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11. Appendix A

A.1. Baseline Model: Indivisible Labor Supply Framework

In the Appendix, we derive the first order conditions of the baseline model presented in Section 3.

The representative household problem is:

$$\max \sum_{t=0}^{\infty} \beta^t U(c_t, l_t) \tag{A.1}$$

subject to

$$c_t + i_t = w_t l_t + r_t u_t k_t + T_t, \tag{A.2}$$

and

$$k_{t+1} = (1 - \delta(u_t))k_t + \left[\frac{\eta_1 \left(\frac{i_t}{k_t}\right)^{1-\nu}}{1-\nu} + \eta_2\right] k_t, \tag{A.3}$$

where T_t are lump-sum taxes. Utility is given by $U(c_t, l_t) = \log(c_t) - \theta l_t$ and $\delta(u_t) = \delta \exp\{\omega(u_t - 1)\}$.

First order conditions are (λ_t and μ_t are the Lagrange multipliers on restrictions A.2 and A.3, respectively):

$$[c_t]: {}^{1}/_{c_t} = \lambda_t, \tag{A.4}$$

$$[l_t]: \theta = \lambda_t w_t, \tag{A.5}$$

$$[k_{t+1}]: \beta \left\{\lambda_{t+1} r_{t+1} u_{t+1} + \mu_{t+1}\left[(1 - \delta(u_{t+1})) + \eta_1 \left(\frac{i_{t+1}}{k_{t+1}}\right)^{1-\nu} \left(\frac{\nu}{1-\nu}\right) + \eta_2\right]\right\} = \mu_t, \tag{A.6}$$

$$[i_t]: \lambda_t = \mu_t \eta_1 \left(\frac{i_t}{k_t}\right)^{-\nu}, \tag{A.7}$$

$$[u_t]: \lambda_t r_t = \delta'(u_t)\mu_t, \text{ where } \delta'(u_t) = \delta\omega \exp\{\omega(u_t - 1)\}, \tag{A.8}$$

together with restrictions A.2 and A.3.

Rearranging equations, we get:

(i) The marginal rate of substitution between consumption and labor:

$$\theta c_t = w_t, \tag{A.9}$$

(ii) The Euler equation for investment:

$$\beta\left\{(1/c_{t+1})r_{t+1}u_{t+1} + \mu_{t+1}\left[(1-\delta(u_t)) + \eta_1(i_{t+1}/k_{t+1})^{1-\nu}\left(\frac{\nu}{1-\nu}\right) + \eta_2\right]\right\} = \mu_t, \tag{A.10}$$

(iii) $$1/c_t = \mu_t\eta_1\left(\frac{i_t}{k_t}\right)^{-\nu}, \tag{A.11}$$

(iv) $$\eta_1(i_t/k_t)^{-\nu}r_t = \delta\omega\exp\{\omega(u_t-1)\}, \tag{A.12}$$

where μ_t is the marginal value (shadow price) of a new unit of capital in period t, and

$$r_t = \alpha(u_t k_t)^{\alpha-1}l_t^{1-\alpha}(K_t^G)^{\alpha^G}, \tag{A.13}$$

$$w_t = (1-\alpha)(u_t k_t)^{\alpha}l_t^{-\alpha}(K_t^G)^{\alpha^G}, \tag{A.14}$$

are set by the firm's optimality conditions.

Turning to fiscal policy and the time-to-build process, we have equations concerning to outside transfers (A_t), local government consumption and investment (I_t^G and C_t^G, respectively), public capital stock (K_t^G) and lump-sum taxes (T_t):

$$A_t = (1-\rho_A)A + \rho_A A_{t-1} + \epsilon_A, \tag{A.15}$$

$$I_t^G = \sum_{n=0}^{N-1}\phi_n A_{t-n}, \tag{A.16}$$

$$C_t^G = \tilde{C}^G + \gamma I_t^G, \tag{A.17}$$

$$K_t^G = (1-\delta_G)K_{t-1}^G + I_{t-M}^G, \tag{A.18}$$

$$T_t = C_t^G + I_t^G, \tag{A.19}$$

where $\tilde{C}^G \equiv C^G - \gamma I^G$, and variables without the *t*-subscripts refer to steady state levels.

Finally, the model is closed with the goods market clearing condition:

$$y_t = c_t + i_t + C^G + I^G + (\pi + \gamma)(I_t^G - I^G), \tag{A.20}$$

where $y_t = (u_t k_t)^{\alpha} {l_t}^{1-\alpha} (K_t^G)^{\alpha^G}$.

A.2. Divisible Labor Supply Framework

A.2.1. Preferences Allowed for Wealth Effects on Labor Supply

In this case, we suppose a utility function of the form:

$$U(c_t, p_t) = \log(c_t) - \varphi \frac{l_t^{\xi}}{\xi}. \tag{A.21}$$

The fully divisible labor supply framework has the same equations derived previously, except to the marginal rate of substitution between consumption and labor:

$$\varphi c_t l_t^{\xi - 1} = w_t. \tag{A.22}$$

A.2.2. GHH Preferences

Now, we assume a utility function of the form:

$$U(c_t, l_t) = \log\left(c_t - \varphi \frac{l_t^{\xi}}{\xi}\right). \tag{A.23}$$

In the case of GHH preferences, we also have the same equations of the baseline model, except to the marginal rate of substitution between consumption and labor as well as the marginal utility of consumption:

$$\varphi l_t^{\xi - 1} = w_t, \tag{A.24}$$

$$\frac{1}{\left(c_t - \varphi \frac{l_t^{\xi}}{\xi}\right)} = \lambda_t. \quad \text{(A. 25)}$$

As can be seen, if $\xi = 1$, wages are thoroughly constant.

A.3. Parameters Set by Steady State Conditions

Note that ω, η_1 and η_2 are not free parameters in the model. In fact, applying steady state conditions – namely, $\delta(1) = \delta$ ($u = 1$), $\partial k_{t+1}/\partial i_t = 1$ and $\lambda = \mu$ –, we have:

$$\frac{\partial k_{t+1}}{\partial i_t} = \eta_1 \left(\frac{i_t}{k_t}\right)^{-\nu} = \eta_1 \delta^{-\nu} = 1 \Leftrightarrow \eta_1 = \delta^{\nu}, \quad \text{(A. 26)}$$

$$\frac{\eta_1 \left(\frac{i_t}{k_t}\right)^{1-\nu}}{1-\nu} + \eta_2 = \frac{\eta_1 \delta^{1-\nu}}{1-\nu} + \eta_2 = 0 \Leftrightarrow \eta_2 = -\frac{\delta \nu}{1-\nu}. \quad \text{(A. 27)}$$

In addition:

$$\beta[r + (1-\delta)] = 1 \Leftrightarrow r = \frac{1}{\beta} + \delta - 1.$$

Thus:

$$\lambda r = \mu \delta \omega \Leftrightarrow \omega = \left(\frac{1}{\beta} + \delta - 1\right)\left(\frac{1}{\delta}\right). \quad \text{(A. 28)}$$

12. Appendix B

B.1. The Growth Acceleration Program (GAP)

In January of 2007, the federal government launched the Growth Acceleration Program (GAP) – *Programa de Aceleração do Crescimento* –, implementing a variety of stimulus measures and institutional reforms to boost the GDP growth rate. Basically, the GAP attempted to revive the role of government as a planner of the economic development, eliminating infrastructure constraints. The first program phase lasted four years, from 2007 up to 2010, and, in 2011, the Brazilian government launched the GAP 2 with similar purposes. Briefly, we list three broad sets of implemented measures between 2007 and 2010.

Firstly, the government attempted to implement tax reliefs in investments in machinery and equipment, housing and infrastructure. An outstanding measure was the PEC 233/2008, a constitutional amendment that intends to unify some federal taxes on consumption in a single tax (IVA-F), as well as to simplify the laws on the ICMS (the ICMS is a sort of consumption tax). Other measures proposed in the PEC 233/2008 are the exemptions from payroll and essential good taxes. However, the bill is waiting to be enacted. Secondly, the government tried to boost mortgage loans, especially for the program My House, My Life (*Minha Casa, Minha Vida*), and to finance working capital for logistics infrastructure projects. In fact, concerning the funding for private firms, the highlight was the capital injections into BNDES (National Bank for the Economic Development) – *Banco Nacional de Desenvolvimento Econômico* – by the federal government (more than R$ 100 billion in 2010) to this end. Other measures include the development of the Fund for Infrastructure Investment (*Fundo de Investimento em Infraestrutura*), financed by payroll contributions (FGTS), and the increase in the credit limit to the public sector for investments in sanitation and housing.

Finally, the third and more important measure implemented by the GAP, which made headlines, was the increase in large infrastructure investments, especially those related to energy and transports. From the R$ 402.1 billion obligated(this total amount does not include R$216.9 billion earmarked for household funding) between 2007-2010, R$ 274.1 billion correspond to

investments in infrastructure undertaken by the government and state-owned enterprises. We can highlight three large-scale projects initiated in the first phase of the GAP: the building of the *Transnordestina* Railroad, North-South Railroad and the Transfer of the São Francisco River. The first two projects had been initiated in previous governments, but had never been concluded. Hence, the federal government decided to undertake them again, improving the original projects within the GAP. Although the mentioned projects are quite ambitious, all of them have suffered serious implementation delays. In fact, the government intended to conclude the *Transnordestina* Railroad (1,728 km) in the end of 2010, but, in this same year, the inauguration was already postponed to 2012. On the other hand, up to May of 2012, only 36% of the transfer had been concluded. These examples give an idea of the large time-to-build process involved in public investment in Brazil.

B.2. First Order Conditions for the Baseline Model

The representative agent maximizes:

$$\sum_{t=0}^{\infty} \beta^t U(c_t, g_t^c, l_t), \tag{B.1}$$

subject to the constraint

$$(1+\tau_t^c)c_t + k_{t+1} + b_{t+1} \leq \left(1-\tau_t^h\right)w_t h_t + \left[\left(1-\tau_t^k\right)r_t^k + 1 - \delta\right]k_t + (1+r_t)b_t, \tag{B.2}$$

Given the first order conditions, labor supply is such that:

$$\left(\frac{1-\chi}{\chi}\right)\left[\frac{(c_t + \theta g_t^c)}{1-h_t}\right] = \frac{w_t(1-\tau_t^h)}{1+\tau_t^c}, \tag{B.3}$$

and we obtain the Euler equation given by

$$(1+\tau_t^c)^{-1}U_c(c_t, g_t^c, l_t)$$
$$= \beta(1+\tau_{t+1}^c)^{-1}U_c(c_{t+1}, g_{t+1}^c, l_{t+1})\left[\left(1-\tau_t^k\right)r_{t+1}^k + 1 - \delta\right], \quad \text{(B. 4)}$$
$$(1+\tau_t^c)^{-1}U_c(c_t, g_t^c, l_t)$$
$$= \beta(1+\tau_{t+1}^c)^{-1}U_c(c_{t+1}, g_{t+1}^c, l_{t+1})(1+r_{t+1}). \quad \text{(B. 5)}$$

B.3. PUblic Investment to GDP Ratios: Data and Model Predictions

Table B1: Quarterly public investment to GDP ratios (Ig/Y) – model and data

	Model N=8 (2 years)	**Data Ig/Y quarterly**	**Ratio model and data**
2007/Q1	0.018	0.018	0.99
2007/Q2	0.018	0.018	1.00
2007/Q3	0.019	0.017	1.11
2007/Q4	0.020	0.017	1.19
2008/Q1	0.021	0.019	1.10
2008/Q2	0.023	0.021	1.09
2008/Q3	0.024	0.023	1.01
2008/Q4	0.025	0.025	0.99
2009/Q1	0.026	0.021	1.26
2009/Q2	0.026	0.023	1.14
2009/Q3	0.026	0.023	1.11
2009/Q4	0.026	0.024	1.07
2010/Q1	0.026	0.025	1.03
2010/Q2	0.026	0.028	0.91
2010/Q3	0.026	0.029	0.89
2010/Q4	0.026	0.027	0.97

The public investment data is deseasonalized. Source: IPEA.

Table B2: Annual public investment to GDP ratios (Ig/Y) – model and data

	Model N=8 (2 years)	**Data Ig/Y annual**	**Ratio model and data**
2007	0.019	0.018	1.05
2008	0.023	0.022	1.03
2009	0.026	0.023	1.11
2010	0.026	0.028	0.93

Source: IPEA.

Table B3: Quarterly public investment to GDP ratios (Ig/Y) – model and data

	Model N=16 (4 years)	Data Ig/Y quarterly	Ratio model and data
2007/Q1	0.018	0.018	0.99
2007/Q2	0.018	0.018	1.00
2007/Q3	0.019	0.017	1.07
2007/Q4	0.019	0.017	1.12
2008/Q1	0.020	0.019	1.01
2008/Q2	0.020	0.021	0.97
2008/Q3	0.021	0.023	0.88
2008/Q4	0.021	0.025	0.85
2009/Q1	0.022	0.021	1.05
2009/Q2	0.022	0.023	0.97
2009/Q3	0.023	0.023	0.97
2009/Q4	0.023	0.024	0.96
2010/Q1	0.024	0.025	0.95
2010/Q2	0.024	0.028	0.86
2010/Q3	0.025	0.029	0.86
2010/Q4	0.026	0.027	0.95

The public investment data is deseasonalized. Source: IPEA.

Table B4: Annual public investment to GDP ratios (Ig/Y) – model and data

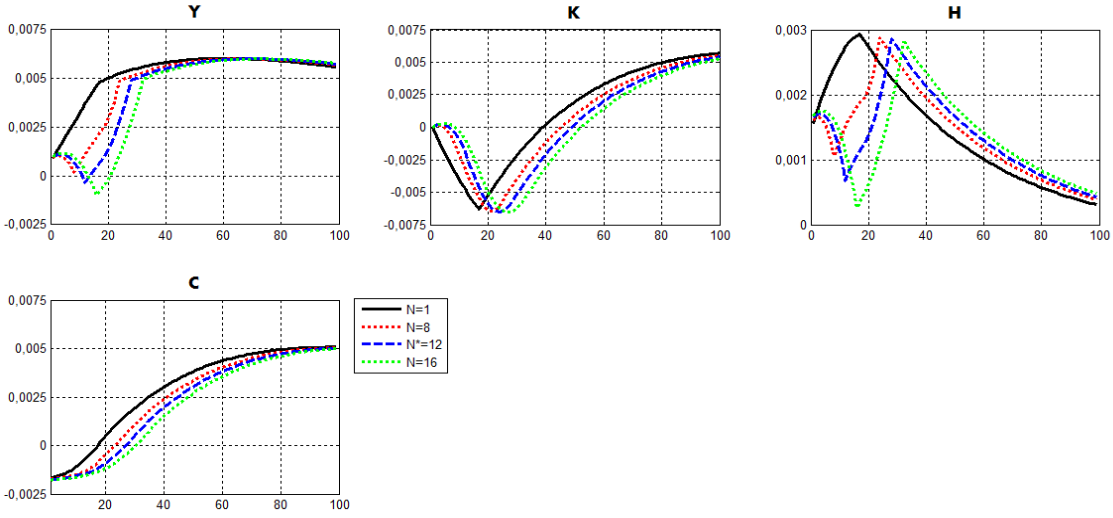
	Model N=16 (4 years)	Data Ig/Y annual	Ratio model and data
2007	0.018	0.018	1.03
2008	0.020	0.022	0.91
2009	0.023	0.023	0.96
2010	0.025	0.028	0.89

Source: IPEA.

B.4. The Short Run Impact of the Time-to-Build Process

B.4.1. Model with Lump-Sum Taxes

Figure B1 – Responses for the public investment shock: Lump-sum taxes



B.4.2. Baseline Model: Alternative Calibration ($\theta = 0$)

Figure B2 – Responses for the public investment shock: Consumption taxes (τ^c)

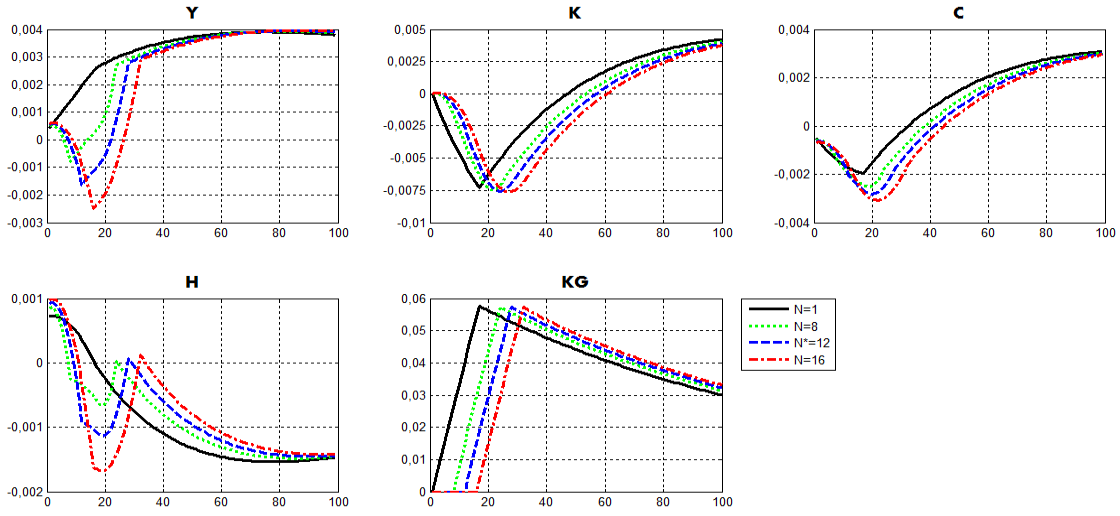


Figure B3 – Responses for the public investment shock: Labor taxes (τ^h)

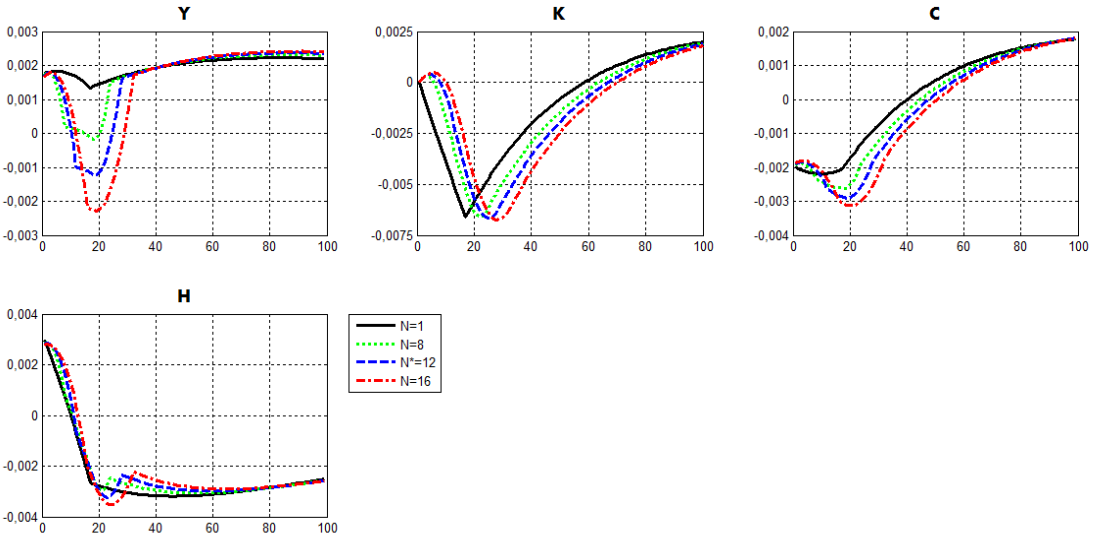
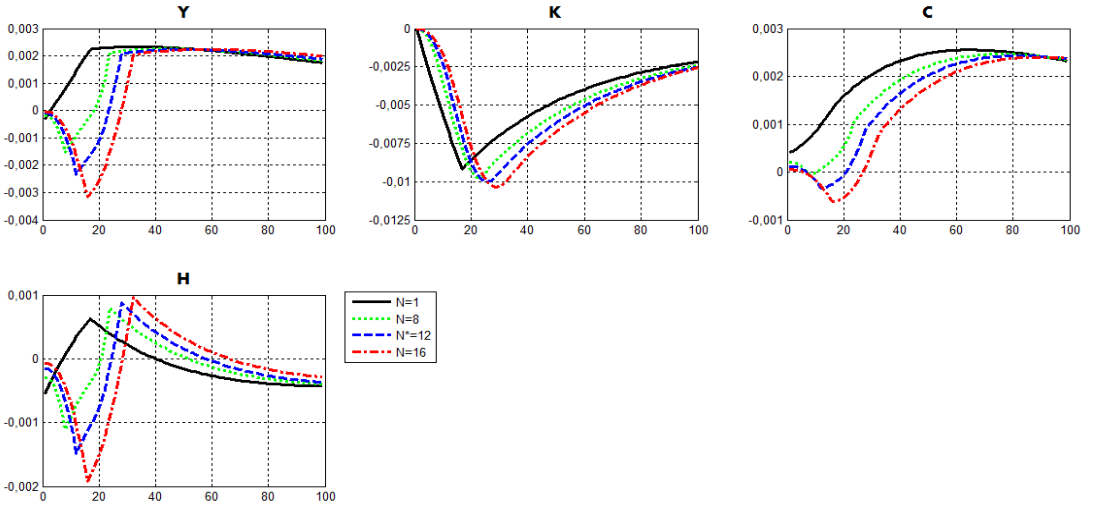


Figure B4 – Responses for the public investment shock: Capital taxes (τ^k)



A.4.3. Baseline Model: Alternative Calibration ($\theta = 1$)

Figure B5 – Responses for the public investment shock: Consumption taxes (τ^c)

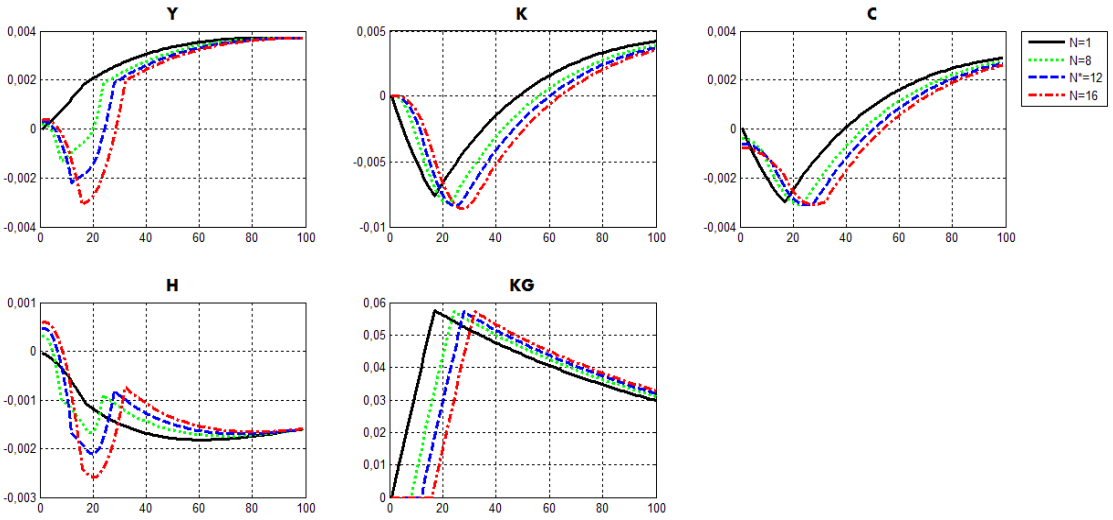


Figure B6 – Responses for the public investment shock: Labor taxes (τ^h)

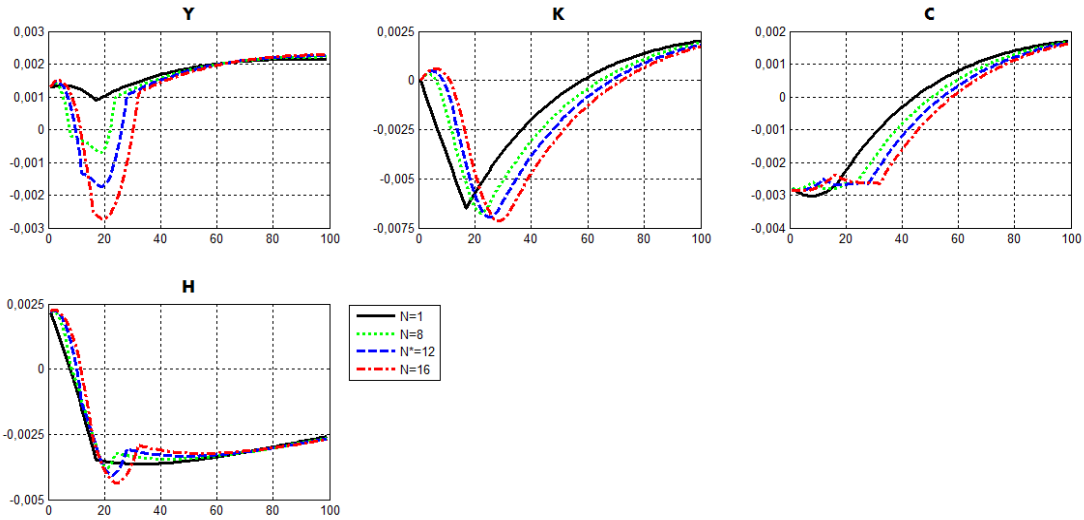
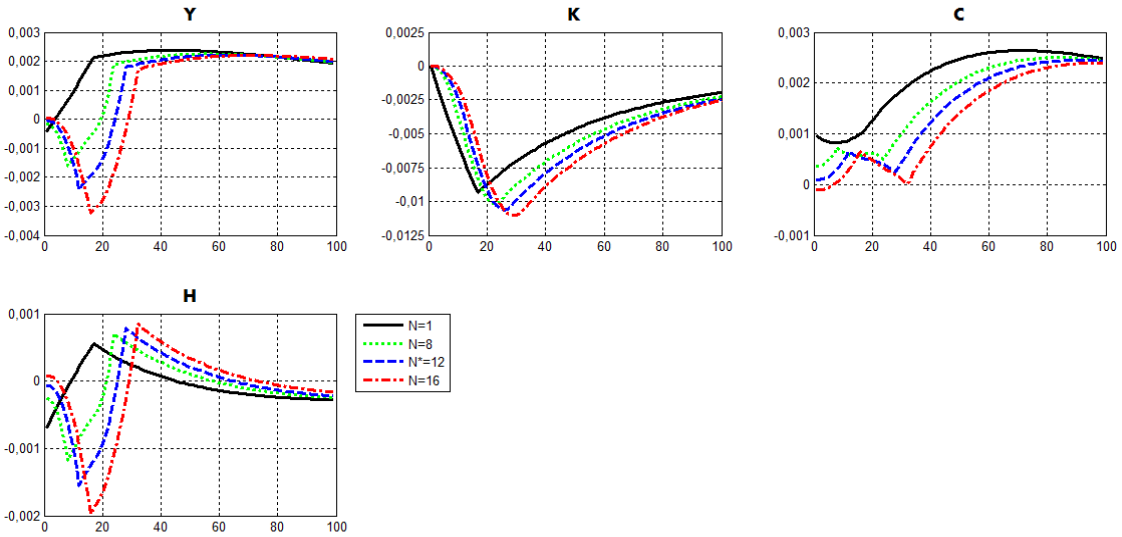


Figure B7 – Responses for the public investment shock: Capital taxes (τ^k)



B.5. The Impact of Tight and Loose Fiscal Adjtments

B.5.1. Lags of Three Years: Alternative Calibration ($\theta = 0$)

Figure B8 – Responses for the public investment shock: Consumption taxes (τ^c)

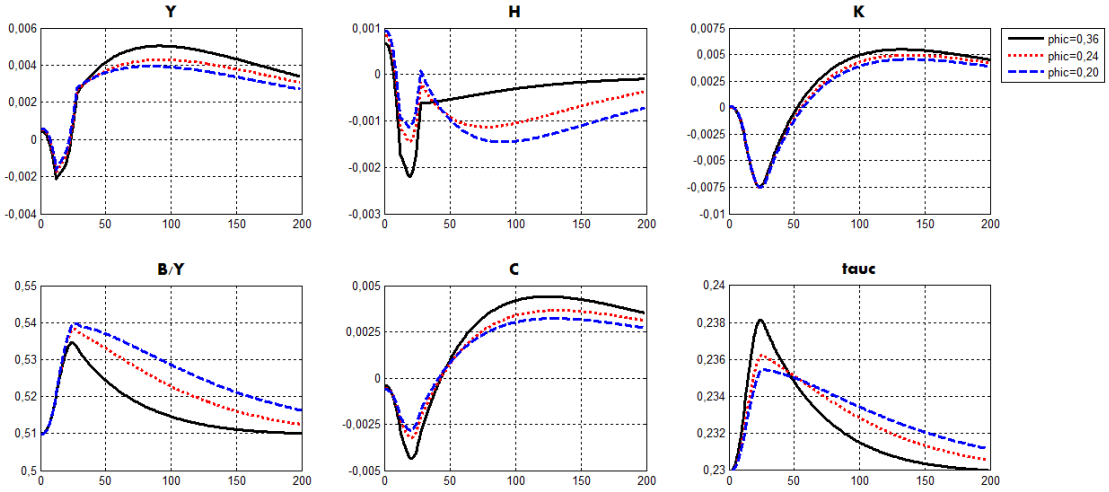


Figure B9 – Responses for the public investment shock: Labor taxes (τ^h)

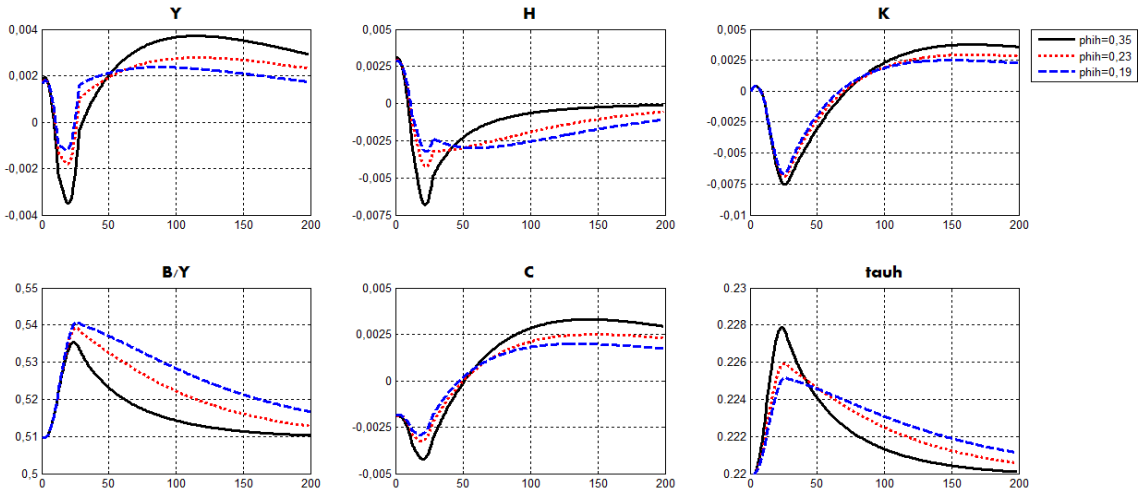
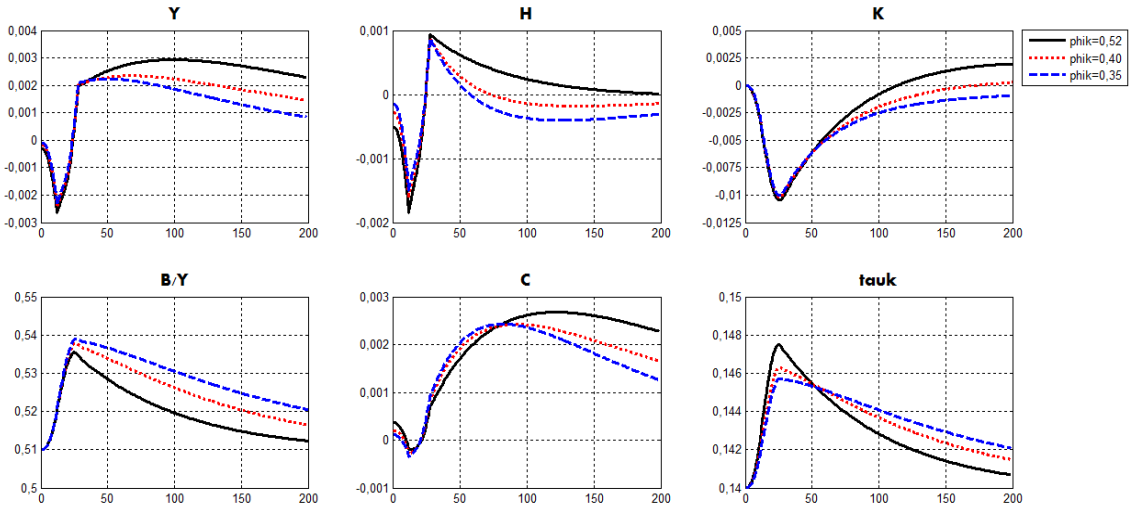


Figure B10 – Responses for the public investment shock: Capital taxes (τ^k)



B.5.2. Lags of Three Years: Alternative Calibration ($\theta = 1$)

Figure B11 – Responses for the public investment shock: Consumption taxes (τ^c)

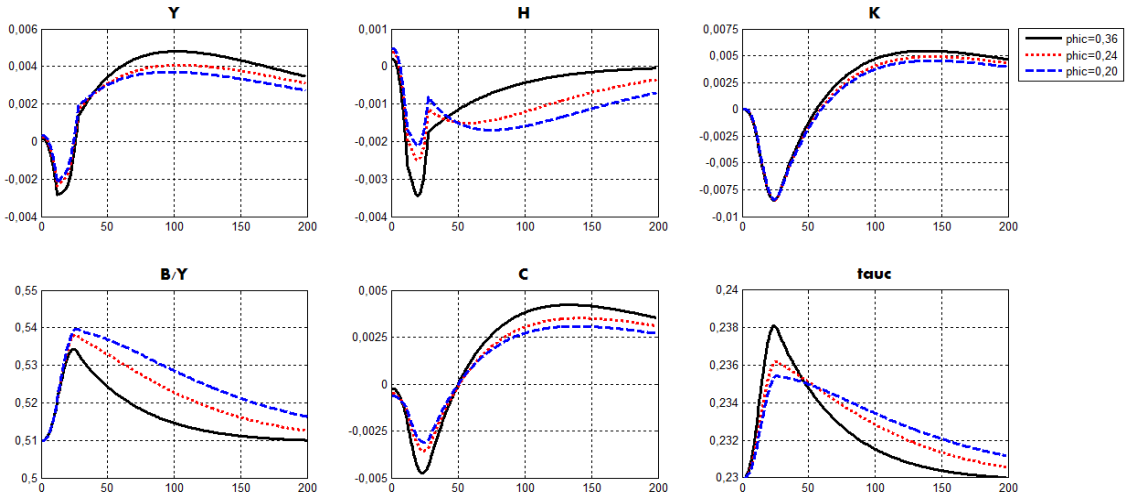


Figure B12 – Responses for the public investment shock: Labor taxes τ^h

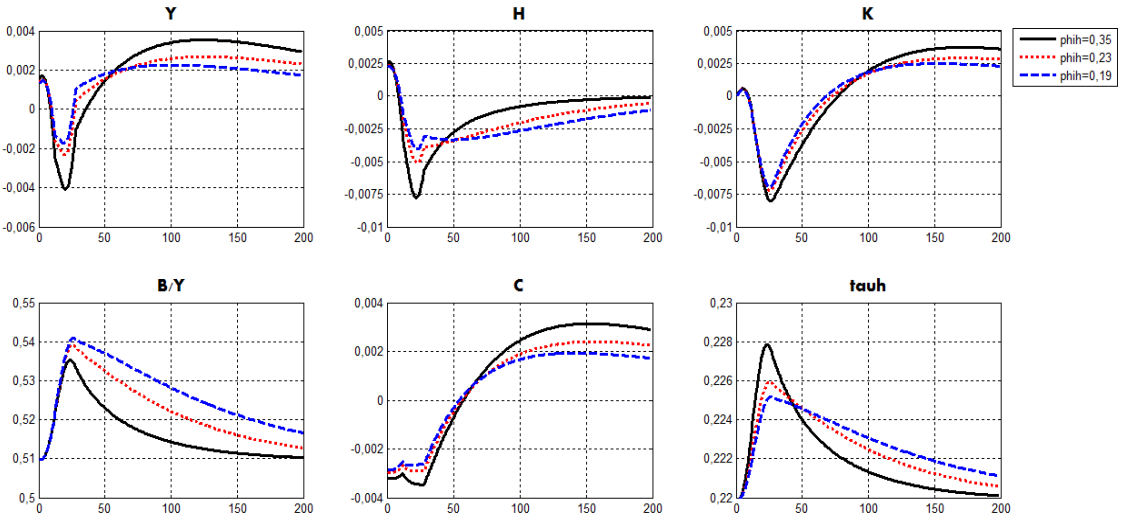


Figure B10 – Responses for the public investment shock: Capital taxes τ^k