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Industrial Policy and the Timing of Trade Liberalization

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Abstract: In a closed (open) economy with a learning-by-doing externality in the manufacturing sector, Matsuyama (1992) found a positive (negative) link between the level of agricultural productivity and economic growth. We extend that framework by introducing a labor subsidy to induce industrialization. We make three contributions to the existing literature. First, we show that a comparative advantage in manufacturing is not a necessary condition for a small open economy to industrialize. Relative sectoral TFP growth determines whether the fraction of labor in manufacturing increases over time. Second, the timing of trade liberalization determines structural development and the use of a labor subsidy can allow a small open economy to industrialize early. Third, we analyze the labor subsidy when there is trade among two open economies. We find that there exists a unique subsidy which enables both economies to industrialize. Therefore, a country with a comparative advantage in producing the manufactured good could benefit from their trading partner using labor subsidies compared to not trading with them at all.

JEL Codes: O13, O14, O41, F43.

Keywords: Labor Subsidy, Production Externality, Industrialization, International Trade.

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1 Introduction

The world economy is characterized by vast cross-country income differences. The economic development literature finds in many cases that sectoral composition differences contribute to income inequality across countries.[1] In less developed economies, agriculture accounts for a large share of production but, at the same time, the importance of agriculture tends to decrease as the economy develops. Córdoba and Ripoll (1999) show that the fraction of the labor force employed in agriculture is larger than the fraction of agriculture in total output in developing economies, indicating that labor productivity in non-agricultural sectors is larger than in the agricultural sector. While neoclassical theory has characterized sectoral composition as a byproduct of growth, a more modern approach by Echevarria (1997) stresses the strong interrelationship between structural change and growth. As a result, structural change has received a lot of attention in the development literature and in policy debates.

Herrendorf et al. (2013) define structural change as the reallocation of economic activity across three broad sectors: agriculture, manufacturing and services. In this paper, we focus on two tradable good sectors: agriculture and manufacturing. Structural transformation is defined as industrialization when factor inputs shift from the agricultural sector into the manufacturing sector. We follow Boldrin and Scheinkman (1988) and Lucas (1988) who use a learning-by-doing externality in the manufacturing sector that increases total factor productivity (TFP) growth the greater the output in that sector. In this framework, industrialization is often seen as a necessary condition for economic development.

Trade openness can have a fundamental impact on resource allocation across sectors and determine the industrialization process of developing economies. According to Matsuyama (1992), closed economies with rich endowment of arable land and natural resources generate more income than closed resource poor economies. Due to non-homothetic preferences, the higher the level of real income, the higher the relative demand for the manufactured good and, thus, the more labor shifts into the manufacturing sector. The higher the output of the manufactured good, the faster the rate of economic growth in the presence of production externalities in the manufacturing sector. Therefore, closed economies with high agricultural TFP will tend to grow faster than closed economies with low agricultural TFP. However, if agricultural TFP leads to a comparative advantage in agriculture when a small economy opens up for trade, labor will shift into the agricultural sector and economic growth declines. The link between agricultural productivity and economic growth can become

[1] A large amount of of studies focus on finding the sources of the cross-country income differences. Sachs and Warner (1999) and Gylfason et al. (2004) show that resource poor economies tend to outperform resource-rich economies in terms of economic growth. Torvik (2001) stresses that natural resource abundance may lower growth depending on the structure of the economy. According to Wijnbergen (1984) and Krugman (1987) trade may shift factors of production away from the pro-growth sector and reduce the rate of economic growth due to natural resource abundance. We will assume in our model that resource abundance can lead to higher initial agricultural TFP in an economy.

negative for an open economy. As a result, developing countries that tend to have a comparative advantage in agriculture can be better off without trade. Nevertheless, recent research by Baldwin (2003) and Sauré (2007) suggests that trade is beneficial for developing economies.

The relationship between trade and growth is fundamentally ambiguous (Grossman and Helpman (1991)) and merits further exploration. The objectives of this paper are to find how industrial policy affects structural change in a small open economy and how the trade-off between subsidy distortions, dynamic gains from productivity growth and gains from trade affect welfare in the long-run. We develop a two-sector growth model with a learning-by-doing externality in the manufacturing sector. We introduce a labor subsidy in manufacturing which distorts wages and shifts labor into this sector. We show that the labor subsidy can accelerate the industrialization process in a closed economy and that the welfare reducing distortions in the short run can be outweighed by accelerated growth in the long run.

In a small open economy, a labor subsidy can break the negative link between agricultural productivity and growth. We find that industrialization in a small open economy does not depend so much on comparative advantage as it does on relative sectoral TFP growth.[2] An economy industrializes when TFP in the manufacturing sector grows faster than in the agricultural sector. If the international relative price of the manufactured good is lower than a critical price that we derive, a small open economy will deindustrialize. By increasing the fraction of labor in manufacturing through the labor subsidy, a small open economy can industrialize if the subsidy is larger than a critical subsidy that is derived. The lower the international relative price of the manufactured good, the higher the subsidy must be in order to lead to industrialization.

In order to analyze the effectiveness of the subsidy in leading to industrialization, we examine different cases pertaining to different international relative prices. If the critical price is very high relative to the international relative price for the manufactured good, consumers can be better off by remaining closed to trade. However, short run gains from trade may make an economy open up for trade and deindustrialize. This might serve as an explanation why many small open developing economies today are still specialized in agriculture. The higher the rate of industrialization the lower the critical price of an economy. Therefore, the critical price for a closed economy will tend to decrease over time. When the critical price falls below the international relative price of the manufactured good, the small economy can open up for trade and industrialize. The labor subsidy bridges the gap between the critical price and the international price, such that a small economy can open up for trade and industrialize earlier.

We also apply the model to the case in which there are two large economies. Comparative advantage determines which economy industrializes. Introducing a labor subsidy has a strict negative effect on both the fraction of labor employed

[2]Dekle and Vandenbroucke (2012) and Üngör (2009) argue that TFP growth differences among sectors and the reduction of the relative size of the government are the main drivers of structural transformation in China.

in manufacturing and welfare in a country's trade partner. We find a critical subsidy that equalizes the fraction of labor employed in manufacturing in both economies and which allows both economies to industrialize at the same time. We show, using numerical simulations, that this subsidy can increase consumer welfare in both countries compared to them being closed to trade.[3] Therefore, a subsidy used by a developing country can make up for welfare losses of exporting the low-growth good.

Our paper is related to existing literature that examines the role of trade in industrialization. Teignier (2014) analyzes how agricultural protectionist policies hindered structural transformation in countries with a comparative advantage in manufacturing. Our model introduces a labor subsidy that allows an economy with a comparative advantage in agriculture to industrialize. Chang et al. (2006) use taxation for infrastructure investment and shows that high agricultural productivity can generate a positive growth effect via increased tax revenue. This revenue is then used for infrastructure investment that can potentially turn a comparative disadvantage in manufacturing into a comparative advantage by increasing manufacturing productivity. We apply the tax revenue mechanism introduced by Chang et al. (2006) but instead of tax revenue being spent on infrastructure, we examine the use of industrial policy by assuming tax revenue is used to subsidize the cost of labor employed in the manufacturing sector.

The paper is organized as follows. Section 2 sets up a closed economy and analyzes welfare effects when a labor subsidy is introduced. Section 3 describes a small open economy and analyzes the relationship between the subsidy that maximizes long run welfare and the international relative price of the manufactured good. Section 4 then introduces two large open economies which differ in their initial labor productivity in the manufacturing sector. Section 5 concludes with policy recommendations and final remarks.

2 The Closed Economy

2.1 Supply Side

We consider a two-sector economy that produces a manufactured good, Y_t^M, and an agricultural good, Y_t^A, at time t. Labor is the only factor of production and its total supply is normalized to one. The production functions for both sectors are given by

$$Y_t^M = M_t F(n_t) = M_t (n_t)^{\alpha} \tag{1}$$

[3] In a model of endogenous growth and international trade between two large economies, Redding (1999) finds that both countries can benefit in the long run from an economy using subsidies to enter sectors in which it has no initial comparative advantage but higher learning-by-doing potential than the trade partner. We show that it can benefit both countries with equal learning-by-doing potential if a subsidy allows both trade partners to industrialize.

and

$$Y_t^A = A_t G(1 - n_t) = A_t(1 - n_t)^\alpha, \tag{2}$$

where n_t is the fraction of labor employed in the manufacturing sector and TFP in the agricultural and manufacturing sectors are given by A_t and M_t, respectively. We assume $0 < \alpha < 1$ so that both sectors are characterized by diminishing returns to scale as in Matsuyama (1992). TFP in the agricultural sector, representing factors such as better fertilizers or level of technology, is assumed to grow at a constant exogenous rate,

$$g^A = \frac{\dot{A}_t}{A_t}. \tag{3}$$

Manufacturing TFP, representing endogenous knowledge capital that accumulates from experience in manufacturing, is assumed to increase in a process of learning-by-doing. Therefore, the more labor employed in manufacturing, the larger the increase in manufacturing TFP[4],

$$\dot{M}_t = \delta Y_t^M = \delta M_t (n_t)^\alpha, \tag{4}$$

so that

$$g_t^M = \frac{\dot{M}_t}{M_t} = \delta n_t^\alpha, \tag{5}$$

where g_t^M is the growth rate of manufacturing TFP at time t and $\delta > 0$ is the asymptotic upper limit as n approaches 1. As it is commonly assumed, there are complete knowledge spillovers within the manufacturing sector so all firms share the same TFP level.

Profits in the agricultural sector are

$$\pi_t^A = A_t(1 - n_t)^\alpha - w_t^A(1 - n_t), \tag{6}$$

where w_t^A is the wage in the agricultural sector and the price of the agricultural good serves as the numeraire. Profits in the manufacturing sector are

$$\pi_t^M = p_t M_t (n_t)^\alpha - w_t^M n_t (1 - s), \tag{7}$$

where w_t^M is the wage in the manufacturing sector, s is a proportional labor subsidy given by the government, and p_t is the price of the manufactured good relative to the agricultural good. The labor subsidy is the only choice variable of the government which is introduced at $t = 0$ and is assumed to remain constant over time. By reducing the labor costs in the manufacturing sector, the subsidy increases the demand for labor in the manufacturing sector relative

[4]We follow Matsuyama (1992) and Chang et al. (2006) in our formulation for the growth rate of manufacturing TFP. The growth rate depends on total output in the manufacturing sector. Matsuyama (1992) shows that the inclusion of capital as a factor input does not change the results of the model.

to the agricultural sector. The first-order conditions in the agricultural sector and the manufacturing sector are

$$\alpha A_t(1-n_t)^{\alpha-1} - w^A = 0 \tag{8}$$

and

$$\alpha p_t M_t(n_t)^{\alpha-1} - w^M(1-s) = 0, \tag{9}$$

respectively. To pay for the subsidy, the government taxes household income which is composed of both firm profits and wages. The tax revenue collected at time t, TR_t, is equal to

$$TR_t = \tau_t\big[A_t(1-n_t)^{\alpha} + p_t M_t n_t^{\alpha} + s w_t^M n_t\big], \tag{10}$$

where τ_t is the tax rate at time t needed to fund a subsidy of s. Government revenue is only spent on the labor subsidy, $sw_t^M n_t$, which combined with (10) gives us the government budget constraint,

$$TR_t = s w_t^M n_t, \tag{11}$$

$$\tau_t = \frac{s w_t^M n_t}{A_t(1-n_t)^{\alpha} + p_t M_t n_t^{\alpha} + s w_t^M n_t}. \tag{12}$$

2.2 Demand Side

We assume that a representative consumer has Stone-Geary preferences given by

$$U_t = \gamma \log\left(c_t^A - \bar{c}^A\right) + (1-\gamma)\log c_t^M, \tag{13}$$

where consumption of the agricultural and manufactured good at time t are represented by c_t^A and c_t^M, respectively, and $\bar{c}^A > 0$ represents the subsistence level, or the minimum requirement, of agricultural consumption. In order to guarantee that the subsistence level of agricultural consumption is met for the whole population, we assume that $A_0 > \bar{c}^A > 0$. With non-homothetic preferences, the income elasticity of demand for the agricultural good is less than unitary and the share of income spent on the manufactured good increases as disposable income increases.

As in Boldrin and Scheinkman (1988) and Echevarria (1997), we assume no borrowing constraints such that consumers spend all their disposable income, I_t, on consumption of the two goods,

$$I_t = (1-\tau_t)\Big(A_t(1-n_t)^{\alpha} + p_t M_t n_t^{\alpha} + s w_t n_t\Big). \tag{14}$$

From the maximization problem, we derive the following demands for each good:

$$c_t^M = (1-\gamma)\frac{(I_t - \bar{c}^A)}{p_t} \tag{15}$$

and

$$c_t^A = \gamma I_t + (1-\gamma)\bar{c}^A. \tag{16}$$

2.3 Equilibrium

The goods market clearing conditions are

$$Y_t^M = c_t^M \tag{17}$$

and

$$Y_t^A = c_t^A. \tag{18}$$

Using equations (8), (9), and the non-arbitrage condition in the labor market, $w_t^M = w_t^A$, we can derive the relative supply in terms of p_t and n_t:

$$p_t = (1-s)\frac{A_t}{M_t}\left(\frac{n_t}{1-n_t}\right)^{1-\alpha}. \tag{19}$$

First, consider an economy in autarky with homothetic preferences ($\bar{c}^A = 0$). From (15) and (16), the relative demand for the manufactured good can be found in terms of p_t,

$$p_t = \frac{1-\gamma}{\gamma}\frac{c_t^A}{c_t^M} = \frac{1-\gamma}{\gamma}\frac{A_t}{M_t}\left(\frac{1-n_t}{n_t}\right)^{\alpha}. \tag{20}$$

Equalizing (19) and (20) will lead to the fraction of labor employed in the manufacturing sector,

$$n = \frac{1-\gamma}{1-\gamma s}, \tag{21}$$

which is constant over time when preferences are homothetic. The subsidy only has a level effect on the fraction of labor employed in manufacturing but does not change over time as shown in Figure 1 for different subsidy rates.

The TFP growth rates, g_A and g_M, determine if the relative price of the manufactured good shrinks or grows over time. Since the subsidy increases the fraction of labor employed in manufacturing, and therefore increases g_t^M,

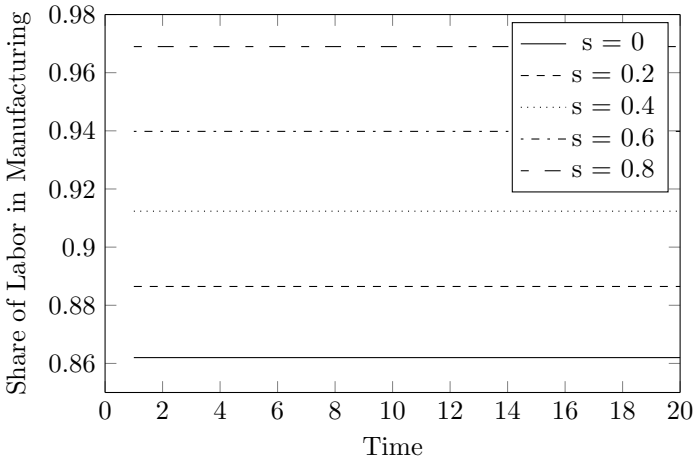
$$\frac{\partial p_t}{\partial s} < 0. \tag{22}$$

Now consider an economy with non-homothetic preferences ($\bar{c}^A > 0$). The higher the level of consumer income, the higher the relative demand for the manufactured good causing labor to shift into the manufacturing sector over time. In the long run, manufacturing TFP will grow faster as the fraction of labor employed in this sector increases while agricultural TFP growth remains constant. As in Matsuyama (1992), closed developing economies with higher agricultural productivity will industrialize faster than economies with smaller agricultural productivity.

Rewriting (21) with non-homothetic preferences gives

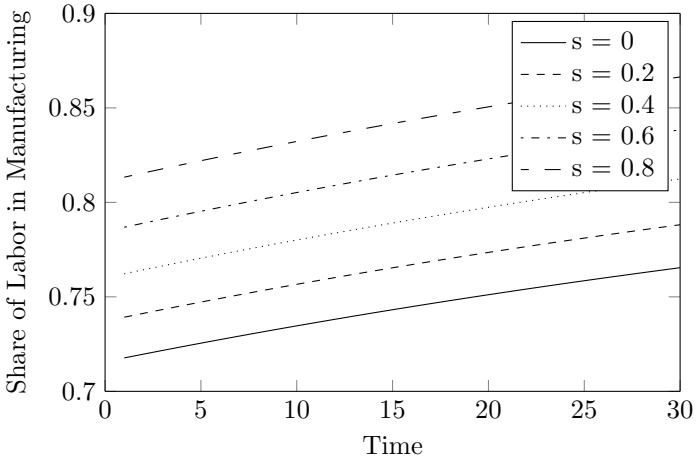
$$n_t = \frac{(1-\gamma)(I_t - \bar{c}^A)}{I_t - s\gamma(I_t - \bar{c}^A) - s\bar{c}^A}. \tag{23}$$

Figure 1: Fraction of Labor in Manufacturing in a Closed Economy under Homothetic Preferences



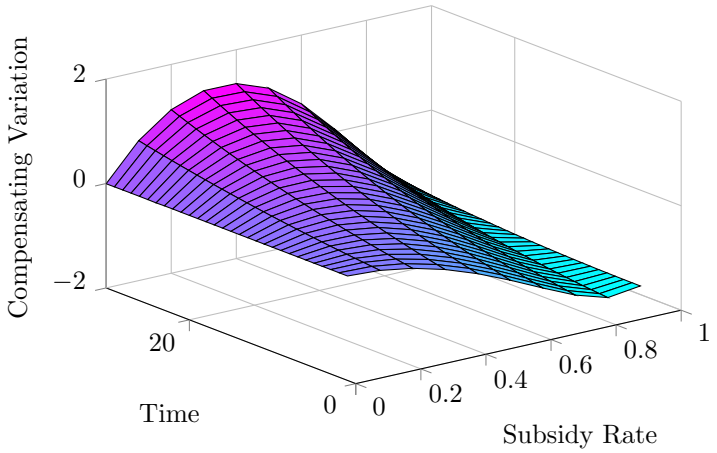
The labor subsidy distorts wages, leading to a suboptimal allocation of labor between the two sectors. However, the increase in n_t leads to faster TFP growth in the manufacturing sector. Figure 2 shows the level of industrialization over time for different subsidy rates.

Figure 2: Fraction of Labor in Manufacturing in a Closed Economy under Non-Homothetic Preferences



A subsidy will lead to a fall in the relative price of the manufactured good and increase the relative consumption of the manufactured good. The distorted consumption of the two goods will decrease consumer welfare in the short run.

Figure 3: Change in Welfare in a Closed Economy with Non-Homothetic Preferences



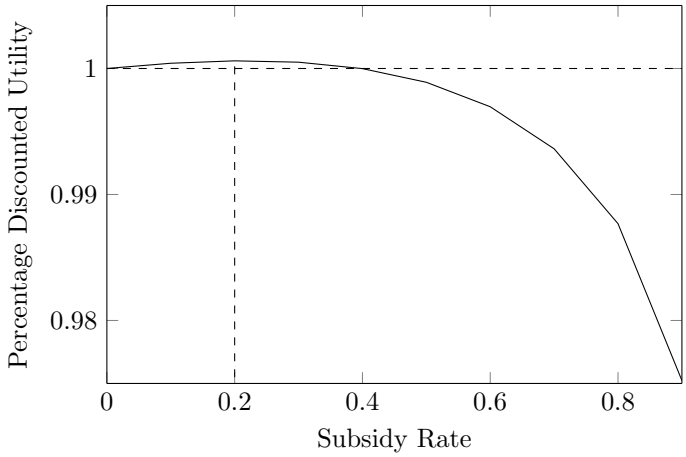
The Y-axis represents compensating variation. Positive values stand for the amount of income consumers can give up for reaching utility levels without a subsidy. Therefore, positive values represent welfare gains. By combining equations (13), (15) and (16), we solve for income level ($I_t(s)$) necessary for acquiring consumer utility ($U_t(s = 0)$) without subsidy. Compensating Variation equals the difference between income levels with and without subsidy ($CV_t = I_t(s; U_t(s = 0)) - I_t(s = 0)$). The X-axis represents time and the Z-axis represents different subsidy rates.

In the long run, the initial increase in labor in the manufacturing sector leads to an accelerated industrialization process. Due to the learning-by-doing externality, labor productivity in the manufacturing sector will grow faster with a larger subsidy. The increase in consumption of the manufactured good exceeds the fall in consumption of the agricultural good in the long run. Figure 3 shows how consumer utility changes over time for different subsidy As Figure 3 suggests, there exists an optimal subsidy that maximizes consumer utility over a given range. We define long run welfare as the sum of discounted consumer utility (shown for a continuum of subsidy rates in Figure 4). The stronger the learning-by-doing effect, represented by δ, the higher the optimal subsidy. The higher the subsistence level of the agricultural good consumption, the lower the initial share of labor employed in manufacturing and the larger the gains in consumer welfare from the optimal subsidy.

3 Small Open Economy

In this section, the effects of a labor subsidy in the manufacturing sector are analyzed for a small open economy. In the long run, a comparative advantage in manufacturing can develop from an initial comparative disadvantage. As will be shown, there is an additional channel in the form of reduced gains from trade

Figure 4: Change in Sum of Discounted Consumer Utility in a Closed Economy with Non-Homothetic Preferences



The Y-axis represents the discounted consumer utility in percent compared to the no subsidy case. Consumer Utility from equation (13) is discounted by five percent ($DU = 0.95^{t-1}U_t$). The X-axis represents different subsidy rates.

in which the subsidy can reduce welfare.

In a classical framework, international trade tends to reallocate resources towards the sector in which a country has a comparative advantage. In contrast to a closed economy, high agricultural productivity can lead to deindustrialization as shown in Matsuyama (1992). Thus, opening up to trade can reduce TFP growth.

3.1 Equilibrium

Consider a SOE which differs from the rest of the world in agricultural and manufacturing TFP, A^* and M^*, respectively. The ratio of these parameters will determine the international relative price of the manufactured good, p^*, which is assumed to be constant and is taken as given by the SOE. Labor is assumed to be immobile across countries and there are no learning-by-doing spillovers across economies as in Matsuyama (1992), Redding (1999) and Young (1991). Facing an constant, exogenous price[5], the allocation of labor is such that p^* equals the marginal rate of transformation. Taking the international relative price of the manufactured good as given,

$$p^* = (1-s)\frac{A_t}{M_t}\left(\frac{n_t}{1-n_t}\right)^{1-\alpha}, \tag{24}$$

[5]The model was also derived with an international price that declines at an exogenous rate over time due to the learning-by-doing process in the rest of the world. The derivation can be found in the Appendix.

determines the allocation of labor between sectors, n_t. Since $\frac{n_t}{1-n_t}$ is increasing in n_t, the fraction of labor employed in manufacturing will increase as the subsidy increases, ceretis paribus. Rearranging (24), we find that

$$n_t = \frac{(p^* M_t)^{\frac{1}{1-\alpha}}}{((1-s)A_t)^{\frac{1}{1-\alpha}} + (p^* M_t)^{\frac{1}{1-\alpha}}}. \tag{25}$$

Combining (3) and (25), manufacturing TFP will grow faster the larger the subsidy

$$\frac{\delta g_t^M}{\delta s} = \frac{\alpha\delta\left[1 + (A_t(1-s))^{\frac{1}{1-\alpha}} + (p^* M_t)^{\frac{1}{\alpha-1}}\right]^{-1-\alpha}}{(1-\alpha)(1-s)} \left(\frac{A_t(1-s)}{p^* M_t}\right)^{\frac{1}{1-\alpha}} > 0. \tag{26}$$

However, a subsidy might not always be sufficiently high to increase n_t over time. From (25), the percentage change of the fraction of labor employed in manufacturing depends on the difference in TFP growth rates in both sectors,

$$\frac{\dot{n}_t}{n_t} = \left(\frac{1}{1-\alpha}\right)\left(1 - n_t\right)\left[\frac{\dot{M}_t}{M_t} - \frac{\dot{A}_t}{A_t}\right]. \tag{27}$$

Home will have a constant fraction of labor employed in manufacturing if TFP in the manufacturing sector grows at an equal rate as in the agricultural sector. In this scenario, the economy will have a constant fraction of labor employed in manufacturing iff the following is satisfied:

$$\widetilde{n} = \left(\frac{g_A}{\delta}\right)^{\frac{1}{\alpha}}, \tag{28}$$

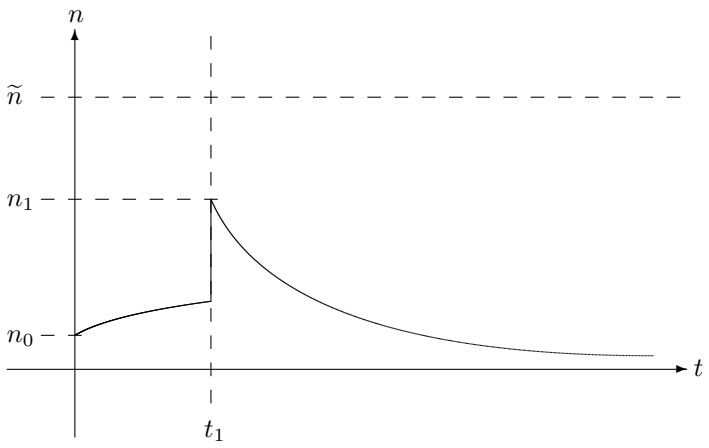
where $\widetilde{n}$ is the critical fraction of labor employed in manufacturing such that $\dot{n}_t = 0$. Combining (24) and (28) and setting $s = 0$, we find

$$\widetilde{p_t} = \left(\frac{A_t}{M_t}\right)\left[\left(\frac{\delta}{g_A}\right)^{\frac{1}{\alpha}} - 1\right]^{\alpha-1}, \tag{29}$$

where $\widetilde{p_t}$ is the critical international relative price of the manufactured good needed for the fraction of labor employed in manufacturing to remain constant ($\dot{n} = 0$). If the international price is larger than the critical price ($p^* > \widetilde{p_t}$) when opening up for trade at t, the fraction of labor in manufacturing will grow over time ($\dot{n} > 0$) and the economy will industrialize. If the international price is smaller than the critical price ($p^* < \widetilde{p_t}$), the fraction of labor in manufacturing decreases ($\dot{n} < 0$) and the economy deindustrializes.

The higher the TFP in manufacturing relative to TFP in agriculture, the smaller the critical price when opening up at time t and the more likely a small economy will industrialize when opening up for trade. However, a comparative advantage in manufacturing is not a necessary condition for industrialization. Assume a small closed economy with the relative price of the manufactured good p_t^A in autarky (19). Due to non-homothetic preferences, the economy

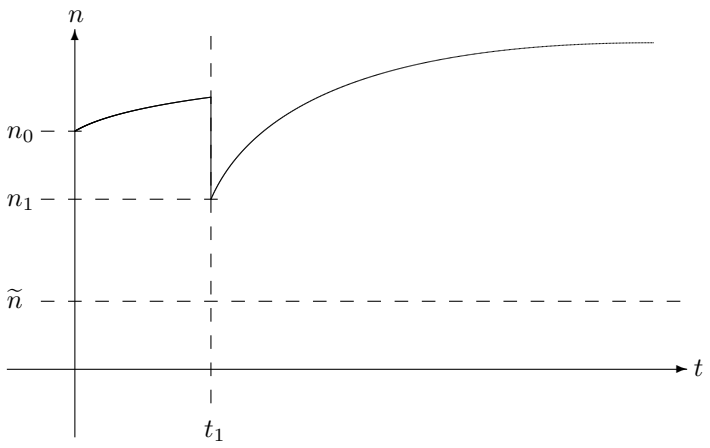
Figure 5: Fraction of Labor in Manufacturing Equilibrium Path when $p_t^A < p^* < \widetilde{p}_t$



Initially, the small closed economy industrializes. At t_1 the economy opens for trade and starts exporting manufacturing goods. There is a positive shock to labor in the manufacturing sector. Since the international relative price is lower than the critical price, the economy deindustrializes over time.

will industrialize. If the international relative price of the manufactured good is larger than the autarky relative price ($p^* > p_t^A$), the small economy has a comparative advantage in manufacturing and will export that good leading to a jump in the fraction of labor employed in manufacturing. However, if the international relative price of the manufactured good is smaller than the critical price, the economy will then deindustrialize over time after the initial jump as shown in Figure 5. This is due to the fact that TFP in the manufacturing sector will grow slower relative to the agricultural sector. In the long run, the small open economy loses its comparative advantage in manufacturing and will start exporting the agricultural good. Therefore, a small open economy can export the manufactured good but deindustrialize iff $p_t^A < p^* < \widetilde{p}_t$. On the other hand, a small economy that opens up for trade and has a comparative advantage in agriculture ($p^* < p_t^A$) will export the agricultural good. There is a negative shock to the share of labor in the manufacturing sector and TFP growth declines in the short run. However, if the international relative price of the manufactured good is larger than the critical price, the economy will industrialize over time as shown in Figure 6. Though exporting the agricultural good, TFP growth in the manufacturing sector will grow faster relative to the agricultural sector and the small open economy will acquire a comparative advantage in manufacturing and begin exporting the manufactured good in the long run. Therefore, a small open economy can begin exporting the agricultural good yet industrialize iff $\widetilde{p}_t < p^* < p_t^A$. A small open economy will export the manufactured (agricultural) good and

Figure 6: Fraction of Labor in Manufacturing Equilibrium Path when $\widetilde{p}_t < p^* < p_t^A$



Initially, the small closed economy industrializes. At t_1 the economy opens for trade and starts exporting the agricultural good. There is a negative shock to labor in the manufacturing sector. Since the international relative price is higher than the critical price, the economy industrializes over time.

(de)industrialize, iff both the autarky price and critical price are smaller (larger) than the international relative price of the manufactured good, respectively, as shown in Figures 7 and 8.

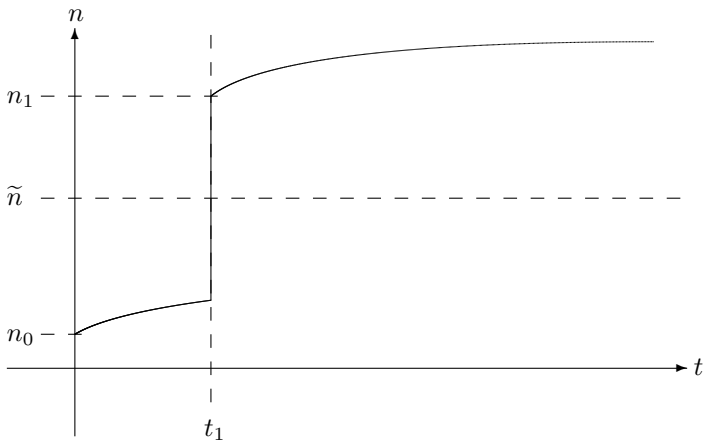
3.2 Subsidy in a Small Open Economy

If the international relative price of the manufactured good is smaller than the critical price ($p^* < \widetilde{p}_t$), it would need to introduce a subsidy in order to industrialize. The government can choose a subsidy that sets the initial fraction of labor employed in manufacturing such that TFP grows at an equal rate in both sectors. Combining equations (28) and (24), we solve for this critical subsidy,

$$\widetilde{s_t} = 1 - p^* \frac{M_t}{A_t} \left[\left(\frac{\delta}{g_A} \right)^{\frac{1}{\alpha}} - 1 \right]^{1-\alpha} = 1 - \frac{p^*}{\widetilde{p}_t}. \tag{30}$$

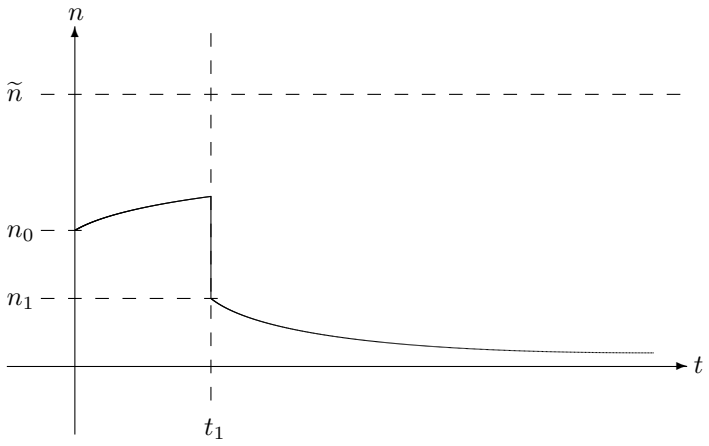
If an economy sets the labor subsidy lower than the critical subsidy ($s < \widetilde{s_t}$), labor shifts from the manufacturing into the agricultural sector over time and TFP growth declines in manufacturing. If an economy sets the subsidy above the critical subsidy ($s > \widetilde{s_t}$), labor shifts into the manufacturing sector over time, TFP growth in manufacturing increases and consumer welfare can increase in the long run. In order to determine the optimal subsidy, we consider the previous cases and analyze the welfare implications.

Figure 7: Fraction of Labor in Manufacturing Equilibrium Path when $p_t^A, \widetilde{p}_t < p^*$



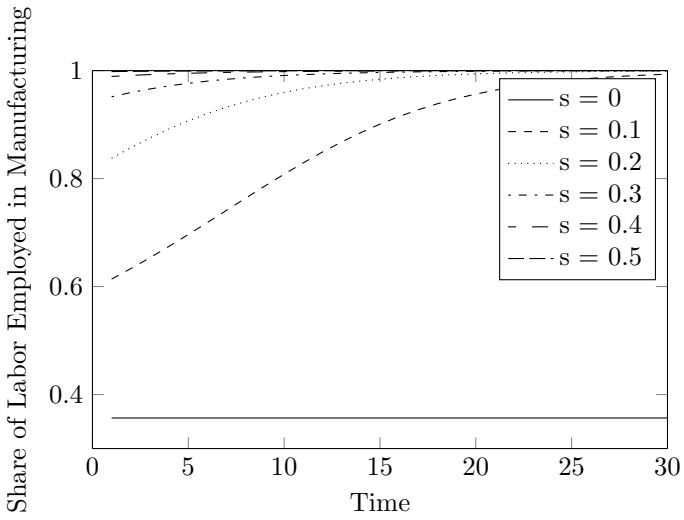
Initially, the small closed economy industrializes. At t_1 the economy opens for trade and starts exporting the manufactured good. There is a positive shock to labor in the manufacturing sector. Since the international relative price is larger than the critical price, the economy industrializes over time.

Figure 8: Fraction of Labor in Manufacturing Equilibrium Path when $p^* < p_t^A, \widetilde{p}_t$



Initially, the small closed economy industrializes. At t_1 the economy opens for trade and starts exporting the agricultural good. There is a negative shock to labor in the manufacturing sector. Since the international relative price is smaller than the critical price, the economy deindustrializes over time.

Figure 9: Fraction of Labor in Manufacturing with International Relative Price equal Critical Price



$\widetilde{p_t} = 0.8284$

3.2.1 International Relative Price Equals the Critical Price

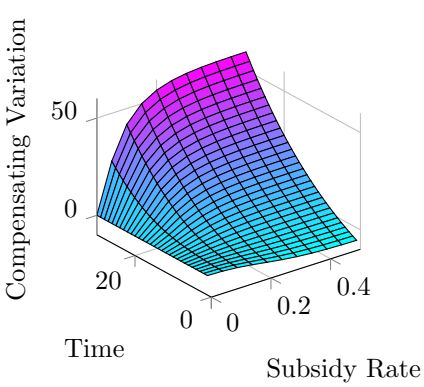
When opening up for trade, if Home faces an international relative price which is equal to the critical price ($p^* = \widetilde{p_t}$), the fraction of labor in manufacturing remains constant ($\dot{n} = 0$) without subsides as shown in Figure 9. Here, the critical subsidy is equal to zero ($\widetilde{s_t} = 0$). In order to industrialize, labor in the manufacturing sector must be subsidized. Tax distortions reduce consumer utility, such that consumers may be worse of in the short run. However, the TFP growth in the manufacturing sector will increase real income in the long run. Consumer welfare (in form of compensating variation) is shown over time in Figure 10a. The sum of discounted consumer utility and the optimal subsidy, defined by the subsidy that maximizes the sum of discounted utility for a range of time is greater than zero, are shown in Figure 10b.

3.2.2 International Relative Price smaller than Critical Price

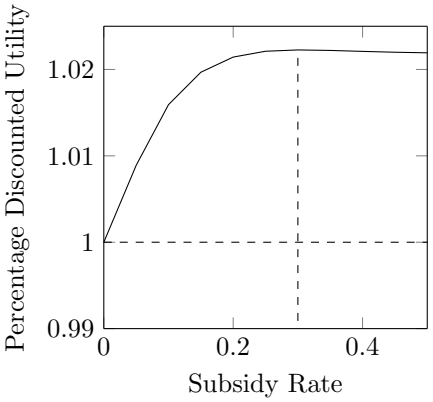
When opening up for trade, if Home faces an international relative price which is smaller than the critical price ($p^* < \widetilde{p_t}$), the economy will tend to deindustrialize over time. Opening up the economy will shift labor into the agricultural sector and reduce the growth rate of TFP in the manufacturing sector. TFP growth declines and, eventually, consumer welfare will be less than in a closed economy. In the long run, consumers may be worse off as shown in Figure 11.

Equation (30) shows that the smaller the ratio between the international relative price and the closed economy relative price of the manufactured good,

Figure 10: SOE with International Relative Price equal Critical Price



(a) Consumption Variation



(b) Discounted Consumer Utility

Figure 11: Consumer Utility in a Closed and Open Economy

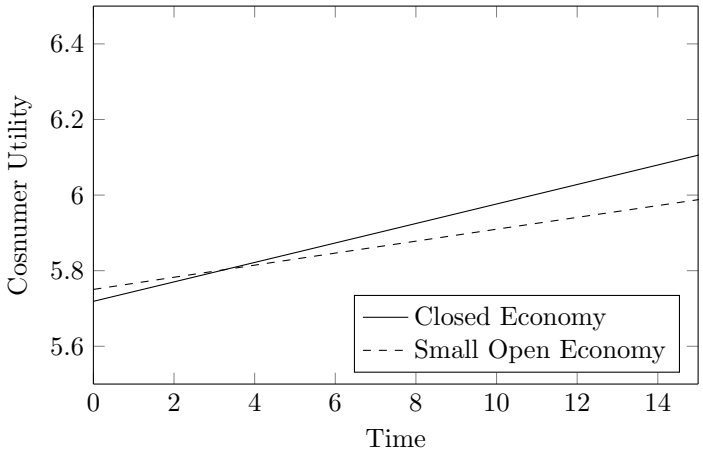
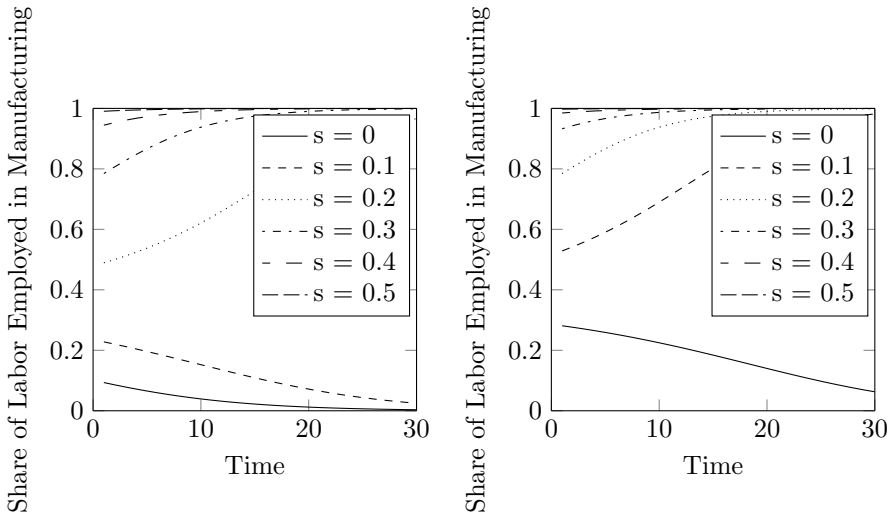


Figure 12: Labor Allocation in a SOE With International Relative Price smaller than Critical Price



(a) $p^* << \widetilde{p_t}$ (b) $p^* < \widetilde{p_t}$

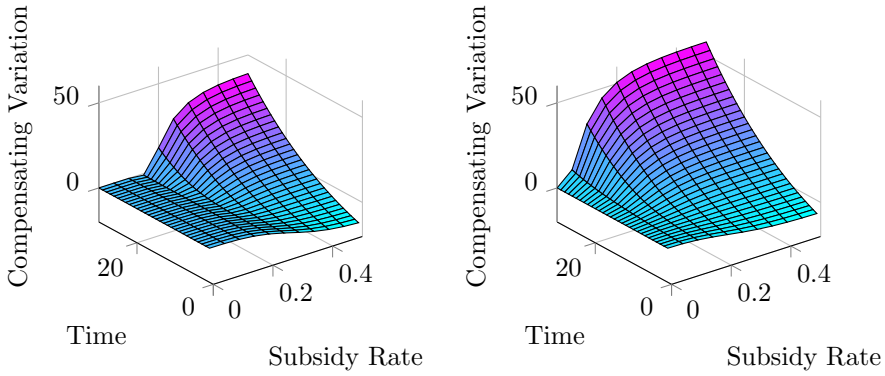
the larger the subsidy needed to industrialize (compare Figures 12a and 12b) and the larger the distortions generated. A small subsidy will only result in decelerating the deindustrialization process. If the critical subsidy ends up being very large, positive TFP growth effect might not outweigh the distortionary effect in the long run (see Figure 13a) and the optimal subsidy will be zero (Figure 14a). Therefore, consumers might be better served by remaining in a closed economy.

The smaller the difference between the international relative price and the critical price, the smaller is the subsidy needed to industrialize. Negative short run income effects will be smaller and can be outweighed by positive TFP growth effect (see Figure 13b). In that case, the optimal subsidy will be greater than zero as shown in Figure 14b. Therefore, countries that are not very developed relative to the rest of the world are less likely to benefit from industrial policy.

3.2.3 International Relative Price larger than Critical Price

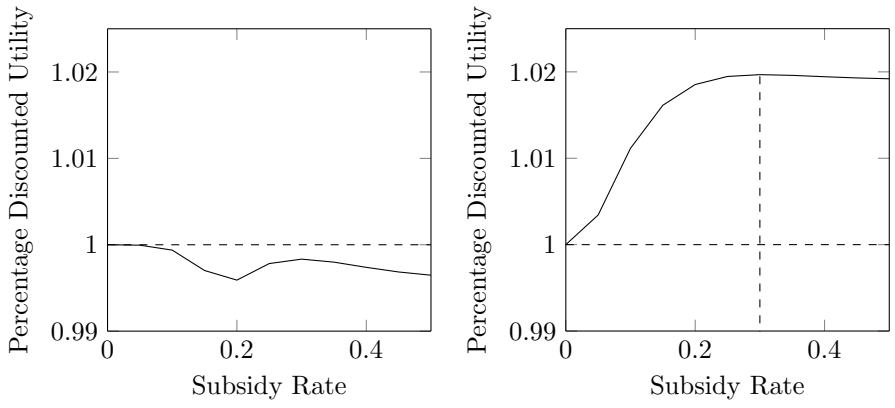
When opening up for trade, if Home faces an international relative price which is larger than the critical price ($p^* > \widetilde{p_t}$), labor will shift into the manufacturing sector and Home benefits from both gains from trade and TFP growth. A labor subsidy can accelerate industrialization (see Figures 15a and 15b) and can lead to welfare gains in the long run (see Figures 16a and 16b). The higher the international relative price of the manufactured good, the higher the initial fraction of labor in manufacturing and the faster the rate of TFP growth in

Figure 13: Compensating Variation in a SOE With International Relative Price smaller than Critical Price



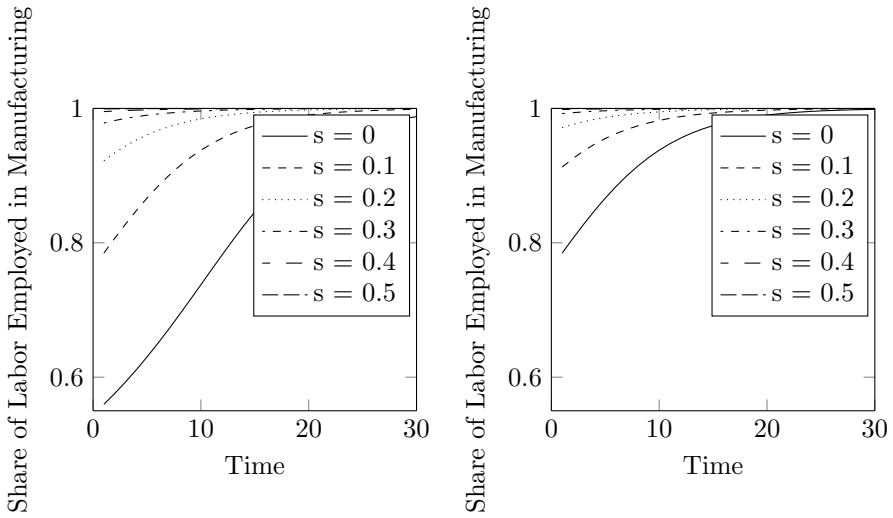
(a) $p^* << \widetilde{p}_t$ (b) $p^* < \widetilde{p}_t$

Figure 14: Discounted Consumer Utility in a SOE International Relative Price smaller than Critical Price



(a) $p^* << \widetilde{p}_t$ (b) $p^* < \widetilde{p}_t$

Figure 15: Labor Allocation in a SOE With International Relative Price larger than Critical Price



(a) $p^* > \widetilde{p_t}$ (b) $p^* >> \widetilde{p_t}$

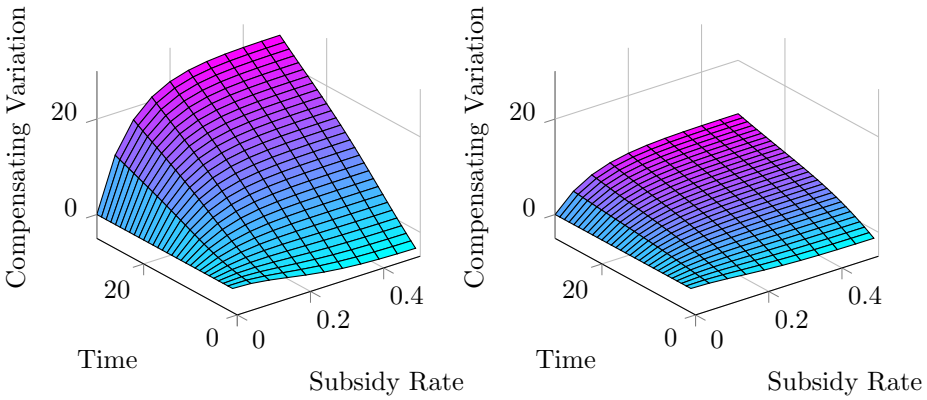
the manufacturing sector. Therefore, the labor subsidy can lose some of their their efficiency as the upper bound of the fraction of labor in manufacturing is reached (see Figures 17a and 17b).

3.3 Policy Implications

We have shown that the optimal subsidy is dependent on the international relative price. A labor subsidy is most effective when the international relative price of the manufactured good equals the critical price. The higher the price is above the critical price, the smaller the positive impact of the subsidy on welfare. The lower the price is below the critical price, the larger the subsidy would have to be and, therefore, the larger the distortions created which reduce welfare.

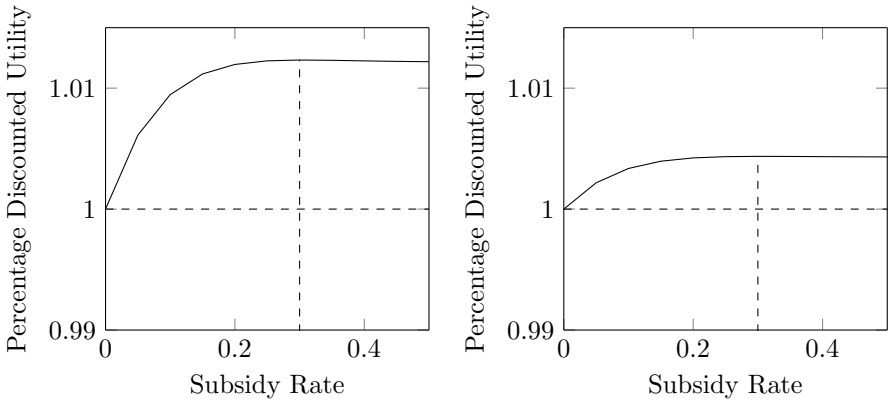
Historically, it has been shown that the international relative price of the manufactured good has been increasing over time relative to the agricultural good, thereby supporting the Prebisch-Singer thesis that countries who export primary goods will have terms of trade that decline over time. In order for a SOE to avoid deteriorating terms of trade, it has been argued that industrialization is necessary. The long-term negative growth effects from trade may outweigh the short-term gains from trade. Using a subsidy with free trade would result in very large distortions. This can explain why many developing economies are still exporters of primary goods. An economy might have opened up too early if short run gains from trade were favored over long run economic development.

Figure 16: Compensating Variation in a SOE With International Relative Price larger than Critical Price



(a) $p^* > \widetilde{p}_t$ (b) $p^* >> \widetilde{p}_t$

Figure 17: Discounted Consumer Utility in a SOE International Relative Price larger than Critical Price



(a) $p^* > \widetilde{p}_t$ (b) $p^* >> \widetilde{p}_t$

Furthermore, industrializing with a subsidy can incur large welfare losses in the short run. The more time spent on specializing in agriculture, the larger the comparative advantage in that sector and the harder it becomes to justify the use of a subsidy as a mean of industrialization later on.

If the international relative price is not too distant from the critical price, a labor subsidy can bridge this gap while increasing consumer welfare over the long run. If the critical price is sufficiently low such that Home industrializes with free trade, the subsidy becomes less efficient but can accelerate the industrialization process and might be welfare enhancing.

To briefly summarize, the decision to open up for trade and the optimal labor subsidy depend on the economy's development relative to the rest of the world. In an earlier stage of economic development, countries might need an appropriate amount of catching-up in manufacturing TFP without trade. Equation (29) shows that the smaller the TFP ratio between the agricultural and manufacturing sector, the smaller the critical price and, thus, the smaller the subsidy needed to lead to industrialization. Therefore, the labor subsidy can be used as an instrument that allows small economies to industrialize faster without trade, allowing for some catch-up, before finally opening up their economies.

4 Two Large Countries

Next, we look at the effects of a labor subsidy when there are only two large economies. We assume the population of both economies are of equal size and they only differ in their relative initial TFP, $\frac{A_0}{M_0}$. With free trade, the relative international price is such that world markets for both goods clear. We will introduce a labor subsidy in one economy, the one with a comparative advantage in agriculture, and analyze how this affects welfare in both countries.

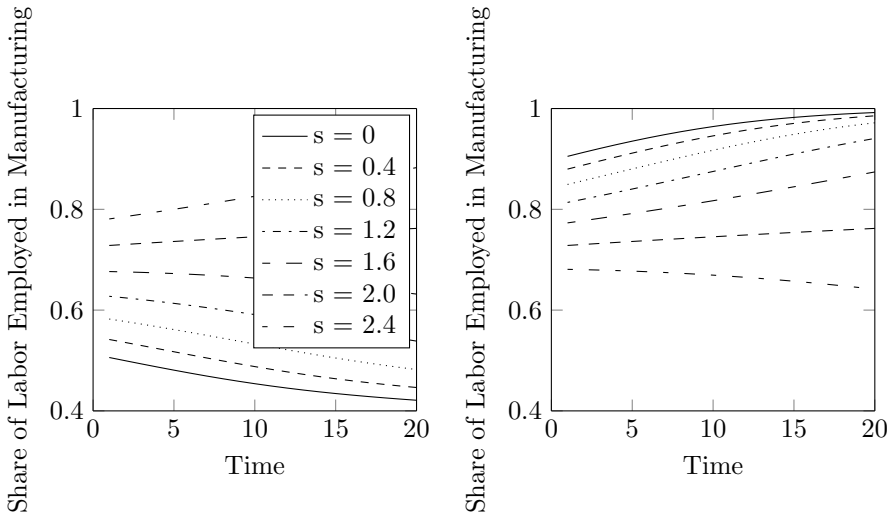
Assume that the initial productivity of the two countries, referred to Home and Foreign, satisfy the following conditions:

$$\frac{M_0}{A_0} < \frac{M_0^*}{A_0^*}, \tag{31}$$

where M_0 and A_0 are the initial total factor productivities in Home and M_0^* and A_0^* are the initial productivities in Foreign. By opening up for trade, the relative price of the manufactured good will decrease at Home which will reduce the fraction of labor employed in manufacturing. Short run welfare gains from trade can be outweighed by the negative effects on lower TFP growth in the manufacturing sector. On the other hand, Foreign experiences a positive shock as the fraction of labor in manufacturing increases which leads to faster industrialization.

By introducing a subsidy as in the previous section, Home can shift labor into the manufacturing sector (see Figure 18a). Home's use of a subsidy negatively affects the terms of trade in Foreign as it reduces the relative international price of the manufactured good. This leads to a reduction in the share of workers in manufacturing in Foreign (see Figure 18b). As before, introducing

Figure 18: Labor Allocation in the Two-Country Case



(a) Home

(b) Foreign

a labor subsidy at Home has negative welfare effects in the short run due to the distortions created, however, the negative impact is reduced by an increase in Home's terms of trade. In the long run, Home might benefit from a labor subsidy that at the very least will decelerate the deindustrialization process (see Figure 19a and 20a). A subsidy at Home will always reduce welfare in Foreign (see Figure 19b and 20b). In the short run, the subsidy reduces Foreign's terms of trade and, in the long run, will also reduce their TFP growth as n_t^* will be lower.

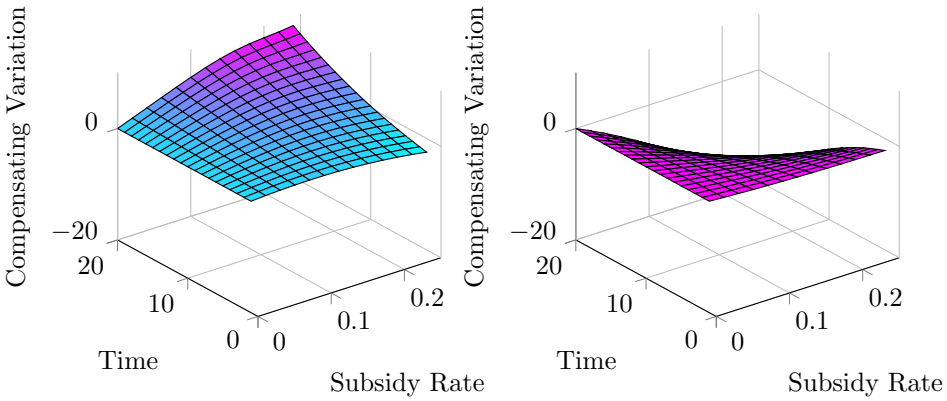
However, Foreign might also industrialize in the short run before deindustrializing as shown in Figure 18b. In this case, TFP growth rate is higher in Home ($g_t^M > g_t^{M*}$) while the change in manufacturing TFP is higher in Foreign ($\dot{M}_t^* > \dot{M}_t$). Therefore, the fraction of labor in manufacturing in Foreign is growing at time t as long as the following condition is satisfied:

$$\left(\frac{n_t}{n_t^*}\right)^{\alpha} < \frac{M_t^*}{M_t}, \tag{32}$$

where n_t and n_t^* are the fractions of labor employed in manufacturing in Home and Foreign at time t, respectively.

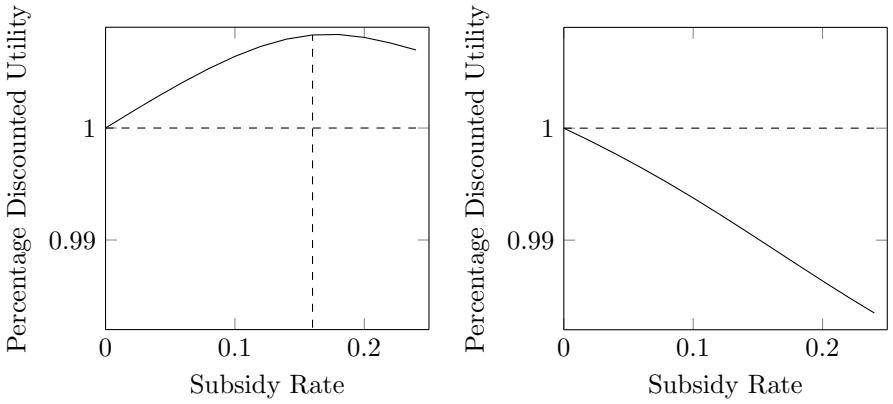
If Home sets its subsidy such that the initial fraction of labor in manufacturing in both economies are equal ($n_t = n_t^*$), it will be possible for both economies to industrialize. The manufacturing productivity in both economies will grow at the same rate and eventually converge diminishing trade. By combining and equalizing the fractions of labor employed in manufacturing in both countries, we find the unique subsidy

Figure 19: Welfare Development in the Two-Country Case



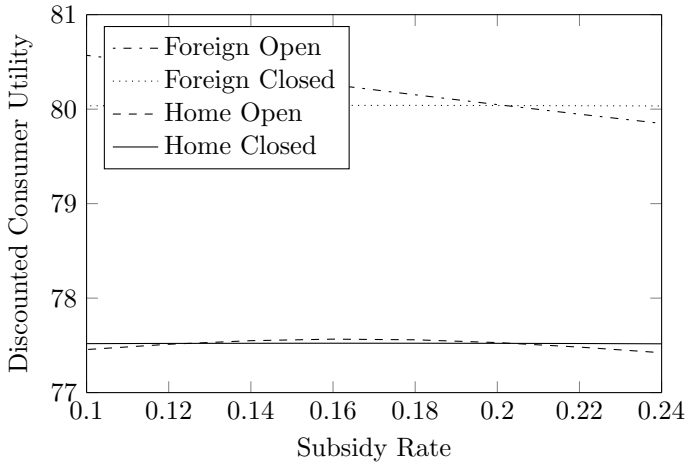
(a) Home (b) Foreign

Figure 20: Discounted Consumer Utility in the Two-Country Case



(a) Home (b) Foreign

Figure 21: Discounted Consumer Utility in Home and Foreign



$\widetilde{s_t}^{TLC} = 0.2$

$$\widetilde{s_t}^{TLC} = 1 - \left(\frac{A_t^*}{M_t^*}\frac{M_t}{A_t}\right), \tag{33}$$

which allows both countries to industrialize in the long run.

Since both economies industrialize at the same time while still benefiting from trade in the short run, the unique subsidy may be optimal in that both economies are better off than without trade. Figure 21 compares the discounted consumer utility of both economies between autarky and free trade with a subsidy in Home. We find that consumer utility in both countries is higher when both countries trade with the unique subsidy compared to remain closed off to trade.

This gives interesting insight into policy implications. a Labor subsidy in manufacturing should not be used as an instrument for protectionism but rather for a cooperative international policy for developing countries. It can be shown that free trade is a weakly dominant strategy relative to autarky for an industrialized country even if the developing country makes use of a labor subsidy. Our model also shows that an industrialized economy can even benefit from a labor subsidy implemented in the less developed economy if this were to lead to the opening of trade. [6]

5 Conclusions

In this paper we have developed a two-sector model of endogenous growth with learning-by-doing in the manufacturing sector. It is assumed that manufactur-

[6] These findings are robust in our model using different parameter values.

ing TFP growth increases with the amount of labor in the manufacturing sector. The labor subsidy shifts labor into this sector, accelerating the industrialization process in a closed economy. However, tax distortions will reduce consumer welfare in the short run. In a small open economy (SOE) we find that industrialization does not depend on comparative advantage but on relative sectoral TFP growth relative to the free trade price. By shifting labor into the manufacturing sector, the labor subsidy can lead to industrialization. However, the greater the difference between the international relative price of the manufactured good and the critical price derived, the less efficient a subsidy becomes. In a case of two large countries, we determine a unique subsidy that can ensure that both economies industrialize.

We have shown that a labor subsidy can be used to support industrialization in developing economies. This can be mutually beneficial for consumer welfare in both the subsidized economy and its trade partners. Therefore, our model suggests that developed economies might have an interest in supporting industrialization policies in developing countries if it would lead to open trade. Further research should analyze under which conditions the labor subsidy in the less developed economy improves long run consumer welfare of both trade partners.

Results in this paper must be interpreted with caution. The assumption of no knowledge spillovers across economies simplifies the model but might not hold true. Furthermore, we assumed exogenous agricultural productivity growth which means that agricultural innovations associated with industrialization (agricultural machinery, chemical innovations, etc.) cannot be assessed. We also exclude capital accumulation and financial markets to make the model tractable. Nevertheless, the paper highlights, in a simple framework, the role a labor subsidy can play for economic development. If agents are sufficiently patient, the subsidy can have a long run positive impact on the structural composition and economic performance of developing economies that can exceed short run costs.

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Appendix A Dynamic International Price

Here we show that the results of the SOE model are not affected by an international price that declines over time. If we assume that the learning-by-doing externality increases labor productivity in the manufacturing sector relative to the agricultural sector, the international price p_t^* declines at a constant exogenous rate g_{p^*}. Taking into account a dynamic international price, the percentage change in the fraction of labor employed in manufacturing derived in equation (27) can be rearranged into

$$\frac{\dot{n}_t}{n_t} = \left(\frac{1}{1-\alpha}\right)\left(1-n_t\right)\left[\frac{\dot{M}_t}{M_t} - \frac{\dot{A}_t}{A_t} + \frac{\dot{p_t^*}}{p_t^*}\right], \tag{34}$$

where $\frac{\dot{p_t^*}}{p_t^*}$ is equal to the constant rate g_{p^*} at which the international price declines over time (note that $g_{p^*} < 0$). If we set the change in the fraction of labor in manufacturing equal to zero, we can derive the critical price from equation (34)

$$\widetilde{p_t} = \left(\frac{A_t}{M_t}\right)\left[\left(\frac{\delta}{g_A - g_{p^*}}\right)^{\frac{1}{\alpha}} - 1\right]^{\alpha-1}. \tag{35}$$

The critical price becomes larger due to the dynamic international price. Therefore, TFP in manufacturing relative to TFP in agriculture must be higher for a SOE to industrialize compared to the case of a constant international price. The larger the critical price, the larger the critical subsidy in equation (30). We derive the critical subsidy by combining equations (35) and (24),

$$\widetilde{s_t} = 1 - p^* \frac{M_t}{A_t}\left[\left(\frac{\delta}{g_A - g_{p^*}}\right)^{\frac{1}{\alpha}} - 1\right]^{1-\alpha}. \tag{36}$$

The critical subsidy increases with the rate of change of the international price. Therefore, a SOE may have to introduce a larger subsidy in order to industrialize compared to the constant international price case. The function of the subsidy as an instrument that allows earlier opening up for trade while industrializing still applies.

Appendix B Parameters

Most parameters are derived from data in Kendrick (1961) which has values for the U.S. for the first half of the 20th century. U.S. trade during this time is lowest, relative to GDP, in which sectoral data is available and therefore the closest proxy to a closed economy. First, we use output and TFP data from 1953 relative to 1899 to calculate average annual growth rates of output and TFP. The average annual growth rates of fraction of labor in each sector is calculated by using data on distribution of persons engaged by sector from 1899 to 1957. We solve for α in each sector in equations (1) and (2), by subtracting the the annual growth rate of TFP from the annual growth rate of output and

divide by the annual growth rate of the fraction of labor. The average from both sectors is the parameter α in our simulation. We use Gross Value Added data, distribution of persons engaged for each sector in 1929 and α to derive TFP in both sectors following the same equations. We derive g_A by using the annual growth rate of TFP in agriculture from 1899 to 1953. The value of our learning-by-doing externality is calculated by using the annual growth rate of TFP, the distribution of persons engaged in the manufacturing sector and α.

In order to derive γ, we use data from the Bureau of Economic Analysis. We divided the sum of Food and Beverages purchased for off-premises consumption and Food Services by Personal Consumption Expenditures in 2014 to calculate γ. From equation (16) we derive $\bar{c}^A$ with total consumption expenditures and consumption expenditures spent on the agricultural good data from 1929 (Carter et al. (2006)).

Table 1: Parameter Table

Parameter	Value	Source
M_0	729.96	Kendrick (1961): manufacturing TFP in U.S. in 1929
A_0	64.14	Kendrick (1961): agricultural TFP in the U.S. in 1929
α	0.9	Kendrick (1961); derived from the average annual growth rate of TFP and output from 1899 to 1953 and average change of labor from 1899 to 1957 in agriculture and manufacturing in the U.S.
g_A	0.0133	Kendrick (1961): average annual growth rate of agricultural TFP from 1899 to 1953 in the U.S.
δ	0.0336	Kendrick (1961): learning-by-doing externality in manufacturing from 1899 to 1953 in the U.S.
γ	0.138	Bureau of Economic Analysis: Share of Personal Consumption Expenditures spent on the agricultural good in the U.S in 2014
$\bar{c}^A$	12.19	Carter et al. (2006): subsistence level of agricultural consumption in the U.S. in 1929