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Growth and Global Imbalances: The Role of Learning-by-Exporting*

Byoung Hoon Seok†

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Abstract

Rapidly growing developing economies have exported heavily and run current account surpluses. Empirical studies suggest that "learning-by-exporting" may be quantitatively large in developing countries and behind some of this dramatic growth. This paper explores if learning-by-exporting helps explain the key macroeconomic behavior of fast growing developing countries. It builds up a two country general equilibrium growth model in which a developing economy benefits from learning-by-exporting as it trades with a developed economy. As the benchmark, I consider a setup in which the policies are restricted to non-trade related ones by the World Trade Organization (WTO) and compare it to a model with "No-WTO restrictions". The optimal policies in the presence of WTO restrictions rationalize the observed current account surpluses of rapidly growing developing economies. However, if there were no WTO restrictions, the developing countries would manipulate their terms of trade rather than their current account, which improves the welfare of both developing and developed countries. This highlights the fact that terms of trade manipulation can be "win-win" in the presence of learning-by-exporting. This paper also considers a "Coordinated Policy" problem to obtain the first-best outcomes for the world. In this setup, the developing country's terms of trade deteriorate even more and it runs a greater current account deficit relative to the "No-WTO Restrictions" case.

Keywords: Current Account, Learning-by-Exporting, Terms of Trade
JEL Classifications: E61, F13, F32, O24

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1 Introduction

Rapidly growing developing economies like China and other Asian countries have exported heavily[1] and run current account surpluses[2]. The fast growth accompanied by current account surpluses contradicts the prediction of the open-economy neoclassical growth model that countries with faster productivity growth should receive more net capital inflows to fund investment and consumption smoothing. Gourinchas and Jeanne (2009) name it the "allocation puzzle". These fast growing countries' current account surpluses contribute to the worldwide current account imbalances, so-called "global imbalances". Since these economies have exported heavily, a popular view is that export-led growth may be behind some of these dramatic Asian miracles. This is supported by empirical studies which suggest that "learning-by-exporting" (exporters' productivity improvement accompanied by increased exports) may be quantitatively large in developing countries. This paper takes the popular view seriously and attempts to explore if learning-by-exporting helps explain the key macroeconomic behavior of fast growing developing countries. This paper also examines what policies exploit learning-by-exporting, their implications for aggregates like the current account and the real exchange rate, the welfare consequences for the growing economy and the rest of the world, and if restricting the set of policies to non-trade related policies matter.

In order to answer these questions, this paper builds up a two country general equilibrium growth model in which a developing economy benefits from learning-by-exporting as it trades with a developed economy. This positive externality in the developing country's export provides it with an incentive to increase export. The model is calibrated to match relevant data moments of the U.S. and China in 1991 and simulated for a transition to a steady state. As the benchmark, I consider a setup in which the policies are restricted to non-

[1] See Figure 1.

[2] See Figure 2.

trade related ones by the World Trade Organization (WTO).[3] In this benchmark model, the optimal policy for the country is to tax non-traded goods consumption and subsidize savings, which shifts labor into the tradable sector and suppresses consumption to increase exports.[4] These policies generate the simultaneous fast growth and current account surpluses observed in the data. These policies improve the welfare of the developing country relative to a "No Policy" competitive equilibrium because the developing economy benefits from rapid growth due to learning-by-exporting. However, the welfare change of the developed country between the benchmark case and the "No Policy" economy is quantitatively negligible.

If there were no WTO restrictions, the developing country has an incentive to manipulate its terms of trade rather than distort savings. Specifically, the developing country subsidizes exports to reduce its consumption of the export good and increase consumption of the import good. This policy generates a large deterioration in the developing economy's terms of trade and reverses the prediction for the current account. In particular, the developing economy now runs a current account deficit as it no longer relies heavily on the savings distortion to promote exports. These policies raise the welfare of both countries relative to the benchmark model as it generates faster economic growth in the developing economy and improvement of the terms of trade in the developed economy, highlighting the fact that terms of trade manipulation can be "win-win" in the presence of learning-by-exporting.

Note that the benchmark model and the No-WTO model assume a passive developed

[3]Since the WTO is an organization designed to liberalize international trade, it forces countries to decrease tariffs and export subsidies. Therefore, the WTO prevents countries from manipulating their terms of trade. The WTO restrictions in this model represent the general state of trade rules which prevent countries from manipulating terms of trade. For instance, a country may not be able to manipulate its terms of trade if its trading partner can implement retaliation trade policies.

[4]These are consistent with current Chinese government policies. The Chinese government is taxing the gross revenue in the service sector (Business Tax), but in the manufacturing sector, they are taxing the difference between a commodity's price and its production cost (Value Added Tax). Ping, Liang, Hao, Zhang, and Mao (2009) shows that if the tax rate of the Business Tax is converted to that of the Value Added Tax, it is 18.2 %. This is greater than the Value Added Tax rate of 17 %. Therefore, the Chinese government is taxing the service sector heavier than the manufacturing sector. The non-traded goods consumption tax is consistent with this Chinese tax regime. Savings subsidy in this model is consistent with China's large government savings which were 4.4% of GDP in 1992 and 10.8% in 2007 according to Ma and Yi (2010).

economy. This paper also considers a "Coordinated Policy" problem to obtain the first-best outcome for the world. In this setup, the developing country's terms of trade deteriorate even more and it runs a greater current account deficit relative to the "No-WTO Restrictions" case. This large deterioration of the developing country's terms of trade causes its real exchange rate to be undervalued. These policies reduce welfare of the developing country and increase that of the developed country relative to the "No-WTO Restrictions" case. However, the welfare changes of both countries between the "Coordinated Policy" case and the "No-WTO Restrictions" economy are quantitatively modest.

This paper is motivated by three distinct lines of study. The first consists of empirical micro studies which show that learning-by-exporting may be quantitatively large in developing countries.[5] A possible explanation is that exporters in developing countries improve their productivity through imitation and technology spillover from developed countries.[6] The most difficult task of these studies is controlling for the effects of the unobserved differences in firm characteristics between exporters and non-exporters. In order to control for this selection bias, Van Biesebroeck (2005) uses ethnicity of the owner and state ownership as instruments, De Loecker (2007) uses matched sampling techniques based on an underlying model of self-selection into export markets, and Park, Yang, Shi, and Jiang (2010) use exogenous firm specific exchange rate shocks as instruments. These studies find significant evidence of learning-by-exporting after controlling for the selection bias. Another issue regarding learning-by-exporting is if it can be distinguished from learning-by-doing. Blalock and Gertler (2004), Van Biesebroeck (2005), De Loecker (2007), and De Loecker (2010) show that there is a jump in firms' productivity accompanied by the initiation of exporting which cannot be explained by learning-by-doing. One might think that learning-by-importing is

[5] These studies include Kraay (1999), Blalock and Gertler (2004), Aw, Roberts, and Xu (2010), Park, Yang, Shi, and Jiang (2010) for East Asian countries, Van Biesebroeck (2005) for Aftrican countries, De Loecker (2007), De Loecker (2010) for Slovenia, and Fernandes and Isgut (2009) for Colombia. Harrison and Rodríguez-Clare (2010) provide extensive reviews of the above.

[6] Empirical micro studies point out that learning-by-exporting also comes from exporters' improved access to advanced production technologies, technical assistance from foreign buyers, competition with foreign firms and higher quality standards in international markets relative to domestic markets.

as important as learning-by-exporting. According to Keller (2004), however, there has not been a firm estimate of the quantitative importance of learning-by-importing.

The second literature addresses "global imbalances". Caballero, Farhi, and Gourinchas (2008) and Mendoza, Quadrini, and Rios-Rull (2009) emphasize that the lack of financial assets in developing countries have generated capital outflows. Fogli and Perri (2006) argue that the "great moderation" (a large reduction in U.S. business cycle volatility in the early 1980s) has raised the U.S. current account deficit by reducing their incentive to accumulate precautionary savings. However, as Aguiar and Amador (2011) point out, these studies are silent on why Latin American countries have volatile business cycles and less developed financial markets, but have run current account deficits. My paper provides an additional explanation regarding the "global imbalances" and may explain why Latin American countries have run current account deficits because they may implement policies which did not take advantage of learning-by-exporting.

My paper is also related to the "allocation puzzle". Aguiar and Amador (2011) claim that since capital will not be invested in a country with high debt, due to the risk of expropriation, only politically stable developing countries can grow by reducing sovereign debt and attracting foreign capital. Song, Storesletten, and Zilibotti (2011) argue that the expansion of efficient private firms has made China grow rapidly. However, these firms are financially constrained and therefore must save for future investment, which generates China's current account surplus. Guo and Perri (2010) and Song and Yang (2010) argue that flatter cross-sectional age-income profile accompanied by fast growth leads to young households saving more, which generates the developing countries' current account surpluses. My paper not only provides an additional explanation regarding this puzzle but also examines the connection between growth, current account surplus and WTO restrictions. In addition, it explores the optimal polices in the presence of learning-by-exporting and the welfare consequences for the growing economy and the rest of the world which were not done by previous studies.

The remainder of the paper is organized as follows. Section 2 presents the model; Section 3 describes the calibration of the model; Section 4 discusses the results; Section 5 explains

a "Coordinated Policy" problem and its results; Section 6 does the welfare analysis; Section 7 does a sensitivity analysis on the degree of learning-by-exporting; Section 8 concludes my findings.

2 Model

The model I present is a two country general equilibrium growth model. Time (t) is discrete and runs from 0 to infinity. The North country, denoted by N, corresponds to a developed economy and owns the most developed technology. The North's human capital stock H^N is assumed to be constant, reflecting that the North has fully exhausted productivity gains from learning-by-exporting. The South country, denoted by S, is equal to a developing economy and has an inferior technology $H_t^S \in \left[H_0^S, H^N\right)$. Given the assumption that H^N is constant, only the South country grows through learning-by-exporting as it trades with the North country. Each country produces one non-traded commodity and both countries share two traded goods ($z \in \{1,2\}$)[7]. There is also an international financial market that buys and sells risk-free bonds b_t^i with a return denoted by $1+r_t$. Each economy is populated by firms who produce goods and workers who provide domestic firms with labor. The South country has a government which implements policies to take advantage of learning-by-exporting.

2.1 Firms

Country $i \in \{N,S\}$ firms in the trade goods sector use labor $n_t^i(z)$ to produce output $y_t^i(z)$ according to a constant returns to scale production function

$$y_t^i(z) = A_t^i(z)\, n_t^i(z), \ i \in \{N,S\}, \ z \in \{1,2\},$$

[7] All the results, I present using this two traded goods model, carry through in a model with a continuum of traded goods except spikes that appear in the time path of South savings subsidy and that of South lump-sum tax in Figures 13 and 17. These spikes are caused by discontinuities that arise when the specialization pattern changes in the two traded goods model.

where

$$A_t^i(1) \equiv H_t^i,\ A_t^i(2) \equiv \left(H_t^i\right)^{1+\phi},\ \phi > 0.^8$$

Labor productivity in the trade goods sector depends on each country's human capital. Since ϕ is greater than zero, the second traded commodity production is more human capital intensive than the first traded commodity production. The South country has a comparative advantage in the first traded commodity production because it has less human capital $H_t^S < H^N$:

$$\frac{A_t^S(2)}{A_t^S(1)} = \frac{\left(H_t^S\right)^{1+\phi}}{H_t^S} < \frac{A^N(2)}{A^N(1)} = \frac{\left(H^N\right)^{1+\phi}}{H^N}.$$

Therefore, the South country exports the first traded commodity. Labor is hired by the firms in a competitive domestic labor market which clears at an equilibrium wage w_t^i. Firms in the traded goods sector maximize their profit

$$p_t(z) A_t^i(z) n_t^i(z) - w_t^i n_t^i(z).$$

Since I assume a perfect competition in the traded goods sector, the law of one price holds. Thus, the world price of traded commodity z is

$$p_t(z) \leq \frac{w_t^i}{A_t^i(z)}.$$

Since the South country produces the first traded commodity and the North produces the second traded commodity, the South domestic wage is

$$w_t^S = \left(\frac{p_t(1)}{p_t(2)}\right) \cdot \left(\frac{A_t^S(1)}{A^N(2)}\right).$$

[8] Gourinchas and Jeanne (2009) show that savings wedge is a key in explaining developing countries' fast growth accompanied by current account surpluses, using the aggregate data. Since my paper looks at questions of savings side and builds up the most parsimonious model to explain this puzzle, it does not include capital in the model. These rapidly growing developing countries, which run current accout surpluses, actually invest a lot but save even more. The saving side is particularly puzzling given the fast growth. We have models of why there may be capital wedges (enforcement, for example), but few regarding savings wedges. Including capital in the model will affect the quantitative results, but the key mechanism still stands that absent the ability to manipulate the terms of trade, learning-by-exporting calls for a savings wedge.

A firm in the non-traded goods sector uses labor n_t^i to produce output y_t^i according to a constant returns to scale production function

$$y_t^i = n_t^i,\ i \in \{N, S\}.$$

I assume that labor productivity in the non-traded goods sector is equal to one in both countries because the focus is on productivity improvement in the traded goods sector.[9] The non-traded goods sector firm maximizes its profit

$$p_t^i n_t^i - w_t^i n_t^i.$$

Therefore, each country's non-traded commodity price is

$$p_t^N = w_t^N = 1 \text{ and } p_t^S = w_t^S.$$

The North's wage/ non-traded good is the numeraire.

The South country's real exchange rate is

$$e_t^S \equiv \frac{P_t^S}{P_t^N} = \left(\frac{p_t^S}{p_t^N}\right)^{1-\psi} = \left(w_t^S\right)^{1-\psi} = \left\{\left(\frac{p_t(1)}{p_t(2)}\right)\cdot\left(\frac{A_t^S(1)}{A^N(2)}\right)\right\}^{1-\psi},$$

where

$$P_t^i \equiv \left(\frac{p_t^i}{1-\psi}\right)^{1-\psi}\left(\frac{p_t(1)}{\eta\psi}\right)^{\eta\psi}\left(\frac{p_t(2)}{(1-\eta)\psi}\right)^{(1-\eta)\psi},\ i \in \{N, S\}.$$

Since the law of one price holds in the traded goods sector, the South country's real exchange rate is defined by the ratio of each country's non-traded commodity price.

2.2 Domestic Workers

A representative worker supplies labor N^i inelastically for domestic firms in both non-traded and traded goods sectors, and can trade a risk-free bond b_t^i with the international financial

[9] The U.S. labor productivity of service industry, relative to China in 1991 is 20.5475 (Data Source: BEA, World Development Indicators, and BLS Monthly Labor Review (July 2005)). Even if I allow the productivity in the non-traded commodity sector to differ across these two countries, all the qualitative results will carry through. If the North labor productivity in non-traded goods sector is greater than that of the South, the North produces more non-traded goods and less traded goods than before. Therefore, the South will grow faster through learning-by-exporting because it exports more than before.

market. The worker enjoys utility flows from consumption of a non-traded commodity c_t^i and two traded goods $c_t^i(z)$, where $i \in \{N, S\}$ and $z \in \{1, 2\}$. The worker discounts the future utility with a discount factor $\beta \in (0, 1)$ and has preferences:

$$\sum_{t=0}^{\infty} \beta^t u(C_t^i),$$

where

$$\begin{aligned} u(C_t^i) &\equiv \frac{(C_t^i)^{1-\gamma} - 1}{1-\gamma}; \\ C_t^i &\equiv \left(c_t^i\right)^{1-\psi} \cdot c_t^i(1)^{\eta\psi} \cdot c_t^i(2)^{(1-\eta)\psi}; \eta \in (0,1), \psi \in (0,1). \end{aligned}$$

Note that Cobb-Douglas preferences feature a unit elasticity of substitution across the non-traded commodity and two traded goods.[10] With this form of utility function, the expenditure share on traded goods and that on the first traded commodity within traded goods are equal to parameters ψ and η, respectively. I assume that the North does not levy taxes, so the representative worker in the North country maximizes utility subject to a budget constraint:

$$1 \cdot c_t^N + p_t(1)c_t^N(1) + p_t(2)c_t^N(2) + b_{t+1}^N = 1 \cdot N^N + (1 + r_t)\, b_t^N.$$

However, the representative worker in the South country maximizes utility subject to a budget constraint:

$$\left(1 + \tau_t^{NT}\right) p_t^S c_t^S + \left(1 + \tau_t^{EX}\right) p_t(1)c_t^S(1) + p_t(2)c_t^S(2) + b_{t+1}^S + T_t = w_t^S N^S + \left\{1 + (1 + \tau_t^r)\, r_t\right\} b_t^S.$$

The South government can tax or subsidize on non-traded commodity consumption $\left(\tau_t^{NT}\right)$, exporting commodity consumption $\left(\tau_t^{EX}\right)$, and domestic savings (τ_t^r). In addition, the government can use a lump-sum tax or transfer (T_t).[11] Note that without loss of generality I

[10] If I relax the unit elasticity assumption, all the qualitative results will be still valid. If I reduce the elasticity of substitution between home and foreign goods, manipulating terms of trade becomes more difficult. Therefore, the developing country distorts savings more and manipulating terms of trade less. This increases its level of current account in the "No-WTO Restrictions" case.

[11] What I am looking at is a long run trend for the past 20 years. Since monetary policy is neutral in the long run, I focus on real economic policies.

normalize taxes on imports to zero.[12]

As the benchmark, I consider a setup in which the policies are restricted to non-trade related ones by the WTO. Thus, in the benchmark model, I assume $\tau_t^{EX} = 0$. This means that the South government cannot directly subsidize exports or manipulate its terms of trade $\left(\frac{p_t(1)}{p_t(2)}\right)$. Then, I will compare the results of the benchmark model to those of a "No Policy" competitive equilibrium $\left(\tau_t^{NT} = \tau_t^{EX} = \tau_t^r = T_t = 0\right)$ and the "No-WTO Restrictions" case in which the South government can tax or subsidize on exporting commodity consumption $\left(\tau_t^{EX} \neq 0\right)$.

2.3 Law of Motion for South Human Capital

I assume the North has exhausted learning-by-exporting, so only the South country grows through learning-by-exporting as it trades with the North country.[13] The common findings in empirical micro studies on learning-by-exporting are that exporters' productivity improves as their value of exports grows. This export-productivity relationship becomes stronger as firms export to more developed countries. On the basis of these evidences, I model the degree of learning-by-exporting as an increasing function of both the South value of exports and the difference in human capital stocks between North and South. Thus, the law of motion for South human capital is

$$H_{t+1}^S = H_t^S + \underbrace{\left(\kappa H^N - H_t^S\right)\left\{1 - \exp\left(-\frac{EX_t^S}{\alpha}\right)\right\}}_{\text{"Learning-by-Exporting"}}, \qquad (1)$$

where

$$EX_t^S \equiv \max\left\{\left(y_t^S(1) - c_t^S(1)\right), 0\right\} + \theta \cdot \frac{p_0(2)}{p_0(1)} \cdot \max\left\{\left(y_t^S(2) - c_t^S(2)\right), 0\right\}.$$

[12] This is not the only way to decentralize the system. Assume that the South workers do not have access to the international financial market and its government trades a risk-free bond b_t^i on behalf of workers. The model implications for the key macroeconomic variables do not change.

[13] Note that the South learning-by-exporting depends on the difference in human capital stocks between North and South. If the North human capital grows over time, the South productivity gains from learning-by-exporting are not exhausted. The South cannot converge to a steady state.

The South human capital can grow up to κH^N, where $\kappa \in (0,1)$, through learning-by-exporting.[14] The difference between North and South human capital stocks is then represented by $\left(\kappa H^N - H_t^S\right)$. The value of South exports $\left(EX_t^S\right)$ is the weighted sum of two traded goods' exports. The parameter $\theta \in \{0,1\}$ determines the degree of learning-by-exporting from the second traded commodity export. The parameter $\alpha > 0$ governs the degree of learning-by-exporting, which is a decreasing function of α.

2.4 Competitive Equilibrium

A competitive equilibrium consists of a set of quantities $\left\{c_t^i, c_t^i(z), b_t^i, H_t^S\right\}$, a set of prices $\{p_t^i, p_t(z), w_t^i, r_t\}$, and a set of taxes $\left\{\tau_t^{NT}, \tau_t^{EX}, \tau_t^r, T_t\right\}$, where $i \in \{N,S\}$ and $z \in \{1,2\}$, such that:

1. given prices and taxes, workers maximize utilities
2. given prices, firms maximize profits
3. the South human capital evolves according to the law of motion stated in equation (1)
4. the South government budget constraint is satisfied:

$$\tau_t^{NT} p_t^S c_t^S + \tau_t^{EX} p_t(1) c_t^S(1) + T_t = \tau_t^r r_t b_t^S$$[15]

5. goods markets clear:

$$\begin{aligned} c_t^i &= y_t^i,\ i \in \{N,S\}; \\ c_t^N(z) + c_t^S(z) &= y_t^N(z) + y_t^S(z),\ z \in \{1,2\} \end{aligned}$$

6. labor markets clear:

$$n_t^i + n_t^i(1) + n_t^i(2) = N^i,\ i \in \{N,S\}$$

[14] The functional form, I use for the law of motion for South human capital, does not allow the South human capital $\left(H_t^S\right)$ to converge to κH^N in finite periods. Therefore, I consider that this model economy arrives at the steady state when the South human capital $\left(H_t^S\right)$ reaches 99% of κH^N.

[15] Without loss of generality, I assume that the government runs a balanced budget using a lump-sum tax or transfer (T_t).

7. bond market clears:

$$b_t^S + b_t^N = 0.$$

2.5 Ramsey Problem

The South government recognizes the law of motion for South human capital and implements policies in order to take advantage of learning-by-exporting.[16] The South government problems in the benchmark model and the "No-WTO Restrictions" case are the Ramsey problem choosing a competitive equilibrium maximizing the South worker's utility, given H_0^S and b_0^S. Following the primal approach to the Ramsey problem (Jones, Manuelli, and Rossi (1997)), I formulate the South government problems as if the government chooses an allocation, subject to constraints that ensure the existence of prices and taxes such that the selected allocation is consistent with the optimizing behavior of workers and firms.

2.5.1 Benchmark

The allocation selected by the South government has to satisfy the law of motion for South human capital, both countries' domestic labor markets clearing conditions, and all goods markets clearing conditions. In addition to these standard constraints, the allocation should also satisfy: (i) the North worker's optimality conditions and present-value budget constraint, (ii) the optimality conditions of the North firms, and (iii) the WTO restrictions.

The North representative worker solves:

$$\max \sum_{t=0}^{\infty} \beta^t u(C_t^N),$$

subject to

$$\sum_{t=0}^{\infty} \left(\prod_{i=0}^{t} \frac{1}{1+r_i} \right) \cdot \left(1 \cdot c_t^N + p_t(1) \cdot c_t^N(1) + p_t(2) \cdot c_t^N(2) - 1 \cdot N^N \right) = b_0^N.$$

[16] Note that firms do not internalize learning-by-exporting in this model. If firms recognize learning-by-exporting, the only thing firms can do to take advantage of learning-by-exporting is dumping. However, firms cannot use dumping because of the WTO restrictions. Therefore, government's macroeconomic policy is important to take advantage of learning-by-exporting.

Therefore, the North worker's optimality conditions are:

$$\begin{aligned}\frac{\beta u_{c_{t+1}^N}}{u_{c_t^N}} &= \frac{1}{1+r_{t+1}};\\ \frac{u_{c_t^N(z)}}{u_{c_t^N}} &= p_t(z),\ z \in \{1,2\},\end{aligned}$$

where $u_{c_t^N(z)}$ is the North worker's marginal utility of consumption for the traded commodity $z \in \{1,2\}$, and $u_{c_t^N}$ is the North worker's marginal utility of consumption for its non-traded commodity.

Note that the North worker's optimality conditions and present-value budget constraint are summarized as the following implementability condition:

$$\sum_{t=0}^{\infty} \beta^t \left(u_{c_t^N} \cdot c_t^N + u_{c_t^N(1)} \cdot c_t^N(1) + u_{c_t^N(2)} \cdot c_t^N(2) - u_{c_t^N} \cdot N^N \right) = u_{c_0^N} \cdot b_0^N.^{17}$$

This implies that any competitive equilibrium must satisfy the North implementability condition, and any allocation that satisfies this condition and goods market clearing conditions can be decentralized as a competitive equilibrium.

The optimality conditions of the North firms are summarized as follows:

$$\begin{aligned}\text{if } p_t(z) &= \frac{u_{c_t^N(z)}}{u_{c_t^N}} < \frac{1}{A_t^N(z)},\ n_t^N(z) = 0;\\ \text{if } p_t(z) &= \frac{u_{c_t^N(z)}}{u_{c_t^N}} = \frac{1}{A_t^N(z)},\ n_t^N(z) > 0,\ z \in \{1,2\}.\end{aligned}$$

The firms in the North traded goods sector do not produce the traded commodity z if its world price $p_t(z)$ is less than the firms' unit labor cost $\frac{1}{A_t^N(z)}$.

The WTO restrictions are represented by

$$\frac{u_{c_t^S(1)}}{u_{c_t^S(2)}} = \frac{u_{c_t^N(1)}}{u_{c_t^N(2)}}.$$

Since the South government cannot directly subsidize exports or manipulate terms of trade in the benchmark model, the South domestic relative price of export good to import good $\left(\frac{p_t(1)}{p_t(2)}\right)$ is equal to the world price.

[17] See the appendix for the derivation of the implementability condition.

Therefore, the South government problem in the benchmark model[18] is formulated as follows: the South government solves

$$\max \sum_{t=0}^{\infty} \beta^t u(C_t^S),$$

subject to

$$H_{t+1}^S = H_t^S + \left(\kappa H^N - H_t^S\right)\left\{1 - \exp\left(-\frac{EX_t^S}{\alpha}\right)\right\};$$

$$N^i = n_t^i + n_t^i(1) + n_t^i(2);\ c_t^i = n_t^i,\ i \in \{N, S\};$$

$$c_t^N(z) + c_t^S(z) = A_t^N(z)\, n_t^N(z) + A_t^S(z)\, n_t^S(z);$$

$$\frac{u_{c_t^N(z)}}{u_{c_t^N}} \leq \frac{1}{A_t^N(z)};\ n_t^N(z) \geq 0;\ n_t^S(z) \geq 0,\ z \in \{1, 2\};$$

$$\sum_{t=0}^{\infty} \beta^t \left(u_{c_t^N} \cdot c_t^N + u_{c_t^N(1)} \cdot c_t^N(1) + u_{c_t^N(2)} \cdot c_t^N(2) - u_{c_t^N} \cdot N^N\right) = u_{c_0^N} \cdot b_0^N;$$

$$\frac{u_{c_t^S(1)}}{u_{c_t^S(2)}} = \frac{u_{c_t^N(1)}}{u_{c_t^N(2)}}.$$

2.5.2 No WTO Restrictions

If there were no WTO restrictions, the allocation chosen by the South government has to satisfy all constraints of the benchmark model above except the last equation $\left(\frac{u_{c_t^S(1)}}{u_{c_t^S(2)}} = \frac{u_{c_t^N(1)}}{u_{c_t^N(2)}}\right)$. Therefore, the "No-WTO Restrictions" problem drops the last constraint. Since the South government can manipulate terms of trade, the South domestic relative price of export good to import good $\left(\frac{p_t(1)}{p_t(2)}\right)$ can be different from the world price.

3 Calibration

This section explains how I set parameter values of the benchmark model economy. I interpret the North country as the U.S. and the South country as China. A set of parameters are adopted from related literature and the U.S. data. The model period is one year. The discount factor β is set at 0.96, which implies 4% real interest rate per annum at the steady

[18] See the appendix for the computation algorithm used to solve the benchmark model.

state, and the preference parameter γ, which determines the intertemporal elasticity of substitution, is set at 2. The expenditure share on traded goods ψ is 0.2438, which is the average U.S. GDP share of traded goods sector[19] from 1991 to 2007[20] and the parameter η is set at 0.5516[21] so that the expenditure share on the first traded commodity ($\eta\psi$) matches the average U.S. imports to GDP ratio from 1991 to 2007 (0.1345)[22]. Among parameters related to the law of motion for South human capital, the parameter κ, which determines the South human capital at the steady state, is 0.99 in order to prevent multiple solutions.[23] The parameter θ, which determines the degree of learning-by-exporting from the second traded commodity export, is set at zero. If θ is equal to one, a discontinuity appears due to $\max\left\{\left(y_t^S(2)-c_t^S(2)\right),0\right\}$ of the law of motion for South human capital. This creates a spike in the time path of aggregates when the South country starts to produce the second traded commodity. However, the main results and implications of the model are still valid. Both the North $\left(N^N\right)$ and the South $\left(N^S\right)$ labors are normalized to 1, and the South initial debt $\left(b_0^S\right)$ is set at 0.

The remaining parameters are chosen so that the model can replicate relevant data moments of the U.S. and China. The South initial human capital H_0^S, the North human capital H^N, and the parameter ϕ, which governs the labor productivity in the second traded commodity production, are selected so that the model matches three targets: (i) China's labor productivity of manufacturing industry relative to service industry in 1991 (0.5269)[24]; (ii) the

[19] Following Stockman and Tesar (1995), the traded goods sector includes agricultural, manufacturing, mining, retail, and transportation sectors.

[20] Data Source: BEA.

[21] This is a lower bound of the first traded commodity expenditure share in traded goods consumption, because I assume that the U.S. does not produce the imported goods. A sensitivity analysis found that the main results are robust to the value of parameter η.

[22] Data Source: World Development Indicators.

[23] If κ is equal to one, the comparative advantage disappears at the steady state $\left(H_t^S=\kappa H^N\right)$, leading to multiple solutions. The parameter κ determines the South human capital at the steady state. If we reduce the value of κ, the South steady state human capital decreases and the growth rate of its human capital declines because of the reduced difference in human capital stocks between North and South. All the qualitative results are still valid.

[24] Data Source: World Development Indicators and BLS Monthly Labor Review (July 2005).

U.S. labor productivity of manufacturing industry relative to China in 1991 (44.1379) [25]; and (iii) the U.S. relative labor productivity of exporters in 1992 (1.169) calculated by Bernard and Jensen (1999). The parameter α, which governs the degree of learning-by-exporting are chosen so that the model matches the average growth rate of China's real GDP per capita relative to the U.S. from 1991 to 2007 (0.0752) [26]. The degree of learning-by-exporting under this calibration implies that if the South country's export increases by 10%, its productivity rises by 12.91%. This is in line with micro estimates for China.[27] The parameter values are summarized in Table 1. I use the same parameters for the "No-Policy" and "No-WTO Restrictions" cases as in the benchmark economy.

4 Results

This section explains the quantitative results and is organized as follows: Subsection 4.1 explains the results of the benchmark model and compares them to the observed data patterns; Subsections 4.2 and 4.3 present the results of the "No-Policy" economy and the "No-WTO Restrictions" case in comparison with those of the benchmark, respectively.

4.1 Benchmark

The period 0 corresponds to the year 1991. When the South government cannot use export subsidy $\left(\tau_t^{EX} = 0\right)$ due to WTO restrictions, the optimal policy for the South country is to tax non-traded goods consumption and subsidize savings as shown in Figure 3. This shifts labor into the tradable sector and suppresses its overall consumption to increase exports. Figure 4 shows that the South government initially shifts labor into the tradable sector by suppressing consumption of non-traded commodity. As the South human capital grows through learning-by-exporting, it gradually raises its labor allocation to the non-traded commodity sector and therefore its consumption. Figure 5 shows that the South government

[25] Data Source: BEA, World Development Indicators, and BLS Monthly Labor Review (July 2005).

[26] Data Source: Penn World Table.

[27] For instance, Park, Yang, Shi, and Jiang (2010) show that if a firm experiences an exogenous 10% increase in exports, its productivity rises by 11% to 13% in China.

suppresses consumption of the export good (Traded Commodity 1) while reducing that of the import good (Traded Commodity 2) for the initial periods. This raises the South export, leading its human capital and real GDP to grow rapidly through learning-by-exporting as shown in Figures 4 and 6. The transition to the steady state takes 112 periods, during which the North produces both traded goods and the South produces the first traded commodity.[28]

The initial pattern of export and import of the South causes the country to run a current account surplus, amid a rapid growth in its real GDP as shown in Figure 6.[29] During the transition, the South terms of trade stay constant. Note that when one country produces both traded goods, the terms of trade are determined by its productivity ratio between two traded goods production. Since the North produces both traded goods for all periods, the South terms of trade are equal to the North productivity ratio between two traded goods $\left(\frac{p_t(1)}{p_t(2)} = \frac{\left(H^N\right)^{1+\phi}}{H^N}\right)$. This is equal to the U.S. relative labor productivity of exporters in 1992 (1.169). The constant South terms of trade makes the South real exchange rate appreciate as its human capital grows. This is because the South real exchange rate is a function of its terms of trade and relative productivity in traded commodity production $\left(e_t^S \equiv \left\{\left(\frac{p_t(1)}{p_t(2)}\right) \cdot \left(\frac{A_t^S(1)}{A^N(2)}\right)\right\}^{1-\psi}\right)$. These simultaneous growth and real exchange rate appreciation are consistent with the Balassa (1964)-Samuelson (1964) hypothesis[30].

Table 2 summarizes the average values of key aggregates of the U.S. and China from 1991 to 2007 and their counterparts in the benchmark model. The model is calibrated to

[28] As I describe in Subsections 4.2, 4.3 and 5.2, the South produces the second traded commodity during the latter part of the transition in the "No Policy", "No-WTO Restrictions", and "Coordinated Policy" cases. This is because initially the South runs a substantial current account deficit. In order to repay the interests on its debt, the South shifts more workers from non-tradable sector to both tradable sectors so that it runs a trade surplus for the rest of the transition periods.

[29] As can be seen in Figure 2, China's current account surplus has increased over time. However, in this model, the South current account surplus is decreasing over time.

In the real world, the Chinese government could have gradually implemented policies to take advantage of learning-by-exporting. However, since this is a perfect foresight model, the South does not gradually implement policies. In order to match the trend, I should introduce some frictions like adjustment costs into this model.

[30] Balassa (1964) and Samuelson (1964) argue that economic growth driven by productivity gains in the traded goods sector should accompany a real exchange rate appreciation.

match the average growth rate of China's real GDP per capita relative to the U.S. (7.52%). As shown in Table 2, the South policies generate the simultaneous fast growth and current account surpluses observed in the data.[31] In addition, the benchmark model replicates both China's export over GDP and the appreciation of its real exchange rate as in the data.

4.2 No Policy Counterfactual

In the "No-Policy" economy, both firms and workers know that the South human capital will grow over time but no one recognizes the law of motion for South human capital. Therefore, they do not have an incentive to raise the South export in order to take advantage of learning-by-exporting. If no policies were implemented in both the North and South countries, the transition to the steady state takes 118 periods as shown in Figure 7. This is 6 periods longer than that of the benchmark economy because no one implements policies to accelerate the South growth through learning-by-exporting in the "No-Policy" economy. During the transition, the patterns of specialization in production undergo three stages: (i) the North produces both traded goods and the South produces the first traded commodity for the first 96 periods; (ii) both countries are completely specialized in period 97; and (iii) the South starts to produce the second traded commodity in period 98.

Figure 7 shows that more South workers produce in the non-traded commodity sector for the initial 85 periods relative to the benchmark case, because the South labor productivity in the first traded commodity production is much less than that in non-traded commodity production over the same periods in the "No-Policy" world. This initially suppresses the South first traded commodity export although its consumption for the first traded commodity is less than in the benchmark economy as shown in Figure 8, delaying the take-off of its human capital relative to the benchmark case.

[31] This model overstates China's current account surplus and understates the U.S. current account deficit. However, what is important is the qualitative result that the model can replicate the sign of current accounts of both countries. In reality, both countries have other trading partners than each other. The discrepancy between current account generated by the model and its data counterpart may come from each country's trade with the rest of the world.

In the "No-Policy" economy, since the South workers know that their income will grow in the future, they want to raise current consumption. The South consumes more non-traded goods in the first 85 periods than in the benchmark economy, leading to a larger aggregate consumption. This makes the South current account deficit[32] increase for the same periods. The South workers move from non-tradable sector to both tradable sectors for the rest of the transition periods so that the South runs a trade surplus in order to repay the interests on its debt.[33] Since more workers produce in both traded commodity sectors in the South country relative to the benchmark economy beginning in period 86, the level of South real GDP becomes greater than that in the benchmark case as Figure 9 presents. This is because labor productivity in the traded goods production is higher than that in non-traded commodity production over the same period. Figure 9 shows that the South terms of trade start to deteriorate in period 97 when both countries are completely specialized.[34] Beginning in period 98 when the South produces both traded goods, its terms of trade, which are equal to the South productivity ratio $\left(\frac{\left(H_t^S\right)^{1+\phi}}{H_t^S}\right)$, improves as its human capital grows. For the same period, the real exchange rate appreciates following the South human capital growth.

4.3 No WTO Restrictions

If there were no WTO restrictions $\left(\tau_t^{EX} \neq 0\right)$, the South country can directly subsidize exports. Figure 10 shows that the transition to the steady state takes 70 periods but the most catch-up takes place for the initial 50 periods. During the transition, the North produces both traded goods and the South produces the first traded commodity for the first 26 periods. As the South human capital grows, it gradually expands the world market share of the first traded commodity. In period 27, the South completely takes over the market for the first traded commodity, which leads to complete specialization of both countries until period 34.

[32] The size of the current account deficits is implausible. This is caused by the full commitment and perfect foresight assumptions.

[33] The right panel of Figure 8 shows that the South exports even the second traded commodity from period 100 in spite of a comparative disadvantage.

[34] The South terms of trade in the benchmark model is normalized to 1 in Figures 9, 12, and 16.

The South starts to produce the second traded commodity in period 35.

As shown in the left panel of Figure 11, the South government suppresses consumption of the export good (Traded Commodity 1) during the transition relative to benchmark outcomes. This raises the South export, making its human capital grow faster through learning-by-exporting relative to the benchmark economy. Figure 10 shows that the South government shifts more workers from the non-traded commodity sector to both traded goods sectors, than in the benchmark economy. Since labor productivity in both traded goods production is higher than that in non-traded commodity production, the level of South real GDP in "No-WTO Restrictions" case is greater than that in the benchmark economy beginning in period 11. The right panel of Figure 11 shows that the South substitutes the alternative import by raising consumption of the import good (Traded Commodity 2) substantially for the initial periods. As the South accumulates human capital through learning-by-exporting, its imports decline to the level which is even below that in the benchmark after period 35 when the South starts to produce the second traded commodity.

The increased South import initially causes the country to run a large current account deficit. As the South import declines, the current account deficit also goes down and ultimately becomes balanced in the steady state. The South government's export subsidy generates a deterioration in its terms of trade $\left(\frac{p_t(1)}{p_t(2)}\right)$ beginning in period 27 when both countries start to be completely specialized, as shown in the lower panel of Figure 12. When the North produces both traded goods for the initial 26 periods, the South terms of trade are equal to the North productivity ratio between two traded goods $\left(\frac{\left(H^N\right)^{1+\phi}}{H^N}\right)$, which is time-invariant. When the South produces both traded goods beginning in period 35, its terms of trade are equivalent to its productivity ratio $\left(\frac{\left(H_t^S\right)^{1+\phi}}{H_t^S}\right)$, which rises with the South human capital.

Figure 13 shows that if there were no WTO restrictions, the South country will use an export subsidy for the initial 34 periods instead of non-traded commodity consumption tax and it no longer relies heavily on the savings subsidy to promote exports. The switch of sign in the current account from the benchmark to the "No-WTO Restrictions" case implies that

ideally the South would like to manipulate its terms of trade rather than its current account. However, if the ability to explicitly subsidize exports is absent due to the WTO restrictions, it must "over" distort both the intertemporal margin and the non-traded margin.

5 Coordinated Policy Problem

In this section, I consider a "Coordinated Policy" problem in which the North and South could coordinate policies, in order to obtain the first-best outcome for the world. I assume that there is a fictitious world planner who maximizes the weighted average of both the North and South utilities by taking advantage of the South country's learning-by-exporting. The world planner solves

$$\max \sum_{t=0}^{\infty} \beta^t \left\{ \mu u(C_t^S) + (1-\mu)\, u(C_t^N) \right\},$$

subject to

$$\begin{aligned}
H_{t+1}^S &= H_t^S + \left(\kappa H^N - H_t^S\right) \left\{ 1 - \exp\left(-\frac{EX_t^S}{\alpha} \right) \right\}; \\
c_t^i &= n_t^i;\ N^i = n_t^i + n_t^i(1) + n_t^i(2),\ i \in \{N, S\}; \\
c_t^S(z) + c_t^N(z) &= A_t^S(z)\, n_t^S(z) + A^N(z)\, n_t^N(z); \\
n_t^S(z) &\geq 0;\ n_t^N(z) \geq 0,\ z \in \{1, 2\},
\end{aligned}$$

where $\mu \in [0, 1]$ is the South country's Pareto weight.

If the South country exports the traded commodity $z \in \{1, 2\}$, the world utility maximizing behavior of the planner implies the following first-order conditions:

$$\mu u_{c_t^S(z)} - \frac{\lambda_t \left(\kappa H^N - H_t^S\right)}{\alpha} \exp\left(-\frac{EX_t^S}{\alpha} \right) = (1-\mu)\, u_{c_t^N(z)}; \tag{2}$$

$$u_{c_t^S(z)} \cdot A_t^S(z) = u_{c_t^S} \cdot 1, \tag{3}$$

where λ_t is a multiplier for the law of motion for South human capital, $u_{c_t^i(z)}$ is the country i's marginal utility of consumption for the traded commodity z, and $u_{c_t^i}$ is the country i's marginal utility of consumption for its non-traded commodity. Note that the second term in

the left side of the condition (2), $\frac{\lambda_t\left(\kappa H^N - H_t^S\right)}{\alpha}\exp\left(-\frac{EX_t^S}{\alpha}\right)$, which appears due to learning-by-exporting, is positive. This implies that when the South country exports the traded commodity z, the world planner reduces the South country's consumption for the exporting good $c_t^S(z)$ in order to take advantage of learning-by-exporting. The condition (3) shows that there is no distortion between the South consumption for the export good and that of non-traded good. If a worker shifts from the non-traded commodity sector to the traded commodity z sector in the South country, this reduces one unit of non-traded commodity. Thus, the welfare loss is marginal utility of consumption for the non-traded commodity. However, the worker produces $A_t^S(z)$ units of the traded commodity z and by consuming it, the worker can enjoy marginal utility of consumption for the commodity times marginal product $\left(A_t^S(z)\right)$. Since the South country does not export the traded commodity z but consumes it, there is no additional welfare gain from learning-by-exporting.[35] The conditions (2) and (3) imply that the planner decreases not only the South country's consumption for the export good but also that for non-traded good. This means that the planner raises the South exports by reducing its consumption of domestically produced goods and increasing consumption of the import good.

5.1 Decentralization

In this subsection, I explain the way I find prices and wedges, which imply the first-best allocation for the world. The North country's non-traded commodity price is normalized to one. Since the North's relative consumptions across goods are undistorted, I use their marginal rate of substitution between non-traded and traded goods as the world prices. The

[35] Note that non-traded goods consumption tax is needed in the presence of WTO restrictions. If a worker shifts from the non-traded commodity sector to the export commodity sector in the South country, this reduces one unit of non-traded commodity. Thus, the welfare loss is marginal utility of consumption for the non-traded commodity. However, the worker produces marginal product of the export commodity and consumes part of that while exporting the remaining part to increase the import commodity consumption. This way, the terms of trade are kept constant. Since the South country exports some of the increased export commodity, there is additional welfare gain from learning-by-exporting.

world price $p_t(z)$ of traded commodity z is defined by

$$p_t(z) \equiv \frac{u_{c_t^N(z)}}{u_{c_t^N}},\ z \in \{1,2\},$$

where $u_{c_t^i(z)}$ is the country i's marginal utility of consumption for the traded commodity z and $u_{c_t^i}$ is the country i's marginal utility of consumption for its non-traded commodity. The world interest rate r_{t+1} is defined by

$$r_{t+1} \equiv \frac{u_{c_t^N}}{\beta \cdot u_{c_{t+1}^N}} - 1.$$

Since the South country has a comparative advantage in the first traded commodity production, it produces the first traded commodity and the North produces the second traded commodity. Therefore, the South domestic wage is defined by

$$w_t^S \equiv \left(\frac{p_t(1)}{p_t(2)}\right) \cdot \left(\frac{A_t^S(1)}{A^N(2)}\right) = p_t^S.$$

A wedge τ_{t+1}^r in the South country's domestic interest rate, a wedge τ_t^{EX} in the South domestic relative price of export good to import good, and a wedge τ_t^{NT} in the South domestic relative price of export good to non-traded good are defined by

$$\begin{aligned}
\tau_{t+1}^r &\equiv \frac{w_{t+1}^S \cdot u_{c_t^S}}{r_{t+1} \cdot w_t^S \cdot \beta \cdot u_{c_{t+1}^S}} - \frac{1}{r_{t+1}} - 1 \iff \frac{w_{t+1}^S \cdot u_{c_t^S}}{w_t^S \cdot \beta \cdot u_{c_{t+1}^S}} - 1 = \left(1 + \tau_{t+1}^r\right) r_{t+1}; \\
\tau_t^{EX} &\equiv \frac{p_t(2) \cdot u_{c_t^S(1)}}{p_t(1) \cdot u_{c_t^S(2)}} - 1 \iff \frac{u_{c_t^S(1)}}{u_{c_t^S(2)}} = \frac{\left(1 + \tau_t^{EX}\right) p_t(1)}{p_t(2)}; \\
\tau_t^{NT} &\equiv \frac{u_{c_t^S}}{A_t^S(1) \cdot u_{c_t^S(1)}} - 1 \iff \frac{u_{c_t^S(1)}}{u_{c_t^S}} = \frac{p_t(1)}{\left(1 + \tau_t^{NT}\right) p_t^S} = \frac{1}{\left(1 + \tau_t^{NT}\right) A_t^S(1)}.
\end{aligned}$$

5.2 Results

I use the same parameters for the "Coordinated Policy" case as in the benchmark economy, except for the South Pareto weight $\mu = 0.3314$ which is chosen so that the model matches the balanced steady state current account.[36]

When both the North and South coordinate policies to achieve the world best allocation, the transition to the steady state takes 64 periods as Figure 14 presents. This is 6 periods

[36] If μ is greater than 0.3314, the South runs a current account deficit at the steady state. If μ is less than 0.3314, it runs a current account surplus at the steady state.

less than that of "No-WTO Restrictions" economy because the world planner facilitates growth through terms of trade distortion even more. During the transition, the patterns of specialization in production undergo three stages as before: (i) the North produces both traded goods and the South produces the first traded commodity for the first 24 periods; (ii) both countries are completely specialized from period 25 to 34; and (iii) the South starts to produce the second traded commodity in period 35. The first stage gets shorter relative to the "No-WTO Restrictions" case.

The left panel of Figure 15 shows that the world planner reduces the South consumption of the export good (Traded Commodity 1) even more from period 19 than in the "No-WTO Restrictions" economy. This increases the South export, making its human capital grow more rapidly through learning-by-exporting than in the "No-WTO Restrictions" case. As can be seen in Figure 14, the world planner moves more workers from non-traded commodity sector to both traded commodity sectors in the South country relative to the "No-WTO Restrictions" economy beginning in period 25. This makes the level of South real GDP greater than that in "No-WTO Restrictions" case over the same period because labor productivity in the traded goods production is higher than that in non-traded commodity production. The right panel of Figure 15 shows that, for the initial periods, the world planner raises the South import by 43% of its GDP relative to the "No-WTO Restrictions" world by increasing its consumption of the import good (Traded Commodity 2).

This difference in the South import between "Coordinated Policy" and "No-WTO Restrictions" economies initially leads to a larger current account deficit (43% of the South GDP) relative to the "No-WTO Restrictions" case. Figure 16 shows that beginning in period 25 when both countries start to be completely specialized, the increase of South export deteriorates its terms of trade $\left(\frac{p_t(1)}{p_t(2)}\right)$ much more than in the "No-WTO Restrictions" economy. This large deterioration of the South terms of trade causes its real exchange rate to be undervalued from period 25 to 34, as shown in Figure 16. Over the same period, the South real GDP grows rapidly due to the fast growth of its human capital which implies a rapid productivity improvement in traded goods sector. These simultaneous growth and

undervaluation contrast with the prediction of the Balassa (1964)-Samuelson (1964) hypothesis. When the South produces both traded goods beginning in period 35, its terms of trade $\left(\frac{p_t(1)}{p_t(2)} = \frac{\left(H_t^S\right)^{1+\phi}}{H_t^S}\right)$ improve due to the growth of South human capital. For the same period, the real exchange rate appreciates following the real GDP growth. This implies that the world planner postpones the Balassa (1964)-Samuelson (1964) effect by deteriorating the South terms of trade.

Figure 17 shows that the world planner uses a bigger export subsidy and a less saving subsidy relative to the "No-WTO Restrictions" case. This implies that the world planner calls for more terms of trade manipulation than the No-WTO policies.

6 Welfare Analysis

This paper explores optimal policies in the presence of learning-by-exporting in various environments: with the WTO restrictions, with no restrictions, and under the policy coordination. An interesting question is what are the welfare consequences of those policies for the developing and developed economies. In order to answer this question, I measure the welfare changes due to moving from the benchmark economy with the WTO restrictions to another environment using the percentage change in per-period consumption that I should give to the worker in each country in the benchmark so that the worker is indifferent between the two environments.

In the "No-Policy" economy, no one recognizes the positive externality from learning-by-exporting and no policy is implemented to facilitate export-led growth. On the other hand, in the benchmark model, the South government, which recognizes learning-by-exporting, has an incentive to implement policies to increase exports. Since it cannot directly subsidize exports due to WTO restrictions, it taxes non-traded goods consumption and subsidizes savings as an alternative. This policy enables the South country to grow faster, benefitting its workers, than in the "No-Policy" world. Moving from the "No-Policy" world to the benchmark economy, the welfare of the North country slightly decreases. The importance

of the policy implemented in the benchmark economy is measured by welfare changes from the benchmark economy to the "No-Policy" world in Table 3. These welfare changes are equivalent to 19.10% decline and 0.06% increase in per-period consumption of the South and the North, respectively.

If the South country is allowed to manipulate its terms of trade ("No-WTO Restrictions" case), both the North and South benefit from welfare improvement relative to the benchmark economy. Without restrictions on the policies, the South country subsidizes exports to reduce its consumption of the export good and increase consumption of the import good. This policy generates a large deterioration in the South terms of trade and a current account deficit. These policies make the South grow faster without raising savings heavily to promote exports, which improves the welfare of the South relative to the benchmark economy. In the "No-WTO Restrictions" world, the North welfare also increases due to improved terms of trade compared with the benchmark economy. This "win-win" outcome through the terms of trade manipulation is reflected in the welfare gains of 14.08% and 0.43% rises in per-period consumption of the South and the North, respectively. This contrasts with Bagwell and Staiger (1999)'s view that the WTO improves the world welfare by preventing zero-sum terms of trade manipulation.[37]

As shown in Table 3, if both countries coordinate policies to achieve the world best allocation, both countries' welfare rises significantly compared with the benchmark economy. The fictitious world planner manipulates the terms of trade of both countries so that the South grows faster through learning-by-exporting. This leads to the welfare gains equivalent to 13.24% and 1.16% increases in per-period consumption of the South and the North, respectively. However, moving from the "No-WTO Restrictions" economy to the "Coordinated Policy" world, the North is better off whereas the South is worse off. The world planner pulls down the relative price of the South export good to its import good even more than in the

[37] There may be other reasons that the WTO restrictions improve the welfare of developing countries. For instance, Bajona and Chu (2010) claim that the WTO restrictions increase China's welfare by reducing subsidies to the inefficient state-owned sector.

"No-WTO Restrictions" economy. Even though this makes the South country grow faster, the larger deterioration of the South terms of trade hurts its welfare. On the other hand, the North benefits from its improved terms of trade. However, the welfare changes of both countries between "No-WTO Restrictions" case and the "Coordinated Policy" economy are quantitatively modest.

7 Sensitivity Analysis

I do a sensitivity analysis on the degree of learning-by-exporting. The degree of learning-by-exporting is measured by a rise in a firm's productivity accompanied by a 10% increase in exports. According to Park, Yang, Shi, and Jiang (2010), a firm's productivity increases by 11% to 13% in China, if it experiences an exogenous 10% rise in exports. Table 4 shows that if I use the lowest value of the micro estimate on the degree of learning-by-exporting, which is 11%, the benchmark model still generates the simultaneous fast growth and current account surplus of the South country. However, the levels of both the average growth rate of China's real GDP per capita relative to the U.S. and China's current account over GDP decrease relative to the benchmark calibration in which the degree of learning-by-exporting is 12.91%. If the degree of learning-by-exporting is about one tenth of the highest value of micro estimate, that is, 1.38%, the South does not need to run a current account surplus to take advantage of learning-by-exporting. This result shows that the cross-country differences in the degree of learning-by-exporting may explain the heterogeneity in the pattern of current account across developing countries.

8 Conclusion

This paper examines if a popular concept, learning-by-exporting rationalizes the key macroeconomic behavior of fast growing developing countries. This paper also explores what policies exploit learning-by-exporting, their implications for aggregates like the current account and the real exchange rate, the welfare consequences for the growing economy and the

rest of the world, and if restricting the set of policies to non-trade related policies matter.

In order to answer these questions, this paper builds a two country general equilibrium growth model in which a developing economy benefits from learning-by-exporting as it trades with a developed economy. If the policies are restricted to non-trade related ones by the WTO, the optimal policy for the developing country is to tax non-traded goods consumption and subsidize savings, which rationalize the observed current account surpluses of rapidly growing developing economies. This policy improves the welfare of developing country relative to a "No-Policy" competitive equilibrium.

If there were no WTO restrictions, the developing country directly subsidizes exports. This policy generates a large deterioration in the developing economy's terms of trade and reverses the prediction for the current account. This policy raises the welfare of both countries relative to the model with WTO restrictions, as it generates faster economic growth in the developing economy and improvement of the terms of trade in the developed economy. This paper also considers a "Coordinated Policy" problem to obtain the first-best outcomes for the world. In this setup, the developing country's terms of trade deteriorate even more and it runs a greater current account deficit relative to the "No-WTO Restrictions" case.

This paper not only provides an additional explanation regarding "global imbalances" but also investigates the connection between growth, current account surplus and WTO restrictions. In addition, it explores the optimal polices in the presence of learning-by-exporting and the welfare consequences for the growing economy and the rest of the world which were not done by previous studies.

Appendix

A Derivation of the Implementability Condition

The North representative worker solves:

$$\max \sum_{t=0}^{\infty} \beta^t u(C_t^N),$$

subject to

$$\sum_{t=0}^{\infty} \left(\prod_{i=0}^{t} \frac{1}{1+r_i} \right) \cdot \left(1 \cdot c_t^N + p_t(1) \cdot c_t^N(1) + p_t(2) \cdot c_t^N(2) - 1 \cdot N^N \right) = b_0^N. \tag{4}$$

The worker's first order conditions are:

$$\begin{aligned} \frac{\beta u_{c_{t+1}^N}}{u_{c_t^N}} &= \frac{1}{1+r_{t+1}}; \\ \frac{u_{c_t^N(z)}}{u_{c_t^N}} &= p_t(z), \ z \in \{1,2\}. \end{aligned}$$

Plugging the above first order conditions into the North worker's present-value budget constraint (4) yields

$$\sum_{t=0}^{\infty} \left(\prod_{i=1}^{t} \frac{\beta u_{c_i^N}}{u_{c_{i-1}^N}} \right) \cdot \left(1 \cdot c_t^N + \frac{u_{c_t^N(1)}}{u_{c_t^N}} \cdot c_t^N(1) + \frac{u_{c_t^N(2)}}{u_{c_t^N}} \cdot c_t^N(2) - 1 \cdot N^N \right) = b_0^N.$$

Since $u_{c_i^N}$'s, $i \in \{1, 2, \cdots, t-1\}$ are canceled out in $\left(\prod_{i=1}^{t} \frac{\beta u_{c_i^N}}{u_{c_{i-1}^N}} \right)$, I have

$$\sum_{t=0}^{\infty} \left(\frac{\beta^t u_{c_t^N}}{u_{c_0^N}} \right) \cdot \left(1 \cdot c_t^N + \frac{u_{c_t^N(1)}}{u_{c_t^N}} \cdot c_t^N(1) + \frac{u_{c_t^N(2)}}{u_{c_t^N}} \cdot c_t^N(2) - 1 \cdot N^N \right) = b_0^N. \tag{5}$$

Multiplying both sides of equation (5) by $u_{c_0^N}$, I obtain the implementability condition

$$\sum_{t=0}^{\infty} \beta^t \cdot \left(u_{c_t^N} \cdot c_t^N + u_{c_t^N(1)} \cdot c_t^N(1) + u_{c_t^N(2)} \cdot c_t^N(2) - u_{c_t^N} \cdot N^N \right) = u_{c_0^N} \cdot b_0^N. \tag{6}$$

B Computation Algorithm

The following algorithm is used to solve the benchmark model.

1. Guess the Lagrangian multiplier Φ of the implementability condition (6).

2. Given Φ and $b_0^N = 0$, solve the following value function using value function iterations and obtain the optimal decision rules:

$$\begin{aligned} & V(H_t^S, \Phi) \\ \equiv \quad & \max \left[\begin{array}{c} u(C_t^S) + \Phi \left(u_{c_t^N} \cdot c_t^N + u_{c_t^N(1)} \cdot c_t^N(1) + u_{c_t^N(2)} \cdot c_t^N(2) - u_{c_t^N} \cdot N^N \right) \\ +\beta V(H_{t+1}^S, \Phi) \end{array} \right], \end{aligned}$$

subject to

$$\begin{gathered} H_{t+1}^S = H_t^S + \left(\kappa H^N - H_t^S\right) \left\{ 1 - \exp\left(-\frac{EX_t^S}{\alpha} \right) \right\}; \\ N^i = n_t^i + n_t^i(1) + n_t^i(2);\ c_t^i = n_t^i,\ i \in \{N, S\}; \\ c_t^N(z) + c_t^S(z) = A_t^N(z)\, n_t^N(z) + A_t^S(z)\, n_t^S(z); \\ \frac{u_{c_t^N(z)}}{u_{c_t^N}} \leq \frac{1}{A_t^N(z)};\ n_t^N(z) \geq 0;\ n_t^S(z) \geq 0,\ z \in \{1, 2\}; \\ \frac{u_{c_t^S(1)}}{u_{c_t^S(2)}} = \frac{u_{c_t^N(1)}}{u_{c_t^N(2)}}. \end{gathered}$$

3. Using the optimal decision rules, simulate for a transition to a steady state.

4. Check if the implementability condition (6) is satisfied. If not, go to Step 1 and repeat the above procedure.

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Table 1: Parameter Values of the Benchmark Model Economy

Parameter	Description
$\beta = 0.96$	Discount factor
$1/\gamma = 0.5$	Intertemporal elasticity of substitution
$\psi = 0.2438$	Expenditure share on traded goods
$\eta = 0.5516$	Expenditure share on the first traded commodity $(\eta\psi)$
$\kappa = 0.99$	South human capital at the steady state $\left(\kappa H^N\right)$
$\theta = 0$	Degree of learning-by-exporting from the second traded commodity export
$N^N = 1$	The North country's labor
$N^S = 1$	The South country's labor
$b_0^S = 0$	The South country's initial debt
$H_0^S = 0.5269$	The South country's initial human capital
$H^N = 19.8941$	The North country's human capital
$\phi = 0.0522$	Labor productivity in the second traded commodity production
$\alpha = 33.8927$	Degree of learning-by-exporting

Table 2: Average of Aggregate Variables from 1991 to 2007 (Unit: %)

Variable	Data	Model
Growth rate of China's real GDP per capita relative to the U.S.	7.52	7.52
China's current account over GDP	3.12	10.99
U.S. current account over GDP	−6.00	−0.85
China's export over GDP	25.22	23.67
Appreciation rate of China's real exchange rate	1.46	9.34

Table 3: Welfare Gain or Loss (Unit: Per-Period Consumption)

	South	North
Benchmark $\Longrightarrow$ No Policy	-19.10%	$+0.06\%$
Benchmark $\Longrightarrow$ No WTO	$+14.08\%$	$+0.43\%$
Benchmark $\Longrightarrow$ Coordinated Policy	$+13.24\%$	$+1.16\%$
No WTO $\Longrightarrow$ Coordinated Policy	-0.74%	$+0.73\%$

Table 4: Impact of Degree of Learning-by-Exporting

Variable (Unit: %)	Data	Degree of Learning-by-Exporting		
		BM	11.00	1.38
Growth rate of China rel. GDPPC	7.52	7.52	4.52	0.15
China CA over GDP	3.12	10.99	6.52	-21.01
U.S. CA over GDP	-6.00	-0.85	-0.36	0.58
China EX over GDP	25.22	23.67	20.60	3.25

Figure 1: China's Exports and Economic Growth

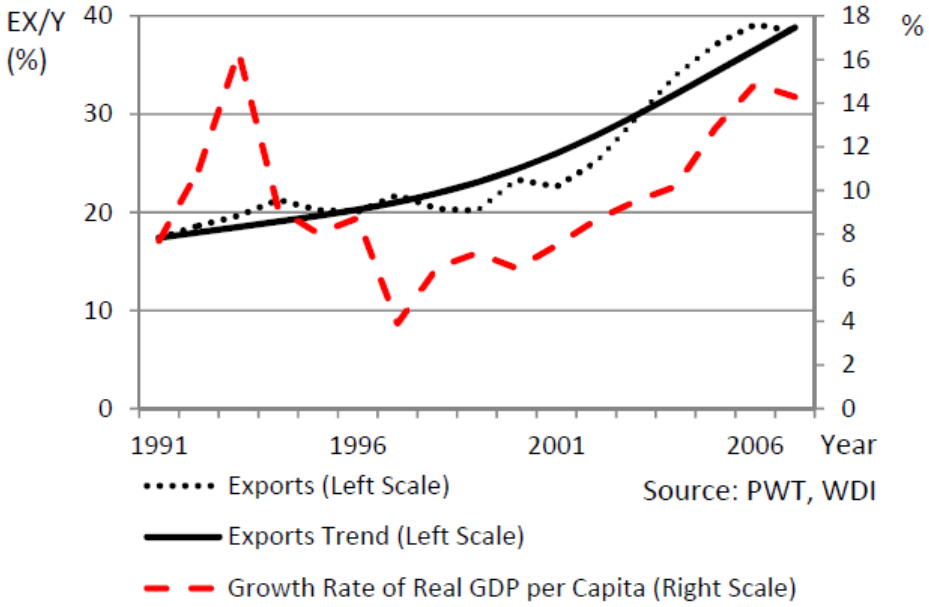

Figure 2: Current Account Imbalances of the U.S. and China

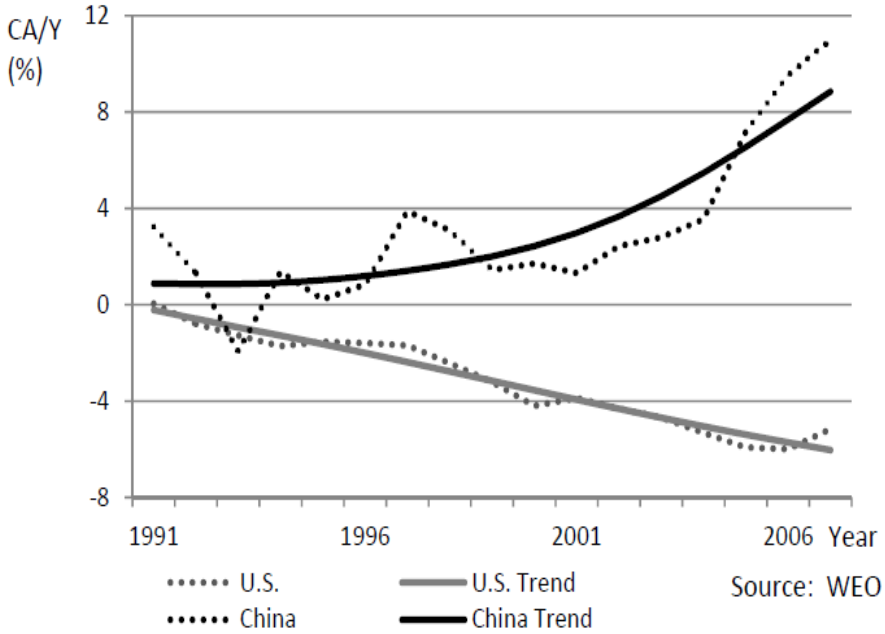

Figure 3: Time Path of South Tax and Subsidy (Benchmark)

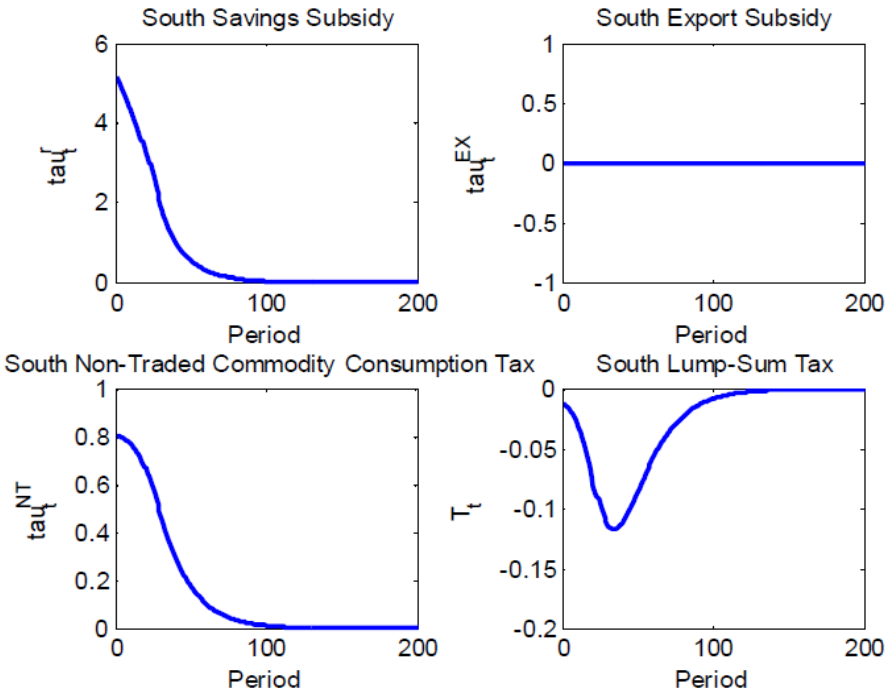

Figure 4: Time Path of South Human Capital and Labor (Benchmark)

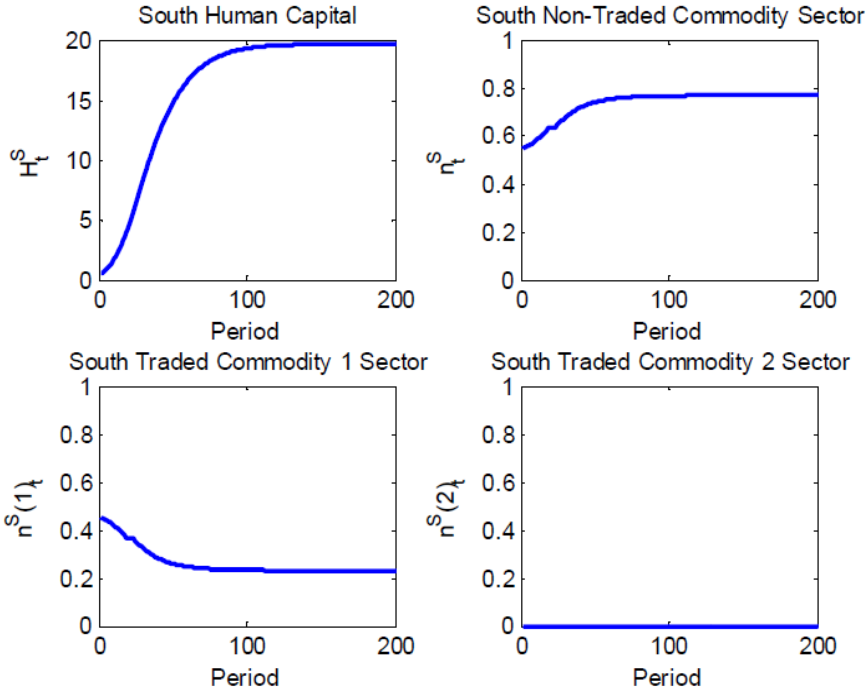

Figure 5: Time Path of South Consumption and Export (Benchmark)

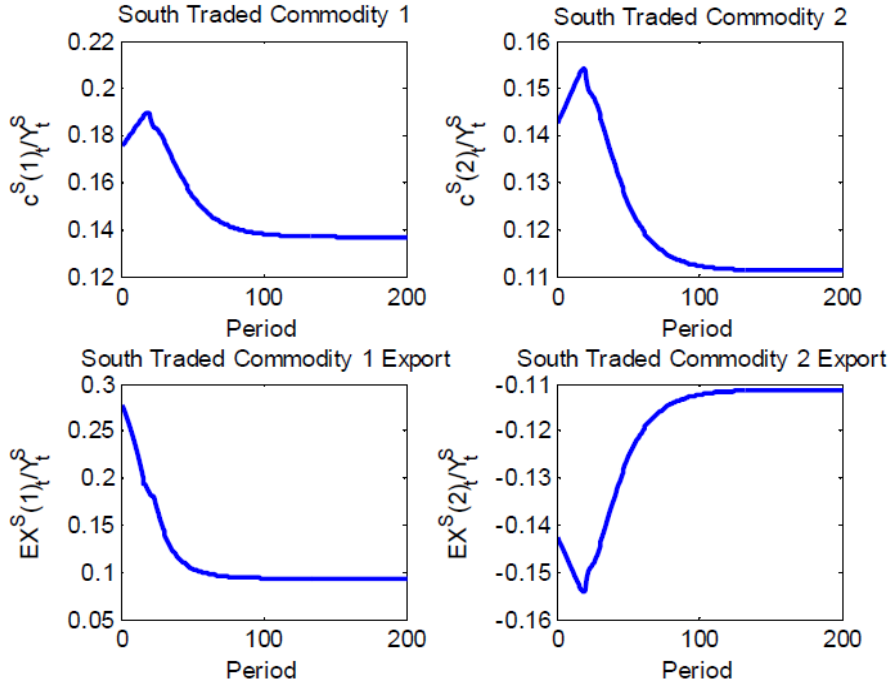

Figure 6: Time Path of South Key Aggregates (Benchmark)

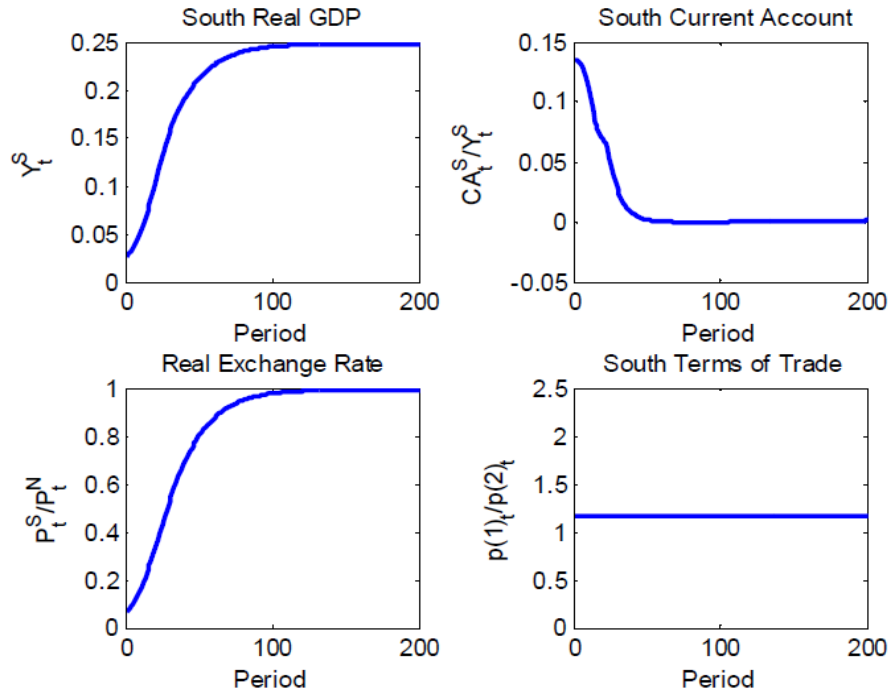

Figure 7: Time Path of South Human Capital and Labor (Benchmark and No-Policy)

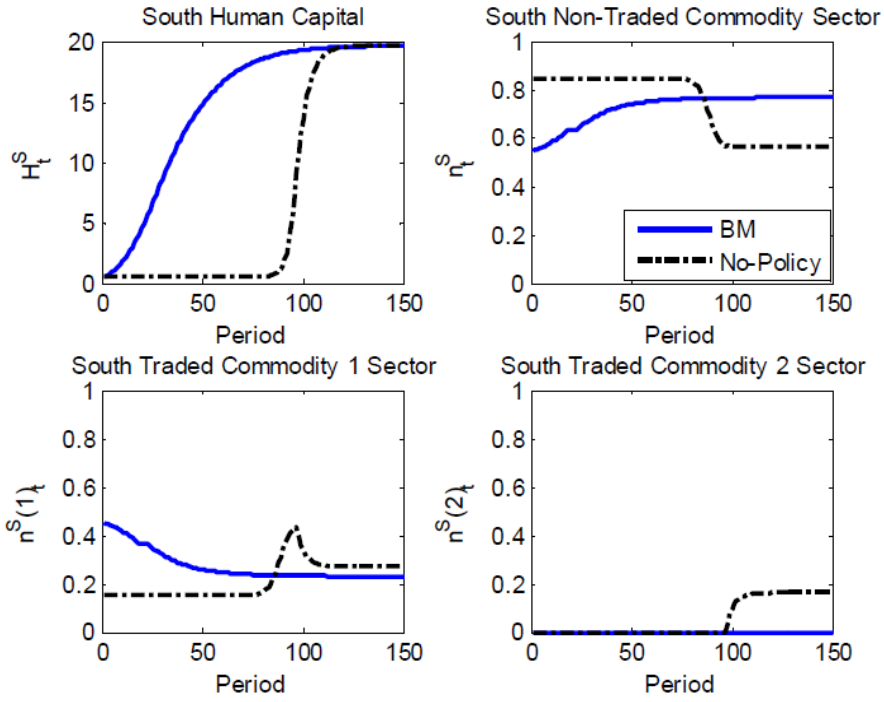

Figure 8: Time Path of South Consumption and Export (Benchmark and No-Policy)

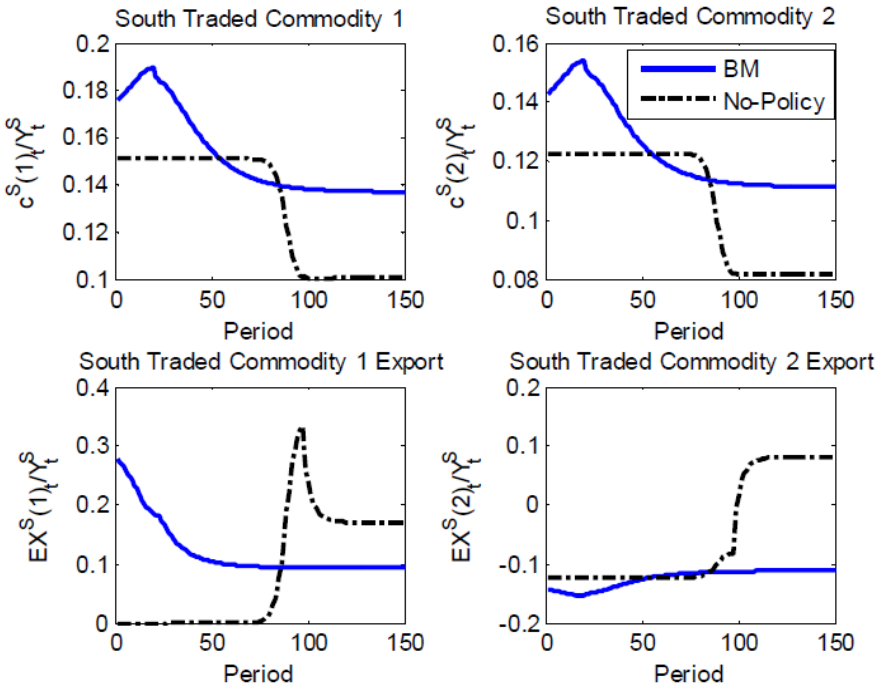

Figure 9: Time Path of South Key Aggregates (Benchmark and No-Policy)

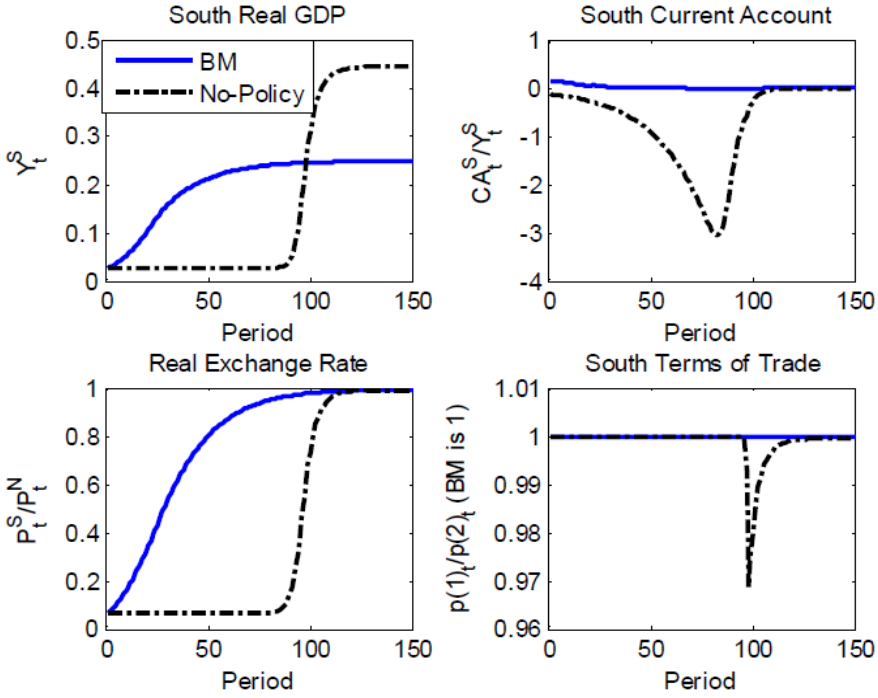

Figure 10: Time Path of South Human Capital and Labor (Benchmark and No-WTO)

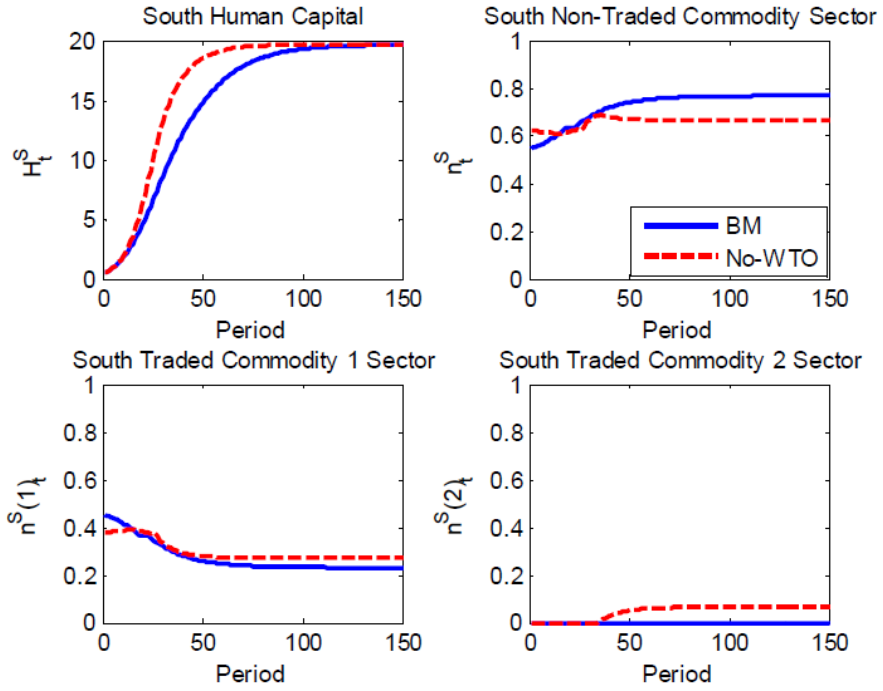

Figure 11: Time Path of South Consumption and Export (Benchmark and No-WTO)

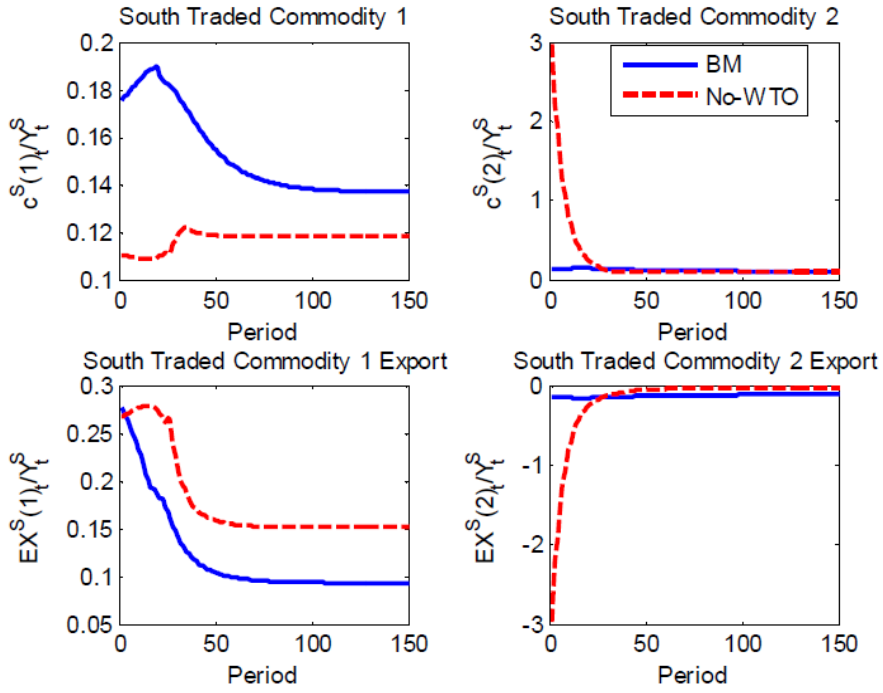

Figure 12: Time Path of South Key Aggregates (Benchmark and No-WTO)

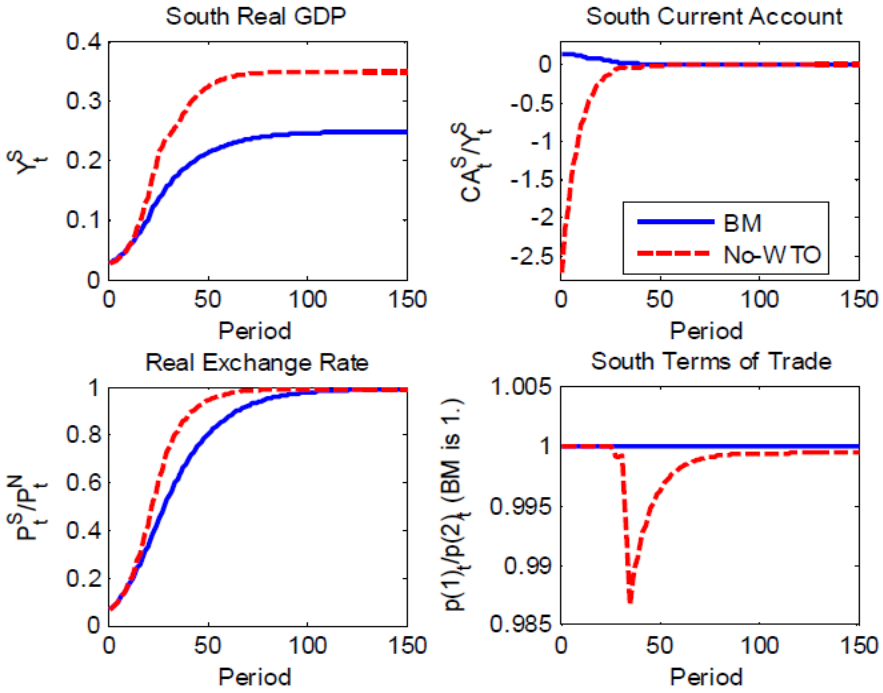

Figure 13: Time Path of South Tax and Subsidy (Benchmark and No-WTO)

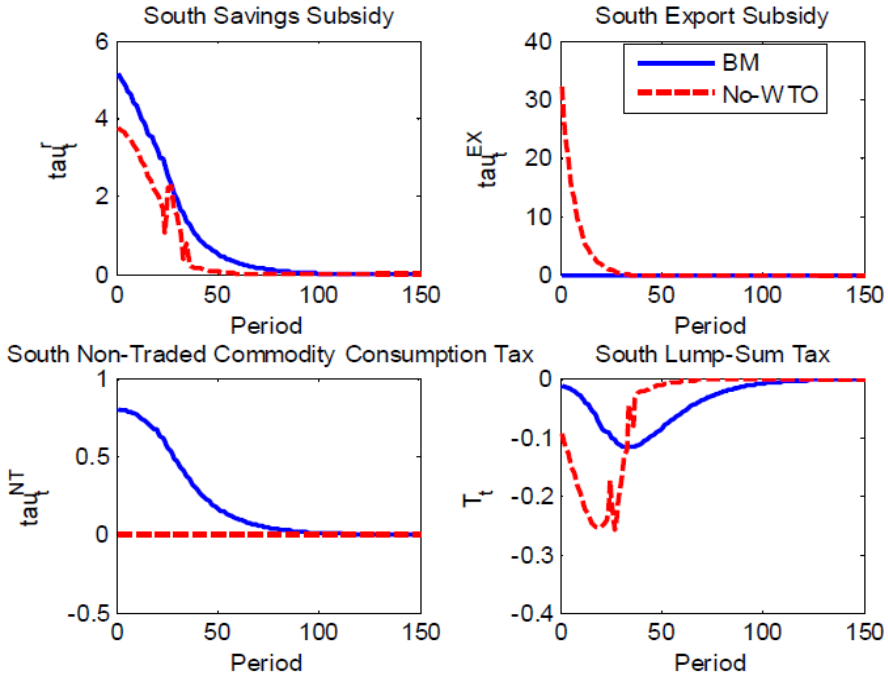

Figure 14: Time Path of South Human Capital and Labor (Benchmark, No-WTO, and Coordinated Policy)

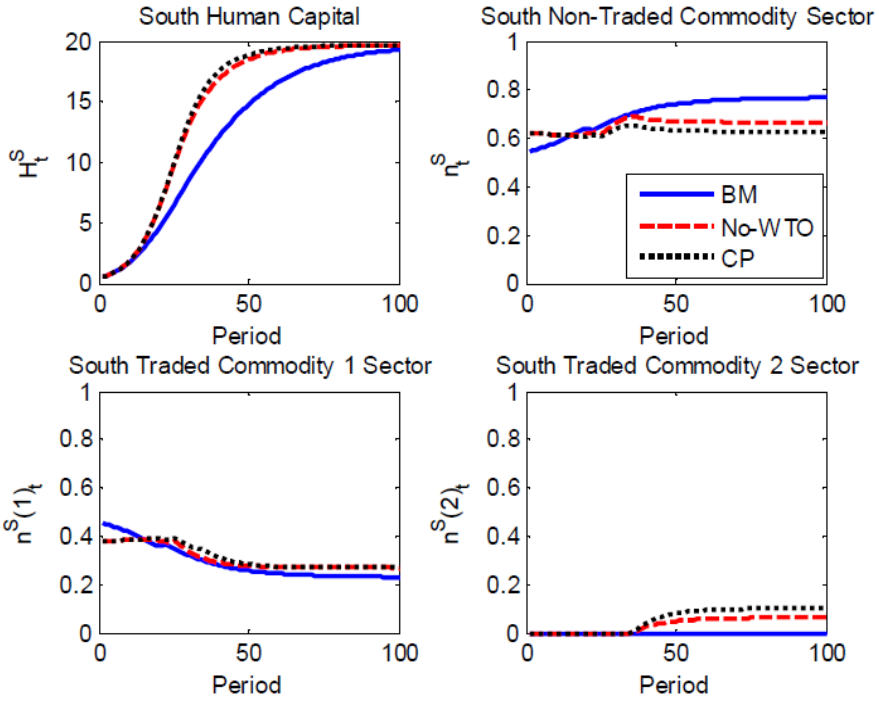

Figure 15: Time Path of South Consumption and Export (Benchmark, No-WTO, and Coordinated Policy)

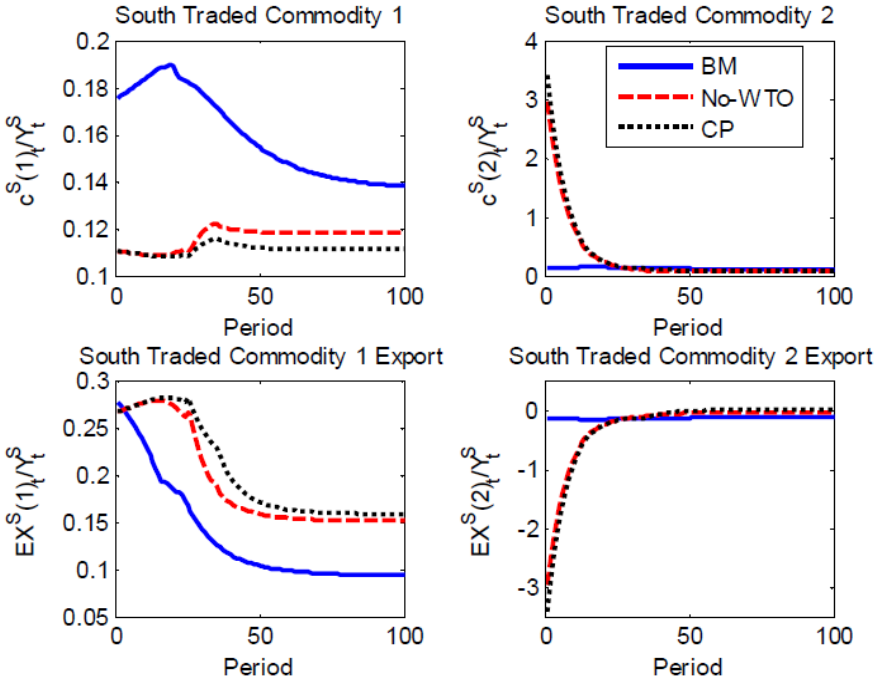

Figure 16: Time Path of South Key Aggregates (Benchmark, No-WTO, and Coordinated Policy)

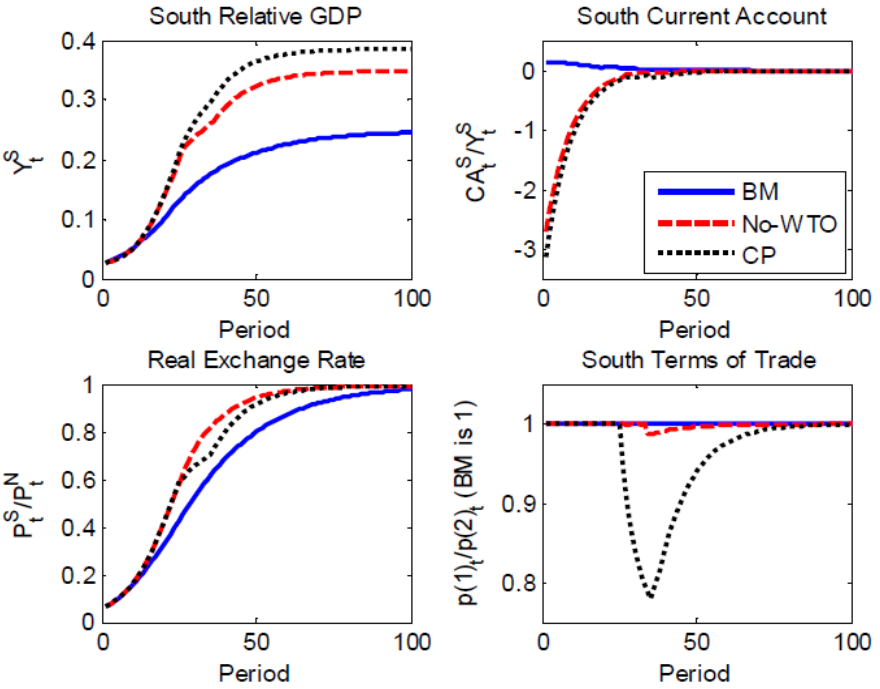

Figure 17: Time Path of South Tax and Subsidy (Benchmark, No-WTO, and Coordinated Policy)