(1-\tau_B\right)I_t\right)\hat{B}^e_{t-1}}{1+\Pi_t} + \tfrac{\left(1+\left(1-\tau_B\right)\left(1-\tau_*\right)I^*_t\right)Q_t\hat{B}^{e*}_{t-1}}{1+\Pi^*_t}\right.\\
&\left. + \left(\left(1-\delta\right) + \left(1-\tau_K\right)R_t + \tau_K\delta\right)K^e_{t-1}\right)\tfrac{f(\varpi_t)\Psi_t}{1-g(\varpi_t)\Psi_t} - \hat{B}^e_t - Q_t\hat{B}^{e*}_t\\
&- \left(1+\Pi_{t+1}\right)\left(\left(1+\tau_C\right)C^e_{t+1} + K^e_{t+1} - \left(1 - \delta\left(1-\tau_K\right)\right)K^e_t\right) = 0
\end{aligned} \tag{22}$$

Entrepreneurs' optimisation problem consists of choosing $\{C^e_t, K^e_t, \hat{B}^e_t, \hat{B}^{e*}_t\}$ for all $t \in [0, \infty)$ to maximise lifetime utility (equation 21) subject to equation (22). Dividends are paid at the end of each period and do not affect entrepreneurs' optimisation problem. The entrepreneur's

first-order conditions are given by

$$\frac{1-N_t^e}{\vartheta C_t^e} - \frac{(1+\tau_C)(1+(1-\tau_B)I_t)}{(1-\tau_L)\hat{W}_t^e \frac{f(\varpi_t)\Psi_t}{1-g(\varpi_t)\Psi_t}} = 0 \tag{23}$$

and

$$\frac{1}{C_t^e} - E_t \left[\frac{\zeta\beta\left((1-\delta(1-\tau_K)) + \frac{(1-\tau_K)R_{t+1}}{1+(1-\tau_B)I_{t+1}}\right) f(\varpi_{t+1})\Psi_{t+1}}{C_{t+1}^e(1-g(\varpi_{t+1}(i))\Psi_{t+1})} \right] = 0 \tag{24}$$

Moreover, entrepreneurs, like households, are indifferent between holding domestic or foreign bonds. The term $f(\varpi_{t+1})\Psi_{t+1}/(1-g(\varpi_{t+1})\Psi_{t+1})$ in equation (24) is the gross expected return on internal funds and is greater than one. It is this additional return that encourages entrepreneurs to accumulate capital even though they discount the future more than households. To avoid self-financing, in the calibration ζ is set to offset the steady state internal return, i.e. $\zeta f(\bar{\varpi})\bar{\Psi}/\left(1-g(\bar{\varpi})\bar{\Psi}\right) = 1$.[10]

As in the case of households, the tax rate on capital income influences entrepreneurs' intertemporal decisions to save and invest, whereas the labour income and consumption tax rates affect consumption and leisure choices at time t only. Moreover, the tax rate on interest income influences both consumption and leisure choices and decisions to save and invest.

II.E. Government

The government collects tax revenue, TR_t, on households' and entrepreneurs' incomes, $\tau_L(\hat{W}_t^h L_t^h + \hat{W}_t^e L_t^e) + \tau_K(R_t-\delta)K_{t-1}^h + \tau_\Omega\Omega_t + \tau_B I_t(\hat{B}_{t-1}^h + \hat{B}_{t-1}^e)/(1+\Pi_t) + \tau_{B^*} I_t^* Q_t(\hat{B}_{t-1}^{h*} + \hat{B}_{t-1}^{e*})/(1+\Pi_t^*)$, and consumption, $\tau_C(C_t^h + C_t^e)$. The government uses this revenue to purchase an index of consumption goods, G_t, from firms. It also makes interest payments on

[10] Letters with a " $^-$ " indicate steady state levels.

government bonds, $I_t^* Q_t \hat{B}_{t-1}^g / (1 + \Pi_t^*)$. The government is indifferent between borrowing domestically or internationally and, for simplicity, all government bonds are assumed to be held by foreigners.[11] The government's primary fiscal deficit, $\hat{F}_t$, in real terms is thus given by

$$\begin{aligned} &\hat{F}_t + \tau_L \left(\hat{W}_t^h L_t^h + \hat{W}_t^e L_t^e \right) + \tau_K \left(R_t - \delta \right) K_{t-1}^h + \tau_\Omega \Omega_t \\ &+ \frac{\tau_B I_t \left(\hat{B}_{t-1}^h + \hat{B}_{t-1}^e \right)}{1+\Pi_t} + \frac{\tau_B (1-\tau_*) I_t^* Q_t \left(\hat{B}_{t-1}^{h*} + \hat{B}_{t-1}^{e*} \right)}{1+\Pi_t^*} + \tau_C \left(C_t^h + C_t^e \right) \\ &- G_t - \frac{I_t^* Q_t \hat{B}_{t-1}^g}{1+\Pi_t^*} = 0 \end{aligned} \tag{25}$$

and the government's budget constraint is given by

$$\hat{F}_t + \frac{Q_t \hat{B}_{t-1}^g}{1+\Pi_t^*} - Q_t \hat{B}_t^g = 0 \tag{26}$$

II.F. Monetary Authority

The monetary authority has an explicit consumer price inflation target, Π^T. To maintain this target the central bank adjusts the nominal rate of interest paid on domestic bonds. Its reaction function is given by a Taylor rule [Taylor 1993]. It depends on deviations of inflation from target and deviations of output from long-run, full capacity output. The interest reaction is constrained to be linear in the logs of the relevant arguments and given by

$$\ln \left(\frac{1+I_t}{1+\bar{I}} \right) = \mu_1 \ln \left(\frac{1+\Pi_t}{1+\Pi^T} \right) + \mu_2 \ln \left(\frac{Y_t}{\bar{Y}} \right) \tag{27}$$

where $\mu_1,\ \mu_2 > 0$ are parameters and $\bar{I}$ and $\bar{Y}$ denote the steady state interest rate and long-run, full capacity output.

[11] The assumption does not change the conclusions.

II.G. Equilibrium Conditions

There are four domestic markets in the economy: two labour markets, a consumption goods market and a capital goods market. The clearing conditions are given by

$$L_t^h = N_t^h \tag{28}$$

$$L_t^e = N_t^e \tag{29}$$

$$\left(1 - \alpha\Phi\left(\varpi_t\right)\right) Y_t = C_t^h + C_t^e + G_t + EX_t + IN_t \tag{30}$$

and

$$IN_t = K_t - \left(1 - \delta\right) K_{t-1} \tag{31}$$

The current account balance and foreign sector clearing condition are given by

$$CA_t = EX_t - Q_t IM_t \tag{32}$$

and

$$\frac{Q_t(1+(1-\tau_*)I_t^*)\left(B_{t-1}^{h*} - B_{t-1}^{g*}\right)}{1+\Pi_t^*} + EX_t - Q_t IM_t - Q_t\left(B_t^{h*} - B_t^{g*}\right) = 0 \tag{33}$$

Uncovered interest rate parity holds

$$1 + \left(1 - \tau_B\right) I_t = E_t\left[\left(1 + \left(1 - \tau_B\right)\left(1 - \tau_*\right) I_t^*\right) \frac{S_{t+1}}{S_t}\right] \tag{34}$$

and implies that households and entrepreneurs are indifferent between holding domestic or

foreign bonds and the government is indifferent between borrowing domestically or internationally. For simplicity, it is assumed that all households' bond holdings are in foreign securities and entrepreneurs do not hold bonds, i.e. $\hat{B}_t^h = \hat{B}_t^e = \hat{B}_t^{e*} = 0$ for all t.[12]

The real exchange rate is given by $Q_t = S_t P_t^*/P_t$ and evolves according to

$$E_t\left[\frac{Q_{t+1}}{Q_t}\right] = E_t\left[\frac{\frac{S_{t+1}}{S_t}\frac{P_{t+1}^*}{P_t^*}}{\frac{P_{t+1}}{P_t}}\right] \tag{35}$$

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.

III. PARAMETERISATION OF THE MODEL

The model is used to evaluate the effects of taxation. To solve the model requires parameterising it. Parameter values are chosen so that the steady state of the model with finance constrained firms is broadly consistent with New Zealand data and/or assumptions made in the literature. A period in the model is assumed to correspond to one quarter and the following parameters are chosen.

Households' discount rate, β, equals 0.992638 and implies a long-run, steady state real interest rate of 3 percent per annum.[13] The coefficients on leisure in households' and entrepreneurs' utility functions, γ and ϑ, are chosen so that their work efforts account for a third of their time endowment in steady state.

[12] The assumption does not change the overall conclusions. Entrepreneurial bond holdings would increase their net worth and reinforce the results.

[13] The nominal interest rate does not approximately equal the sum of the real interest rate and inflation because of taxation.

Productivity, $\bar{Z}$, is normalised to 1 in steady state. The elasticity of substitution between labour, capital and commodity inputs, $1/(1-\nu)$, is less than unity and set to 0.85 in line with estimates for New Zealand by Hall and Scobie [2005]. The assumptions for the labour, capital and import shares in firms' production function are broadly in line with New Zealand input-output data for 1995-96. The coefficients on capital, η_k, and commodity inputs, η_{im}, are 0.36 and 0.11. The coefficients on household and entrepreneurial labour, η_l and $(1-\eta_l-\eta_k-\eta_{im})$, are assumed to be equal and set to 0.265. A relatively large coefficient on entrepreneurial labour is consistent with a high proportion of working proprietors in New Zealand and a proportionally large share of business capital provided by individuals in control of a business.[14] It is also consistent with a large number of small firms in New Zealand. The capital depreciation rate is set to 8.5 percent per annum, the same as in the Reserve Bank of New Zealand's macroeconomic model [Black, Cassino, Drew, Hansen, Hunt, Rose and Scott 1997], and depreciation is fully tax deductible. Firms' mark-up due to monopolistic competition in the goods market is 20 percent ($\theta/(\theta-1)=1.2$), i.e. $\theta=6$, the same as in McCallum and Nelson [1999].

The assumptions for entrepreneurs' additional discount factor and for financial intermediaries are the same as in Carlstrom and Fuerst [1997]. Entrepreneurs' extra discount factor, ζ, is 0.947. The monitoring cost, α, is set to 0.25. The bankruptcy rate, $\Phi(\bar{\varpi})$, is 0.974 percent per quarter and the standard deviation of the idiosyncratic technology shocks, σ, is 0.207.[15] This leads to a mark-up on output due to imperfect information and risk of 2.38

[14] See http://www.stats.govt.nz/analytical-reports/business-finance-2004.htm.

[15] The standard deviation and entrepreneurs' discount factor imply an annual risk premium of 187 basis points.

percent, i.e. $\bar{\Psi} = 1.0238$.

In steady state, monetary policy affects the economy through the central bank's choice of inflation target and hence steady state inflation rate. The steady state inflation rate is set equal to the Reserve Bank of New Zealand's inflation target rate, Π^T, of 2 percent per annum, which is the mid-point of the 1 to 3 percent target band for consumer price inflation.

The income tax rates for households and entrepreneurs, τ_L, τ_K, τ_Ω and τ_B, are set to 30 percent, broadly in line with the current average tax rate in New Zealand. The consumption tax, τ_C, is 12.5 percent, the same as the goods and services tax (GST) rate. The government's steady state debt to output ratio is given by the current target of the New Zealand government, which is 20 percent.

For simplicity, 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. The foreign tax rate on interest income is set to 2 percent, reflecting that only a proportion of foreign earned income is double taxed. The price and foreign demand elasticities of exports, κ and ς, are equal to unity, as in McCallum and Nelson [2000] and 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].

IV. LONG-RUN EFFECTS OF TAXATION WITH FINANCE CONSTRAINED FIRMS

This section first examines the effects of imperfect information and agency costs by solving the model with and without a finance constraint on firms.[16] It then examines the

[16] The solution for the baseline finance constraint model is contained in the appendix.

impact of taxation. To evaluate the long-run effects of taxation the model with and without finance constrained firms is solved with a lower income tax rate. The income tax rate is reduced from 30 percent to 20 percent and two possible scenarios to finance the tax change are considered: (i) a reduction in government consumption and (ii) a higher consumption tax rate. Table 1 reports the results for the model with finance constrained firms and Table 2 for the model without finance constraints. In both tables column (1) reports the steady state values for the economies with an income tax rate of 30 percent, while columns (2) and (3) are the differences between the 30 percent income tax models and the two alternative tax reduction scenarios.

IV.A. Effects of the Finance Constraint

Column (1) in Table 1 reports the results for the model with finance constrained firms and an income tax rate of 30 percent. The steady state ratios of aggregate (household plus entrepreneurial) consumption, investment, exports and imports to output are 47, 14.1, 11 and 12.9 percent respectively. These ratios are lower than in the Reserve Bank of New Zealand's macroeconomic model, in part, because in this model all imports are intermediate goods whereas in the Reserve Bank's model a proportion of imports is for final demand. The current account at -1.9 percent of steady state output is slightly lower than the current account deficit in the Reserve Bank's model (-2.4 percent). The ratio of government consumption to output is 27.7 and larger than in the Reserve Bank's model because of a higher income tax rate assumption. The government's steady state debt to output ratio is 20 percent, leading to a fiscal deficit of 0.1 percent. The ratio of tax revenue to steady state output is 28 percent and lower than the income tax rate of 30 percent because of the capital depreciation

allowance.

To assess the effects of the finance constraint on firms the steady state model is solved without agency costs and imperfect information. Agency costs and the finance constraint arose because firms' production technology is stochastic and because firms (entrepreneurs) use external financing to pay for production inputs. Agency costs disappear when firms' production process is certain. Without idiosyncratic technology shocks entrepreneurs no longer become bankrupt and default on their debt. Moreover, with a certain production process there are no ex post information asymmetries about the returns to production. Financial intermediaries' monitoring costs become zero. Firms (entrepreneurs) can borrow directly from households and no longer face a finance constraint. In fact, firms obtain all financing from households and no longer require entrepreneurs' internal funds (net worth). As a result, in the model without finance constrained firms, entrepreneurs play no role.[17] Moreover, output no longer sells at a mark-up due to agency costs, i.e. $\bar{\Psi} = 1$.

Column (1) in Table 2 reports the steady state values for the variables in the model without finance constrained firms (and an income tax rate of 30 percent). The results show that without credit market frictions steady state investment, capital and output rise. The increase in output raises households' wage rate. Households' rental income is also higher because of a larger capital stock. The increase in households' income raises aggregate consumption. Moreover, households' savings in the form of foreign bonds increase.[18] Government consumption is also higher due to an increase in tax revenue. Commodity imports, which are an input into production, increase with the rise in output and steady state exports, which

[17] Without entrepreneurs firms' dividend payments are made to households.

[18] The increase is determined residually to ensure that the foreign sector clearing condition holds.

are a fixed proportion of output, are also higher.

IV.B. Effects of Taxation

The effects of a reduction in the income tax rate are discussed next. The model with and without a finance constraint on firms is solved with a lower income tax rate. The income tax rate is reduced from 30 percent to 20 percent and the tax change is financed with (i) a reduction in government consumption and (ii) a higher consumption tax rate.

Columns (2) and (3) in Table 1 show the differences between the 30 percent income tax model and finance constrained firms and the two alternative tax reduction scenarios. A reduction in income tax rates that is financed by lower government consumption (column 2 in Table 1) leads to an increase in capital accumulation, investment, employment and output. Steady state capital and investment are about 5.9 percent higher than in the baseline model, while output rises by about 2.3 percent. Entrepreneurial labour rises by more than household labour (0.8 percent compared to 0.5 percent). This is because of an additional return to working for entrepreneurs. The decline in the income tax rate raises entrepreneurs' after-tax income, which in turn increases their internal funds (net worth) and firms' ability to access external finance to expand production.

The increase in output and employment leads to a rise in the wage rate. But households' wage rate increases by more than that of entrepreneurs. This is because entrepreneurs' higher labour supply to accumulate internal funds and expand production puts downward pressure on their wage rate. The larger rise in households' wage rate raises their labour earnings relative to entrepreneurs' wage earnings and leads to a larger rise in household consumption. Also contributing to higher household consumption is an increase in their

rental and interest incomes. Households' rental and interest incomes are higher, despite a lower rental rate of capital and domestic interest rate (discussed further below), because of increased savings in the form of capital and bonds. The decline in the rental rate of capital leads to a fall in entrepreneurs' capital stock and rental income. But the decline in rental income is more than offset by larger after-tax dividend payments due to increased firm profits. Also contributing to the rise in household and entrepreneurial consumption is the decline in the interest rate, which lowers the opportunity cost of having to hold demand deposits to purchase consumption goods.

The income tax reduction financed by lower government spending leads to a decline in government consumption by about 22.1 percent. The decline in government consumption is slightly larger than the fall in tax revenue (21.9 percent). This is because government debt increases with output to maintain the debt target of 20 percent, raising interest payments on bonds (and the fiscal deficit).

Imports, which are production input, increase with the rise in output, while exports fall, leading to a small deterioration in the current account deficit. Exports, which are a function of foreign demand and the real exchange rate, decline because of a real exchange rate appreciation. The exchange rate appreciates because uncovered interest rate parity is assumed to hold and because the tax rate reduction leads in an increase in the demand for domestic funds and inflow of capital. Demand for domestic funds rises as the lower tax rate raises the after-tax rate of return from holding domestic assets and lowers the pre-tax rate of return investors demand for the use of their funds.

Financing the tax reduction with a higher consumption tax rate (column (3) in Table 1)

has similar effects to the tax change financed by a decline in government consumption. The steady state values are almost identical for most variables except for consumption (aggregate and government consumption) and tax revenue. In the case of an income tax reduction financed by a higher consumption tax rate, government consumption is the same as in the baseline model and the consumption tax rate adjusts to offset the decline in tax revenue. Here, a 10 percentage point reduction in income tax rates requires an increase in the consumption tax rate from 12.5 to around 26.7 percent. The higher consumption tax rate leads to a smaller increase in aggregate (household and entrepreneurial) consumption.

Next, the effects of lower income taxation are examined when firms are no longer finance constrained (columns (2) and (3) in Table 2). A comparison of Tables 1 and 2 shows that finance constraints magnify the distortionary impact of income taxation. Lower income taxation increases the capital stock, investment, employment and output and leads to a larger increase in aggregate consumption when the tax change is financed by a reduction in government spending rather than an increase in the consumption tax rate. But overall the effects are smaller when firms no longer face a finance constraint. When firms are finance constrained, the reduction in income taxation leads to a larger increase in the capital stock, investment, employment, output and consumption. This is because lower income tax rates raise firms' after-tax profits and entrepreneurs' after-tax income, leading to higher net worth and internal funds. Higher entrepreneurial net worth and internal funds in turn increase firms' ability to access finance and expand production and output.

V. SENSITIVITY ANALYSIS

The finding that the effects of income taxation are magnified in the presence of finance constraints is robust to different specifications of the model. This section presents some sensitivity analysis with respect to households' and entrepreneurs' labour supply and utility function, the production function, the tax treatment of capital depreciation and the assumption of monopolistic competition.[19]

V.A. Inelastic Labour Supply

To assess the robustness of the results, households' and entrepreneurs' labour supply is first assumed to be inelastic. When labour supply is inelastic, households and entrepreneurs no longer respond to wage rate movements that may result from tax changes. Fixing their labour supply has two main effects. First, it reduces the economic benefits from income tax reductions. With inelastic labour supply steady state capital, investment and output increase by less. Second, the differences in effects with and without a finance constraint on firms become smaller. This is because the assumption of inelastic labour supply eliminates entrepreneurs' labour supply response and reduces the effect on net worth. Nevertheless the income tax reduction still leads to larger economic benefits when firms are finance constrained as entrepreneurial net worth increases with higher firm profits and dividend payments but the gains are smaller.

V.B. Alternative Utility Function

In the benchmark model, households' and entrepreneurs' utility function implies an in-

[19] The results are not presented but available on request.

tertemporal elasticity of substitution between consumption and leisure of unity. To reduce this elasticity a constant elasticity of substitution (CES) utility function is considered. It is given by

$$E_t \sum_{k=0}^{\infty} \beta^k \left[\left(C_{t+k}^h \right)^{\mu} + \gamma \left(1 - N_{t+k}^h \right)^{\mu} \right]^{\frac{1}{\mu}} \tag{36}$$

for households. The intertemporal elasticity of substitution between consumption and leisure is $1/(1-\mu)$ and set to 0.8. Entrepreneurs' utility function is given accordingly.

The results show that the effects of taxation are smaller with the alternative utility function. This is because, with a lower elasticity of substitution, employment falls (rather than increases) as the income effect of the lower income tax rate offsets the substitution effect.[20] Moreover, with an elasticity of less than unity the income tax reduction financed by a higher consumption tax rate yields larger economic gains compared to the tax reduction financed by lower government consumption. Employment falls by less and capital, investment and output increase by more compared to the tax change financed by lower government consumption. This is because the income effect is partly offset with the rise in the consumption tax rate. The higher consumption tax rate raises the cost of consumption, leading to a smaller rise in consumption, a smaller decline in employment and a larger increase in savings, capital, investment and output. But the overall finding that the economic effects of taxation are magnified in the presence of finance constraints continues to hold with the alternative utility function for households and entrepreneurs.

[20] The income effect arises because taxation lowers after-tax income. As a result, to maintain a given level of consumption, work effort tends to increase with higher tax rates. The substitution effect arises because taxation reduces the return to investing and working.

V.C. Production Function

To examine the effects of the production function the elasticity of substitution between production inputs is increased. In the benchmark model, it is less than unity and set to 0.85. Increasing the elasticity of substitution in production to near unity ($1/(1-\nu) = 1.000001$) approximates a Cobb Douglas production function.[21] With a near unit elasticity of substitution the conclusion that finance constraints augment the effects of taxation continues to hold. The results are also supportive of the hypothesis that capital taxation is more harmful than labour taxation. Compared to the results in section IV capital and investment (and hence output) increase by more, while labour rises by less with a higher degree of substitutability between factors of production. This suggests a larger distortionary effect of taxation on capital accumulation than on labour supply decisions. When firms have more scope to substitute other inputs with capital, the gains from income tax reduction increase.

V.D. Capital Depreciation

To assess the robustness of the results with respect to the capital depreciation assumption, the model (with and without finance constrained firms) is solved with no capital depreciation allowance. In both models, the removal of the depreciation allowance increases the rental rate of capital and lowers steady state capital, investment, consumption and output. The results also show that the depreciation allowance reduces the economic benefits from lower income taxation. With a depreciation allowance capital, investment, consumption and output increase by less than without an allowance. This is because the capital depreciation

[21] The coefficient on imports is also increased to 0.15 to yield a current account deficit in steady state similar to the benchmark case.

allowance declines with the tax rate. But the result that the effects of taxation are magnified in the presence of finance constraints continues to hold.

V.E. Perfect Competition

Finally, the robustness of the results to the assumption of monopolistic competition is assessed by setting firms' mark-up from monopolistic competition to zero. A zero mark-up reduces firms' profits and dividend payments to zero and leads to perfect competition. With perfect competition steady state capital, investment, consumption and output increase in the model with and without finance constrained firms. But the conclusion of important economic effects of taxation continues to hold. A reduction in income tax rates leads to a larger rise in capital, investment, employment, output and consumption when firms are finance constrained. Lower income tax rates increase firms' after-tax profits and internal funds. This raises their ability to access finance and expand production.

VI. CONCLUSION

This paper developed an open economy model to assess the long-run effects of taxation when firms are finance constrained. The model was calibrated for New Zealand. Finance constraints arose because of imperfect information between borrowers and lenders. Only firms could costlessly observe actual returns from production. The analysis showed that finance constraints magnify the effects of taxation. This is because taxation affects firms' after-tax profits and the income of entrepreneurs, who own the firms. A reduction in income taxation would increase internal funds and firms' ability to access finance to expand production. The

results are robust to different specifications of the model. The findings thus underline the importance of incorporating access to finance into models that assess the effects of taxation.

APPENDIX

The system of steady state equations is given by

$$N\bar{W}I\bar{R} - (1+\tau_C)\,\bar{C}^e - \bar{K}^e = 0$$

$$(1-\tau_L)\,\bar{W}^h\left(1-\bar{L}^h\right) - \gamma\,(1+\tau_C)\,\bar{C}^h\left(1+(1-\tau_B)\,\bar{I}\right) = 0$$

$$(1-\tau_L)\,\bar{W}^e\left(1-\bar{L}^e\right)I\bar{R} - \vartheta\,(1+\tau_C)\,\bar{C}^e\left(1+(1-\tau_B)\,\bar{I}\right) = 0$$

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

$$\beta\left(1-\delta\,(1-\tau_K) + \tfrac{(1-\tau_R)\bar{R}}{1+(1-\tau_I)\bar{I}}\right) - 1 = 0$$

$$\tfrac{\bar{Y}}{\bar{\Psi}} - \bar{W}^h\bar{L}^h - \bar{W}^e\bar{L}^e - \bar{Q}I\bar{M} - \bar{R}\bar{K} - \bar{\Omega} = 0$$

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

$$\bar{W}^e - \tfrac{(1-\eta_l-\eta_k-\eta_{im})\left(\frac{\bar{Y}}{L^e}\right)^{1-\nu}}{\bar{\Psi}\frac{\theta}{\theta-1}} = 0$$

$$\bar{Q} - \tfrac{\eta_{im}\left(\frac{\bar{Y}}{I\bar{M}}\right)^{1-\nu}}{\bar{\Psi}\frac{\theta}{\theta-1}} = 0$$

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

$$\bar{Y} - \bar{Z}\left(\left(\eta_l\left(\bar{L}^h\right)^{\nu} + \eta_k\bar{K}^{\nu} + \eta_{im}I\bar{M}^{\nu} + (1-\eta_l-\eta_k-\eta_{im})\left(\bar{L}^e\right)^{\nu}\right)^{\frac{1}{\nu}}\right) = 0$$

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

$$\bar{K}^h+\bar{K}^e-\bar{K}=0$$

$$\left(\left((1-\tau_L)\,\bar{W}^e\bar{L}^e+(1-\tau_\Omega)\,\bar{\Omega}+\left((1-\delta)+(1-\tau_K)\,\bar{R}+\tau_K\delta\right)\bar{K}^e\right)-N\bar{W}=0\right.$$

$$f\left(\bar{\varpi}\right)\bar{Y}-\bar{IR}N\bar{W}=0$$

$$\bar{IN}-\delta\bar{K}=0$$

$$\Phi\left(\bar{\varpi}\right)=0.00974$$

$$\bar{\Psi}=\frac{1}{1-\alpha\Phi(\bar{\varpi})+\frac{\alpha\phi(\bar{\varpi})f(\bar{\varpi})}{f'(\bar{\varpi})}}$$

$$\bar{IR}-\frac{f(\bar{\varpi})\bar{\Psi}}{1-g(\bar{\varpi})\bar{\Psi}}=0$$

$$\bar{C}^h+\bar{C}^e-\bar{C}=0$$

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

$$\left(1-\alpha\Phi\left(\bar{\varpi}\right)\right)\bar{Y}-\bar{C}^h-\bar{C}^e-\bar{G}-\bar{EX}-\bar{IN}=0$$

$$\bar{F}+\tau_L\left(\bar{W}^h\bar{L}^h+\bar{W}^e\bar{L}^e\right)+\tau_K\left(\bar{R}-\delta\right)\bar{K}+\tau_\Omega\bar{\Omega}$$
$$+\frac{\tau_B(1-\tau_*)\bar{I}^*\bar{Q}\bar{B}^{f*}}{1+\bar{\Pi}^*}+\tau_C\left(\bar{C}^h+\bar{C}^l\right)-\bar{G}-\frac{(1-\tau_*)\bar{I}^*\bar{Q}\bar{B}^{g*}}{1+\bar{\Pi}^*}=0$$

$$\bar{F}+\frac{\bar{Q}\bar{B}^{g*}}{1+\bar{\Pi}^*}-\bar{Q}\bar{B}^{g*}=0$$

$$\bar{TR} - \left(\tau_L \left(\bar{W}^h \bar{L}^h + \bar{W}^e \bar{L}^e\right) + \tau_K \left(\bar{R} - \delta\right) \bar{K} + \tau_\Omega \bar{\Omega}\right.$$
$$\left. + \frac{\tau_B (1-\tau_*) \bar{I}^* \bar{Q} \bar{B}^{f*}}{1+\bar{\Pi}^*} + \tau_C \left(\bar{C}^h + \bar{C}^l\right)\right) = 0$$

$$\frac{\bar{B}^{g*}}{\bar{Y}} - 0.2 = 0$$

$$\bar{L}^h = \bar{L}^l = 0.3$$

$$\bar{CA} = \bar{EX} - \bar{Q} I \bar{M}$$

$$1 + (1 - \tau_B) \bar{I} = \left(1 + (1 - \tau_B)(1 - \tau_*) \bar{I}^*\right) \left(1 + \bar{\Delta S}\right)$$

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

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Table 1: Numerical steady state with a finance constraint on firms

		Baseline	Lower government consumption	Higher consumption tax rate
		(1)	(2)	(3)
Income tax rate		30.0 %	20.0 %	20.0 %
Consumption tax rate		12.5 %	12.5 %	26.7 %
K	capital	3.2855	5.9 %	5.9 %
$\bar{K}^e$	entrepreneurial capital	0.0472	−42.3 %	−42.3 %
$N\bar{W}$	entrepreneurial net worth	0.1912	2.3 %	2.3 %
$I\bar{N}$	investment	0.0722	5.9 %	5.9 %
$\bar{C}^h$	household consumption	0.1034	16.4 %	3.3 %
$\bar{C}^e$	entrepreneurial consumption	0.1374	15.9 %	2.9 %
$\bar{C}$	aggregate consumption	0.2409	16.1 %	3.1 %
$\bar{G}$	government consumption	0.1422	−22.1 %	0.0 %
$E\bar{X}$	exports	0.0564	−0.2 %	−0.2 %
$\bar{Y}$	output	0.5129	2.3 %	2.3 %
$\bar{L}^h$	household labour	0.3000	0.5 %	0.5 %
$\bar{L}^e$	entrepreneurial labour	0.3000	0.8 %	0.8 %
$\bar{W}^h$	household wage rate	0.4054	2.1 %	2.1 %
$\bar{W}^e$	entrepreneurial wage rate	0.4054	1.7 %	1.7 %
$I\bar{M}$	imports	0.0659	2.4 %	2.4 %
$\bar{\Psi}$	mark-up	1.0238	0.0 %	0.0 %
$\bar{R}$	rental rate of capital (quarterly)	3.30 %	−0.1 p.p.	−0.1 p.p.
$I\bar{R}$	return to internal funds (quarterly)	5.59 %	0.0 p.p.	0.0 p.p.
$\bar{B}^{f*}$	households' bonds	0.8739	15.0 %	15.0 %
$\bar{I}$	nominal interest rate (quarterly)	1.77 %	−0.2 p.p.	−0.2 p.p.
$\bar{Q}$	real exchange rate	1.0003	−0.2 %	−0.2 %
$\bar{\Omega}$	firms' profits (dividend payments)	0.0835	2.3 %	2.3 %
$\bar{F}$	government deficit	0.0005	2.1 %	2.1 %
$\bar{B}^{g*}$	government debt	0.1026	2.3 %	2.3 %
$T\bar{R}$	tax revenue	0.1435	−21.9 %	0.0 %

Note: Colums (2) and (3) present the differences between the baseline and alternative tax policy models in percent (%) or percentage points (p.p.).

Table 1 continued

		Baseline	Lower government consumption	Higher consumption tax rate
		(1)	(2)	(3)
Income tax rate		30.0 %	20.0 %	20.0 %
Consumption tax rate		12.5 %	12.5 %	26.7 %
$\bar{C}/\bar{Y}$	consumption to output	47.0 %	6.4 p.p.	0.4 p.p.
$\bar{G}/\bar{Y}$	government consumption to output	27.7 %	−6.6 p.p.	−0.6 p.p.
$\bar{IN}/\bar{Y}$	investment to output	14.1 %	0.5 p.p.	0.5 p.p.
$\bar{EX}/\bar{Y}$	exports to output	11.0 %	−0.3 p.p.	−0.3 p.p.
$\bar{IM}/\bar{Y}$	imports to output	12.9 %	0.0 p.p.	0.0 p.p.
$\bar{CA}/\bar{Y}$	current account to output	−1.9 %	−0.3 p.p.	−0.3 p.p.
$\bar{F}/\bar{Y}$	government deficit to output	0.1 %	0.0 p.p.	0.0 p.p.
$\bar{B}^{g*}/\bar{Y}$	government debt to output	20.0 %	0.0 p.p.	0.0 p.p.
$\bar{TR}/\bar{Y}$	tax revenue to output	28.0 %	−6.6 p.p.	−0.6 p.p.

Note: Columns (2) and (3) present the differences between the baseline and alternative tax policy models in percent (%) or percentage points (p.p.).

Table 2: Numerical steady state without a finance constraint on firms

		Baseline	Lower government consumption	Higher consumption tax rate
		(1)	(2)	(3)
Income tax rate		30.0 %	20.0 %	20.0 %
Consumption tax rate		12.5 %	12.5 %	27.6 %
$\bar{K}$	capital	3.4001	5.6 %	5.6 %
$I\bar{N}$	investment	0.0747	5.6 %	5.6 %
$\bar{C}^h$	household consumption	0.2412	16.3 %	2.5 %
$\bar{G}$	government consumption	0.1472	−22.6 %	0.0 %
$E\bar{X}$	exports	0.0572	−0.2 %	−0.2 %
$\bar{Y}$	output	0.5203	1.9 %	1.9 %
$\bar{L}^h$	household labour	0.3000	0.3 %	0.3 %
$\bar{W}^h$	household wage rate	0.8442	1.9 %	1.9 %
$I\bar{M}$	imports	0.0682	2.1 %	2.1 %
$\bar{R}$	rental rate of capital (quarterly)	3.30 %	−0.1 p.p.	−0.1 p.p.
$\bar{B}^{f*}$	households' bonds	0.9959	11.8 %	11.8 %
$\bar{I}$	nominal interest rate (quarterly)	1.77 %	−0.2 p.p.	−0.2 p.p.
$\bar{Q}$	real exchange rate	1.0003	−0.2 %	−0.2 %
$\bar{\Omega}$	firms' profits (dividend payments)	0.0867	1.9 %	1.9 %
$\bar{F}$	government deficit	0.0005	1.8 %	1.8 %
$\bar{B}^{g*}$	government debt	0.1041	1.9 %	1.9 %
$T\bar{R}$	tax revenue	0.1485	−22.4 %	0.0 %

Note: Colums (2) and (3) present the differences between the baseline and alternative tax policy models in percent (%) or percentage points (p.p.).

Table 2 continued

		Baseline	Lower government consumption	Higher consumption tax rate
		(1)	(2)	(3)
Income tax rate		30.0 %	20.0 %	20.0 %
Consumption tax rate		12.5 %	12.5 %	27.6 %
$\bar{C}/\bar{Y}$	consumption to output	46.3 %	6.5 p.p.	0.3 p.p.
$\bar{G}/\bar{Y}$	government consumption to output	28.3 %	−6.8 p.p.	−0.5 p.p.
$I\bar{N}/\bar{Y}$	investment to output	14.4 %	0.5 p.p.	0.5 p.p.
$E\bar{X}/\bar{Y}$	exports to output	11.0 %	−0.2 p.p.	−0.2 p.p.
$I\bar{M}/\bar{Y}$	imports to output	13.1 %	0.0 p.p.	0.0 p.p.
$\bar{CA}/\bar{Y}$	current account to output	−2.1 %	−0.2 p.p.	−0.2 p.p.
$\bar{F}/\bar{Y}$	government deficit to output	0.1 %	0.0 p.p.	0.0 p.p.
$\bar{B}^{g*}/\bar{Y}$	government debt to output	20.0 %	0.0 p.p.	0.0 p.p.
$T\bar{R}/\bar{Y}$	tax revenue to output	28.5 %	−6.8 p.p.	−0.5 p.p.

Note: Columns (2) and (3) present the differences between the baseline and alternative tax policy models in percent (%) or percentage points (p.p.).