# International Reserves Accumulation and Endogenous Growth*

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November 2010

**Abstract**

This paper investigates the interaction between capital flows and economic development in a dual-economy growth model. In the presence of a market failure in the allocation of resources between a traditional non-traded sector and a modern capital-intensive sector, a government can enhance welfare by a second-best policy that encourages investment and discourages consumption. If installing new capital is costly, then at low levels of development, inducing savings can take precedent over encouraging investment, leading to an inverted U-shaped schedule for government savings as a by-product of the policy. During the accumulation stage of development, labor is attracted to the modern sector, the real-exchange rate depreciates and growth is faster, in comparison to the laissez-faire equilibrium with free capital flows. In a North-South variation of the model, the implications of the South's second-best policy are a fall in the world interest rate and a welfare deterioration in the North.

## 1 Introduction

What has been the role of foreign capital in the process of economic development? This question has received considerable attention due to rising capital flows from the world's developing countries to its richest nations. Contrary to what one might expect, it seems that developing countries that use less foreign capital actually grow faster. This positive correlation–between current-account balances and growth rates–has

*I would like to thank Gene Grossman, Oleg Itskohki, Nobuhiro Kiyotaki and Esteban Rossi-Hansberg for helpful comments and suggestions. All errors are my own. I would also like to thank the International Economics Section at Princeton University for finanicial support. Email: shlomik@princeton.edu.

been graphed in figure 1 for 56 non-industrial countries between 1970 and 2007.[1] In fact, in an empirical investigation, Prasad, Rajan and Subramanian (2007) have found this relationship to be considerably robust for non-industrial countries but not to hold for industrialized ones.[2]

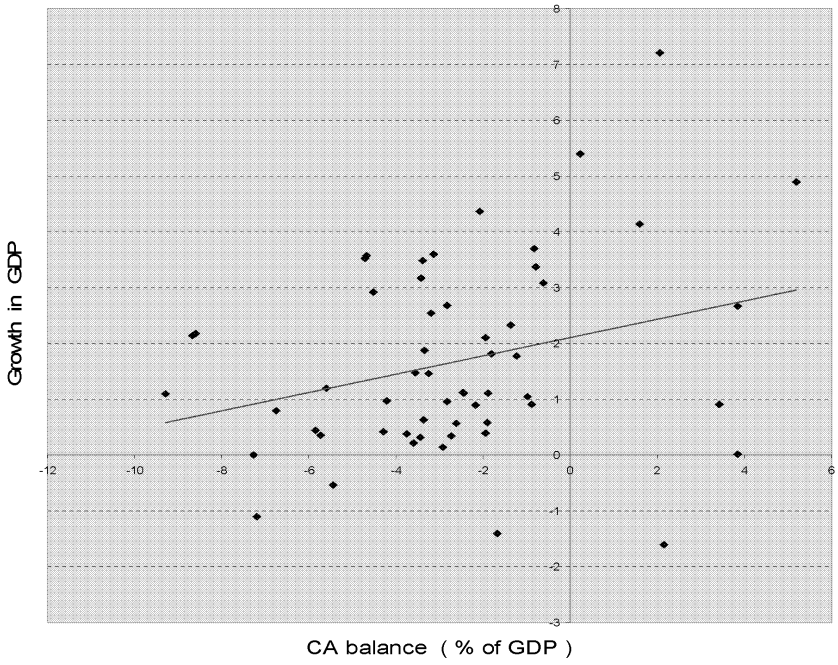


Figure 1. Growth and current-account balances in 56 countries

The most striking example of this phenomenon is the rapid accumulation of reserves assets by some of the fastest-growing, emerging-market economies. This trend that began its ascent in the 1990s and rapidly accelerated in the last decade, is presented in figure 2 for the major

[1] Current-account balances as a share of GDP were obtained from the World Bank's World Development Indicators database and growth rates of real GDP per-capita are from the Penn World Table. I based the sample of countries on Prasad, Rajan and Subramanian (2007) who divided a group of roughly 100 countries to industrial, transition and non-industrial economies. From the 59 non-industrial countries in their sample, I omitted 3 outliers for which the average current-account balance as a percent of GDP was lower than -10%. See figure 4 in their paper, which uses data from 1970 to 2004.

[2] This topic has also been studied by Gourinchas and Jeanne (2007), who find that developeing countries with faster productivity growth attract less foreign capital and dubbed this phenomenon as the allocation puzzle.

holding countries and regions.[3] For the most part, the world's greatest new creditors are the fast-growing emerging nations of Asia. This unprecedented rapid accumulation has been explained as a precautionary savings response to the Asian financial crisis of 1997.[4] Recently, it has been argued that these levels are excessive, and that the insurance motive alone cannot account for the surge in international reserves (see for example, Summers (2006) and Jeanne (2007)).

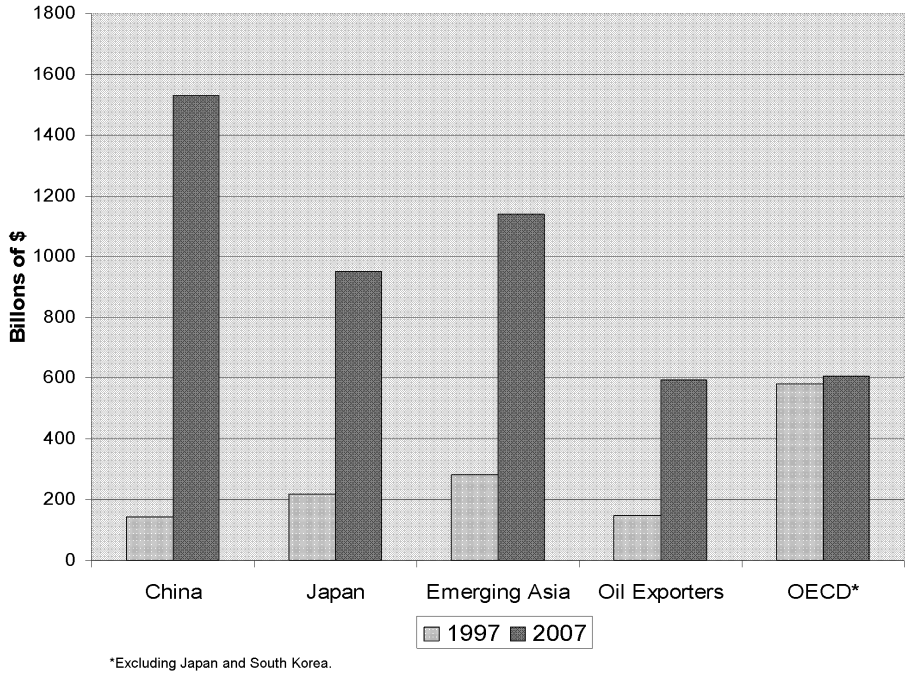


Figure 2. Total reserves minus gold

It is hard to ignore the role that governments of several emerging-market economies have played in the development of current account imbalances within the last decade. Consider the aggregate balance of payments of emerging-market economies in figure 3 and developing Asia

[3]The data were obtained from the World Bank's World Development Indicators database. The group of Emerging Asia consists of Hong Kong, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand and Vietnam. The OECD group excludes Japan and South Korea.

[4]A large stock of reserves can reduce the risk of financial turmoil from occurring and is useful during the management of a crisis. See Aizenman and Marion (2003), Obstfeld, Shambaugh and Taylor (2008) and Carroll and Jeanne (2009).

in figure 4.[5] The four columns for each year–consisting of the current-account balance, net foreign direct investment, other private capital flows and (the negative of) changes in reserves–roughly add up to zero, allowing one to examine their respective contribution over time. As current-account surpluses began to rise in emerging economies, they were mostly offset by accumulations of reserves, while net foreign direct investment and other private capital flows were smaller. The secondary role of FDI and other private capital flows in this build-up of imbalances is especially prominent in the sub-sample of developing Asia.[6]

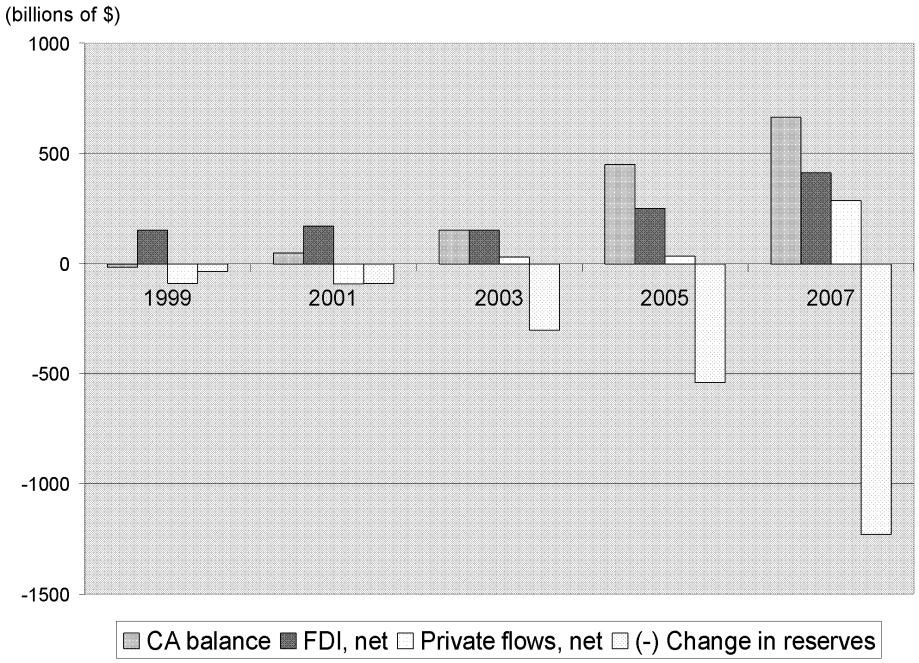


Figure 3. Aggregate balance of payments - emerging markets

Following Dooley, Folkerts-Landau and Garber (2005) and Rodrik (2008), I pursue a growth-based motivation for explaining these facts.

[5]Data obtained from the International Monetary Fund, World Economic Outlook Database, October 2009. The sub-sample of developing Asia excludes the newly industrialized nations: Hong Kong, Singapore, South Korea and Taiwan.

[6]While these patterns are dominated by the behavior of developing Asia, and China in particular, in some regions capital flows were very different in the last decade. For example, in Central and Eastern Europe rising current-account deficits were mostly balanced by private capital flows, as changes in reserves were less important. See Wolf (2008) for a detailed analysis.

This paper will investigate the interaction between capital flows and economic growth and examine potential government interventions in that context. I study a dual-economy variation of the Ramsey growth model, in which a government's foreign investment is rationalized as a development strategy.[7]

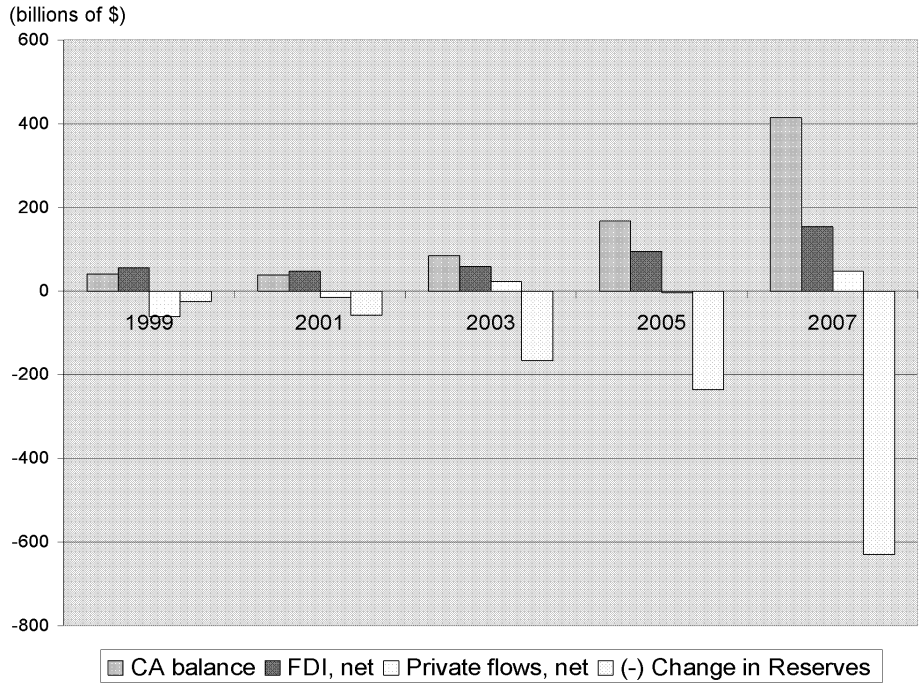


Figure 4. Aggregate balance of payments - emerging Asia

Capital accumulation is assumed to be the driving force behind economic growth, emphasizing the role of savings and investment, an appealing factor in the context of current-account imbalances. In this dual-economy model with a traditional non-tradable and labor-intensive sector and a modern tradable and capital-intensive sector, the interaction between growth and labor allocation is central. While capital accumulation leads to a rising share of employment in the modern sector, it is also reasonable to expect that the transition of labor from agriculture to industry will affect growth, as has been recently argued by Lucas (2009)

[7] A policy that results in the government's increased foreign lending will be interpreted as an accumulation of reserves assets. More on this interpretation in section 3.

and Rodrik (2009).[8]

Motivated by Arthur Lewis's dual-sector model of economic development (1954), I focus on the allocation of labor between sectors, as a potential source of inefficiency and an impediment to growth. It is assumed that productivity in the traditional sector is affected by the share of traditional employment and that firms do not take this effect into account. This feature creates a gap between marginal products across sectors and is based on two ideas: first, there are substantial economy-wide benefits to be gained from expanding the modern sector; and second, developing countries are prone to inefficiently allocating resources, especially at early stages of development. I chose to focus on the share of labor employed in the traditional sector as the source of the externality that leads to government intervention, because it clearly links the impact of the policy to the level of development; as the pool of underemployed labor is absorbed in the modern sector, the benefit of the policy diminishes. Moreover, this motivation seems especially relevant for emerging Asia and China, in particular.[9]

Government intervention can be justified when the market equilibrium fails to attain the optimal social outcome.[10] The paper analyses and compares two types of policies: a first best intervention that directly alters the incentives of producers in the two sectors and a second-best policy that addresses the market failure through government involvement in international capital markets. It will be shown that an indirect policy that encourages investment and discourages consumption can also raise welfare by affecting the sectoral allocation of resources and alleviating the market failure. The link between the pattern of consumption and labor allocation is a general-equilibrium feature of the model; reducing consumption, which is assumed to be a non-traded good, lowers the expenditure on non-traded traditional intermediates and consequently, attracts labor to the modern sector where its marginal product is greater. The reallocation of labor away from the non-traded sector

[8] Rodrik emphasizes the importance of developing a modern tradable sector: "The general lesson to be drawn from the experience of these post war growth champions [Japan, South Korea, and China] is this: High-growth countries are those that are able to undertake rapid structural transformation from low-productivity ('traditional') to high-productivity ('modern') activities. These modern activities are largely tradable products, and within tradables, they are mostly industrial ones." According to Lucas: "Migration out of traditional agriculture is a central element of growth, both as a consequence, and I believe, as a cause."

[9] A recent article on migration in China states that about 150 million rural residents migrated to cities in the last two decades, and another 300 million are predicted to follow in the next 20-30 years. See "Invisible and heavy shackles," *The Economist*, May 6th, 2010.

[10] See Bhagwati (1971).

alleviates the market failure and improves the current-account balance as a by-product since increased domestic production of traded, modern intermediates raises net exports. In contrast, inducing investment, which also alleviates the market failure, leads to the opposite effect on the current account. It is shown that at low levels of development, when the cost of investment is likely to be high, inducing savings takes precedent over encouraging investment and government lending thereby rises in order to reduce the sub-optimal level of international borrowing by the private sector. A mechanism that links the accumulation of reserves to the growth path of a developing economy can be used to study how such a process may come to an end and what are its implications on growth, the real exchange rate and the welfare of trading partners.

In practice, there are good reasons to believe that the second-best intervention would be preferred over the first-best optimal policy since it tends to be easier to implement successfully. In a dynamic business environment ripe with uncertainty and information asymmetry, designing the appropriate policy and updating it over time to meet changing conditions is quite challenging; fine-tuning targeted policies requires detailed knowledge and industry-specific expertise, which at times could be costly or unrealistic to obtain. For example, Klimenko (2004) provides a theoretical argument that explains why a partially-informed government might fail to "pick winners" among various sectors that differ in uncertain characteristics.[11]

In many cases, non-economic considerations might be at least as important in constraining the set of government instruments. Participation in the WTO limits the use of production subsidies in exporting industries, and the informal nature of the traditional non-tradable sectors in many developing economies prevents their effective taxation. In addition, special interest groups tend to exaggerate the benefits of sector-specific subsidies and lobby for their continuation even when they become irrelevant on economic grounds. Even though developing countries have extensively used industrial policies to promote specific "growth-enhancing" sectors since the 1950s, their success, even in the fastest-growing economies, is highly controversial.[12] Through their hard-earned

[11] Klimenko develops a stochastic model in which a government encourages the entrance of new firms in selective industries, through a process of experimentation and learning. He shows that the non-intervention outcome might be closer to the full-information social optimum than the targeting scheme of the government, which might steer the economy toward the "wrong industries," i.e. away from its true comparative advantage.

[12] A World Bank study on the East Asian growth miracle, published in 1993, was critical of industrial targeting: "Industrial policies to promote particular sectors, to determine the structure of the economy, and thereby to accelerate development and

experience, development policy in emerging Asia, has shifted toward less refined, second-best government interventions.[13]

The view that global imbalances are largely driven by the actions of governments in emerging Asia has been developed in a series of essays by Michael Dooley, David Folkerts-Landau and Peter Garber, and became known as "Bretton Woods II."[14] The authors describe a core-periphery global economic system, in which the periphery maintains undervalued exchange rates in order to stimulate export-led growth, consequently accumulating vast amounts of low-yielding international reserves.[15] These assets are issued by the core region that runs persistent current-account deficits and is happy to live beyond its means. The authors suggest two main motivations for the governments' pursuit of such a development policy: the first explanation, on which I have based my argument, emphasizes the desire of the periphery to eliminate excess labor in rural areas, which is underemployed by the standards of developed countries, and promote economic growth. Another motivation interprets the role of the international reserves assets as a collateral set against U.S. FDI flows to the periphery. The authors also suggest that this asymmetric system, which allows the core region to live beyond its means, eases the required shift in the U.S. labor force away from import substitutes

productivity growth failed to explain the region's rapid growth. State intervention was ineffective at best and counterproductive at worst." Quoted in Gilpin (2001); Gilpin also presented views contradicting the World Bank's assessment.

[13] Speaking at an EU-China summit in 2009, Wen Jiabo, the Chinese premier, provided a development motive for his country's exchange-rate policy: "We will maintain the stability of the renminbi at a reasonable and balanced level... Maintaining the basic stability of the renminbi exchange rate has benefited China's economic development and benefited world economic recovery." Quoted in "Wen labels renminbi pressure 'unfair,'" *Financial Times,* November 30th, 2009.

In another article about China's exchange-rate policy, the Chinese premier emphasized the job-creation responsibility of his government: "Mr. Wen said that the challange of job creation in the U.S. pales in comparison to the demands on Chinese leaders to generate tens of millions of jobs for farmers moving from the countryside to the cities and students entering the work force every year." Quoted in "Chinese Premier Pushes Back Against U.S. Criticism" *The Wall Street Journal,* September 23rd, 2010.

[14] For an alternative view on global imbalances, see Caballero, Farhi and Gourinchas (2008) and Mendoza, Quadrini and Rios-Rull (2009). These papers emphasize financial underdevelopment in emerging countries as a motive for channeling their savings to the advanced capital markets of the developed economies.

[15] Of course, the idea that exchange rate policy can be used to improve the competitiveness of the tradable sector is not new. Corden (1994) studies the effects of a devaluation in a short-term Keynesian framework where nominal policy instruments can have real effects. He provides a distributional motivation for depreciating the nominal exchange rate, aimed at favoring one sector at the expense of others. See also Bar-Ilan and Marion (2009) for a New-Keynesian perspective.

and discourages protectionism. Dooley et al. stress that the Bretton Woods II system is potentially sustainable since the gradual absorption of excess labor in the periphery can last for many years.[16]

This paper is most closely related to Rodrik (2008) and Korinek and Serven (2010). Rodrik provides evidence that undervaluation of the exchange rate promotes economic growth among developing countries. He also presents a two-sector AK growth model, in which both the tradable and non-tradable sectors suffer from distortions, but the distortion in the tradable sector is more severe. A policy that depreciates the exchange rate improves the inefficient allocation of resources between sectors and stimulates growth. In a similar model developed by Korinek and Serven, the source of the distortion is a learning-by-doing externality linked to the accumulation of capital.

My work differs in several ways: first, instead of using the real exchange rate as a policy instrument, the model directly deals with international capital flows, which allows it to capture the behavior of the accumulation of reserves over time. This feature also allows me to compare the second-best policy to the laissez-faire benchmark with free capital flows (among others). Second, the analysis focuses on the transitional dynamics of a developing economy and illustrates the interaction of capital flows and growth along the development path of the economy, rather than focusing on a steady-state phenomenon. The outcome of the government's policy is an inverted U-shaped path for the accumulation of reserves, accompanied by rapid growth and a depreciated real exchange rate before the peak and the opposite patterns after (in comparison to the laissez-faire benchmark). Third, I also consider a North-South variant of the model, which allows me to address the global implications of the policy.

Section 2 presents the dual-economy model in a two-period endowment setting. Its purpose is to describe the market failure in the allocation of labor between sectors and illustrate its relation to the level of development. This section also highlights the link between the pattern of consumption and the efficiency of resource allocation. Section 3 extends the dual-economy structure to an open-economy growth model. It describes the implementation of the government intervention scheme in a decentralized setting and simulates the model in various environments.

[16] In his book, *Global Imbalances and the Lessons from Bretton Woods*, Barry Eichengreen discusses the Bretton Woods II view and compares it to the original international monetary system that lasted from the late 1950s to the early 1970s. Eichengreen also emphasizes the differences between the two environments and argues that the dramatic changes that took place in the world economy since the 1960s make the current system less sustainable.

Section 4 presents a North-South variation of the model and investigates the implication of the second-best policy pursued by the South on the world interest rate, the welfare of the North and other variables. The final section concludes.

## 2 A Two-Period Model

This section introduces the dual-economy structure of the model in a simple two-period setup. Its main goal is to present the market failure in the allocation of labor between a modern traded sector and a traditional non-traded and labor-intensive sector and explain the interaction between the pattern of consumption and resource allocation. It will also be shown under what conditions a government intervention that influences the incentives to save can improve welfare by alleviating the sectoral misallocation of labor. The exposition of the two-period case is designed to facilitate its extension to a multi-period growth model with adjustment costs for investment, a task that will be taken up in sections 3 and 4.

In the Arthur Lewis model of economic development, the market failure arises from traditional production that is not driven by profit maximization. Lewis (1954) considers a two-sector model in which the traditional sector has an unlimited supply of labor that receives a subsistence wage which is lower than the wage in the modern sector. As long as there is a surplus of workers in the traditional sector, immigration of workers from agriculture to industry need not raise the wage in the modern sector. Eventually when capital accumulation catches up with population growth and all the surplus labor is absorbed in the modern sector, this process comes to an end and the traditional sector becomes competitive as well. This point has been termed by Ranis and Fei (1961) as the "end of the take-off stage."[17]

In this paper, firms are competitive and the market failure is a direct consequence of a negative externality that links the growth of traditional productivity to the level of employment in that sector. In poor economies, where a large portion of the labor force is employed in agriculture, simple production techniques are employed by workers who tend to be low skilled. As the share of employment in agriculture falls, more sophisticated techniques are adopted which in turn require more skilled workers. This interpretation of the externality follows Lucas (2009). In addition, I also assume that the strength of the externality decreases as more labor shifts to the modern sector and eventually disappears when a critical level of employment is reached, i.e. at the end of the take-off

[17] Quoted in Thirlwall (1994).

stage.

## 2.1 Setup of the Model

Consider a two-period, small-open economy. There are two primary factors of production, labor and capital, and the amount of labor $l$, is fixed over time and normalized to 1, while the level of capital $k$, is given for each period. Labor is employed in the production of traditional and modern intermediate goods, but only modern firms use capital. These intermediates are combined with imports to produce a unique final good that is used only for consumption. Both the traditional and consumption goods are non-traded, while intertemporal trade allows the domestic production of modern intermediates to diverge from domestic expenditure on them. Let the world price of traded intermediates be the numeraire.

In each period $t \in \{1, 2\}$, firms in the modern sector produce a modern good $x_t$, using the following constant returns to scale production function:

$$x_t = A_x k_t^{\alpha} l_{x,t}^{1-\alpha},$$

where $l_{x,t}$ is the share of labor employed in the sector at date $t$, $A_x$ is a productivity parameter and $\alpha \in (0, 1)$ is the share of capital in production. At each period, modern firms hire workers in order to maximize their profits, which are distributed to the agents as dividends, $d_t = x_t - w_t l_{x,t}$ (the price of a modern intermediate is 1). The first-order condition links the wage to the share of labor in the modern sector

$$w_t = (1 - \alpha) A_x \left( \frac{k_t}{l_{x,t}} \right)^{\alpha}. \tag{1}$$

A crucial feature in the model is the potential presence of an externality that distorts the allocation of labor between sectors. It is assumed that the productivity of traditional producers is affected by the share of employment in the sector and that firms do not take this effect into account. Traditional firms employ a share of $l_{z,t}$ of the labor force to produce a traditional good $z_t = A_{z,t} l_{z,t}$. Productivity in the sector is denoted by $A_{z,t}$, and is given by

$$A_{z,t} = \begin{cases} 1 & l_{z,t} < \bar{l} \\ 1 - \phi \left( l_{z,t} - \bar{l} \right)^2 & l_{z,t} \geq \bar{l} \end{cases}, \tag{2}$$

where $\bar{l} \in [0, 1]$ is a cut-off, above which the externality is present and the parameter $\phi$ determines the strength of the externality. This functional form is convenient since $A_{z,t}$ is continuous and differentiable at the

cut-off, which facilitates solving the model numerically.[18] However this specific form is not essential for the analytical results of the paper; the important aspect is that the inefficiency decreases as labor shifts to the modern sector. An additional intuitive assumption that will be useful later requires that the marginal product of labor in the traditional sector be non-negative. To sum up, the assumptions regarding the externality are[19]

$$\frac{\partial A_{z,t}}{\partial l_{z,t}} \leq 0; \quad \frac{\partial^2 A_{z,t}}{\partial l_{z,t}^2} \leq 0; \quad \frac{\partial z_t}{\partial l_{z,t}} \geq 0. \tag{3}$$

At each date, traditional firms take $A_{z,t}$ as given, so profit maximization and a zero profit condition imply the following expression for the wage as a function of the share of labor in the traditional sector

$$w_t = p_{z,t} A_{z,t}. \tag{4}$$

Note that the wage will be higher than the value of the marginal product of labor whenever $l_{z,t} > \bar{l}$, leading to the anticipated market failure in the allocation of labor. Alternatively, I could have assumed a learning-by-doing externality in the modern sector that is linked to the share of modern employment, which would have also resulted in a gap in the marginal product of labor across sectors.

As was mentioned above, the production of the final good also consists of imported intermediate goods. Let $z_t$ be the sum of domestically produced modern intermediates and imports $m_t$,

$$y_t = x_t + m_t. \tag{5}$$

The final good, $c_t$, is produced with a constant returns to scale technology that combines modern and traditional intermediates

$$c_t = \left( y_t^{\frac{\eta-1}{\eta}} + z_t^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \tag{6}$$

where $\eta > 1$ is the elasticity of substitution between modern and traditional intermediates. This restriction on $\eta$ ensures that labor will be drawn to the modern sector as it expands and implies that the intermediates are fairly substitutable. My preferred interpretation is that both the traditional and modern techniques produce consumption goods that

[18] In addition, the quadratic specification is not crucial, any exponent greater than 1 will ensure that $\partial A_{z,t}/\partial l_{z,t}$ is continuous at $\bar{l}$.

[19] The assumption that $\partial Z_t/\partial l_{z,t} \geq 0$, while easy to interpret, is only a sufficient condition. The analytical results below would follow with a weaker condition, see section 7.3 in the appendix.

domestic consumers perceive as similar, but the more capital-intensive modern intermediates satisfy higher quality standards that allow them to be internationally traded. The first-order condition, resulting from profit maximization of the final good producers, can be written in terms of the real exchange rate

$$\frac{1}{p_{z,t}} = \left(\frac{z_t}{y_t}\right)^{\frac{1}{\eta}}; \tag{7}$$

the relative price of modern to traditional intermediates is inversely linked to the levels of intermediates used in the production of the final consumption good. In addition, the price of the final good is $p_t = \left(1 + p_{z,t}^{1-\eta}\right)^{1/(1-\eta)}$.

The economy is populated by identical agents that own labor and financial assets. At each period, agents supply labor inelastically in exchange for wage $w_t$, and receive dividends $d_t$, from firms in the modern sector. Agents can also lend or borrow at a given interest rate $R$. Let $B$ denote the aggregate savings held by agents in the first period. Agents take prices as given and maximize the following utility function:

$$U = \frac{c_1^{1-\theta} - 1}{1-\theta} + \beta \frac{c_2^{1-\theta} - 1}{1-\theta},$$

where $\beta < 1$ is the time preference parameter and $1/\theta > 0$ is the intertemporal elasticity of substitution. The aggregate budget constraints for the two periods are

$$p_1 c_1 + B = w_1 + d_1;$$

$$p_2 c_2 = w_2 + d_2 + RB.$$

In the first period agents' income from wages and dividends is spent on consumption and savings, while in the second period income (including accumulated savings) is used only for consumption. The solution to the optimization problem results in an Euler equation

$$\frac{c_2}{c_1} = \left(\beta R \frac{p_1}{p_2}\right)^{\frac{1}{\theta}}, \tag{8}$$

which relates the consumption pattern to the relative price of the consumption good over time, the interest rate, the time preference parameter and the intertemporal elasticity of substitution.

## 2.2 Competitive Equilibrium

The equilibrium consists of a set of prices and quantities, such that consumers maximize their utilities subject to their budget constraints, producers optimize and earn zero profits (after dividends) and markets clear. Since $k_1$ and $k_2$ are given, solving the two-period case will require four equations in the labor allocation and consumption for both periods. The period $t$ equilibrium allocation of labor is obtained by equalizing the expressions relating the wage to labor in each sector, with the labor market clearing condition $l_{x,t} + l_{z,t} = 1$, and the first order condition of the final good (see equations 1, 4 and 7). The result is an implicit equation in the share of labor employed in the modern sector, consumption and capital

$$F_t\left(l_{x,t}, c_t, k_t\right) = z p_{z,t}^{\eta} - y_t = 0. \tag{9}$$

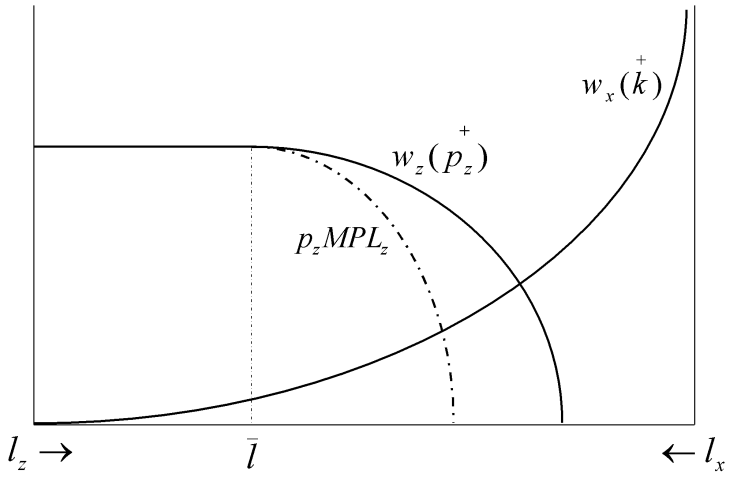


Figure 5. Market failure in the allocation of labor

The labor allocation corresponds to the intersection of the wage schedules, diagramed in figure 5. The horizontal axis measures the total labor endowment, which is divided between the traditional sector (measured from the left corner) and the modern sector (measured from the right corner). Wage in the modern sector (equation 1) is upward-sloping, while the second schedule is the wage in the traditional sector (equation 4) graphed for a fixed price of the traditional good. Note that the traditional wage schedule is decreasing only beyond the cut-off

$\bar{l}$, where the negative externality is present and the wage is higher than labor's marginal product in that sector (the dashed line). In the diagram, the intersection point was drawn to the right of the cut-off, but if the level of capital is high enough then the marginal product of labor in the modern sector would rise and intersect the other schedule left of the cut-off, where marginal products are equal. Similarly, in a partial-equilibrium analysis, a rise in the price of the traditional good will shift the traditional wage schedule up, raising the equilibrium wage and increasing the share of employment in the traditional sector. This relation implies that in general equilibrium, consumption and the allocation of resources are determined simultaneously; an increase in demand for the non-traded consumption good in a certain period, will raise the relative price of the traditional to modern intermediates and draw resources to the non-traded traditional sector.

The behavior of consumption is described by the agent's Euler equation and intertemporal budget constraint. Combining the zero profit condition of the final good producers $p_t c_t = y_t + p_{z,t} z_t$, with the expressions for dividends and net imports allows one to restate the agent's intertemporal budget constraint as follows:

$$x_1 - y_1 + \frac{x_2 - y_2}{R} = 0, \tag{10}$$

implying that in equilibrium the discounted sum of exports is zero. All period $t$ variables can be expressed in terms of that period consumption and capital. Since capital levels are given, this condition together with the Euler equation determine equilibrium prices and quantities. It is important to note that international lending and borrowing allows for some flexibility in determining the labor allocation and the consumption pattern. Therefore, intertemporal trade, motivated by the desire to smooth consumption, has an additional role in affecting labor allocation which is expected to be inefficient at early stages of development.

## 2.3 Efficiency and Government Intervention

It is convenient to start the analysis by first considering the case of a closed economy, since the link between the inefficiency of the market equilibrium and the level of development of the economy is more transparent, as stated in

**Proposition 1** *In a closed economy there exists a unique cutoff $\overline{k}$ such that if and only if $k_t < \overline{k}$, then the market allocation of labor across sectors at period t is inefficient.*

In a closed economy, the interest rate, denoted by $R^A$, adjusts to ensure that, in each period, the expenditure on traded intermediates is

equal to the domestic production of the modern sector. Consequently, consumption and labor allocation depend on the level of capital (see section 7.2 in the appendix for details). The cutoff $\overline{k}$ is the level of capital that uniquely corresponds to $\overline{l}$, the point that determines whether the externality exists and if the equilibrium is efficient or not.

Figure 5 suggests the nature of potential policies that could alleviate the market failure. The negative externality leads to a market equilibrium in which the wage is higher and the share of modern employment is lower than what is socially optimal. By raising the relative price of modern to traditional intermediates ($1/p_{z,t}$), it is possible to directly compensate for the effect of the negative externality, to reallocate labor to the modern sector and to achieve the optimal allocation. This outcome can be achieved (also in an open economy) by a first-best policy that taxes the traditional intermediate good and subsidizes the modern good, which in effect depreciates the real exchange rate.

As was emphasized in the introductory section of the paper, it seems plausible that a government of a developing economy could be constrained in its choice of policy instruments. In an open-economy with intertemporal trade, the government's ability to influence the incentives of agents to save can partially compensate for its assumed inability to directly affect the incentives of producers. A successful intervention would introduce a distortion that will diminish the inefficient underemployment in the modern sector. For instance, discouraging consumption at a given period will lower the domestic demand for traditional and modern intermediates. As a consequence, the wage falls as does the price of traditional intermediates (implying a depreciation of the exchange rate), which like the consumption good are also non-traded. It follows that labor shifts to the tradable sector, where the additional resources can be used in the production of modern intermediates either for exports or to replace imports. Similarly, the figure also suggest that a rise in the level of capital would also alleviate the market failure, therefore a potential indirect policy, in the dynamic setting of the next section, would be to subsidize investment.[20]

[20] It can be shown that

$$\frac{\partial l_{x,t}}{\partial c_t} < 0; \quad \frac{\partial l_{x,t}}{\partial k_t} > 0,$$

since the partial derivatives of $F\left(l_{x,t}, c_t, k_t\right)$ satisfy

$$F_c < 0; \quad F_k > 0; \quad F_l < 0. \tag{11}$$

See section 7.3 in the appendix for details.

In an open economy, whenever the externality is present, the pattern of consumption has an additional influence on welfare through its interaction with labor allocation. A natural case to consider in the two-period model is the transition of an economy from a developing stage to a developed one, as presented in

**Proposition 2** *Suppose that $k_1 < \overline{k} < k_2$ and $R \leq R^A$, then the government of a small-open economy can raise welfare by encouraging consumption in the second period at the expense of first period consumption.*

The conditions of the proposition ensure that the negative externality would be present in the first period and absent in the second. A policy that discourages consumption in the development period and encourages it in the developed period can be welfare improving since it attracts resources to the modern sector when they are needed to alleviate the market failure and draw them away when it is less costly. While agents will be inclined to borrow when they are poor, they neglect the general-equilibrium relation between consumption and labor allocation that contradicts their desire to smooth consumption. Note that the conditions in proposition 2 are not necessary for the government policy to be welfare improving. In fact, only when both $k_1$ and $k_2$ are greater than $\overline{k}$, is there no place for government intervention. This point would be further elaborated in the next section.

Finally, it is important to note the necessary structure the economy must have to obtain the result above: the labor-intensive sector is non-traded, the capital-intensive sector is traded and that the final good is non-traded, so that labor will be drawn to the traded sector when consumption is discouraged. If, for example, the labor-intensive sector of a developed economy supplies traded goods, while the world demand for the products of the capital-intensive sector are negligible, then this result would be reversed. This case might be plausible for commodity exporters, but seems less likely for emerging Asia.

# 3 A Dual-Economy Growth Model

This section incorporates the dual-economy setup of the previous section in a multi-period growth model with adjustment cost for investment based on Abel and Blanchard (1983). Considering adjustment costs is needed in this open-growth model in order to prevent an unrealistic instantaneous convergence of the capital stock. By slowing down the pace of capital accumulation, the development stage is characterized by an inefficient allocation of resources which motivates intervention policies.

The model is solved and simulated under three scenarios, laissez-faire, first-best and second-best government intervention, and the implications of the government's policy on the development process of a small-open economy are studied. In the second-best scenario the government's policy involves participation in international capital markets. Under certain conditions such an intervention results in a build up of government savings during early stages of development followed by a de-accumulation process later on. This process is interpreted as an accumulation of international reserves and is a by-product of the government's desire to discourage consumption. This interpretation–in the context of a long-term, perfect-foresight model–side steps the opportunity cost that is typically associated with holding highly-liquid and low-risk international reserves assets. However, in recent years many of the largest reserves hoarders have diversified their holdings to less liquid and more long-term investments, usually managed by sovereign wealth funds.[21]

## 3.1 Description and Equilibrium

The first modification involves the extension of the agent's consumption and savings decision to a multi-period setting. Consider a small-open economy in which agents maximize utility $U$, derived from their consumption over an infinite time horizon,

$$U = \sum_{t=1}^{\infty} \beta^{t-1} \frac{c_t^{1-\theta} - 1}{1-\theta},$$

given the following period $t$ budget constraint

$$p_t c_t + B_t = w_t + d_t + R_{t-1} B_{t-1},$$

where $R_t$ is the interest rate at date $t$. Throughout most of this section, I will focus on the small-open economy case in which the interest rate is equal to the fixed and given world interest rate. However, I will also discuss the closed economy case and a two-country model (in the next section) where the interest rate is endogenous.

The solution to the dynamic optimization problem results in an Euler equation (replacing equation 8) and a transversality condition

$$\frac{c_{t+1}}{c_t} = \left( \beta R_t \frac{p_t}{p_{t+1}} \right)^{\frac{1}{\theta}}; \tag{12}$$

[21] See Rozanov (2005) for more details on the rising importance of sovereign wealth funds.

$$\lim_{t\to\infty}\frac{B_t}{\overline{R}_1^t}=0,$$

where $\overline{R}_t^T=\prod_{t'=t}^{T-1}R_{t'}$ is the discounted value of date $T$ income evaluated at $t$ (so $\overline{R}_t^t=1$).

The only substantial change with respect to the previous section is the process of capital accumulation. Capital $k_t$, is owned by firms in the modern sector who at each period make an investment decision denoted by $I_t$. Abstracting from capital depreciation, the next period capital stock is given by

$$k_{t+1}=k_t+I_t. \tag{13}$$

The cost of investment is borne in units of the numeraire and is assumed to be convex in $I_t$ and decreasing in $k_t$, with the following typical quadratic specification: $I_t\left(1+bI_t/2k_t\right)$, where $b>0$. Firms produce modern intermediates, hire labor and invest in order to maximize the present value of profits and distribute all their cash flows to the agents at each period as dividends, $d_t=x_t-w_tl_{x,t}-I_t\left(1+bI_t/2k_t\right)$. As is common in investment problems with adjustment costs, it is convenient to set up the firms' optimization problem using Tobin's q as the discounted Lagrange multiplier:

$$L=\sum_{t=1}^{\infty}\frac{\left[x_t-w_tl_{x,t}-I_t\left(1+\frac{b}{2}\frac{I_t}{k_t}\right)+q_t\left(k_t+I_t-k_{t+1}\right)\right]}{\overline{R}_1^t}.$$

Solving this problem leads to the following first order conditions (with respect to $l_{x,t}$, $I_t$ and $k_{t+1}$):

$$w_t=\left(1-\alpha\right)A_x\left(\frac{k_t}{l_{x,t}}\right)^{\alpha};$$

$$I_t=\frac{q_t-1}{b}k_t;$$

$$q_t=\frac{q_{t+1}+\alpha A_x\left(\frac{l_{x,t+1}}{k_{t+1}}\right)^{1-\alpha}+\frac{b}{2}\left(\frac{I_{t+1}}{k_{t+1}}\right)^2}{R_t}; \tag{14}$$

and a transversality condition,

$$\lim_{t\to\infty}\frac{q_t}{\overline{R}_1^t}=0. \tag{15}$$

The first order condition with respect to the share of modern employment equates the wage to the marginal product of labor (identical to equation 1 from the previous section) and the second equation shows that investment is positive only when the shadow price of installed capital is greater than 1. The third condition describes the optimal evolution of Tobin's q; the date $t$ shadow price of capital is equal to the sum of the shadow price of capital in the next period, the next period marginal product of capital and the marginal contribution of capital to reducing next period adjustment costs, all divided by the interest rate.

No modifications are required in the traditional sector or in the production of the final good, since these firms operate in an environment that is essentially static (equations 2-4, 6 and 7 are unaltered). The only exception is with regards to the tradable market-clearing condition, which now also includes the cost of investment, so

$$y_t = x_t - I_t \left(1 + \frac{b}{2}\frac{I_t}{k_t}\right) + m_t, \tag{16}$$

replaces equation 5.

The next step is to characterize the market equilibrium. In each period, all the variables can be expressed as functions of the capital stock, the level of consumption and Tobin's q. The equilibrium condition that determines the labor allocation (equation 9) is unaltered. Combining the zero profit condition of the final good producers with the consumer's aggregate budget constraint and the expressions for dividends and net imports (equation 16) yields the following period $t$ balance of payments:

$$B_t - R_{t-1}B_{t-1} = -m_t,$$

which states that the increase in savings is equal to exports. The equation above allows one to restate the intertemporal budget constraint in terms of net imports

$$\lim_{T\to\infty} \sum_{t=1}^{T} \frac{m_t}{R_1^t} = 0, \tag{17}$$

which is a function of $\{k_t, c_t, q_t\}_{t=1}^{\infty}$. This last equation is the counterpart of the two-period condition given by equation 10.

The model's dynamics are governed by a system of three difference equations, consisting of the Euler equation, the resource constraint and the difference equation in q (see equations 12, 13 and 14 above). To sum up, given an initial level of capital and the two transversality conditions (see equations 15 and 17), this system of difference equations together with the labor market equilibrium condition can be solved for the time

paths of $l_{x,t}$, $c_t$, $k_t$, $q_t$ and the rest of the variables in the model. Given a set of parameters ($A_x$, $\alpha$, $\beta$, $\eta$, $\phi$, $\theta$, $b$, and $\bar{l}$), a "shooting" algorithm can be used to compute the equilibrium.[22]

## 3.2 The Steady State and Transitional Dynamics

An important feature in this paper is the interaction between consumption and labor allocation, which manifests itself in a dynamic setting, in the nature of the steady state. In the open-economy model, the long run values of the capital stock, the share of modern employment and consumption depend on the development path of the economy. If an economy starts from a relatively low level of capital and is relatively inclined to borrow, then its long-run consumption will have to be relatively low in order to meet its obligations to creditors. Because the steady state level of capital is inversely related to steady-state consumption, it depends on the pattern of consumption, which in turn, depends on the initial level of capital as well as on the elasticity of intertemporal substitution.

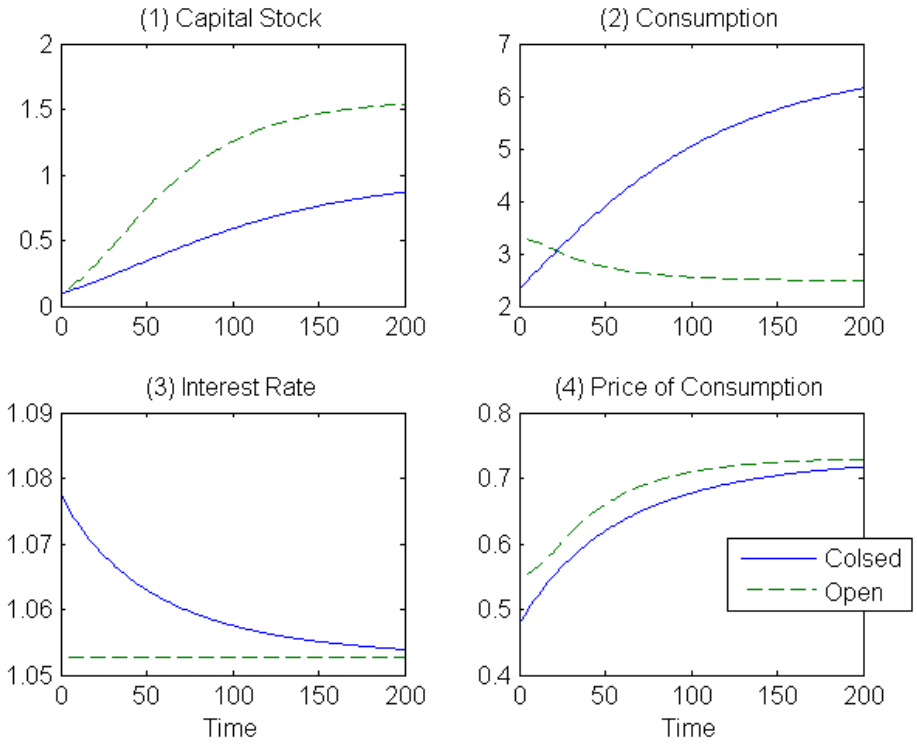


Figure 6. Comparison between Open and Closed economies

[22]For more details on the shooting algorithm, see Ljungqvist and Sargent (2004).

In the open-economy steady state, the equilibrium conditions described above are consistent with various combinations of $l_{x,ss}$, $k_{ss}$ and $c_{ss}$ that are constant over time (I focus on the case where $\beta R = 1$, so that consumption approaches a constant positive level in the long run). This indeterminacy does not mean that the steady state is not unique. Each potential steady state corresponds to a different level of long-run imports, and the steady state is the unique combination for which the long-run discounted sum of imports is zero. However, unlike the closed-economy steady state, it is path dependent (see the appendix for more details).

In order to illustrate the effect of international lending and borrowing on the long run level of capital, consider figure 6, which compares the transitional dynamics of two economies with the same characteristics, except that one is closed and the other is open.[23] Access to international capital markets allows a country to borrow at early stages of development when its production is low. Consequently, its long run exports will have to be positive in order to meet its repayment obligations, implying a higher steady-state level of capital (and labor) and lower long run consumption than in a closed economy, as can be seen in the first two panels of the figure. Note also that the open economy's capital stock grows much faster as it is able to invest more due to the lower level of the interest rate (panel 3). An additional difference between the two economies is the pattern of consumption. The declining path in the open economy is a consequence of the rising price of the consumption good (panel 4) and a constant interest rate, while in the closed economy, the declining interest rate outweighs the price effect, leading to a rising consumption trajectory.[24]

The first two panels of figure 7 compare the time paths of the capital stock and net exports for two small and open economies whose initial level of capital is different, but are otherwise identical. The vertical axis of panel 1 measures the level of capital as a fraction of the steady-state capital level of a closed economy. Both economies approach higher steady-state levels than a closed-economy, with the one starting from a lower level coming on top. Higher levels of capital support a larger share of employment in the modern sector and greater net exports as can be seen in panel 2. A possible interpretation of this result relates the

[23] In the first example (figure 6) I used: $A_x = 0.5$, $\alpha = 0.6$, $\beta = 0.95$, $\eta = 2$, $\phi = 2$, $\theta = 1$, $b = 10$, $\bar{l} = 0.5$ and $k_1^A = k_1^B = 0.1k_{ss}$. In the second example (panels 1 and 2 of figure 7), I changed the initial level of capital in the second economy: $k_1^A = 0.1k_{ss}$ and $k_1^B = 0.5k_{ss}$. In the third example, I used: $\theta^A = 1/5$ and $\theta^B = 5$. The choice of parameters will be discussed at greater length in the Growth Dynamics subsection.

[24] This trend can be reversed by adding technological improvement to the model which will put downward pressure on consumption's price over time.

timing of a country's decision to open up to capital flows to its long-run, steady-state levels.

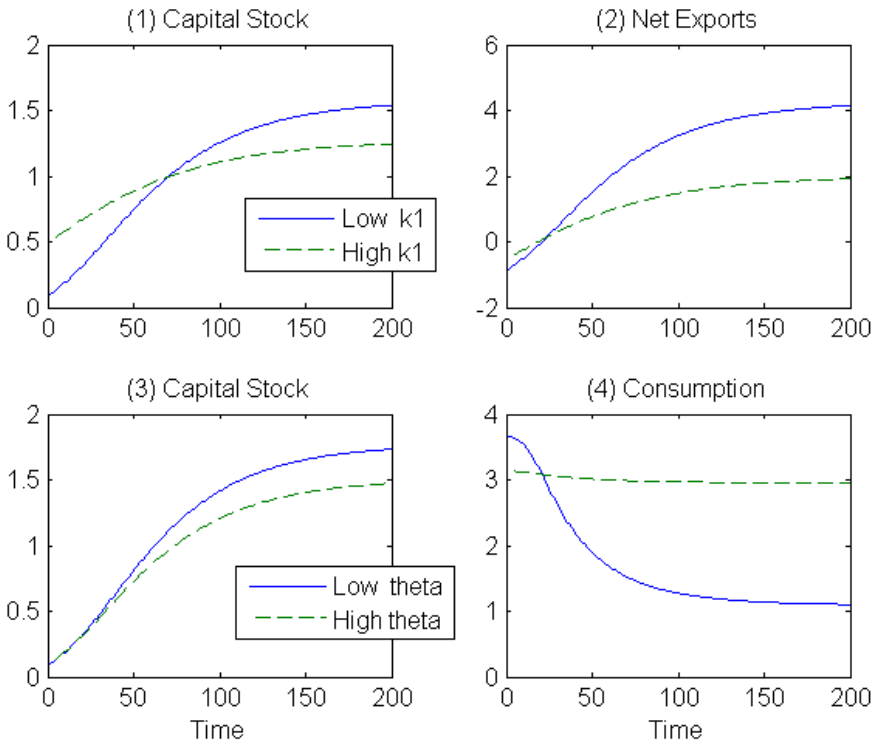


Figure 7. Various parameters in the Open economy

Another similar implication links the steady state levels to the willingness of agents to smooth consumption. Panels 3 and 4 of figure 7 display capital and consumption over time for two open economies that differ only in their intertemporal elasticity of substitution ($1/\theta$). Panel 3 is analogues to panel 1 and shows that both open economies reach higher levels of capital than a closed economy (for which the value of $\theta$ is immaterial) and that the low-theta economy goes further. Since the price of the labor-intensive consumption good is upward sloping, agents with low-theta borrow more in order to take advantage of price differentials, resulting in lower long-run consumption as in panel 4.

These predictions contrast those of one-sector open growth models, in which an economy converges to the long run closed-economy level of capital. In one sector models (or in two-sector models with a Cobb-Douglas aggregate production function) consumption and production decisions are independent. The path-dependence property is a consequence of the relation between agent's borrowing decision and the allocation of resources. Note that the existence of the externality is not relevant for

this result. It is the dual-sector structure of the model and the CES production function of the final good in particular, that link the sectoral allocation of labor to the level of capital and the pattern of consumption.

## 3.3 Government Intervention

The main purpose of this section is to derive potential policies that can alleviate the market failure, study their implementation, compare them to the laissez-faire benchmark and investigate their implications. The analysis involves solving a Ramsey problem, in which a benevolent social planner can choose the equilibrium allocation directly in order to maximize welfare while facing certain constraints. In the first-best environment, there is only an intertemporal borrowing constraint and the social planner can enhance welfare by directly addressing the misallocation of labor. In the second-best environment, an additional constraint is introduced–the labor market equilibrium condition holds. This setup corresponds to a situation where the government cannot directly affect the incentives of producers by using sector-specific taxes or subsidies. Yet the government can still improve welfare by affecting the savings and investment decisions of agents and firms. While both policies have similar effects on the main variables of interest (i.e. labor allocation, consumption, net exports, the real exchange rate, etc.), the implementation of the second-best policy involves intervention in capital markets and under certain conditions might result in reserves accumulation.

### 3.3.1 First-Best Policy

Consider a social planner that maximizes utility $U$, subject to the resource constraint. Since the planner operates in an open-economy environment an additional borrowing constraint that requires a nonnegative discounted sum of net exports has to be imposed. Let $G_t$ denote net exports (i.e. $G_t = -m_t$) and the intertemporal budget constraint can be written as follows:

$$\sum_{t=1}^{\infty} \frac{G_t\left(l_{x,t}, c_t, I_t, k_t\right)}{\overline{R}_1^t} \equiv \sum_{t=1}^{\infty} \frac{x_t - I_t\left(1 + \frac{b}{2}\frac{I_t}{k_t}\right) - y_t}{\overline{R}_1^t} \geq 0. \qquad (18)$$

The Lagrangian of the social planner's optimization problem is

$$L = \sum_{t=1}^{\infty}\left[\beta^{t-1}\frac{c_t^{1-\theta}-1}{1-\theta} + \lambda_{k,t}\left(k_t + I_t - k_{t+1}\right) + \frac{\lambda_G}{\overline{R}_1^t}G_t\right],$$

where $\lambda_{k,t}$ is the shadow price of the period $t$ resource constraint and the multiplier $\lambda_G$ corresponds to the borrowing constraint above.

The solution to this optimization problem is identical to the market equilibrium with one exception, it involves a modified labor-market equilibrium given by

$$(1-\alpha)\,A_x\left(\frac{k}{l_x}\right)^{\alpha}=\left(\frac{y}{z}\right)^{\frac{1}{\eta}}\left(A_z+l_z\frac{\partial A_z}{\partial l_z}\right) \tag{19}$$

This condition ensures that the marginal product of labor in the modern sector (on the left) is equal to the marginal product of labor in the traditional sector, and substitutes for equation 9. Intuitively, the optimal allocation internalizes the negative effect of the externality, therefore, no changes are required in the behavior of consumption or investment.

### 3.3.2 Second-Best Policy

The second-best policy is interpreted as the optimal allocation given an additional constraint that holds every period–the labor market equilibrium condition. The implied assumption is that the government cannot use direct policy instruments, such as sector-specific subsidies or taxes, to affect the labor allocation. The Lagrangian of the social planner's optimization problem becomes

$$L=\sum_{t=1}^{\infty}\left[\beta^{t-1}\frac{c_t^{1-\theta}-1}{1-\theta}+\lambda_{k,t}\left(k_t+I_t-k_{t+1}\right)+\lambda_{F,t}F_t+\frac{\lambda_G}{R_1^t}G_t\right],$$

where $\lambda_{F,t}$, the multiplier associated with the new constraint, represents the marginal value for the social planner of a marginal relaxation of the labor market equilibrium condition at period $t$. The solution of this problem involves modified behavior for consumption and investment as given by the following equations (replacing equations 12 and 14):

$$\frac{c_{t+1}}{c_t}=\left(\beta R_t\frac{p_t}{p_{t+1}}SB_t^C\right)^{\frac{1}{\theta}}, \tag{20}$$

$$q_{t+1}+\frac{1}{2b}\left(q_{t+1}-1\right)^2+\alpha A_x\left(\frac{l_{x,t+1}}{k_{t+1}}\right)^{1-\alpha}+SB_{t+1}^I=R_tq_t, \tag{21}$$

where the extra terms denoted by $SB_t^C$ and $SB_{t+1}^I$ link the patterns of consumption and investment to the allocation of labor.[25]

[25] The extra terms are given by

$$SB_t^C=\frac{F_{l,t+1}}{F_{l,t}}\left(\frac{G_{l,t}-F_{l,t}}{G_{l,t+1}-F_{l,t+1}}\right);$$

The next proposition summarize the characteristics of the modified consumption and investment equations.

**Proposition 3** *If condition 3 holds then the second-best equilibrium satisfies:*

*(I)*

$$\frac{\lambda_{F,t}}{R_t} > \lambda_{F,t+1} \Longleftrightarrow SB_t^C > 1.$$

*(II)*

$$l_z > \bar{l} \Longrightarrow SB_{t+1}^I > 0;$$
$$l_z \leq \bar{l} \Longrightarrow SB_{t+1}^I = 0.$$

Postponing consumption between consecutive periods, which corresponds to $SB_t^C > 1$, is beneficial if the marginal value of relaxing the labor-market equilibrium condition in period $t$ is greater than the marginal value of relaxing that condition in the next period multiplied by the interest rate and vice versa. Discouraging consumption of the non-traded final good can be helpful, since it raises the demand for modern, traded intermediates and indirectly shifts labor to the modern sector, which alleviates the market failure. Relaxing the labor-market equilibrium conditions at early stages of development is desirable since the market failure is especially severe. This result will be illustrated in the next subsection.

Turning to investment, the government subsidizes investment as long as the negative externality is present. The policy's effect on investment can be understood by solving forward for Tobin's q and applying the relevant transversality condition,

$$q_t = \sum_{\widetilde{t}=t+1}^{\infty} R^{t-\widetilde{t}} \left[ \alpha A_x \left( \frac{l_{x,\widetilde{t}+1}}{k_{\widetilde{t}+1}} \right)^{1-\alpha} + \frac{b}{2} \left( \frac{I_{\widetilde{t}+1}}{k_{\widetilde{t}+1}} \right)^2 + SB_{\widetilde{t}+1}^I \right].$$

The value of installed capital equals a discounted sum with three components, the future marginal product of capital in the modern sector, the marginal contribution to lowering future installation costs (the second term in the brackets) and the extra term $SB_{t+1}^I$, which captures the additional contribution of increasing the capital stock to alleviating the

$$SB_{t+1}^I = -\frac{G_{l,t+1}F_{k,t+1}}{F_{l,t+1}}.$$

market failure during the development stage. The fact that the social planner encourages investment beyond the market value during the development stage is intuitive, since the accumulation of capital reduces the inefficiency in the allocation of labor.

The time paths of $l_{x,t}$, $c_t$, $k_t$ and $q_t$ can be obtained by a shooting algorithm using the modified Euler equation and the difference equation in $q$ (equations 20 and 21 above), the resource constraint and the labor market equilibrium condition (which are unaltered, see equations 13 and 9) and the transversality conditions (equations 15 and 17). After obtaining the constrained optimal allocation $\left\{l^*_{x,t},\ c^*_t,\ k^*_t,\ q^*_t\right\}$, as well as the rest of the prices and quantities, it is straight forward to recover the consumption taxes $\{\tau^*_t\}$ and investment subsidies $\{s^*_t\}$ that could be used by a government to implement this allocation in a decentralized environment (see the appendix for more details).

To sum up, in the absence of policy instruments that directly address the misallocation of labor, welfare can be improved by encouraging investment at early stages of development and by modifying the path of consumption. A higher level of capital raises the marginal product of labor in the modern sector and attracts labor to it. In general equilibrium, resource allocation is also linked to the path of consumption. Therefore, discouraging consumption of the non-traded final good can be beneficial (when the marginal value of relaxing the labor market equilibrium condition is relatively high) since it raises the demand for modern, traded intermediates and shifts labor to the modern sector where its marginal product is greater.

## 3.4 Growth Dynamics and Reserves Accumulation

In order to illustrate the effects of government intervention on the growth path of a developing economy, the model is simulated under the various scenarios, but primarily focuses on the comparison between the market equilibrium with no government intervention and the second-best policy. While the implications of the first-best and second-best policies are similar as was discussed in the previous section (and will be shown in the next subsection), the second-best policy involves government participation in capital markets. Because the income received from consumption taxes and the cost of subsidizing investment need not balance at every period, it is likely that the implementation of the second-best policy would require additional lending or borrowing by the government. Whether this policy will result in the accumulation of reserves (i.e. positive government saving) depends on the balance between the benefits of discouraging consumption and encouraging investment.

Government lending arises when the cost of investment is relatively

high (i.e. a high adjustment cost parameter $b$ and a low initial level of capital, $k_1$). In addition, the policy's effects would be significant, if agents are inclined to deviate from a smooth consumption path (low $\theta$) and the externality is sizeable (high $\phi$). The choice of parameters reflect these considerations. The time preference parameter was set to $\beta = 0.95$. In order for labor to shift to the modern sector as it expands, the elasticity of substitution between the traditional and modern sector has to be greater than 1, it was set to $\eta = 2$. The intertemporal elasticity of substitution is 5 (so $\theta = 1/5$) and the adjustment cost parameter is $b = 10$, both parameters are relatively high. The initial level of capital was set to 5% of the open-economy steady state. In assigning values to the capital share and the productivity parameter in the modern sector, my main concern was to allow for a large range of modern employment levels along the growth path. High values of $A_x$ and $\alpha$ lead to a high share of modern employment in the steady state, whereas a low value of $A_x$ contributes to high traditional employment at the initial level of capital. Choosing $A_x = 0.5$ and $\alpha = 2/3$ allows for 80% of the labor force to migrate between sectors throughout the growth process.[26] Lucas (2009) uses data by Kuznets (1971) to show that the employment shares in agriculture in the US, for example, fell from above 80% to below 10% over the course of roughly a century and a half, while in Japan this process, which started almost a century later, took about 120 years. The last two parameters concern the externality. The cut-off, which determines when the externality ceases to exist, was set to $\bar{l} = 0.5$. The U.K. was well above this level already in 1800 while the U.S. passed it around 1880. The cost coefficient was set to $\phi = 2$. This last value is sufficient to generate sizeable reserves accumulation and implies a rather modest $A_{z,1} \simeq 0.85$, in comparison to $A_z = 1$ when $l_z \geq \bar{l}$.

Figure 8 presents the long-run time paths of capital, consumption, share of employment in the modern sector and productivity in the traditional sector in a laissez-faire, small-open economy. When comparing the paths of capital and labor (panels 1 and 3), labor converges much faster to its long-run value; in less than 50 periods employment in the modern sector increased from less than 20% to more than 80%, while capital rose to only 40% of its steady state level (with a higher elasticity of substitution between intermediates this result would be even more

[26] The share of capital in production is usually assigned one of two values, $\alpha = 3/4$ according to a broad definition of capital and $\alpha = 1/3$ for a narrow definition of mainly physical capital. In this model $\alpha = 1/3$ allows for a very small migration of workers, while $\alpha = 3/4$ is satisfactory. However, I prefer lower values ($0.6 \leq \alpha \leq 0.7$) in order to speed up the convergence, which is relatively slow due to high adjustment costs.

skewed). This early period of development is of particular interest since there is scope for government intervention only when modern employment is below 50% (which is reached at $t \simeq 16$) and implied productivity in the traditional sector is below 1 (see panel 4). Note how quickly the effect of the externality diminishes, a consequence of the quadratic functional form of $A_z$.

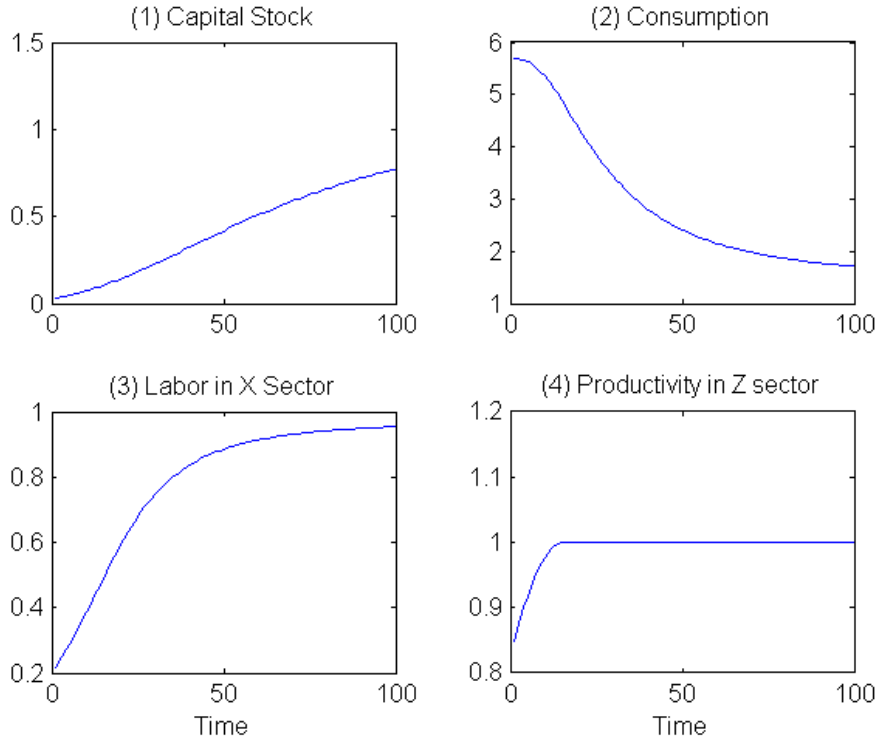


Figure 8. Laissez-faire dynamics

The government implements the second-best policy using time-varying consumption taxes and investment subsidies, which are displayed in the first two panels of figures 9. Both start from levels that are higher than 5% and decrease gradually during the early development period ($t \leq 20$). Panel 3 displays the income receipts of the government at each period and panel 4 shows the stock of government savings over time, which includes accumulated interest payments. Since investment is low at early stages of development, the income received from the consumption tax is greater than the investment subsidy, so government savings build up. Note that the peak is reached before the externality completely fades out, as subsidizing investment becomes more expensive than taxing consumption. After the economy graduates from its development phase, the investment subsidy becomes zero and the accumulated savings are

gradually reduced to subsidize consumption at a constant rate. The government's desire to alleviate a market failure with indirect instruments results in a quick hoarding of reserves assets and a longer period of winding them down (about three times longer from peak to 20% of peak). The parameter $\phi$, which corresponds to the severity of the externality, was chosen such that the peak of the reserves would be comparable to the Chinese level of about 45% of GDP as of 2010. As mentioned above, high values for adjustment costs ($b$) and the intertemporal elasticity of substitution ($1/\theta$) are required to obtain an inverted U-shaped path for government savings.

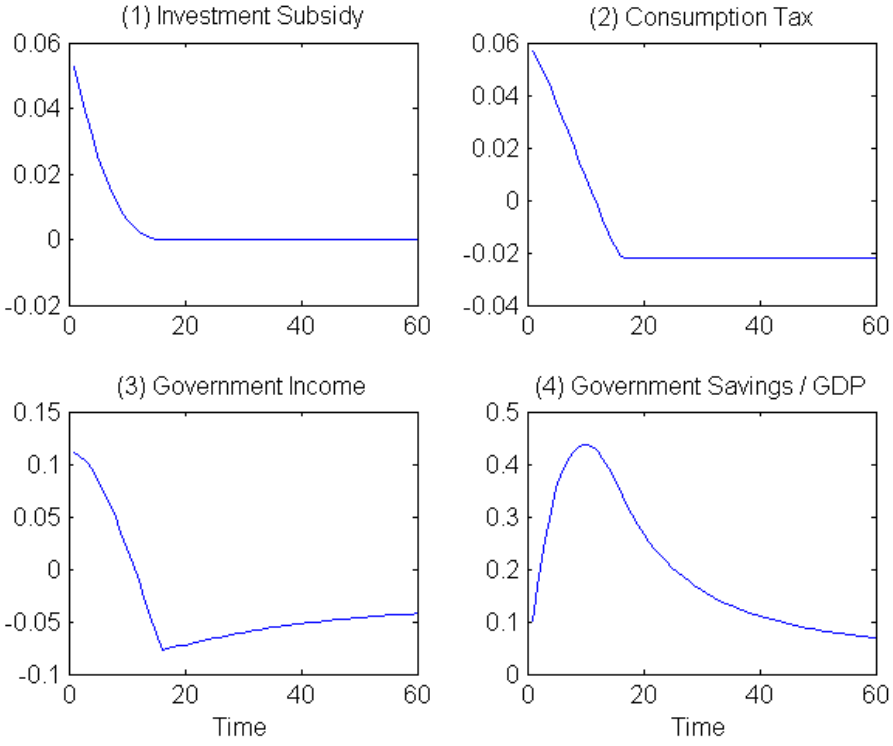


Figure 9. Reserves accumulation

It is possible to compare the equilibrium time paths of different variables in the two policy environments, as shown in figure 10, which focuses on the early stages of development ($t \leq 20$). The second-best policy (SB) encourages investment and discourages consumption in comparison to the laissez-faire equilibrium (LF) and it is clear that for this set of parameters, discouraging consumption takes precedent. The first two panels focus on the paths of investment and Tobin's q over time. During most of the critical stage when the effect of the externality is significant, investment is higher in the second-best scenario, leading to faster capital

accumulation. Note that investment rises during the development stage since for low level of capital adjustment costs are fairly high. Only after capital has passed more than 50% of its steady state level investment begins to decline. The levels of Tobin's q, during the development stage, are higher than those reported by Blanchard, Rhee and Summers (1993) for the U.S. Only after more than 50% of the labor force is absorbed in the modern sector, the q values approach 1.5 and become comparable to their levels. However it seems plausible to expect a higher shadow price of capital in a developing economy in comparison to a developed one.

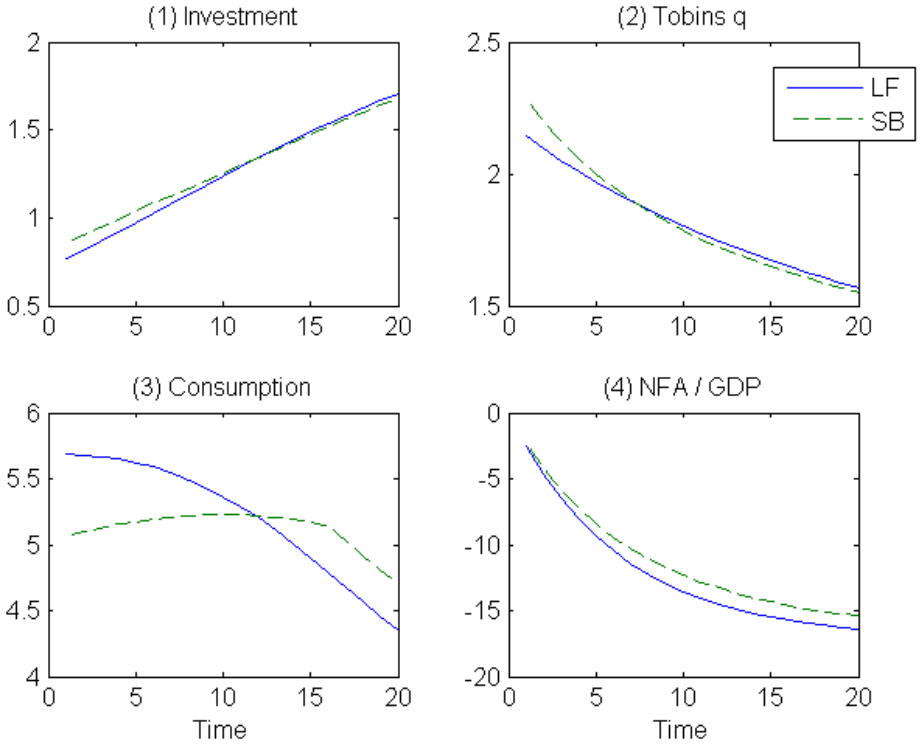


Figure 10. Compariosn between laissez-faire and second-best scenarios

Panels 3 and 4 of figure 10 compare the time paths of consumption and net-foreign assets. The net-foreign asset position of the economy is presented as a share of modern production which proxies for GDP.[27] The second-best policy discourages consumption early, leading to a smaller level of national debt, but the desire of the economy to borrow is greater and the overall effect of the policy on the total stock of debt is small. This excessive level of borrowing is a common feature in open growth

[27] Expenditure on the final good is a problematic measure of GDP since consumption is not monotonic and its price is decreasing over time.

models with free capital flows. Note that consumption in the second-best scenario eventually becomes higher than in the laissez-faire case, and indeed, it converges to a higher steady state level.

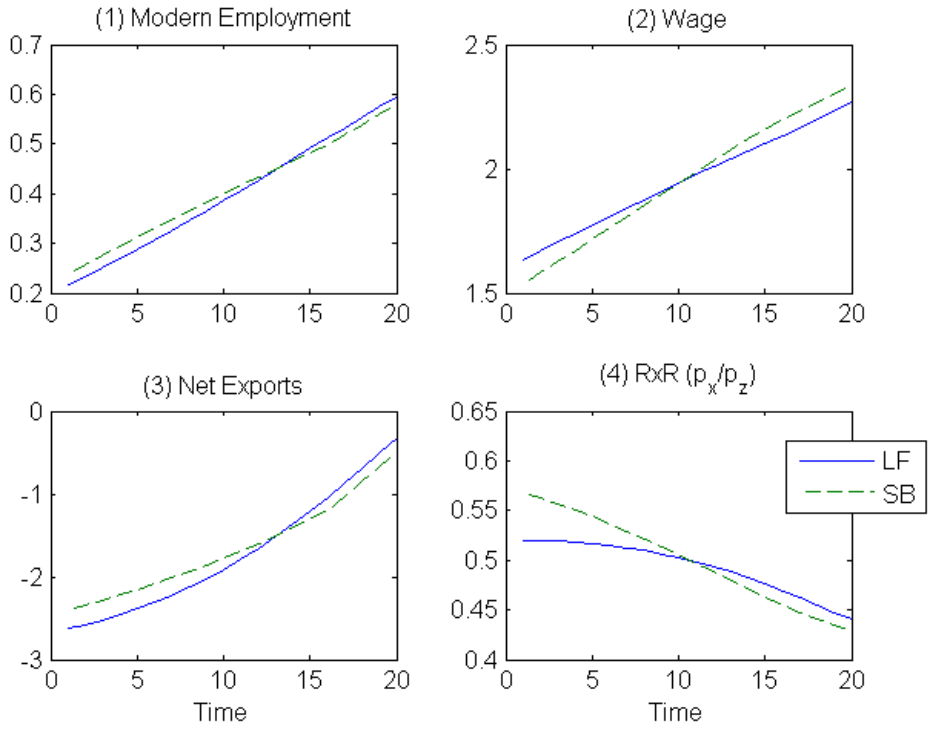


Figure 11. Comparison between laissez-faire and second-best scenarios

Figure 11 presents some of the trends associated with the second-best policy in comparison to the laissez-faire benchmark. The first two panels of figure 11 focus on the labor market, where the misallocation of resources prompted government intervention. The first panel shows the share of labor employed in the modern sector and the second panel exhibits the economy-wide wage rate over time. The second-best policy results in a depressed wage and higher employment in the modern sector during the early stages of development. The implications on net exports and the real exchange rate $(1/p_z)$ are depicted in panels 3 and 4. The accumulation stage is accompanied by an increase in net exports and a depreciation of the real exchange rate in comparison to the market equilibrium. These patterns, as well as those in the labor market, are reversed when the accumulation stops.

The dual-economy structure of this model is crucial for obtaining the links described above between the pattern of consumption, resource allocation and the behavior of exports and the real exchange rate. Lower

wages, a rise in net exports and a depreciated exchange rate are the by-product of the government's attempt to raise welfare and improve the sectoral allocation of labor by discouraging consumption. However, it can be seen that a sizeable accumulation of reserves leads to only modest changes in these variables; the variation over time is much greater than the differences between the second-best environment and the laissez faire benchmark. It is possible that in a model with financial frictions, in which reserves account for a more significant fraction of total capital flows, the impact of the government's policy on these variables will be stronger. This issue will be further discussed in the next section.

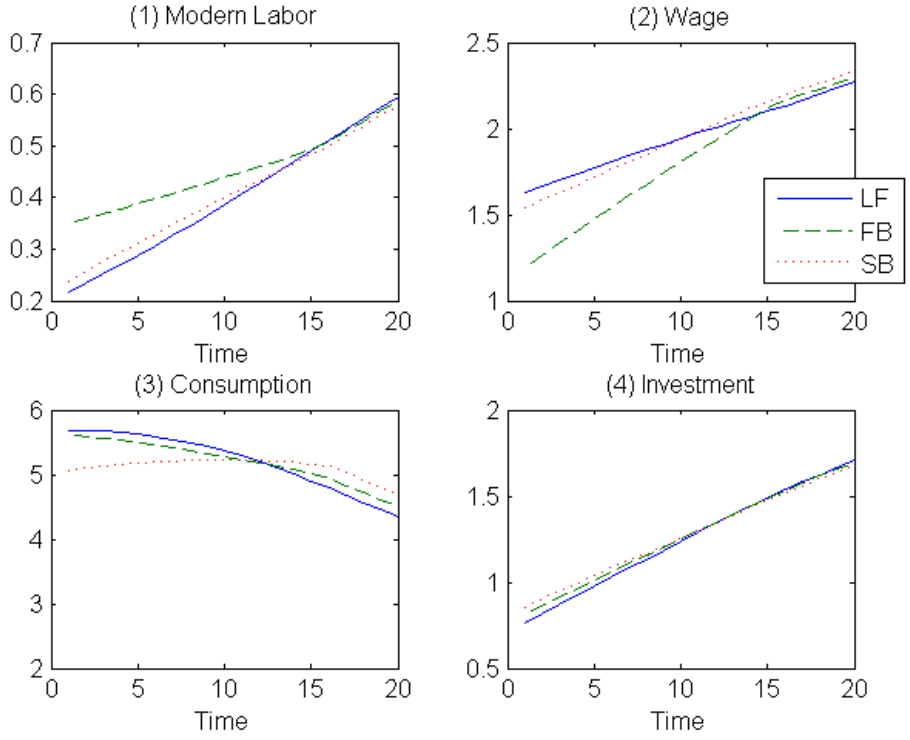


Figure 12. Comparison to the first-best scenario

Aside from the laissez-faire benchmark, an alternative environment for comparison is the first-best optimal allocation. Similarly to the analysis above, it can be obtained by solving the problem of a social planner that is not constrained by the labor-market equilibrium condition. The planner's solution involves a modified labor-market equilibrium condition, but does not require any changes in the behavior of consumption or investment (see equation 19 above). In general, the impact of the first-best policy on the various variables in comparison to the laissez-faire benchmark is similar to the effect of the second-best policy.

The differences are most noticeable in the behavior of consumption and labor allocation which are directly linked to the way of implementing these policies.

Figure 14 displays the paths of consumption, investment, the share of modern employment and wages in the three environments during the early stage of development. In panels 1 and 2, which focus on the labor market, it can be seen that the first-best policy (FB) raises modern employment and reduces the wage more drastically than the second-best policy. In contrast, the second-best policy's impact on consumption and investment is greater (panels 3 and 4). It can also be seen, for example, that the first-best policy raises investment more than the laissez-faire benchmark, indirectly leading to (slightly) faster growth of the capital stock.

# 4 A North-South Model

This section presents a two-region, North-South variation of the model in which countries in the Southern region start from a lower initial level of capital. It is assumed that the cause of the gap in economic development is the initial scarcity of capital in the South which leads to an inefficient allocation of resources. This approach is plausible for most of emerging Asia, since the lag in technology, education, and the quality of institutions seems less of a constraint on growth than it is elsewhere in the developing world. This section simulates the North-South model in a dynamic setting and examines the implications of the policy on various variables in the North. One notable difference in this environment is that the interest rate is an endogenous variable so economic policy pursued by one region can impact the other region through its effect on the world interest rate.

Consider a world economy that is made up of two regions, each consisting of many small and identical countries. Let $j \in \{N, S\}$ be the index of the representative country of each region. I will present simulations of the model in which the world economy opens up to intertemporal trade when the North is at its steady-state level of capital while the South is very far from it. For simplicity, it is assumed that the level of capital in the North is fixed. Of course, one would expect that the North would adjust its capital stock to the new world interest rate, but this assumption highlights the growth of the South as the main driving force in the model.

Since capital accumulation takes place only in the South, the dynamics of the North-South model are given by a system of four difference equations: an Euler equation for each country and the resource constraint and difference equation in q for the South. In addition, the

equilibrium is characterized by the labor-market equilibrium condition in each country and a global market-clearing condition for tradables, which now takes into account also the cost of investment in the South

$$y_{N,t} + y_{S,t} = x_{N,t} + x_{S,t} - I_{S,t}\left(1 + \frac{b}{2}\frac{I_{S,t}}{k_{S,t}}\right).$$

With a given fixed level of capital in the North and a given initial level of capital in the South, the system requires two additional transversality conditions (equations 15 and 17), in order to solve for the equilibrium time-paths of prices and quantities in both countries.

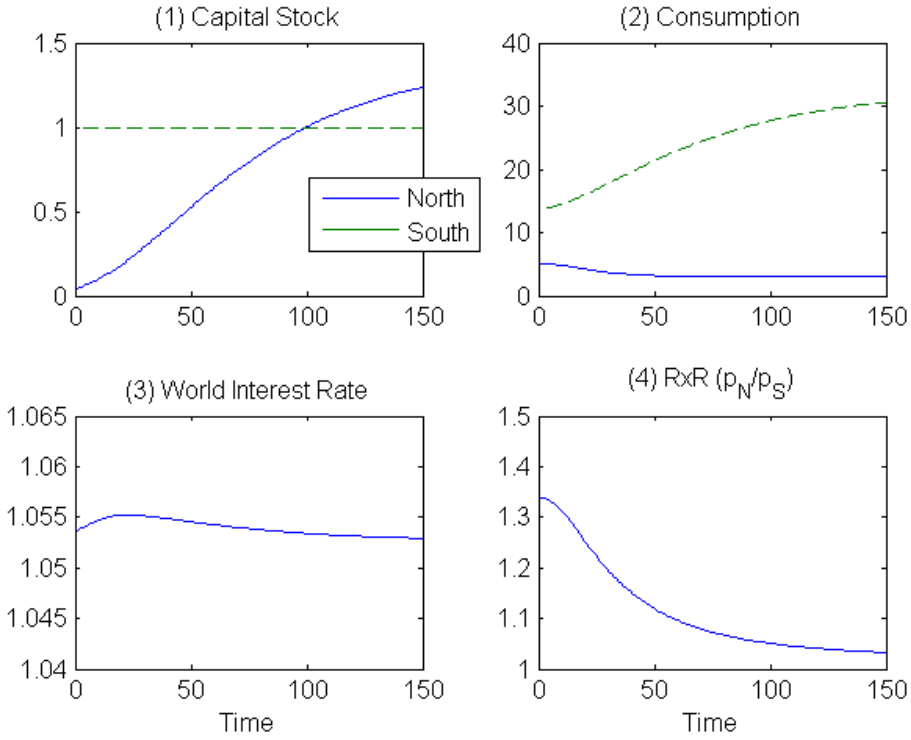


Figure 13. North-South dynamics

Figures 13 through 15 present simulations of the North-South model using the same parameter values from the previous section. The first two panels of figure 13 display the equilibrium paths of capital and consumption in both regions in the laissez-faire scenario. While the capital stock in the North is fixed at the closed-economy, steady-state level by assumption, Southern capital grows gradually over time and eventually passes the Northern level. Intertemporal trade leads to very different consumption patterns; Consumption is increasing in the North, whereas

in the South it is generally decreasing. Moreover, long run gaps in consumption are much greater than in capital or output.

The third panel of figure 13 displays the path of the world interest rate. As a result of the high level of capital in the North, the interest rate is very close to its steady-state value throughout the development process of the South, suggesting that in terms of the interest rate's behavior, the North-South model is more similar to the open-economy model than to the closed-economy setting (compare to figure 6, panel 3). The non-monotonic pattern is a result of the modest level of investment (due to high adjustment costs) during the early stages of developments.

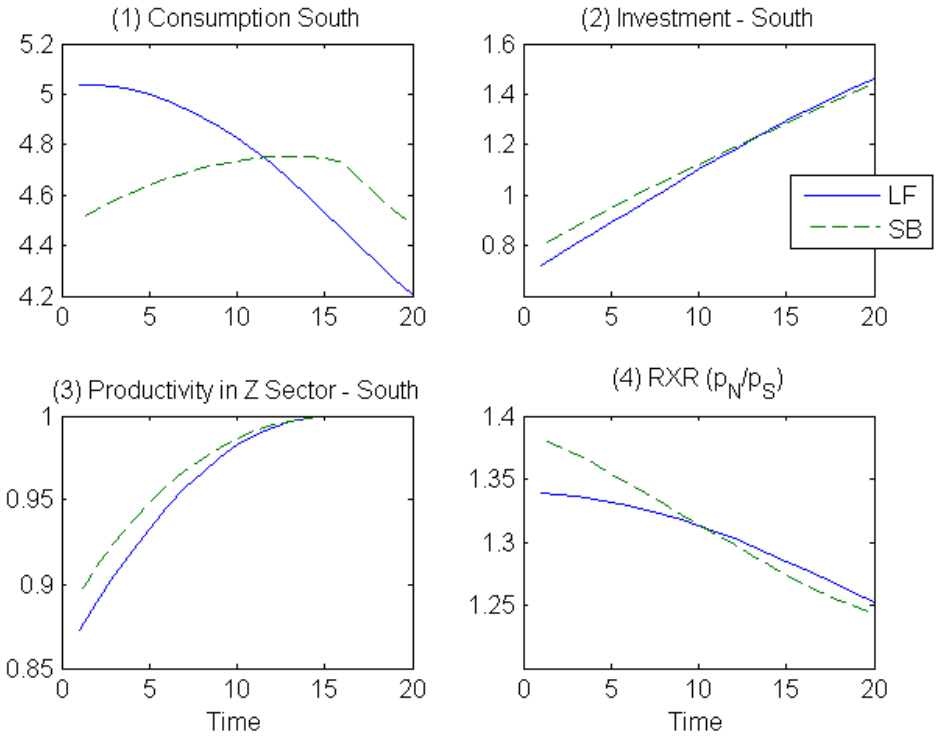


Figure 14. Comparison between laissez-faire and second-best scenarios

In the North-South model the real exchange rate can also be expressed as the relative price of the final goods across countries (i.e. $p_N/p_S$). This definition compares purchasing power across countries, while the previous one from section 2 and 3 (the price of the traded intermediate over the non-traded intermediate) is usually used as a measure of international competitiveness. In both cases, a higher value of the exchange rate corresponds to an exchange-rate depreciation in the South. It can be seen in the fourth panel of figure 14, that the real-exchange

rate falls over time; rapid economic growth of the South is accompanied by an appreciation of the real exchange rate and a deterioration of its competitiveness. Finally, while the real-exchange rate approaches 1 over time, as long as long run net exports are not zero, PPP does not hold in the steady-state.

Figure 14 compares the laissez-faire and second-best scenarios in the South, during the critical stage of development. In general, the behavior of the Southern variables is very similar to the open-economy model of the previous section, as can be seen for consumption and investment in panels 1 and 2 (compare to panels 1 and 3 in figure 10). One notable difference is that a higher real interest rate leads to lower consumption in the South in both scenarios which in turn result in a higher traditional productivity in the North-South model (compare panel 3 of this figure to panel 4 of figure 8). The last panel presents the real-exchange rate in the two scenarios. The accumulation of reserves is not able to stop the appreciation of the exchange rate of the South, however, the early stages of development coincide with a fairly depreciated exchange rate.

The impact of the second-best government intervention on the North can be best understood through its effect on the world interest rate, which is depicted in the first panel of figure 15. During the accumulation stage, the interest rate is generally lower, and then it jumps back to the laissez-faire level as the accumulation ends. Low real interest rates have been an important characteristic of the world economy in the last decade however the difference between the two scenarios is small.[28] The lower world interest rate reduces the incentives to save as can be seen in panel 2. The pattern of Northern consumption mirrors that of the South (compare to panel 1 in the previous figure); in the laissez faire scenario, Northern consumption starts off from a lower level, but quickly overtakes the second-best consumption path and eventually converges to a higher long-term level.

The final two panels of figure 15 focus on patterns in the labor market under the two scenarios. The general trend in both cases is for labor to shift away from the modern sector and for wages to rise. The allocation of labor between sectors responds to the pattern of intertemporal trade; since the North lends to the South its consumption of the non-traded final good rises over time attracting resources to the non-traded sector (i.e. the traditional sector). It can be seen that at the early stages of development, the Southern policy raises Northern wages and lowers the share of Northern labor employed in the modern sector.

Finally, for any set of parameters, one can calculate and compare the

[28] Obstfeld and Rogoff (2009) document a fall of about 3 percentage points in long-term real interest rates (see figures 6a and 6b in their paper).

effect of the Southern's policy on Northern welfare. The North is worst off in the second-best scenario, moreover the North's best response is not to intervene. This last result depends on two conditions: first, countries in the North are developed enough not to suffer from the negative externality. Second, no country in the North is large enough to be able to affect the world interest rate. This final point is crucial, since the impact of the Southern policy is transmitted to the North through its effect on the world interest rate. Because the South's policy results in a generally lower world interest rate, the North, which is a net lender is worst-off, as it suffers a deterioration in its intertemporal terms of trade. Of course, if not all Northern countries are net lenders then those who borrow would tend to benefit from a lower interest rate.

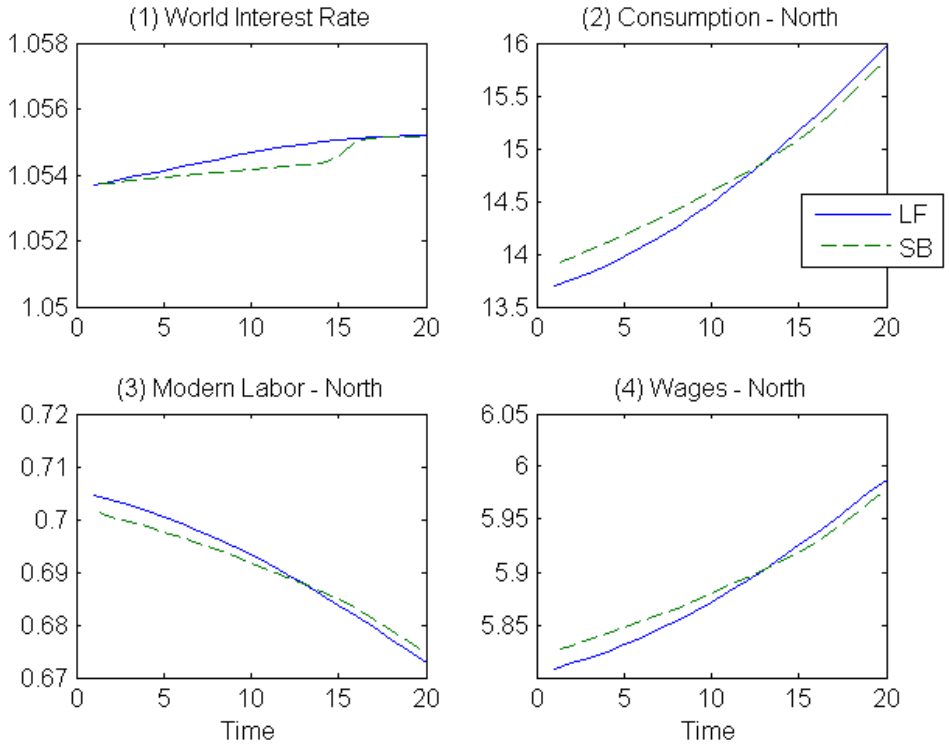


Figure 15. Comparison between laissez-faire and second-best scenarios

As was discussed earlier, the large initial gap in capital levels draws financial flows from the North to the South. The Southern second-best policy attempts to counteract this process, but the private flows are much larger than the accumulated savings of the government. Therefore, a sizeable accumulation leads to only modest changes in the interest rate and the exchange rate. If, for example, domestic and foreign assets are perceived as imperfect substitutes and agents exhibit a home-bias

in their portfolio decision, then it is possible that the extended model would be able to generate more realistic patterns of capital flows in line with figures 3 and 4 in the introductory section.

In one of the first papers on global imbalances, Blanchard, Giavazzi and Sa (2005) develop a model of exchange rate and current-account determination with this feature. They show that an exogenous rise in both US demand for foreign goods and in foreign demand for US assets can explain the behavior of the US current account and the dollar since the late 1990s to the early part of this century. Potentially, by incorporating this feature in a dual-economy growth model, these two "shocks" can emerge as a consequence of a second-best strategy of economic growth.

# 5 Conclusion

The paper presented a development rationale for government intervention in capital markets, in a setting with free capital flows. In the presence of a market failure to efficiently allocate workers across sectors, a government policy that encourages investment and discourages consumption was shown to be welfare enhancing. The mechanism relied on a general-equilibrium link between the pattern of savings and investment and the sectoral allocation of resources.

This second-best policy can generate a reversed U-shaped path for government accumulated savings if adjustment costs are high, especially at early stages of development. During the accumulation stage, wages fall, labor is attracted to the modern sector, the exchange rate depreciates and net exports rise in comparison to the laissez-faire benchmark. The accumulation of reserves by the Southern government results in a lower world interest rate, higher consumption in the North, higher wages and a shift of Northern labor away from the modern sector relative to the benchmark.

It is clear that in the context of this model, a Southern policy that directly addresses the market failure in the labor market would be superior to the second-best government intervention. Rodrik (2009) argues that greater permissiveness of the WTO and policy makers in the developed countries toward the use of industrial policies by developing economies would contribute to the stability of the world economy. Whether governments can successfully implement such policies in an uncertain business environment with asymmetric information is controversial, nevertheless this paper shows that the effect of indirect policies pursued by developing countries could also be detrimental to their trading partners.

Finally, in order to generate South to North capital flows, one has to expand the financial side of the model. As discussed above, if agents exhibit a home-bias toward domestic assets, private international flows

will be lower and the share of official capital flows out of the total will likely be higher. Such an extended model could be used to address the debate on global imbalances from an economic development perspective and could potentially lead to more realistic quantitative predictions concerning current-account imbalances and exchange-rate misalignments.

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# 7 Appendix

In all the derivations in the appendix, the time subscripts will be omitted whenever no ambiguity results.

## 7.1 Derivation of equation 9

The labor market equilibrium condition $F(l_x, c, k) = 0$ (equation 9), can be derived by combining equations 1, 4, 6 and 7 leading to the following equation:

$$A_z^{\eta-1} l_x^{\alpha\eta} \left( c^{\frac{\eta-1}{\eta}} - z^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} = \left[ (1-\alpha) A_x k^{\alpha} \right]^{\eta} (1 - l_x).$$

For a given level of $c$ and $k$ the equation above uniquely determines $l_x$, since the left hand is zero when $l_x = 0$ and is increasing in $l_x$ (see condition 3), while the right hand side is decreasing in $l_x$ and zero when $l_x = 1$, ensuring a unique intersection.

## 7.2 Proof of Proposition 1

In a closed economy, plugging $y = x$ in the above equation leads to the following simpler expression

$$\left( \frac{A_z}{A_x} \right)^{\eta-1} l_x^{\alpha(\eta-1)+1} = (1-\alpha)^{\eta} k^{\alpha(\eta-1)} (1 - l_x),$$

This equation eliminates $c$ from the labor market condition and defines $l_x$ as an implicit and increasing function of $k$ (for the increasing property, see the subsection below which covers the more general open-economy case). Define $\overline{k}$ as the unique level of capital that corresponds to $1 - \bar{l}$. Therefore if $k < \overline{k}$, then $l_x < 1 - \bar{l}$, and $l_z > \bar{l}$, implying that the spillover effect is present (i.e., $A_z < 1$) and the labor market equilibrium condition leads to an inefficient allocation. If $k \geq \overline{k}$, then $l_x \geq 1 - \bar{l}$, and $l_z \leq \bar{l}$, so the market allocation is efficient (since $A_z = 1$).

## 7.3 Derivation of condition 11

The partial derivatives of $F(c, k, l_x) = z p_z^{\eta} - y$ with respect to $c$, $k$ and $l_x$ evaluated at the vicinity of the market equilibrium are:

$$F_c = -p < 0;$$

$$F_k = \alpha\eta p_z^{\eta} / k > 0;$$

$$F_l = \frac{\partial z}{\partial l_x} (p_z^{\eta} + p_z) - \eta z p_z^{\eta} \left( \frac{\alpha}{l_x} + \frac{1}{A_z} \frac{\partial A_z}{\partial l_x} \right) < 0.$$

The second expression in the third partial derivative is negative while the first is non-negative, since $\partial z/\partial l_x \leq 0$ according to condition 3. All the analytical results of section 2 would hold if and only if $F_l < 0$. Therefore, this final derivation implies that $\partial z/\partial l_x \leq 0$ is only a sufficient condition.

## 7.4 Proof of Proposition 2

The two-period market equilibrium is given by a system of four equations: The Euler equation, the labor market equilibrium condition for $t \in \{1, 2\}$ and the discounted net exports condition (see equations 8, 9 and 10). Let $\left(\widehat{l}_{x,1}, \widehat{l}_{x,2}, \widehat{c}_1, \widehat{c}_2\right)$ be the solution to the system, and denote by $G$ the discounted sum of exports

$$G\left(l_{x,1}, l_{x,2}, c_1, c_2\right) = G_1\left(l_{x,1}, c_1\right) + \frac{G_2\left(l_{x,2}, c_2\right)}{R} = x_1 - y_1 + \frac{x_2 - y_2}{R}. \quad (22)$$

The goal is to show that a small deviation from the consumption pattern of the Euler equation will be welfare improving

$$\frac{\partial U}{\partial c_2}(\widehat{l}_{x,1}, \widehat{l}_{x,2}, \widehat{c}_1, \widehat{c}_2) > 0 \Leftrightarrow \frac{\partial c_1}{\partial c_2}(\widehat{l}_{x,1}, \widehat{l}_{x,2}, \widehat{c}_1, \widehat{c}_2) + \frac{\widehat{p}_2}{R\widehat{p}_1} > 0,$$

where the Euler equation (which holds for the market equilibrium allocation) was used to obtain the expression on the right. I will use three of the four equilibrium conditions ($F_1 = 0$, $F_2 = 0$ and $G = 0$, while excluding the Euler equation) to derive $\partial c_1/\partial c_2$ and evaluate it at $\left(\widehat{l}_{x,1}, \widehat{l}_{x,2}, \widehat{c}_1, \widehat{c}_2\right)$. The implicit function theorem for a system of three equations imply

$$\begin{pmatrix} \frac{\partial l_{x,1}}{\partial c_2} \\ \frac{\partial l_{x,2}}{\partial c_2} \\ \frac{\partial c_1}{\partial c_2} \end{pmatrix} = - \begin{pmatrix} \frac{\partial F_1}{\partial l_{x,1}} & \frac{\partial F_1}{\partial l_{x,2}} & \frac{\partial F_1}{\partial c_1} \\ \frac{\partial F_2}{\partial l_{x,1}} & \frac{\partial F_2}{\partial l_{x,2}} & \frac{\partial F_2}{\partial c_1} \\ \frac{\partial G}{\partial l_{x,1}} & \frac{\partial G}{\partial l_{x,2}} & \frac{\partial G}{\partial c_1} \end{pmatrix}^{-1} \begin{pmatrix} \frac{\partial F_1}{\partial c_2} \\ \frac{\partial F_2}{\partial c_2} \\ \frac{\partial G}{\partial c_2} \end{pmatrix} \Leftrightarrow$$

$$\begin{pmatrix} \frac{\partial l_{x,1}}{\partial c_2} \\ \frac{\partial l_{x,2}}{\partial c_2} \\ \frac{\partial c_1}{\partial c_2} \end{pmatrix} = - \begin{pmatrix} F_{l,1} & 0 & -p_1 \\ 0 & F_{l,2} & 0 \\ G_{l,1} & G_{l,2}/R & -p_1 \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ -p_2 \\ -p_2/R \end{pmatrix}.$$

After inverting the matrix and some more algebra, one can show that

$$\frac{\partial c_1}{\partial c_2} = -\frac{p_2}{p_1 R} \frac{1 + G_{l,2}/F_{l,2}}{1 + G_{l,1}/F_{l,1}}.$$

Plugging this derivative at the expression for welfare evaluated at the market equilibrium delivers the following condition for improving welfare:

$$\frac{\widehat{G}_{l,1}}{\widehat{F}_{l,1}} < \frac{\widehat{G}_{l,2}}{\widehat{F}_{l,2}}, \tag{23}$$

where $G_{l,t} = MPL_{x,t} - p_{z,1}MPL_{z,t} = \partial A_{z,t}/\partial l_{x,t}$ and $F_{l,t} < 0$ (see equations **??** and 11). The assumptions of proposition 2 ensure that $\widehat{l}_{x,1} < \bar{l} < \widehat{l}_{x,2}$, so $\widehat{A}_{z,1} > 0$ and $\widehat{A}_{z,2} = 0$, implying that the condition above is satisfied.

## 7.5 North-South variation in a Two-Period Model

In a two period model with two regions it is possible to show that the second-best policy of the South leads to a fall in the interest rate and a welfare reduction in the North. Suppose that countries in the South differ only in their first-period level of capital, i.e., $k_{S,1} < k_{N,1}$, and that all capital levels are given. Equilibrium in the global market of modern intermediates require that in each period expenditure on modern goods in both regions will equal total production

$$y_{N,t} + y_{S,t} = x_{N,t} + x_{S,t}.$$

This equilibrium condition replaces equation 5. The rest of the equilibrium relationships are just as in the small-open economy case of section 2.

**Proposition 4** *Suppose that $k_{S,1} < \overline{k} < k_{S,2}$ and $k_{N,1} = k_{N,2} >> \overline{k}$, then a Southern policy that encourages consumption in the second period at the expense of first period consumption leads to a fall in the world interest rate and a reduction in Northern welfare.*

The assumptions of this proposition ensure that the externality is present only in the South and only in the first period.[29] The two-period, two-region market equilibrium is given by a system of nine equations: four labor-market equilibrium conditions, two Euler equations, two modern-intermediates market-clearing conditions and one condition requiring that the discounted sum of imports of one of the countries (North below) will be zero. Let $\left(\widehat{l}_{x,S,1}, \widehat{l}_{x,S,2}, \widehat{c}_{S,1}, \widehat{c}_{S,2}, \widehat{l}_{x,N,1}, \widehat{l}_{x,N,2}, \widehat{c}_{N,1}, \widehat{c}_{N,2}, \widehat{R}\right)$ be the solution to the system. Let $G_{j,t}$ be the level of exports in country $j$ at period $t$ and denote by $E_N$ the Euler equation of the North. As in the proof of proposition 2, I consider the effect of a small deviation

[29] The second inequality requires that the capital stock in the North will be sufficiently greater than the cut-off level $\overline{k}$ in order to avoid a situation in which the North–who is a net lender–will activate the negative externality by lending "too much."

from the Southern Euler equation on the variables of interest. By applying the implicit function theorem for the system of equations, I use the remaining eight equilibrium conditions to obtain expressions for the derivatives of the main variables with respect to $c_{S,2}$ and evaluate it at the market equilibrium:

$$\begin{pmatrix} \frac{\partial l_{x,S,1}}{\partial c_{S,2}} \\ \frac{\partial l_{x,S,2}}{\partial c_{S,2}} \\ \frac{\partial c_{S,1}}{\partial c_{S,2}} \\ \frac{\partial R}{\partial c_{S,2}} \\ \frac{\partial l_{x,N,1}}{\partial c_{S,2}} \\ \frac{\partial l_{x,N,2}}{\partial c_{S,2}} \\ \frac{\partial c_{N,1}}{\partial c_{S,2}} \\ \frac{\partial c_{N,2}}{\partial c_{S,2}} \end{pmatrix} = - \begin{pmatrix} F_{l,S,1} & 0 & -p_{S,1} & 0 & 0 & 0 & 0 & 0 \\ 0 & F_{l,S,2} & 0 & 0 & 0 & 0 & 0 & 0 \\ G_{l,S,1} & 0 & -p_{S,1} & 0 & G_{l,N,1} & 0 & -p_{N,1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -p_{N,1} & \frac{-p_{N,2}}{R} \\ 0 & 0 & 0 & 0 & F_{l,N,1} & 0 & -p_{N,1} & 0 \\ 0 & 0 & 0 & 0 & 0 & F_{l,N,2} & 0 & -p_{N,2} \\ 0 & 0 & 0 & E_{R,N} & E_{l,N,1} & E_{l,N,2} & E_{c,N,1} & E_{c,N,2} \\ 0 & G_{l,S,2} & 0 & 0 & G_{l,N,2} & 0 & 0 & -p_{N,2} \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ -p_{S,2} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ -p_{S,2} \end{pmatrix}.$$

The conditions of proposition **??** ensure that South borrows in the first period ($\widehat{G}_{N,1} > 0$) and that the externality is present only in the South during the first period, i.e., $\widehat{l}_{x,S,1} < \bar{l} < \widehat{l}_{x,S,2}$ and ensure that $\bar{l} < \widehat{l}_{x,N,1}, \widehat{l}_{x,N,2}$ (so $\widehat{G}_{l,S,2}$, $\widehat{G}_{l,N,1}$ and $\widehat{G}_{l,N,2}$ are zero). After inverting the matrix and quite a bit of algebra it follows that

$$\begin{pmatrix} \frac{\partial R}{\partial c_{S,2}} \\ \frac{\partial c_{N,1}}{\partial c_{S,2}} \\ \frac{\partial c_{N,2}}{\partial c_{S,2}} \end{pmatrix} = \begin{pmatrix} \frac{\widehat{p}_{S,2}}{\widehat{p}_{N,2}} \frac{\widehat{p}_{N,1}}{\widehat{G}_{N,1}} \left[ \frac{a_1}{a_2} - \frac{\widehat{p}_{N,2}}{R\widehat{p}_{N,1}} \right] \\ -\frac{\widehat{p}_{S,2}}{\widehat{p}_{N,2}} \\ \frac{\widehat{p}_{S,2}}{\widehat{p}_{N,2}} \frac{a_2}{a_1} \end{pmatrix},$$

where

$$a_t = \widehat{E}_{c,Nt} + \frac{\widehat{p}_{Nt}\widehat{E}_R}{\widehat{G}_{Nt}} + \frac{\widehat{p}_{Nt}\widehat{E}_{l,Nt}}{\widehat{F}_{l,Nt}}.$$

It can be shown that the expression in the square brackets is negative, therefore $\partial\widehat{R}/\partial\widehat{c}_{S,2}$ is negative. As in the proof of proposition 2, the Euler equation of the North can be used to derive an expression for the derivative of utility with respect to $c_{S,2}$

$$\frac{\partial \widehat{U}_N}{\partial \widehat{c}_{S,2}} = \frac{\partial \widehat{c}_{N,1}}{\partial \widehat{c}_{S,2}} + \frac{\widehat{p}_{N,2}}{\widehat{R}\widehat{p}_{N,1}} \frac{\partial \widehat{c}_{N,2}}{\partial \widehat{c}_{S,2}} = c_{N,1}^{-\theta} \frac{p_{S,2}}{p_{N,2}} \left[ \frac{a_1}{a_2} - \frac{\widehat{p}_{N,2}}{R\widehat{p}_{N,1}} \right] < 0.$$

The expression in the square brackets is the same as above and is negative. Therefore, a small increase in Southern consumption in the second period at the expense of first-period consumption, will reduce the world interest rate and Northern welfare.

## 7.6 Closed-Economy Steady State and Comparison to the Open-Economy Case

The dynamics of the closed economy are also given by the system of equations of section 3, the primary difference being that the interest rate is determined endogenously. The closed-economy market-clearing condition of the tradable sector

$$y_t = x_t - I_t \left(1 + \frac{b}{2}\frac{I_t}{k_t}\right),$$

provides an additional condition to determine the interest rate (note same as equation 16, except that $m_t = 0$). In the closed-economy steady state $R_{ss} = 1/\beta$, $q_{ss} = 1$ and the q-difference equation becomes

$$\frac{l_{x,ss}}{k_{ss}} = \left(\frac{1-\beta}{\alpha\beta A_x}\right)^{\frac{1}{1-\alpha}}, \tag{24}$$

which determines a constant steady-state ratio for the share of modern employment to the capital stock. When $I = 0$, the labor market equilibrium condition in the closed economy becomes an implicit function of two variables, $l_x$ and $k$, so together with the above equation it is possible to solve for the steady-state. In fact, when $l_{x,ss} \geq 1 - \bar{l}$, it is possible to obtain explicit expressions for the steady state values. For example, $l_{x,ss} = a/(1+a)$, where

$$a = (1-\alpha)^{\eta} A_x^{\frac{\eta-1}{1-\alpha}} \left(\frac{\alpha\beta}{1-\beta}\right)^{\frac{\alpha(\eta-1)}{1-\alpha}}$$

and $k_{ss}$ can be obtained by using equation 24.

In the open-economy case, the labor-market equilibrium condition is also an implicit function of $c$. In all potential open-economy steady states, i.e. when $q_{ss} = 1$, for every $l_{x,ss} \in (0, 1]$ there are unique corresponding values of $k_{ss}$ and $c_{ss}$. Therefore, there is a mass of potential steady states for the system and the actual steady state depends on the initial condition.

## 7.7 Proof of Proposition 3

I. The condition is equivalent to the condition for welfare improvement in proposition 2 (see inequality 23 above).

II. Condition 11 states that $F_k < 0$ and $F_l > 0$, while $G_l$, which represents the gap between the marginal products of labor in the modern and traditional sectors, is positive when $l_x < 1 - \bar{l}$ and zero otherwise (see section 7.4 above for further details).

## 7.8 Decentralization of the Second-Best Policy

The agent's Euler equation and the firm's difference equation in $q$ (equations 12 and 14) have been rewritten as difference equations in the policy variables

$$\frac{c_{t+1}^*}{c_t^*} = \left( \beta R_t \frac{(1+\tau_t)\, p_t^*}{(1+\tau_{t+1})\, p_{t+1}^*} \right)^{\frac{1}{\theta}};$$

$$(1-s_{t+1})\, q_{t+1}^* + \alpha A_x \left( \frac{l_{x,t+1}^*}{k_{t+1}^*} \right)^{1-\alpha} + \frac{b}{2} \left( \frac{I_{t+1}^*}{k_{t+1}^*} \right)^2 = R_t\, (1-s_t)\, q_t^*.$$

These two equations, together with an intertemporal balanced budget condition for the government,

$$\sum_{t=1}^{\infty} R^{1-t} \left[ \tau_t p_t^* c_t^* - s_t I_t^* \left( 1 + \frac{b}{2} \frac{I_t^*}{k_t^*} \right) \right] = 0,$$

and a boundary condition requiring that the investment subsidy will be zero at the steady state, can be solved for the time paths of the consumption taxes and investment subsidies.