Industrialized Growth In Developing Economies

PhD Dissertation Defense

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APRIL 2017

Outline

Introduction

Chapter 1: Supply Side Dynamics in Closed Developing Economies
- DSGE Equations

Chapter 2: General Equilibrium Growth in Closed Economies
- Growth at General Equilibrium
- Steady State Analysis
- Impact of Government Intervention on Growth
- Optimum Subsidy and Growth Speed

Chapter 3: Sovereign Debt and Growth in Open Economies
- Growth Limitation in a Closed Economy
- Expanding Growth Using Sovereign Debt
- Borrowing Policies
- Modeling Default
- Production Quality Impact

Goals

Primary Goal: To derive a dynamic model to explain industrialized growth for developing countries.

Secondary Goals: Use my model to analyze the following:

1. Government’s role to trigger and speed up the development.
2. Taxation and subsidization impact.
3. Impact of sovereign debt on growth.
4. Farewell and societal impacts.
5. Possibility of default.
6. Quality of manufacturing production.

Policy Recommendations:

1. Domestic polices: taxation and subsidies.
2. Foreign polices: borrowing.

Related Research

Growth

Me

Debt

1. Endogenous innovation in the theory of growth (Grossman, 93)
2. Endogenous Technological Change (Romer, 90)
3. Frankel Lucas's Human Capital Model (1988)

Debt Dynamics and Default

Me

1. Debt path determined by the course of overall fiscal balances (Escolano, 2010)
2. General equilibrium model of sovereign default and business cycles (Mendoza 2011)
3. Debt Overhang (Krugman, et al 2010)

Impact of Foreign Borrowing on Growth

1. Growth, debt and economic transformation: The capital flight problem (Calvo 98)
2. Sovereign Debt: A premier (Eaton 93)
3. External Debt and Growth (Patitillo, et al 02)

Growth Research

$$(1)\ Y = F(A, K, L), (2)\ \dot{K} = \mathrm{G(Y, K)}$$

Exogenous Models:

- Solow/Swan (1956): Long term growth is achieved through technological progress and short term through saving rate which is not explained by the model

$$F(A, K, L) = K^{\alpha}(AL)^{1-\alpha}$$
$$G(Y, K) = sY - \delta K$$

Limitations:

1. Growth rate of of world economic leaders has been rising over time (not converging to a balanced growth path predicted by Solow/Swan)
2. Income per capita is not similar across countries which should have been given similar saving rate and technology diffusion across countries over time.

Growth Research

Endogenous Models:

- Endogenous saving rate: Ramsey/Cass/Coopman (1965): $\dot{c}/_{c} = \frac{r-\theta}{\rho}$
- Endogenous technology

Frankel (1962)	Romer (1986)	Lucas (1988)	Grossman (1991)
Capital Variation $A = A_0\left(\sum K_j\right)^{\eta}$	Innovation $A_{t+1} - A_t = \theta L_{A,t}{}^{\varphi} A_t$	Human Capital $Y = AK^{\alpha}(LH)^{1-\alpha}\overline{H}^{\psi}$	Trade $\dot{T}/_{T} = \frac{g\beta(1-\alpha)}{\alpha}$

Limitations:

Do not fully combine internal and external factors in growth, e.g. government subsidy or foreign borrowing.

Debt Research

Only focus on the borrowing separate from the internal dynamics of growth: A BLACK BOX

- Calvo (1998) identifies traps the might defeat he growth endeavor.
- Patitillo (2002) applies a regression analysis on HIPC countries to find what level of debt is optimum.
- Krugman(2010} focuses on inability of countries to borrow due to debt overhang.
- Mendoza(2011) derives a model for default but look the economy as a black box.

My study is differentiated because it is A WHITE BOX

- Interaction of internal growth and external debt and possibly default.
- Provides a comprehensive model including government domestic and foreign policies.
- Explains how industrializations takes place beyond Romer's model.
- Generalizes Romer's general equilibrium.

Industrialization Stylized Facts

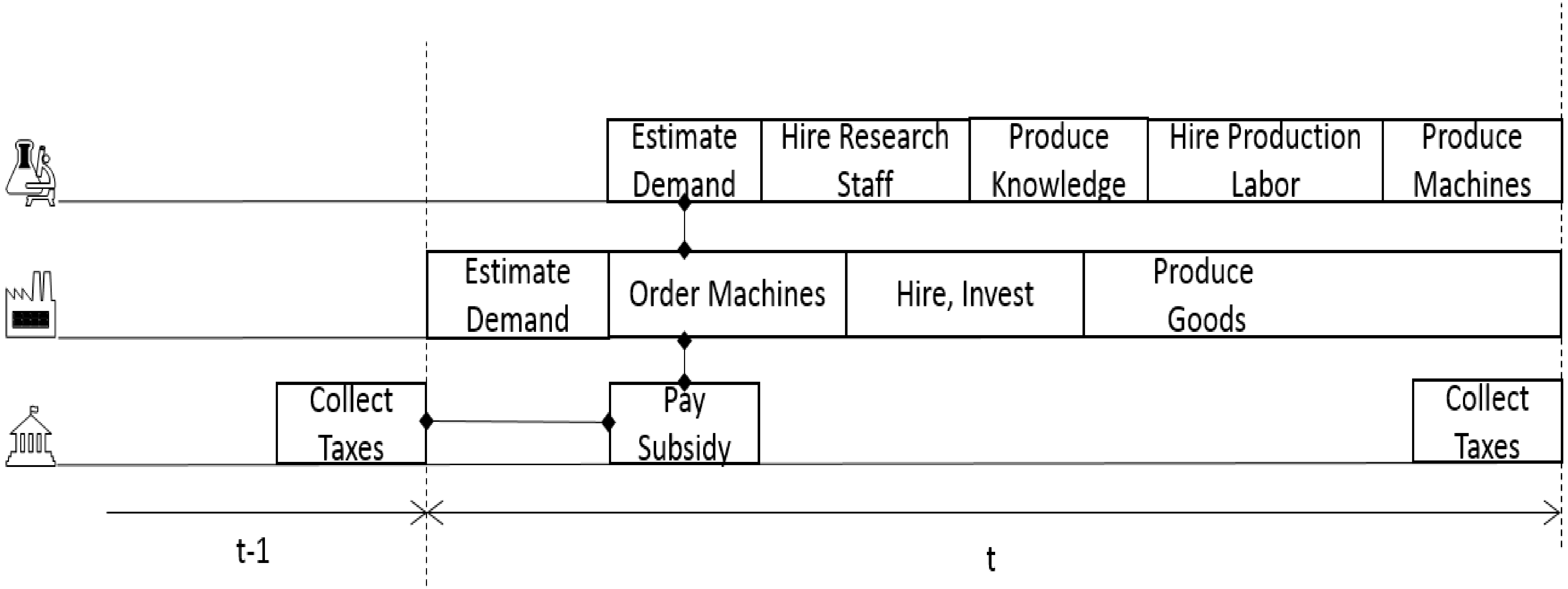
Fact	How I Have Used it
Requires significant amount of investment in the initial stages	Effect of Gov't domestic policies on growth
Funded by bank loans	Effect of sovereign debt on growth
Established domestically controlled public or publically supported enterprises	Domestic subsidized innovation and manufacturing sectors
Home-grown research and technology generation is very important in achieving high quality in production	

Fact	How I Have Used it
International markets significantly increase demand but also increase the risk of default	Steady state level of debt/output ratio
Pushes for higher quality to compete in International markets	Quantifying the impact of quality on default possibility

Chapter 1

SUPPLY SIDE DYNAMICS IN CLOSED DEVELOPING ECONOMIES

Components of the Model



Assumptions

1. Each firm maximizes the profits for each period separately.
2. The tax rate remains fixed for the duration of industrialization.
3. Government maximizes output for the entire period of industrialization.

Justification for assumptions 1 and 3: Private firms also consider long term in their strategies, however, their plans are not as long as gov't specific policies to overhaul the economy which can span decades.

R&D Sector

(1) $A_{t+1} - A_t = \theta L_{A,t} A_t$

(2) $M_t = h(A_t) H(L_{M,t}, K_{M,t})$

(3) $$\Pi_R = \sum_{t=0}^{\infty} (1-\tau_t)\left(\frac{1}{1+r}\right)^t \left[p_{M,t} M_t - w_t\left(L_{A,t} + L_{M,t}\right) - \Delta K_{M,t}\right]$$

(4) $$\Lambda_R = \sum_{t=0}^{\infty} (1-\tau_t)\left(\frac{1}{1+r}\right)^t \left[p_{M,t} M_t - w_t\left(L_{A,t} + L_{M,t}\right) - \Delta K_{M,t}\right]$$
$$- \lambda_{y,t}\left[\frac{1}{2}\left(\frac{\partial y_t}{\partial M_t}\right) + p_{M,t} - s_t - T_t(p_{M,t-1} - s_{t-1})\right]$$
$$- \lambda_{M,t}\left(M_t - A_{M,t} H(L_{M,t}, K_{M,t})\right)$$

(5) $K_{M,t}\colon \lambda_{M,t} h(A_t) H_K(.) + 1 = T_t$

(6) $L_{M,t}\colon \lambda_{M,t} h(A_t) H_L(.) = w_t$

(7) $L_{A,t}\colon \lambda_{M,t} \dot{h}(A_t) H(.) \dfrac{t\theta A_0 A_t}{A_1} = w_t$

(8) $M_t\colon \lambda_{M,t} = p_{M,t} - \frac{\lambda_{y,t}}{2}\left(\frac{\partial^2 y_t}{\partial {M_t}^2}\right)$

(9) $p_{M,t}\colon M_t = \lambda_{M,t} - \lambda_{y,t+1}$

Primary Sectors

(13) $A_{T,t} = A_T + \Omega\left(\frac{M_{T,t}}{M_t}\right)A_t$

(14) $A_{N,t} = A_N + \Omega\left(\frac{M_{N,t}}{M_t}\right)A_t$

(15) $\Pi_T = \sum_{t=0}^{\infty}(1-\tau_t)\left(\frac{1}{1+r}\right)^t \left[A_{T,t}F\left(K_{T,t}, M_{T,t}, L_{T,t}\right) - w_t L_{T,t} - \Delta K_{T,t} - (p_{M,t} - s_t)\Delta M_T\right.$

(16) $\Pi_N = \sum_{t=0}^{\infty}(1-\tau_t)\left(\frac{1}{1+r}\right)^t \left[p_{N,t}A_{N,t}G\left(K_{N,t}, M_{N,t}, L_{N,t}\right) - w_t L_{N,t} - \Delta K_{N,t} - (p_{M,t} - s_t)\Delta M_{N,t}\right]$

(17) $s_{t+1}(\Delta M_{T,t+1} + \Delta M_{N,t+1}) = \tau_t(\pi_{T,t} + \pi_{N,t} + \pi_{R,t})$

(18) $K_{T,t}: A_{T,t}F_K(.) + 1 = T_t$

(19) $K_{N,t}: p_{N,t}A_{N,t}G_K(.) + 1 = T_t$

(20) $L_{T,t}: A_{T,t}F_L(.) = w_t$

(21) $L_{N,t}: p_{N,t}A_{N,t}G_L(.) = w_t$

(22) $M_{T,t}: \left(\frac{\partial y_{T,t}}{\partial M_t}\right) + p_{M,t} - s_t = T_t(p_{M,t-1} - s_{t-1})$

(23) $M_{N,t}: p_{N,t}\left(\frac{\partial y_{N,t}}{\partial M_t}\right) + p_{M,t} - s_t = T_t(p_{M,t-1} - s_{t-1})$

Government

$$(24) \quad \underbrace{\max_{s_t}}_{s.t\ firms\ profits\ are\ maximized} \quad Y = \sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t (Y_T + p_{N,t} Y_N)$$

$$(26) \quad \frac{1-\tau_t}{1-\tau_{t+1}} = \frac{M_t}{M_{t+1}} \xrightarrow{yields} \Delta\tau_t = \frac{\Delta M_t}{M_t}(\tau_t - 1)$$

Solution for Special Form

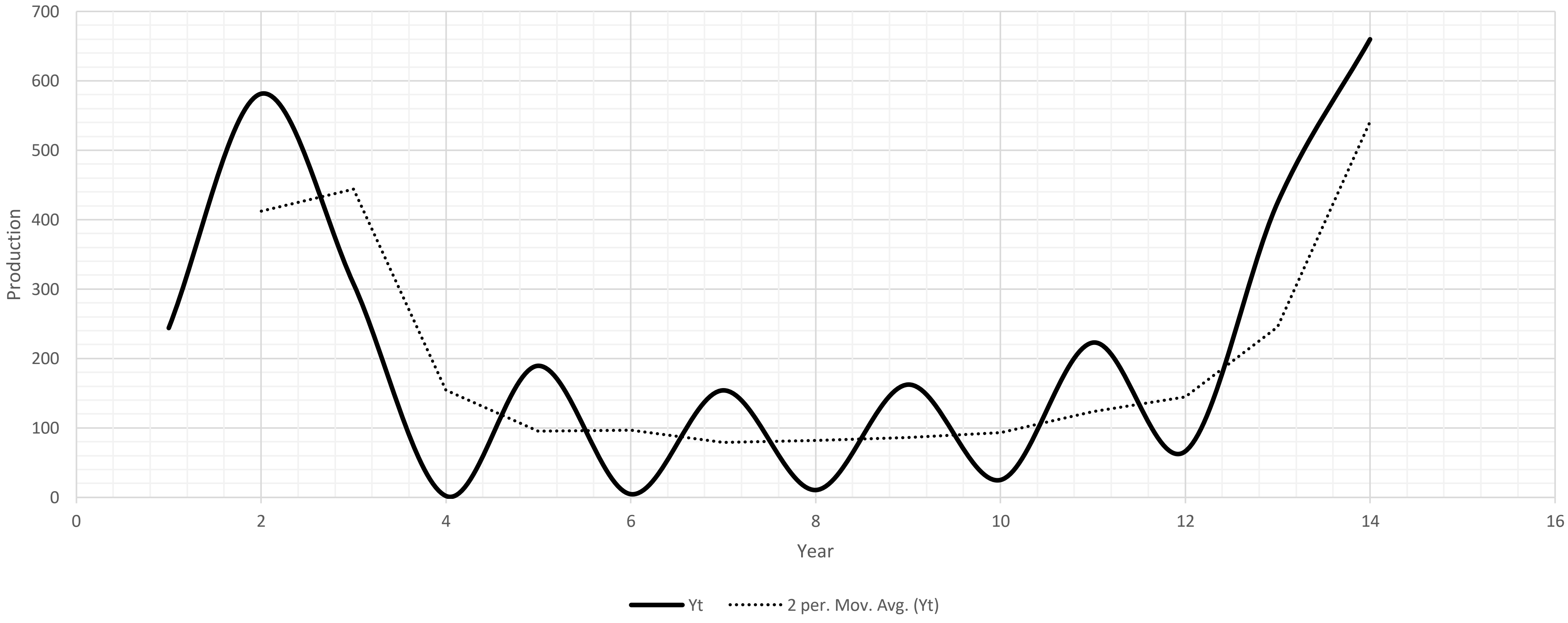
Function	Special Case Used for Simulation
R&D productivity in producing machinery	$h(A_t) = A_t$
Production function for machinery	$H\left(L_{M,t}, K_{M,t}\right) = {K_{M,t}}^{\alpha} {L_{M,t}}^{1-\alpha}$
Technology diffusion function	$\Omega\left(\frac{M_{T,t}}{M_t}\right) = \frac{M_{T,t}}{M_t}$
Production function for traditional sectors	$F\left(L_{T,t}, K_{T,t}, M_{T,t}\right) = {K_{T,t}}^{\alpha} {M_{T,t}}^{\beta} {L_{T,t}}^{1-\alpha-\beta}$

(31) $$w_t = \left[(\mathrm{A}_T + \mathrm{A}_t)\mathrm{C}_t \left(\frac{M_t}{L_{T,t}}\right)^{\beta}\right]^{\frac{1}{1-\alpha}}$$

(32) $$\frac{K_{T,t}}{L_{T,t}} = \mathrm{C}_t w_t$$

(33) $$(1-\alpha)M_t = \frac{(\mathrm{A}_T + \mathrm{A}_t)\mathrm{C}_t \left(\frac{M_t}{L_{T,t}}\right)^{\beta}}{\mathrm{A}_t \mathrm{B}_t} - \frac{(\mathrm{A}_T + \mathrm{A}_{t+1})\mathrm{C}_{t+1} \left(\frac{M_{t+1}}{L_{T,t+1}}\right)^{\beta}}{\mathrm{A}_{t+1} \mathrm{B}_{t+1}}$$

Closed Economy Solution



Chapter 2

GENERAL EQUILIBRIUM GROWTH IN CLOSED ECONOMIES

Supply Side

R & D Sector:

$$A_{t+1} - A_t = \theta {L_{A,t}}^{\varphi} A_t$$

Manufacturing Sector:

$$Y = {L_{Y,t}}^{\beta} {K_{Y,t}}^{\alpha} \sum_{i=0}^{A_t} h_i$$

Product Maximizing Firms:

$$\Pi_{Y,t} = (1 - \tau_t)\left[p_{y,t} {L_{Y,t}}^{\beta} {K_{Y,t}}^{\alpha} \sum_{i=0}^{A_t} {h_i}^{\gamma} - w_t L_{Y,t} - r_t K_{Y,t} - \sum_{i=0}^{A_t} p_{i,t} h_i + \sum_{i=0}^{A_t} s_t p_{i,t} h_i\right]$$

Two Effective Subsidy Level Propositions

<u>Effective Subsidy Level</u>

A level of subsidy that equates the marginal revenue of innovation to its cost.

Proposition 1. Without government intervention, a firm will employ human capital if Inequality 36 is satisfied. (See appendix A for proof).

$$\sum_{i=0}^{A_t} {h_i}^{\gamma} > \frac{1}{1-\gamma} \tag{36}$$

Proposition 2. With government intervention, a firm will employ human capital if inequality 37 is satisfied. (See appendix B for proof).

$$\sum_{i=0}^{A_t} {h_i}^{\gamma} > \frac{1}{1-\gamma(1-s)} \tag{37}$$

Supply Side Model

(35) $$\Pi_{Y,t} = (1-\tau_t)\left[p_{y,t}{L_{Y,t}}^{\beta}{K_{Y,t}}^{\alpha}\sum_{i=0}^{A_t}{h_{i,t}}^{\gamma} - w_t L_{Y,t} - r_t K_{Y,t} - \sum_{i=0}^{A_t}p_{i,t}h_{i,t} + \sum_{i=0}^{A_t}s_t p_{i,t}h_{i,t}\right]$$

(38) $$\mathrm{g}_{A,t} = \frac{A_{t+1}-A_t}{A_t} = \theta L_{A,t}^{\varphi}$$

(39) $$h_{i,t} = \left[\frac{\gamma^2 p_{y,t}L_{Y,t}^{\beta}K_{Y,t}^{\alpha}}{(1+r)(1-s_{i,t})}\right]^{\frac{1}{1-\gamma}}$$

(40) $$\mathrm{p}_{i,t} = \frac{1+r}{\gamma}$$

(41) $$\pi_{i,t} = \left(\frac{1-\gamma}{\gamma}\right)\left[\frac{\gamma^2 p_{y,t}L_{Y,t}^{\beta}K_{Y,t}^{\alpha}}{(1+r)(1-s_{i,t})}\right]^{\frac{1}{1-\gamma}}$$

(42) $$\mathrm{p}_{A,t} = \frac{(1+r)\pi_{A,t}}{r}$$

(43) $$MPL_A = MPL_Y$$

Supply Side Solution

Division of Labor:

$$L_{Y,t} = QL_{A,t}^{\varphi-1} \text{ where } Q = \frac{Br(1-s_t)}{\gamma(1-\gamma)\theta\varphi}$$

$$When\ \phi = 0.5:\ \mathrm{L}_{A,t} = \left(\frac{\sqrt{Q^2+4L}-Q}{2}\right)^2$$

Firm Output:

$$\mathrm{Y}_t = A_t {C_t}^{\gamma} {L_{Y,t}}^{\mathrm{B}} {K_{Y,t}}^{\Lambda}$$

$$\Lambda = \frac{\alpha}{1-\gamma} \text{ and } B = \frac{\beta}{1-\gamma} \text{, and } C_t = \left[\frac{\gamma^2 p_{y,t}}{(1-s_t)(1+r)}\right]^{\frac{1}{1-\gamma}}$$

Supply Side Growth:

$$\mathrm{g}_{s,t} = \left(1 + \theta {L_{A,t}}^{\varphi}\right)^{\frac{1}{1-\Lambda}} - 1$$

Growth at Equilibrium

Demand side utility:

$$U(C_t) = \sum_{s=t}^{\infty} d^{s-t} \frac{c_s^{1-\rho}}{1-\rho}$$

Demand side growth:

$$g_{d,t} = [(1 + r_t)d]^{\frac{1}{\rho}} - 1$$

$$g_{d,m} = g_{s,m} \Longrightarrow \left(1 + \theta L_{A,t}{}^{\varphi}\right)^{\frac{1}{1-\Lambda}} = [(1 + r_t)d]^{\frac{1}{\rho}}$$

Growth vs Interest Rate

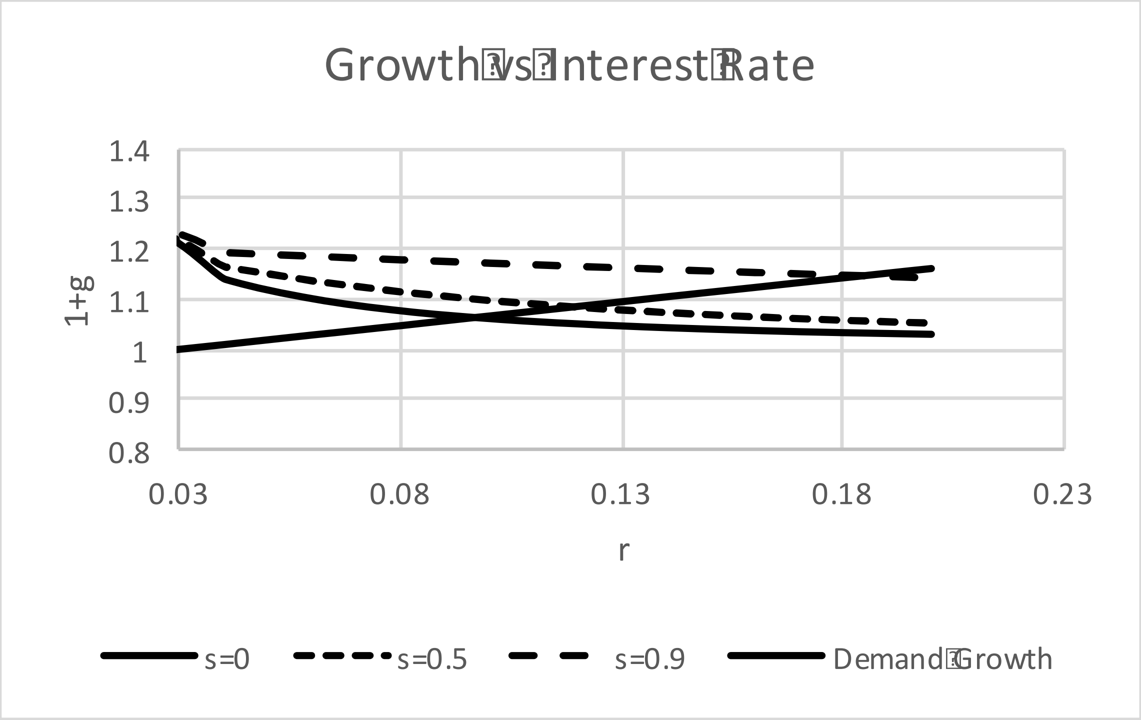


Figure 4. The increasing line shows the growth on the demand side. Dashed decreasing curves show the supply side growth with government intervention. The higher the subsidy, the higher the growth rate. The intersection of the demand and supply side curves specifies the general equilibrium growth.

Economy Output

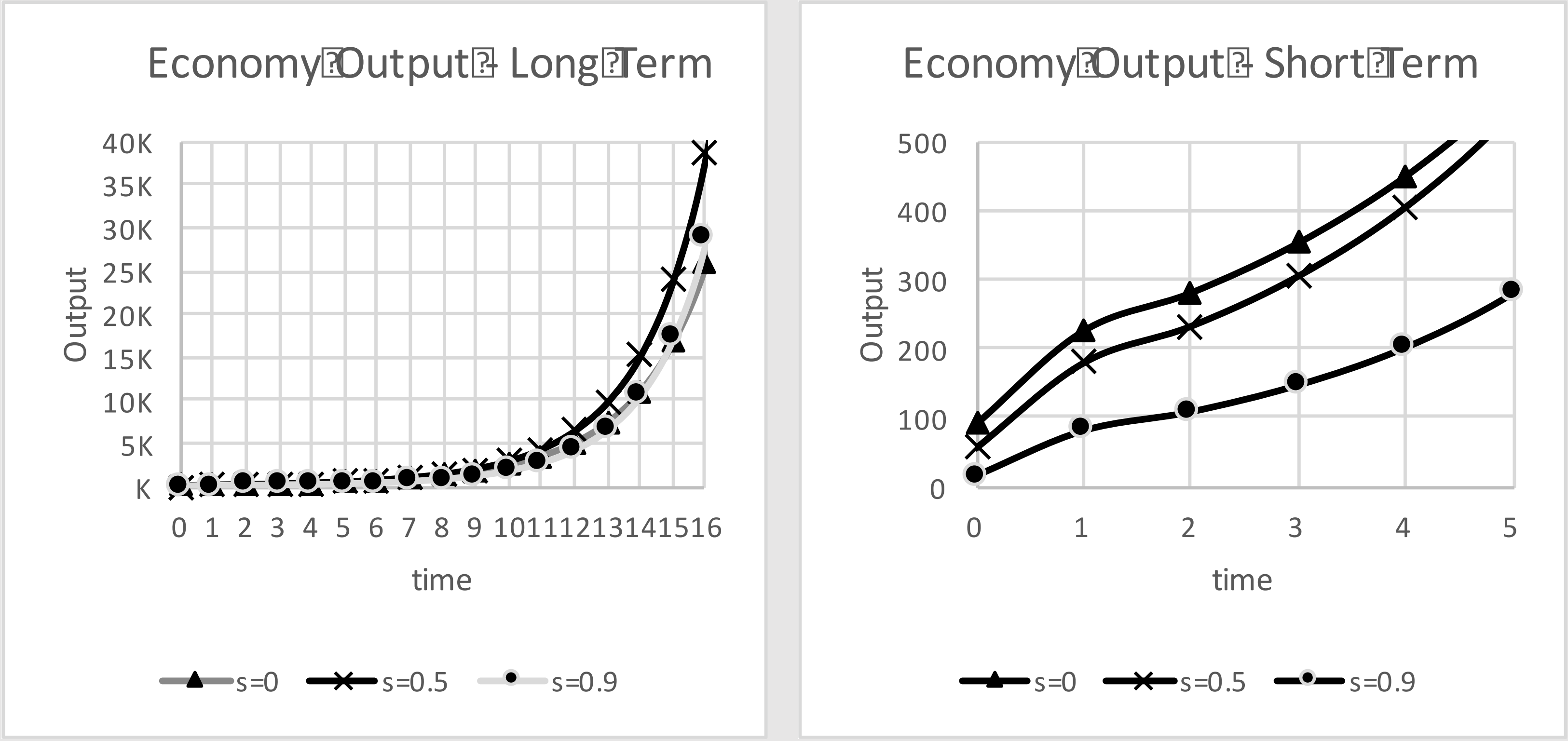


Figure 5. On the left figure, we can compare economy's output over the long-term for different values of subsidy. We see that having a high value of subsidy underperforms while a mid-range value for subsidy yields the best growth in the shortest amount of time. On the right, we see that the no-subsidy policy performs better early on.

Income Per Capita

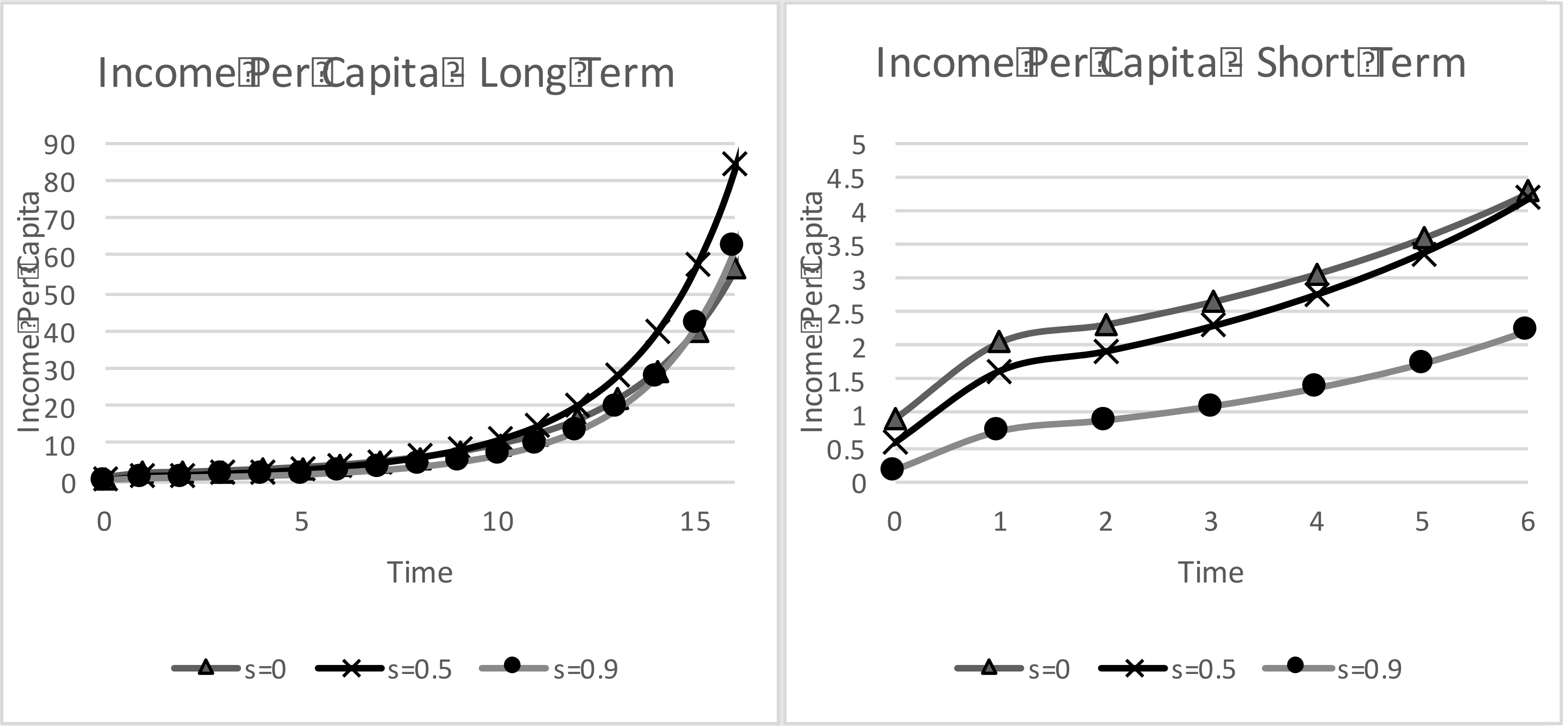


Figure 7. On the left, we see that in the long-term the mild subsidy policy provides a higher income per capita; however, as we see on the right, in the early stages of development, the high and mild subsidy policies lower income per capita which combined the high wage growth causes dualism.

Chapter 3

SOVEREIGN DEBT AND GROWTH IN OPEN ECONOMIES

Growth Limitation in a Closed Economy

$$\sum_{i=0}^{A_t} s_t p_{i,t} h_i < T_t$$

$$\mathrm{T}_t = \tau_t \left[{L_{Y,t}}^{\beta} {K_{Y,t}}^{\alpha} \sum_{i=0}^{A_t} {h_i}^{\gamma} - w_t L_{Y,t} - r_t K_{Y,t} - \sum_{i=0}^{A_t} p_{i,t} h_i + \sum_{i=0}^{A_t} s_t p_{i,t} h_i \right]$$

$$s_{A,t} \leq \frac{(1-\gamma)(1-B)(1-\Lambda)\tau_t}{\gamma+(1-\gamma)(1-B)(1-\Lambda)\tau_t}$$

Maximum Attainable Subsidy

This is for a tax rate 0f 100%

For a tax rate of 50% the max attainable subsidy rate is 25%

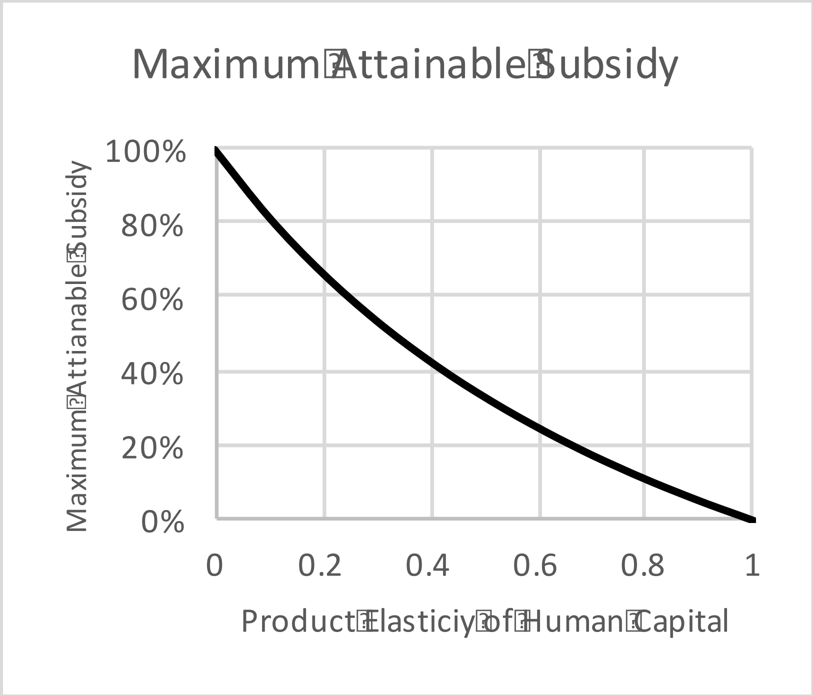


Figure 8. In a closed economy, the maximum attainable subsidy rate is a decreasing function of product elasticity of human capital.

Expanding Growth Using Sovereign Debt

Government Objective Function

$$\chi_t = \max_{s_t, B_t} \sum_{t=0}^{T} \left[\left(\frac{1}{1+r} \right)^t p_{y,t} Y_t \right]$$

$$G_t = T_t + B_{t+1} - B_t - rB_t$$

$$\chi_t = \max_{s_t, B_t} \sum_{t=0}^{T} \left[\left(\frac{1}{1+r} \right)^t \frac{rB_t - B_{t+1} + B_t}{\tau_t (1-\gamma)(1-B)(1-\Lambda) - \frac{s_t \gamma}{1-s_t}} \right]$$

<u>This is an increasing function of subsidy, therefore set the subsidy to the maximum attainable subsidy rate in the early stages of growth.</u>

Short-Term Borrowing Policies

The Growth-First Policy:

In the early stages of growth, government borrows to be able to subsidize above the attainable rate.

The Growth-and-Distribution Policy:

In the early stages of growth, government borrow to be able to subsidize above the attainable rate and also provide a minimum level of income per capita.

Mid-to-Long-Term Borrowing

Government can borrow only if it can show it can avoid a default on its debt.

One of the measures used to assess government's ability to pay its debt is the ratio of debt to output.

$$\frac{B_{t+1}}{Y_{t+1}} = \left[\frac{\left((1+r)d\right)^{\frac{1}{\rho}}}{1+g_{s,t}}\right]\frac{B_t}{Y_t} - \frac{1+g_{s,t}+\left((1+r)d\right)^{\frac{1}{\rho}}}{(1+g_{s,t})(r-g_{s,t})}\left[1+\frac{\Lambda p_y(1-\gamma)(1-B)}{r}-\gamma\right]$$

$$g_s + 1 = (1+\theta {L_A}^{\varphi})^{\frac{1}{1-\Lambda}}$$

$$g_d + 1 = [(1+r)d]^{\frac{1}{\rho}}$$

Steady-State Analysis
Case 1. Stable Debt to Output Ratio

$g_s > g_d$

debt to output ratio will be stable and converges to the steady state ξ:

$$\xi = \frac{1 + \frac{\Lambda p_y (1-\gamma)(1-B) g_S}{r} - \gamma}{r - g_S}$$

Capped Growth:

$$g^* = \frac{1 - \gamma - \eta r}{\frac{\Lambda p_y (1-\gamma)(1-B) g_S}{r} - \eta}$$

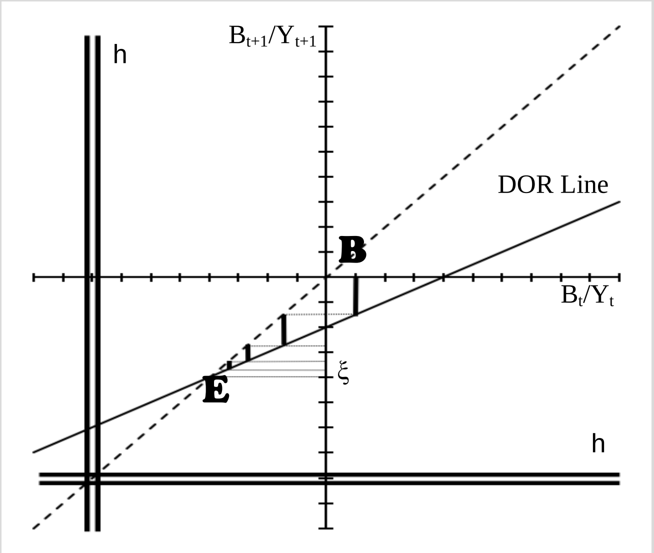


Figure 9. The debt to output ratio gradually converges to steady state. Starting from a positive current account (point B), debt-to-output gradually reaches the negative steady state ratio (point E). The double line shows the max allowed debt-to-output by the lender. In this case since point E is above η, the steady-state is valid.

Case 2. Romer's Case and Case 3. Transient Unstable Case

$g_{s,t} = g_d = g^*$

Discussed in [Romer 1990]

Transition to steady state is instantaneous and $B_t = \eta Y_0 (1 + g^*)^t$.

$g_{s,t} < g_{d,t}$

Debt to output ratio will be transiently unstable.

One Example

β=0.3, α=0.4, γ=0.3, r=2%, θ=0.01, φ=0.5, d=0.93, $P_{Y,t}$=1, ρ=1, and population growth=0%. τ=50%

Maximum attainable subsidy is 13%

Income-per-capita has reduced from 3.19 to 1.87

Assume that government decides to keep income-per-capita at least at 75% of its original level.

Period	Growth-First Debt	DOR	Growth-&-Dist. Debt	DOR
1	6.682001046	0.12	186.8617141	3.55
2	20.82533391	0.12	99.62395642	0.60
3	26.13684629	0.12	84.20432815	0.40
4	33.18502635	0.12	57.76653817	0.22
5	42.64841	0.127	15.24014721	0.04

Modeling Default

Lending country's interest rate is raised from its original level r_1 to r_2 where $1 + g_{s,t} > \left((1 + r_2)d\right)^{\frac{1}{\rho}}$.

This will reduce the steady state DOR.

$$\Delta DOR = \frac{(r_2 - r_1)\left(1 - \gamma + \frac{r_2 + r_1 - g}{r_2 r_1} V\right)}{(r_2 - g)(r_1 - g)}$$

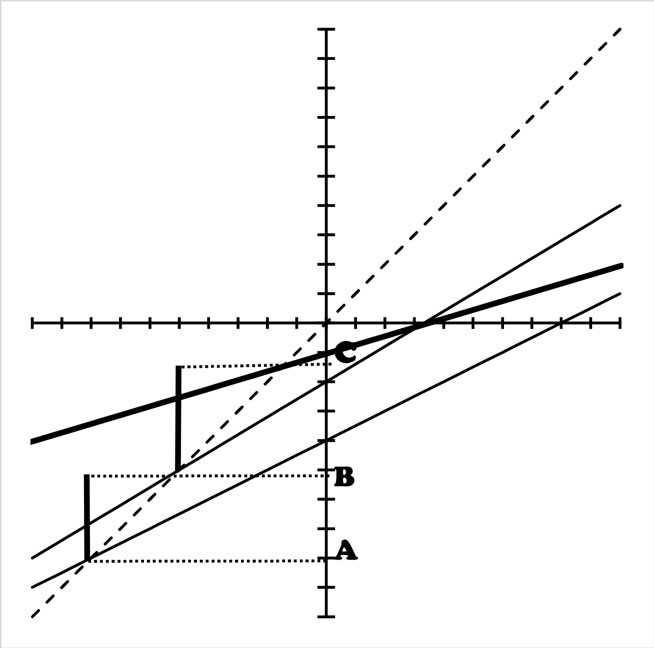


Figure 10. When interest rate is increased, DOR will enter a vicious cycle where DOR and growth push each other down repeatedly. In this figure, DOR was initially at the steady state point A. Increase in interest rate pushes DOR to the new steady state B lowering the growth which will lower DOR even further to steady state point C.

Production Quality Impact

Change in net foreign assets when interest rate rises from r_1 to r_2 is given by

$$\Delta B_u = \left(\psi\epsilon(r_2)P_{y,u}\right)^{1-\lambda} - \left(\psi\epsilon(r_1)P_{y,u}\right)^{1-\lambda}$$

Exchange rate pass through: ψ

Elasticity of demand for manufactured goods in the importing country with λ

Exchange rate at a given interest rate by $\epsilon(r_t)$

1. If the goods have high quality, their demand will be elastic ($\lambda > 1$) and therefore a decrease in prices will provide a positive net foreign assets.
2. For unit-elastic goods ($\lambda = 1$), net foreign assets do not change
3. For low quality inelastic goods, net foreign assets decreases when price are reduced.

Conclusion

- The borrower should use the funds to increase its long-term capacity to produce at world-level quality, increase its domestic growth, and guarantee its debt obligations.

- The borrower not only must consider growth but also welfare effects of its borrowing policy.

Future Research

This study does not consider other important economic factors that have considerable impact on growth including

- Inflation
- Distributional effects
- Currency destabilization
- Recessionary periods caused by external shocks

This thesis considers a positive scenario in which the industrializing economy can execute per its plan, there are always chances of facing unforeseen shocks

THANK YOU!