National Accounting Review

NAR, 6(1): 95–115.
DOI: 10.3934/NAR.2024005
Received: 17 October 2023
Revised: 25 January 2024
Accepted: 31 January 2024
Published: 06 March 2024

https://www.aimspress.com/journal/NAR

Research article

Public investment as a growth driver for a commodity-exporting economy: Sizing up the fiscal-monetary involvement

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JEL Codes: H54, H12, E61, C31

Appendix

Appendix A. Expanded supplementary stuff.

Equation	Definition
$\frac{\left(C_t^R - hC_{t-1}^R + \phi C_t^G\right)\left(C_{t+1}^R - hC_t^R + \phi C_{t+1}^g\right)}{\left(C_{t+1}^R - hC_t^R + \phi C_{t+1}^g\right) - E_t \beta h\left(C_t^R - hC_{t-1}^R + \phi C_t^G\right)} = \frac{W_t}{\chi_L L_t^{R\varphi} P_t}$	Ricardian Euler equation
$\chi_L L_t^{R\varphi} = \left(\frac{i_t + 1}{i_t}\right)\frac{\chi_M W_t}{M_t}$	Ricardian labor supply
$C_t^{NR} + \phi C_t^g = \frac{W_t}{\chi_L L_t^{NR\varphi} P_t}$	Non-Ricardian labor supply
$i_t + 1 = E_t \pi_{t+1}\left(r_{t+1} - \delta + 1\right)$	Investment-capital trade-off

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Equation	Definition
$\frac{1+i_t}{1+i_t^*}=\frac{s_{t+1}}{s_t}$	Uncovered interest parity
$w^{\circ}_{j,t}=\chi_L\left(\frac{\omega^w}{\omega^w-1}\right)E_t\sum_{i=0}^{\infty}\left[\left(\beta\theta^w\right)^i\left(\frac{\left(C^R_{j,t+i}-hC^R_{j,t-1+i}+\phi C^g_{j,t+i}\right)\left(C^R_{j,t+1+i}-hC^R_{j,t+i}+\phi C^g_{j,t+1+i}\right)}{C^R_{j,t+1+i}-hC^R_{j,t+i}+\phi C^g_{j,t+1+i}-\beta h\left(C^R_{j,t+i}-hC^R_{j,t-1+i}+\phi C^g_{j,t+i}\right)}\right)L^{R\ \varphi}_{j,t+i}P_{t+i}\right]$	Ricardian optimal wage level
$w^{\circ}_{j,t}=\chi_L\left(\frac{\omega^w}{\omega^w-1}\right)E_t\sum_{i=0}^{\infty}\left[\left(\beta\theta^w\right)^i\left(C^{NR}_{j,t+i}+\phi C^G_{j,t+i}\right)L^{NR^{\varphi}}_{j,t+i}P_{t+i}\right]$	Non-Ricardian optimal wage level
$W_t=\left[\theta^w W_{t-1}^{\ 1-\omega^W}+\left(1-\theta^w\right)W_t^{\circ 1-\omega^W}\right]^{\frac{1}{1-\omega^W}}$	Aggregate wage
Commodity goods sector	
$MC_t^z=\frac{1}{K_{t-1}^{g\ \alpha_g^z}}\left(\frac{W_t/P_t^z}{1-\alpha_k^z}\right)^{1-\alpha_k^z}\left(\frac{r_t}{\alpha_k^z}\right)^{\alpha_k^z}$	Marginal cost
$P_t^{z^{\circ}}=\left(\frac{\omega^z}{\omega^z-1}\right)E_t\sum_{n=0}^{\infty}\left(\beta\theta^z\right)^n MC_{t+n}^z$	Optimal price level
$P_t^z=\left[\theta^z P_{t-1}^{z\ \ 1-\omega^Z}+\left(1-\theta^z\right)P_t^{z^{\circ}1-\omega^Z}\right]^{\frac{1}{1-\omega^Z}}$	Aggregate price level
Final goods sector	
$MC_t^f=\frac{1}{K_{t-1}^{g\ \alpha_g^f}}\left(\frac{W_t/P_t^f}{1-\alpha_k^f-\alpha_z^f}\right)^{1-\alpha_k^f-\alpha_z^f}\left(\frac{r_t}{\alpha_k^f}\right)^{\alpha_k^f}$	Marginal cost
$P_t^{f^{\circ}}=\left(\frac{\omega^f}{\omega^f-1}\right)E_t\sum_{n=0}^{\infty}\left(\beta\theta^f\right)^n MC_{t+n}^f$	Optimal price level
$P_t^f=\left[\theta^f P_{t-1}^{f\ \ 1-\omega^f}+\left(1-\theta^f\right)P_t^{f^{\circ}1-\omega^f}\right]^{\frac{1}{1-\omega^f}}$	Aggregate price level

Source: Obtained using some mathematics about micro-conceptions in detail.

Appendix B. Baseline calibration.

Parameter	Description	Value	Source
β	Subjective discount factor	0.9828	annualized real interest rate is 7%
h	Degree of private consumer's habit formation	0.7	Medina and Soto (2016)
ϕ	Elasticity of substitution between private and government consumption	0.3	normal value
χ_M	Steady-state utility of real money holdings	0.4	normal value
χ_L	Steady-state disutility of labor supply	0.3	normal value
φ	Inverse of the Frisch elasticity of labor supply	2	normal value
δ	Depreciation rate	0.025	normal value
α_k^z	Capital income share in commodity goods production	0.28	Kitano and Takaku (2021)
α_k^f	Capital income share in final goods production	1/3	Kitano and Takaku (2021)
α_z^f	Commodity inputs share in final goods production	0.05	Kitano and Takaku (2021)
α_g^z	Output elasticity of productive government spending in commodity goods production	0.15	Melina et al. (2016)
α_g^f	Output elasticity of productive government spending in final goods production	0.16	Melina et al. (2016)
ε^0	Marginal efficiency of public investment	0.5	Agenor (2016), Melina et al. (2016)
ε^1	Exceeding adjustment costs of public investment	0.1	Agenor (2016)
ω^w	Elasticity of substitution between differentiated labors	20	normal value
ω^z	Elasticity of substitution between wholesale commodity goods	6	normal value
ω^f	Elasticity of substitution between wholesale final goods	6	normal value
ς^{z*}	Price elasticity of foreign demand for commodity goods	8	normal value
ς^{f*}	Price elasticity of foreign demand for final goods	8	normal value
θ^w	Degree of nominal wage stickiness	0.75	normal value
θ^z	Degree of price stickiness in commodity goods production	0.75	normal value
θ^f	Degree of price stickiness in final goods production	0.75	normal value
η	Share of rule-of-thumb consumers	0.6	Melina et al. (2016)
Policy parameters			
τ^{z*}	Tax rate on exported raw materials	0.05	author's decision
σ	Share of tax-financed public investment	0.1	Zeyneloglu (2018)
k	Allocation of public spending in favor of investment	1.2	Zeyneloglu (2018)
ρ_i	Persistence of interest rate	0.6	normal value
ρ_π	Response of interest rate to inflation	1.5	normal value
ρ_Y	Response of interest rate to total output	0.1	normal value
ρ_B	Response of interest rate to total public debt-to-output ratio	0.02	author's decision
ρ_{B*}	Elasticity of the international external premium on public debt in foreign currency	0.01	Drechsel and Tenreyro (2018)
ρ_{Pz*}	Elasticity of the international external premium to external commodity prices	−0.02	Drechsel and Tenreyro (2018)
Steady-state parameters			
υ	Initial public investment share of public spending	0.08	average observed data for developing economies
B^{tot}/Y	Initial total public debt-to-output ratio	0.8	average observed data for developing economies
Violation parameters			
$\kappa^{P^{z*}}$	Degree of autoregressive foreign commodity price shock	0.9	normal value
κ^g	Degree of autoregressive public spending shock	0.9	normal value

Source: Author's decision unless otherwise stated.

Appendix C. Log-linearization of the model structure.

Equation	Definition
$\bar{C}^R\tilde{C}^R_t + \bar{K}^P\left[\tilde{K}^P_t - \tilde{K}^P_{t-1}(\bar{r}+1-\delta) - \bar{r}\tilde{r}_t\right] + \bar{M}(\tilde{M}_t - \tilde{M}_{t-1}) + \bar{B}\left[\tilde{B}_t - \tilde{B}_{t-1}(1+\bar{i}) - \bar{i}(\tilde{i}_{t-1} - \tilde{P}_t)\right] + \bar{B}^*\left[\tilde{B}^*_t - \tilde{B}^*_{t-1}(1+\bar{i}^*) - \bar{i}^*(\tilde{s}_t + \tilde{i}^*_{t-1} - \tilde{P}_t)\right] = \overline{WL}^R(\tilde{W}_t + \tilde{L}^R_t - \tilde{P}_t) - \bar{T}\tilde{T}_t$	Ricardian budget constraint
$\tilde{C}^{NR}_t = \tilde{L}^{NR}_t + \tilde{W}_t - \tilde{P}_t$	Non-Ricardian budget constraint
$\bar{C}^R(\tilde{C}^R_{t+1} - h\tilde{C}^R_t) + \phi\bar{C}^g\tilde{C}^g_{t+1} - \beta h\left(\bar{C}^R(\tilde{C}^R_t - h\tilde{C}^R_{t-1}) + \phi\bar{C}^g\tilde{C}^g_t\right) = (1-\beta h)\left(\bar{C}^R(1-h) + \phi\bar{C}^g\right)\left(\varphi\tilde{L}^R_t - (\tilde{W}_t - \tilde{P}_t)\right)$	Ricardian Euler equation
$\bar{C}^{NR}(\tilde{C}^{NR}_t + \varphi\tilde{L}^{NR}_t) + \phi\bar{C}^g(\tilde{C}^g_t + \varphi\tilde{L}^{NR}_t) = \frac{\bar{W}}{\chi_L \bar{L}^{NR\varphi}}(\tilde{W}_t - \tilde{P}_t)$	Non-Ricardian labor supply
$\varphi\tilde{L}^R_t = \tilde{W}_t - \tilde{M}_t - \frac{1}{\bar{i}+1}\tilde{i}_t$	Ricardian labor supply
$\bar{i}\tilde{i}_t = \bar{r}\tilde{r}_{t+1} + (\bar{r}-\delta+1)\tilde{\pi}_{t+1}$	Investment-capital tradeoff
$\tilde{i}_t - \tilde{i}^*_t = \tilde{s}_{t+1} - \tilde{s}_t$	Uncovered interest parity
$\tilde{K}^P_t = (1-\delta)\tilde{K}^P_{t-1} + \delta\tilde{I}^P_t$	Law motion of private capital
$\tilde{\pi}^w_t = \beta^w\tilde{\pi}^w_{t+1} + \frac{(1-\theta^w)(1-\beta\theta^w)}{\theta^w}\left[\frac{1}{(1-\beta h)(\bar{C}^R(1-h)+\phi\bar{C}^g)}\begin{pmatrix}(1-\beta h)\begin{pmatrix}\bar{C}^R(\tilde{C}^R_t + \tilde{C}^R_{t+1}) - h\bar{C}^R(\tilde{C}^R_{t-1} + \tilde{C}^R_t) + \\ +\phi\bar{C}^g(\tilde{C}^g_t + \tilde{C}^g_{t+1})\end{pmatrix} - \\ -\bar{C}^R(\tilde{C}^R_{t+1} - \beta h\tilde{C}^R_t) + h\bar{C}^R(\tilde{C}^R_t - \beta h\tilde{C}^R_{t-1}) - \phi\bar{C}^g(\tilde{C}^g_{t+1} - \beta h\tilde{C}^g_t)\end{pmatrix} + \varphi\tilde{L}^R_t - (\tilde{W}_t - \tilde{P}_t)\right]$	Ricardian Phillips equation for wage
$\tilde{\pi}^w_t = \beta^w\tilde{\pi}^w_{t+1} + \frac{(1-\theta^w)(1-\beta\theta^w)}{\theta^w}\left[\frac{\bar{C}^{NR}\tilde{C}^{NR}_t + \phi\bar{C}^g\tilde{C}^g_t}{\bar{C}^{NR} + \phi\bar{C}^g} + \varphi\tilde{L}^{NR}_t - (\tilde{W}_t - \tilde{P}_t)\right]$	Non-Ricardian Phillips equation for wage
$\tilde{\pi}^w_t = \tilde{W}_t - \tilde{W}_{t-1}$	Wage inflation
$\tilde{Y}^z_t = \alpha^z_k\tilde{K}^z_{t-1} + (1-\alpha^z_k)\tilde{L}^z_t + \alpha^z_g\tilde{K}^g_{t-1}$	Production function for the commodity goods sector
$\tilde{L}^z_t = \tilde{MC}^z_t + \tilde{Y}^z_t - \tilde{W}_t + \tilde{P}^z_t$	Demand for labor in the commodity goods sector
$\tilde{K}^z_{t-1} = \tilde{MC}^z_t + \tilde{Y}^z_t - \tilde{r}_t$	Demand for capital in the commodity goods sector
$\tilde{MC}^z_t = (1-\alpha^z_k)(\tilde{W}_t - \tilde{P}^z_t) + \alpha^z_k\tilde{r}_t - \alpha^z_g\tilde{K}^g_{t-1}$	Marginal cost in the commodity goods sector
$\tilde{\pi}^z_t = \beta E_t\tilde{\pi}^z_{t+1} + \left[\frac{(1-\theta^z)(1-\beta\theta^z)}{\theta^z}\right](\tilde{MC}^z_t - \tilde{P}^z_t)$	Phillips equation in the commodity goods sector
$\tilde{Y}^f_t = \alpha^f_k\tilde{K}^f_{t-1} + \alpha^f_z\tilde{Z}_t + (1-\alpha^f_k-\alpha^f_z)\tilde{L}^f_t + \alpha^f_g\tilde{K}^g_{t-1}$	Production function for the final goods sector
$\tilde{L}^f_t = \tilde{MC}^f_t + \tilde{Y}^f_t - \tilde{W}_t + \tilde{P}^f_t$	Demand for labor in the final goods sector
$\tilde{K}^f_{t-1} = \tilde{MC}^f_t + \tilde{Y}^f_t - \tilde{r}_t$	Demand for capital in the final goods sector

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Equation	Definition
$\tilde{MC}_t^f = (1-\alpha_k^f-\alpha_z^f)(\tilde{W}_t - \tilde{P}_t^f) + \alpha_k^f \tilde{r}_t - \alpha_g^f \tilde{K}_{t-1}^g$	Marginal cost in the final goods sector
$\tilde{\pi}_t^f = \beta E_t \tilde{\pi}_{t+1}^f + \left[\frac{(1-\theta^f)(1-\beta\theta^f)}{\theta^f}\right](\tilde{MC}_t^f - \tilde{P}_t^f)$	Phillips equation in the final goods sector
$\tilde{\pi}_{t+1} = \tilde{P}_{t+1} - \tilde{P}_t$	Gross inflation rate
$\tilde{\pi}_t^z = \tilde{P}_t^z - \tilde{P}_{t-1}^z$	Inflation in the commodity goods sector
$\tilde{\pi}_t^f = \tilde{P}_t^f - \tilde{P}_{t-1}^f$	Inflation in the final goods sector
$\tilde{T}_t^{z*} = \tilde{P}_t^{z*} + \tilde{Y}_t^{z*}$	Tax on exported raw materials
$\bar{B}\left[\tilde{B}_t - \tilde{B}_{t-1}(1+\bar{i}) - \bar{i}(\tilde{i}_{t-1} - \tilde{P}_t)\right] + \bar{B}^*\left[\tilde{B}_t^* - \tilde{B}_{t-1}^*(1+\bar{i}^*) - \bar{i}^*(\tilde{s}_t + \tilde{i}_{t-1}^* - \tilde{P}_t)\right] + \bar{M}(\tilde{M}_t - \tilde{M}_{t-1}) + \bar{T}\tilde{T}_t + \bar{T}^{z*}(\tilde{s}_t + \tilde{T}_t^{z*} - \tilde{P}_t) = \bar{G}\tilde{G}_t + \bar{F}^*\left[\tilde{F}_t^* - \tilde{F}_{t-1}^*(1+\bar{i}^*) - \bar{i}^*(\tilde{s}_t + \tilde{i}_{t-1}^* - \tilde{P}_t)\right]$	Government budget constraint
$\tilde{M}_t = \tilde{B}_t + \frac{\bar{B}}{\bar{Y}}(\tilde{B}_t - \tilde{P}_t)$	Money supply
$\bar{T}\tilde{T}_t + \bar{i}^*\bar{F}^*\left[\tilde{F}_{t-1}^* + \tilde{s}_t + \tilde{i}_{t-1}^* - \tilde{P}_t\right] = \sigma\bar{I}^g\tilde{I}_t^g + \bar{C}^g\tilde{C}_t^g + \bar{i}\bar{B}(\tilde{i}_{t-1} + \tilde{B}_{t-1} - \tilde{P}_t) + \bar{i}^*\bar{B}^*(\tilde{s}_t + \tilde{i}_{t-1}^* + \tilde{B}_{t-1}^* - \tilde{P}_t)$	Government revenues
$\tilde{K}_t^g = \tilde{K}_{t-1}^g(1-\delta+\varepsilon^1\delta) + \delta(\tilde{I}_t^g - \varepsilon^1\tilde{I}_{t-1}^g)$	Law motion of public capital
$\tilde{I}_t^g = \tilde{G}_t$	Public investment
$\tilde{C}_t^g = \tilde{G}_t$	Public consumption
$\bar{G}\tilde{G}_t = \bar{C}^g\tilde{C}_t^g + \bar{I}^g\tilde{I}_t^g$	Public spending
$\bar{F}^*\tilde{F}_t^* = 0$	Law motion of the SWFs
$\tilde{s}_t = \tilde{P}_t^z - \tilde{P}_t^{z*}, \quad \tilde{s}_t = \tilde{P}_t^f - \tilde{P}_t^{f*}$	Nominal exchange rate
$\bar{i}^*\tilde{i}_t^* = \tilde{s}_{t+1} - \tilde{s}_t + \rho_{B^*}\bar{B}^*\tilde{B}_t^* + \rho_{p^{z*}}\tilde{P}_t^{z*}$	Foreign interest rate
$\bar{i}^n\left(\tilde{i}_t^n - \tilde{i}\right)_t = \tilde{\pi}_t$	Nominal interest rate
$\bar{i}^n\tilde{i}_t^n = \rho_i\bar{i}_n\tilde{i}_{t-1}^n + \rho_\pi\bar{\pi}\tilde{\pi}_{t-1} + \rho_Y\bar{Y}\tilde{Y}_{t-1} + \rho_s\tilde{s}_{t-1} + \rho_b\frac{\bar{B}(\tilde{B}_{t-1}-\tilde{P}_t) + \bar{B}^*(\tilde{s}_{t-1}+\tilde{B}_{t-1}^* - \tilde{P}_t)}{\bar{Y}}$	Tailor rule
$\bar{Y}\tilde{Y}_t = \bar{C}^p\tilde{C}_t^p + \bar{I}^p\tilde{I}_t^p + \bar{G}\tilde{G}_t + \overline{NX}\,\tilde{NX}_t$	Equilibrium condition
$\tilde{Y}_t^{z*} = \tilde{Y}_t^* + \varsigma^{z*}(\tilde{P}_t^* - \tilde{P}_t^{z*})$	Foreign demand for commodity goods
$\tilde{Y}_t^{f*} = \tilde{Y}_t^* + \varsigma^{f*}(\tilde{P}_t^* - \tilde{P}_t^{f*})$	Foreign demand for final goods
$\bar{Y}^*\tilde{Y}_t^* = 0$	Foreign output
$\overline{NX}\,\tilde{NX}_t = \bar{Y}^{z*}(\tilde{Y}_t^{z*} + \tilde{P}_t^{z*} - \tilde{P}_t^*) + \bar{Y}^{f*}(\tilde{Y}_t^{f*} + \tilde{P}_t^{f*} - \tilde{P}_t^*)$	Foreign trade balance
$\overline{NX}(\tilde{NX}_t + \tilde{P}^*) + \bar{B}^*(\tilde{B}_t^* - \tilde{B}_{t-1}^*) - \bar{i}^*\bar{B}^*(\tilde{i}_{t-1}^* + \tilde{B}_{t-1}^*) + \bar{T}^{z*}\tilde{T}_t^{z*} = \bar{F}^*(\tilde{F}_t^* - \tilde{F}_{t-1}^*) - \bar{i}^*\bar{F}^*(\tilde{i}_{t-1}^* + \tilde{F}_{t-1}^*)$	External account
$\bar{Y}\tilde{Y}_t = \bar{Y}^f(\tilde{Y}_t^f + \tilde{P}_t^f - \tilde{P}_t) + \bar{Y}^z(\tilde{Y}_t^z + \tilde{P}_t^z - \tilde{P}_t) - \bar{Z}(\tilde{Z}_t + \tilde{P}_t^z - \tilde{P}_t)$	All goods production

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Equation	Definition
$\widetilde{K}_t^p = \frac{\widetilde{K}_t^z + \widetilde{K}_t^f}{2}$	Aggregate private capital
$\frac{\widetilde{L}_t^z + \widetilde{L}_t^f}{2} = (1-\eta)\widetilde{L}_t^R + \eta\widetilde{L}_t^{NR}$	Aggregate labor
$\widetilde{C}_t^P = (1-\eta)\widetilde{C}_t^R + \eta\widetilde{C}_t^{NR}$	Aggregate consumption
$\overline{BY}\,\widetilde{BY}_t = \frac{\overline{B}}{\overline{Y}}\left(\widetilde{B}_t - \widetilde{Y}_t - \widetilde{P}_t\right) + \frac{\overline{B}^*}{\overline{Y}}\left(\widetilde{s}_t + \widetilde{B}_t^* - \widetilde{Y}_t - \widetilde{P}_t\right)$	Total debt ratio
$\widetilde{P}_t^{z^*} = \kappa^{p^{z^*}}\widetilde{P}_{t-1}^{z^*} + \widetilde{\nu}_t/10$	Foreign commodity price shock
$\widetilde{G}_t = \kappa^g\widetilde{G}_{t-1} + \widetilde{\nu}_t$	Public spending shock

Source: Product of author's derivation.