"BARRIERS TO TRADE: BARRIERS TO GROWTH."

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Barriers to Trade: Barriers to Growth*

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Alberto Trejos
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Abstract

We study the extent to which differences in international trade policies contribute to the significant cross-country disparities in macroeconomic performance. In particular, we concentrate on the effect of protectionism on generating differences in levels (of income and of measured total factor productivity), in growth rates (of output, productivity and inputs), in volatility and in trends (or development traps). We document that these relationships are strong in cross-country data, integrate a Heckscher-Ohlin model of international trade into the standard macroeconomic model to derive those relationships analytically, and to quantify them. Our results suggest that a large fraction of the cross-country variations can be attributed to trade policy.

1 Introduction

There is a large disparity across countries in income, growth rates, and other key macroeconomic variables. Recently, much effort has been directed at explaining these differences. Some of that research has studied the extent to

*This is a very preliminary version. We thank Fernando Alvarez, Pete Klenow and Alan Taylor for their input. Financial support from CNPq, PRONEX and from NSF is gratefully acknowledged.
which differences in institutions and national policies (rather than in more permanent, idiosyncratic fundamentals) can be the reason why some countries are rich and others are poor. Some grow fast and others grow slow, some are volatile and others are stable, etc. In this paper, we join those efforts and ask whether much of the disparity in macroeconomic performance can be attributed to differences in tariffs and other international trade policies. It is our belief that for many countries, the large degree of protectionism carries a good part of the blame for their disappointing macroeconomic performance.

The notion that trade policy affects macroeconomic variables significantly is, of course, not new. At least in Latin America, this idea is an integral part of the policy debate. There is abundant empirical support for the notion that protectionism is behind the disappointing performances of many countries. Also, one cannot help but notice that the four South East Asian “dragons,” happen to be among the Third World countries that trade most intensively with the rest of the world. We study here if the simplest open-economy macroeconomic model can deliver the most salient qualitative features of the data. Then, using standard procedures to discipline our choice of parameters, we quantify the importance of the link between trade policy and macroeconomic performance.

We provide below some illustration of the strong correlations between trade policy and economic performance that can be found in the data. Those relationships, while strong, do not imply causality. There are good static, microeconomic reasons why a country is better off without protectionist trade policies. A government or a set of institutions that can pick the right macroeconomic policy (and thus get high levels of productivity and growth rates) is more likely to be able to pick the right international trade policy (and thus select low tariffs and eliminate non-tariff trade restrictions), even if those two sets of policies have nothing to do with one another. To understand if the relationships are not coincidence, one needs a macroeconomic model with international trade, to study which channels establish the link between trade and macroeconomic performance within the model, and then use the data to evaluate the quantitative importance of those channels. That is what we do.

1For example, Chari, McGrattan and Kehoe (1996) show how differences in income levels could respond to differences in the level and trend of capital taxes. Parente and Prescott (1996) study how the protection of monopolies can generate “technological barriers” that multiply the differences in total factor productivity. Rebelo (1991) shows how fiscal policy can affect long-run growth.

2For a survey of some of this work, see Edwards (1993).
To pursue this, we integrate a static Hecksher-Ohlin model of international trade into the standard Cass-Koopmans macroeconomic model. As in Trejos (1992) and Ventura (1994), the way this is done is by allowing for the existence of tradable and non-storable intermediate goods, which are used in the production of a non-tradable final good. These intermediate goods are produced with different factors than the final good. As a consequence, one can solve this model sequentially. The problem of factor allocation and trade in intermediate goods is static: one can then treat the solution to this problem as an implicit technology, and the dynamic problem becomes homeomorphic to a one-good optimal growth model. To distinguish between permanent differences and differences along transition paths, the model is designed so that, if all countries are identical except for their trade policies, an economy in autarchy and an economy with completely free-trade would have the same steady state.

The main results are as follows. First, we show that there is a clear positive correlation between the total factor productivity of nations and their openness to trade: our model delivers that correlation, as in it gains from trade show up in output rather than in consumption. Quantifying the model we find that for the median country 1/6 of TFP differences with respect to the US can be attributed to different trade policies; for some countries with extremely high tariffs, it is 1/2 of TFP differences. Second, we show that there is a clear positive correlation between the growth rate (in inputs, productivity and output) of nations and their openness to trade: our model delivers those correlations: it predicts that changes in trade policy are correlated with TFP growth and that, because trade affects the marginal returns to capital, levels in trade policy are correlated with inputs growth. Quantifying the model we find that, for some countries, changes in trade policy between 1970 and 1985 have generated TFP gains or losses of as much as 10% of total output, and that such channel has been more important than human capital accumulation; also, for the average country, in that period the difference between a very open and a very closed trade policy would amount to as much as 5% more input growth and 12% more output growth. and for a quarter of the world economies those numbers would be 15% and 24%.

Third, we identify a group of poor and middle-income countries that have grown over the last 25 years at a very steady pace that is not faster than that of the world richest countries, and thus failed to converge. We show that those countries have a much more restrictive trade policy than the world average, and than other countries with similar initial incomes: our model
also delivers that result. as under high tariffs the distortions in the economy generate a non-convexity, that allows there to be a second, stable state at a lower level of inputs than the free-trade steady state. Quantifying the model we find that this “development trap” exists, at our baseline parameters, for effective protection rates of about 50% or over: at the trap, depending of the tariff rate, the income level may be 10% to 25% of the free-trade steady state income level.

In Section 2 we present the model and the solution method, and also discuss the data that we use. Section 3 then addresses the topic of cross-country differences in levels of output and of measured total factor productivity. First, we document the extent of those differences, and how they relate to trade policy. Then, we show how and why our model predicts a qualitatively similar pattern as the one displayed in the data. Finally, we quantify the model to assess the importance of the relationship between output levels and trade policies, and compare it with the quantitative importance displayed in the data. In Section 4, we look at the topic of cross-country differences in growth rates (of inputs, productivity and output). The analysis follows the same order outlined before: first we look at the data, then study the model analytically, and finally quantify the results. The same is done in Section 5, where we study cross-country differences in trends and the apparent occurrence of “development traps.” In Section 6 we summarize and conclude.

2 The model

Time is discrete and unbounded. Our representative country is small, and populated by a continuum of identical, infinitely-lived individuals. There are three goods produced in this economy. Two of those goods, called $A$ and $B$, are non-storable intermediate products, and can be traded with the rest of the world (at a relative price denoted $p$: from the point of view of our small economy $p$ is taken as given, and we provide details about its determination and law-of-motion below). The other good, called $Y$, is a final good that can be consumed or invested, but that cannot be traded. There are also three factors of production in this economy, inelastically supplied: raw labor (denoted $L$, and growing at a constant rate $\mu$ due to population growth and exogenous, labor-augmenting technological progress), human capital ($H$) and physical capital ($K$).

The technology is as follows: physical capital and labor can be used in
the production of the intermediate goods $A$ and $B$, with constant returns technologies. For now, we assume that this technologies are Cobb-Douglas: most of the theoretical results only require homogeneity of degree one:

$$
A = K_A^{\alpha_a} L_A^{1-\alpha_a} \\
B = K_B^{\alpha_a} L_B^{1-\alpha_a}.
$$

Without loss of generality, we assume that $A$ is the labor-intensive good, that is, $\alpha_a < \alpha_b$.

The production of the final good $Y$ utilizes the intermediate goods as well as human capital. Denoting by $a$ and $b$ the amounts used of intermediate goods (since these are tradable, it is possible that $a \neq A$ or $b \neq B$), it obtains that

$$
Y = \Theta I H^{1-\sigma} (a^\gamma b^{1-\gamma})^\sigma.
$$

(1)

Notice that we have assumed, at the cost of some generality, that those factors used in intermediate goods production cannot be used in final good production: this will simplify matters very significantly, as will be seen below.

Final goods can be used in either consumption $C$ or investment (in physical capital, $I_K$, or in human capital $I_H$), and cannot be stored. The process by which these investments show up in next-periods capital is not a linear accumulation function, as investment is a convex technology and existing capital facilitates accumulation:

$$
K' = (1 - \delta)K + \Gamma \left( \frac{K}{I_K} \right)^{1-\phi} I_K.
$$

(2)

This type of law-of-motion is emulated from Lucas-Prescott (1971) and others, and in our model delivers a better calibration than the standard law-of-motion. Notice that a higher $K$ would facilitate investment, but $K$ does not appear in (2) as an input. For human capital, we will try two alternative formulations, detailed in Section 4. In the first formulation, we just give $H$ a law of motion identical to (2); in the second formulation, we assume that the human capital is embedded in the acquisition of physical capital, so whenever one invests in a unit of $K$ one also acquires one unit of $H$.

The representative agent maximizes the standard intertemporal maximization problem, with discount rate $\beta$ and instantaneous log utility. All markets (except possibly for the international trade market: see below) are perfectly competitive. The only government-imposed distortion in this economy comes from the presence of tariffs to imports of intermediate goods. We
assume that the government chooses a flat, ad-valorem tariff $\tau$: the proceeds of that tariff are transferred back to the households.

The world contains many countries, all with identical preferences and technologies, although with different trade policies. All but one of those countries are small, in the sense that they also take the international price $p$ as given. There is one large country, whose domestic shadow price of $A$ in terms of $B$ becomes the international price $p$: it has tariffs $\tau = 0$, and has been around for long enough to have converged to its stochastic balanced growth path. When calibrating the model, we will pick data to make that large economy resemble the United States.

### 2.1 Solution of the model

Notice that the allocation of capital $K$ and labor $L$ among the production of the intermediate goods $A$ and $B$ is a purely static problem: this because the two intermediate goods are not storable, there is trade balance in every period, and the factors used in the production of $A$ and $B$ have no other use. Similarly, the amounts used of those intermediate products, $a$ and $b$, are also determined in a static problem. Consequently, one can solve the model in two steps: first, one can obtain the equilibrium quantities $(A, B, a, b)$ as functions of $(K, L, \tau, p)$, and derive an equilibrium mapping $Y = F(K, H, L|\tau, p)$ by substituting those equilibrium quantities into (1). Second, one can use that equilibrium mapping $F$ as if it was an exogenously given technology, and solve the standard dynamic problem that emerges as a result.

To derive the mapping $F$, notice that $K$ and $L$ are allocated in a way that maximizes the domestic value of intermediate good production:

$$A, B = \arg \max_{A,B} qA + B$$

subject to:

$$A \leq K_A^{\alpha_0} L_A^{1-\alpha_0}$$
$$B \leq K_B^{\alpha_0} L_B^{1-\alpha_0}$$
$$K_A + K_B \leq K$$
$$L_A + L_B \leq L$$

---

3When talking about total factor productivities, we will interpret them as if all the differences were in the parameter $\Theta$, and not in the other parameters of the production function.
Similarly, the input of intermediate goods in to the final good sector satisfies

\[
\begin{align*}
a, b &= \arg\max_{a, b} \alpha^\gamma b^{1-\gamma} \\
\text{s.t.} qA + B &\geq qa + b
\end{align*}
\]

and the two problems are linked by the current account balance \( pa + b = pA + B \). The local prices satisfy \( q = p(1 + \tau) \) if the country is labor-abundant (if \( K/L < K^*/L^* \), where \( K^* \) and \( L^* \) are the levels available in the large foreign economy described above): \( q = p(1 + \tau) \) if \( K/L > K^*/L^* \).

The allocation of \( K \) and \( L \) between the sectors \( A \) and \( B \) will maximize the value of total tradables output, under local prices \( q \). This means that in equilibrium

\[
MRT_{BA} = q
\]

or, calling \( k_i \equiv K_i/L_i \)

\[
\frac{a^\alpha a^1}{b^\alpha b^1} = \frac{(1 - \alpha_a)k_a^{\alpha_a}}{(1 - \alpha_b)k_b^{\alpha_b}} = q.
\]

The demand for \( a \) and \( b \) will satisfy

\[
MRT_{S_{ba}} = q \quad \text{or} \quad \frac{\gamma b}{(1 - \gamma)a} = q.
\]

It can be shown that there is a tariff rate \( \tau \), which depends on \( K/L \), such that if \( \tau \geq \overline{\tau} \) international trade shuts down and the equilibrium is autarchic. When \( \tau \geq \overline{\tau} \) one can represent the map \( F \) as the solution for the planning problem for an economy that cannot trade. Conveniently, this takes also the form of a Cobb-Douglas technology, namely

\[
F(K, H, L|\infty, p) = \Omega H^{1-\sigma} \left( K^\overline{\alpha} L^{1-\overline{\alpha}} \right)
\]

where \( \overline{\alpha} = \gamma \alpha_a + (1 - \gamma) \alpha_b \) and \( \Omega \) is a function of parameters.

Under free trade \( (\tau = 0) \) there is a critical level \( k^* \) such that:

1. If \( k < k^* \) the country exports \( A \), the labor-intensive good:
2. If \( k > k^* \) the country exports \( B \), the capital-intensive good:
3. The closer \( k \) is to \( k^* \), the less trade there will be, and if \( k = k^* \) there is no trade \((a = A, b = B)\).
The capital-labor ratio $k^*$ is a function of $p$, which would be the price of $A$ in a closed economy that had capital-labor ratio $k^*$. Therefore, $\partial k^*/\partial p > 0$.

Also, there are critical levels $k_A < k^*$ and $k_B > k^*$, also functions of $p$, such that:

1. If $k < k_A$ then the country only produces $A$;
2. If $k > k_B$ then the country only produces $B$.

With a positive but "small" tariff, there is an interval $[k_1^*, k_2^*]$, containing $k^*$, such that if $k \in [k_1^*, k_2^*]$ the economy does not trade. $\partial k_1^*/\partial \tau < 0$, and $\lim_{\tau \to \infty} k_1^* = \lim_{\tau \to \infty} k_A = 0$. Analogous statements can be made for $k_2^*$ and $k_B$.

Recall that what matters for production is the equilibrium value $g(K, L|\tau, p) \equiv a^\gamma b^{1-\gamma}$.

If the economy trades freely ($\tau = 0$) then

$$g(K, L|\tau = 0, p) = \begin{cases} \Omega_2 K^{\alpha_\sigma} L^{1-\alpha_\sigma} & \text{if } K/L < \tilde{k}_A \\ \Omega_3 K + \Omega_4 L & \text{if } K/L \in [\tilde{k}_A, \tilde{k}_B] \\ \Omega_5 K^{\alpha_\sigma} L^{1-\alpha_\sigma} & \text{if } K/L > \tilde{k}_B \end{cases}$$

(3)

If $\tau > 0$ but $\tau < \infty$ then

$$g(K, L|\tau, p) = \begin{cases} \Omega_6 K^{\alpha_\sigma} L^{1-\alpha_\sigma} & \text{if } K/L < \tilde{k}_A \\ \Omega_7 K + \Omega_8 L & \text{if } K/L \in [\tilde{k}_A, k_1^*] \\ \Omega_9 K^{\alpha_\sigma} L^{1-\alpha_\sigma} & \text{if } K/L \in [k_1^*, k_2^*] \\ \Omega_9 K + \Omega_{10} L & \text{if } K/L \in [k_2^*, \tilde{k}_B] \\ \Omega_{11} K^{\alpha_\sigma} L^{1-\alpha_\sigma} & \text{if } K/L > \tilde{k}_B \end{cases}$$

The values $\Omega_i$ are functions of parameters; most are affected by $p$ and $\tau$.

Consider for starters the dynamic problem of an economy facing constant prices $p$ and constant tariffs $\tau$, taken as given. From the point of view of that dynamic problem, the production function

$$F(K, H, L) = g(K, L|\tau, p)^\sigma H^{1-\sigma}$$

can be taken parametrically. Relevant properties of the function $F$ are summarized in the following Lemma:
Lemma 1 The implicit production function $F$ is continuous, and homogeneous of degree one. For $\tau = 0$ and for $\tau = \infty$, $F$ is also $C^1$ and strictly concave. Concavity, and continuity of the first derivative, are generic but not global properties of $F$ if $\tau \in (0, \bar{\tau})$. In particular,

$$F(K, H, L|\tau, p) = g(K/L|\tau, p)\sigma(H/L)^{1-\sigma}$$

and the function $g(k|\tau, p)$ is increasing and continuous in $k$, but there is a finite number of values of $k$ for which $g'(k)$ has a discrete variation (up or down).

For all values of $p$, there is a level of $K/L$ (call it $\kappa(p)$) such that $F$ is invariant in $\tau$; for all other values of $K/L \neq \kappa(p)$, $F$ is decreasing in $\tau$.

Given that both $F$ and the law-of-motion (2) are homogeneous of degree one, and that $L$ grows at an exogenous rate $\mu$, we can define $k_t = K_t/(L_0\mu^t)$ and $h_t = H_t/(L_0\mu^t)$ and work on the stationary model thus implied.

Below, we will solve the dynamic problem for this model for $\tau = 0$ and $\tau = \infty$. As we are interested in out-of-steady-state behavior, we use policy function iteration on Coleman’s grid method. We are leaving for future versions a solution for the dynamic problem with $\tau \in (0, \bar{\tau})$: notice that the non-concavity of $F$ for those cases precludes us from using policy function iteration. For a closed economy (one where the tariff exceeds $\bar{\tau}$ for all the values of $k$ along the transition path: for instance, one where $\tau = \infty$), the production function is Cobb-Douglas, and consequently the dynamic problem is known to converge to a balanced growth path where $K/L = k^*$ and $H/L = h^*$. If prices are constant, and if they are determined as the equilibrium prices at a large economy that has converged to such balanced growth path, then it can be shown that a perfectly open economy (one where $\tau = 0$) with the same technology will also converge to the same balanced growth path characterized by $(k^*, h^*)$. For other economies with $0 < \tau < \bar{\tau}$, it can be shown that $(k^*, h^*)$ also defines a stable balanced growth path. But, as will be shown in Section 5, that may not be the only one.

2.2 Data

We use cross-country data for large samples of countries in this paper. Whenever possible, we utilize the Summers-Heston dataset. Output, investment, consumption, population and prices are all derived from Summers-Heston.
directly. For physical capital, we derived our own series using Summers-Heston’s investment data and the accumulation function (2): we verified that it is not very different from other series (used by other authors) derived from the same investment data and linear accumulation functions.

For some variables, we need to look outside Summers-Heston. In those cases, we repeat each experiment with several available series. For instance, for human capital we use four different series: a- the Barro-Lee (1996) series of population-wide educational attainment; b- the World Bank series of secondary education enrollment; c- the Klenow-Rodriguez (1996) index of human capital; and d- our physical capital series as a proxy for human capital. In some of the tables below, we will refer to some results by the human-capital series used: BL, WB or KR, respectively.

For tariffs, we use several alternatives as well. First, we have a direct measurement of tariffs compiled by Swagel and Wagner for a large number of countries. Second, we use the distortion in the relative price of consumption to investment, relative to the US relative price, compiled from Summers-Heston. Third, we use an indirect measure by correcting for population the \textit{OPEN} variable in Summers-Heston and then asking from the model what the tariff would have to be for \textit{OPEN} to take the value shown in the data.

2.3 Calibration

The parameters \( \mu, \beta, \rho \) and \( \theta \) are picked as in the real-business cycles literature. For lack of information on the parameter \( \gamma \), we opt for symmetry and choose the value 1/2. To follow convention, we pick \( \sigma = 2/3 \), and constrain choices of \( \alpha_A \) and \( \alpha_B \) to make sure that \( \sigma \hat{\alpha} = 1/3 \). This still leaves one of the values \( \alpha_i \) as a free parameter, so we run each of our experiments with a variety of values. We use for \( p \) the shadow price of \( A \) at steady state.

We set the values for \( \delta, \Gamma \) and \( \phi \) to match in steady state the US investment/capital ratio of 7.6\%, a rate of return of capital in steady state of 6.5\% per annum, and a depreciation rate of 8\%. 
3 Differences in Levels

3.1 The data

Cross-country differences in total output are vast. In the Summers-Heston sample, the poorest economy in the world in 1985, Ethiopia, had less than 1/50 of the US per-capita GDP; the median country in that 155 country sample had an income of less than 1/6 of the US, and standard deviation of per-capita incomes was about 1/4 of the American level. Much concentration happens in the lower end of the distribution: the mean almost doubles the median. These differences are both caused by differences in productivity and in inputs available. For example, in the estimates from the Klenow-Rodriguez (1997) study we find that there are differences of as much as 10-1 in productivity, 8-1 in human capital stocks, and over 100-1 in physical capital stocks. Other studies (for example. Mankiw-Romer-Weil(1992)) find lower estimates for the productivity dispersion: all agree on a vast dispersion in physical capital stocks. Estimates of the relative importance of the two sources in explaining the variations in output give between 50 to 80% of the weight to inputs, and between 20 to 50% of the weight to productivity. We aim to derive the contribution that trade policy may have in the determination of both margins.

How does international trade policy correlate with these differences? Using, for example, the Klenow-Rodriguez data, we obtain the following correlations of indicators of trade policy with input, productivity and output levels.

<table>
<thead>
<tr>
<th></th>
<th>Openness residual</th>
<th>S-W Tariffs</th>
<th>S-H price distortions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>0.28</td>
<td>-0.44</td>
<td>-0.74</td>
</tr>
<tr>
<td>Capital</td>
<td>0.29</td>
<td>-0.42</td>
<td>-0.74</td>
</tr>
<tr>
<td>Human capital</td>
<td>0.24</td>
<td>-0.30</td>
<td>-0.70</td>
</tr>
<tr>
<td>TFP residual</td>
<td>0.22</td>
<td>-0.33</td>
<td>-0.56</td>
</tr>
</tbody>
</table>

The correlations are all significant and have the expected sign; quantitatively and qualitatively similar results are derived if one correlates the same

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4The openness residual is the residual from regressing trade as a fraction of GDP (the variable OPEN in Summers-Heston) on total population. Many authors (see for instance Edwards (1993)) have noted that one has to correct for size as in large countries many transactions that are recorded as domestic share many features with international trade transactions.
trade policy indicators with other series for inputs and productivity that have been estimated in the literature.

Section 4 works on differences in inputs: for now, lets concentrate on the differences in productivity. We regress differences in total factor productivity on Swagel-Wagner's tariffs and obtain the following results:

<table>
<thead>
<tr>
<th>H series used</th>
<th>Tariffs</th>
<th>t-stat</th>
<th>R²</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>-0.23</td>
<td>4.01</td>
<td>0.18</td>
<td>74</td>
</tr>
<tr>
<td>KR</td>
<td>-0.56</td>
<td>2.90</td>
<td>0.11</td>
<td>72</td>
</tr>
</tbody>
</table>

We find that the relationships are strong (an extra point in the tariff rate reduces productivity by at least a quarter of a percent) and robust, but that they do not explain much of the variation in productivity (low R²) as many countries have similar tariffs.

3.2 What the model says

The function $f(k, h|\tau, p)$ is decreasing in the tariff rate. Tariffs reduce output for two reasons, both completely standard within the Hecksher-Ohlin model of international trade. First, they distort the prices used in the decision of how to allocated the factors $K$ and $L$ between the intermediate goods production; for example, a labor-abundant country (meaning one that has lower $K/L$ than the large price-setting economy) would, in the presence of the tariff, reallocate factors from the production of $A$ to the production of $B$, as the tariff makes the capital-intensive good more expensive. This reallocation reduces the value of national product at international prices. In other words, for high $\tau$, the maximand of $qA + B$ (which is what is maximized by local firms) is very different from the maximand of $pA + B$ (which is what determines the international purchasing power of the national output).

The second reason why $\tau$ reduces productivity in this model is that it distorts the way in which the revenue from intermediate good production is spent. In the same example, a tariff would push final goods producers to an input mix that has a higher $a/b$. A high tariff distorts $q$ away from the real opportunity cost of one intermediate good in terms of the other (which is equal to their international relative prices), leading to a solution that is suboptimal.

The losses from imposing a tariff are, of course, increasing on the tariff rate, up to a prohibitive tariff at which trade disappears. As a proportion of total output these losses are, also, increasing on the difference between $k$ and $k^*$ (see the middle panel of figure 1); that is, the farther the capital-labor
ratio is from the balanced growth path. the higher the proportional sacrifice from giving up the gains from trade.

Consider the difference in output between a country that has a capital-labor ratio $k$, and a country that has the steady-state $k^*$. The gains from trade, as a fraction of that difference, is not decreasing in $k$. This is because for a very poor economy, with very low $k$, the gains from trade are a very large fraction of its own output. that output is very small compared to the difference with the steady state output. As the third panel in figure 1 illustrates, it is for middle income countries that the gains from trade are a largest fraction of the steady state output: consequently, it will be for middle-income countries that tariffs will explain a highest fraction of the total productivity residual.

3.3 The Results

We perform a levels-accounting analysis analogous to those in Hall-Jones (1997) and Klenow-Rodriguez (1996), using a variety of different data, and using the production function $F$ derived from this model. The objective is to account for the differences in income between the United States and each of the countries in our sample, attributing the portions that correspond to differences in human capital, differences in physical capital, differences in productivity emerging from tariffs, and differences from productivity emerging from other unaccounted sources. Each exercise is performed for three baseline values for the parameter $\alpha_a$.

The results are summarized in the tables below$^5$.

<table>
<thead>
<tr>
<th>$\alpha_a$ = 0.45</th>
<th>h</th>
<th>k</th>
<th>$\tau$</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>24.0%</td>
<td>32.9%</td>
<td>3.1%</td>
<td>39.9%</td>
</tr>
<tr>
<td>Median</td>
<td>19.6%</td>
<td>34.3%</td>
<td>3.3%</td>
<td>41.5%</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td>5.6%</td>
<td></td>
</tr>
<tr>
<td>Top-10%</td>
<td></td>
<td></td>
<td>4.5%</td>
<td></td>
</tr>
<tr>
<td>Top -25%</td>
<td></td>
<td></td>
<td>3.8%</td>
<td></td>
</tr>
</tbody>
</table>

$^5$The exercises use Swagel-Wagner tariffs and Barro-Lee human-capital data.
\[ \alpha_a = 0.35 \]

<table>
<thead>
<tr>
<th></th>
<th>( h )</th>
<th>( k )</th>
<th>( \tau )</th>
<th>( a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>24.1%</td>
<td>27.9%</td>
<td>4.6%</td>
<td>43.4%</td>
</tr>
<tr>
<td>Median</td>
<td>20.0%</td>
<td>28.6%</td>
<td>3.1%</td>
<td>43.7%</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
<td>12.4%</td>
</tr>
<tr>
<td>Top-10%</td>
<td></td>
<td></td>
<td></td>
<td>10.0%</td>
</tr>
<tr>
<td>Top-25%</td>
<td></td>
<td></td>
<td></td>
<td>8.5%</td>
</tr>
</tbody>
</table>

As expected, we find that the exercise attributes about 50-60% of the cross-country variation in income to inputs, and the rest to "productivity." More importantly, we focus now on the role of trade policy. We find that, again as predicted, the lower \( \alpha_a \), the higher the relative importance of tariffs in explaining cross-country income variations. This occurs because, the more different the capital shares in the two intermediate good sectors, the bigger the gains from trade to be realized, and hence the costlier that trade restrictions will be.

For the baseline value of \( \alpha_a = 0.35 \), we find across all four data sets that, on average, only about 5% of the total income variation can be explained by productivity differences induced by trade policy. This is only between 1/9 and 1/6 of the importance of other, unspecified productivity differences. On the other hand, the results do not seem to indicate that tariffs are unimportant. In fact, for those countries that do have excessively restrictive trade policies, our t% columns show much larger numbers. In a quarter of the countries we find that between 10 and 12% of output differences can be attributed to tariffs (this is about 2/5 of overall productivity differences); in some countries as much as 17%. These numbers can be made much larger with lower values for the parameter \( \alpha_a \).

The effects of tariffs are indeed larger in some middle income countries. In general, we find that the effect of trade policy is largest in Latin America (Brazil, Argentina, Mexico, Uruguay), South Asia (India, Pakistan, Sri Lanka) and North Africa (Tunisia, Algeria). In the countries mentioned, between 16 to 28% of the total productivity residual can be attributed to trade policy. We find much smaller numbers for Sub-Saharan Africa, as the model predicts they are too poor. More importantly, for about half of the countries in the sample (Europe, East Asia, and most of the smaller nations) the trade policy is very similar to that of the US. and thus little of the variation can be attributed to this source. This is consistent with an explanatory variable that yields high t-statistics but low \( R^2 \).
4 Differences in Growth Rates

4.1 The data

Differences across countries in growth rates are also very large. For example, between 1960 and 1985, the per-capita annual GDP growth of the eight fastest-growing countries was at least 3.5% faster per year than that of the US. As that rate, their income as a share of US income is multiplied by between 2.5 and 3.3 in only one generation. This group included both rich and poor countries. During the same time, output per-capita grew by at least 2.5% per year less than in the US in another eight countries (all of which happen to be African). The differences in growth rates are manifested both in terms of productivity and in terms of inputs. Even excluding African countries, there are plenty of nations that are not catching up with the US.

The relationship between trade and growth is also very pronounced. In terms of the growth rate of output, the following table summarizes the results from regressing the growth rate of GDP per-capita on various measure of trade policy.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>R²</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH-implicit tariffs</td>
<td>-1.36</td>
<td>-3.65</td>
<td>0.12</td>
<td>98</td>
</tr>
<tr>
<td>OPEN residual</td>
<td>1.56</td>
<td>5.02</td>
<td>0.21</td>
<td>98</td>
</tr>
<tr>
<td>Δ in OPEN residual</td>
<td>0.96</td>
<td>3.05</td>
<td>0.09</td>
<td>98</td>
</tr>
<tr>
<td>SW tariffs</td>
<td>-0.69</td>
<td>-1.96</td>
<td>0.05</td>
<td>73</td>
</tr>
</tbody>
</table>

As can be observed from the table, all the coefficients are high, have the expected sign, and are significant. In terms of productivity growth similar results are obtained too.

Perhaps a more anecdotal but also indicative piece of evidence comes from picking some representative countries. Consider, for example, the four “dragons” of South East Asia: Singapore, Taiwan, Hong Kong and Korea. According to SW data, their average tariff rates are, respectively, 2%, 7%, 0% and 14%. Consider now the following, much less successful, list of countries: Argentina, Peru, Uruguay, India and Bangladesh. The numbers are: 29%, 41%, 21%, 132% and 41%.
4.2 What the model says

There are two ways of interpreting the relationship between trade and growth in our model; in our quantitative experiments, both are going to end up being of roughly equal importance. First, and most simply, economies that reduce trade barriers have a productivity increase, for the reasons detailed in the section on levels. This means that the changes in trade policy can help explain growth. Second, because the implicit technology in the model is in part determined by trade policy, we find that tariffs can affect average and marginal output, and consequently affect the rate of accumulation of inputs. This means that levels in trade policy can help explain growth.

Compare, for instance, the production function for an economy without tariffs, versus the one for an economy with prohibitive tariffs (see figure 1). We know that both functions have the same level of output at two input levels: zero, and the steady state. Since the open economy has a higher output everywhere else, we know that its production function is steeper for low levels of inputs but becomes flatter as the economy approaches the steady state.

For very poor economies, both the average and the marginal productivity of inputs are higher in an open than in a closed economy. Intuitively, this means that both through an income and a substitution effect we are to observe higher savings rates in the open economy. That means that poor economies, when open, grow faster in inputs, and this effect goes in addition to the difference in productivity.

As the economy approaches steady state, on the other hand, we know that average productivity is still higher for the open economy, but marginal productivity must be lower (this has to be the case, as the two economies have the same level of output in steady state). Now, a substitution effect goes in the opposite direction, and as we approach steady state we see that the closed economy grows faster. For economies that are not too poor, the gains from trade are channelled into consumption rather than investment.

In figure 2 we show a similar result for consumption. The results discussed in the rest of this section correspond to the model where we assume that human capital is embedded in physical capital, so the dynamic problem only has one state variable. The figure show, for alternative levels of the capital stock, the ratio for open economy consumption over closed economy consumption. As mentioned before, the gains from trade can be large, especially for relatively poor economies. More importantly, the gains from trade
are manifested in consumption much more than in output. For example, an economy with 20% of the steady state capital level produces 5% more if it is open than if it is closed, but consumes roughly 12% more.

Figure 3 shows next period's capital for an open (the initially steeper curve) and a closed economy, again as functions of this period's capital. As can be seen, if the economies are very poor then the savings when open can be much higher than when closed: around $k = 0$, the growth rate of capital is four percentage points higher for the open economy. However, as the closed economy overtakes the open economy in marginal productivity, the differences in savings levels begin to disappear. For an economy that has 20% of the steady state capital stock, trade does not affect the accumulation of capital (all the gains from trade are consumed), and for a wealthier economy trade can actually slow down input growth (by as much as one percentage point). We obtained our results for the same baseline values for the parameter $\alpha_0$ used in Section 3, and the effects are robust.

Finally, figure 4 shows the ratio of output for an open over a closed economy, this time along a typical transition path. We start both economies with the same level of initial $k$, but have one economy open up in the first period, while the other one remains closed throughout. On impact, output in the first one becomes 11% higher in the open economy, due to the productivity increase. Furthermore, the difference between the two keeps getting wider for a few periods, as the open economy also saves more and accumulates more capital. As both get wealthier (so the gains from trade lose importance, as they are resembling more their wealthy trading partner) and marginal productivity in the open economy gets lower, we see the closed economy beginning to catch up. After many periods, they indeed have similar output levels.

We have also solved the more complicated model with both human and physical capital (where we arbitrarily assign to human capital the same law-of-motion (2) that was assigned and calibrated for physical capital). The results from this second experiment are fairly similar to the ones in the first experiment. There are only two notable differences. First, with two state variables the speed of convergence is much slower; this has the added advantage that even at extremely low levels of inputs the growth rates observed are not implausibly high. Second, we find that the initial mix of the two capital stocks matters: while the marginal productivity of physical capital may be higher or lower when the economy is open than when it is closed, the one for human capital is always higher when the economy is open, and
so paths that require more human capital accumulation display much more transitional growth for the open economy.

4.3 The results

In this section, we present two types of results. First, to evaluate the effect of trade policy variations on productivity growth, we do a growth accounting exercise analogous to the levels accounting analysis performed in Section 3. Second, to evaluate the effect of trade policy levels on input growth, we simulate several transition paths for the economies in our data sample, under alternative scenarios for trade policy.

In table 6 (see appendix) we present an example of the results of growth accounting using changes in trade policy, for the period 1970-85.\(^6\) We only report those countries for which the trade-policy component is most significant.

For seven countries, we find that increased protectionism reduced growth relative to the US significantly (by as much as 12% in some cases). For a larger group of countries, opening up to trade contributed significantly to growth; for the top four countries (Indonesia, Tanzania, Korea and Taiwan) the contribution is between 7 and 12% of total growth relative to the US.\(^7\) For Indonesia, Korea, Ireland and Chile, for example, trade liberalization contributes more to growth than human capital accumulation. Sadly, we cannot report at this time, due to lack of data, analogous results for the period 1960-1985. Presumably, as this is the period were most Latin American and African countries de-liberalize trade, as well as when South East Asia does most of its trade liberalization, we would see much more prominent results for that other time period.

As important as the contributions to productivity are the contributions of trade to input accumulation. To assess them, we conducted the following experiment. We take the capital stock of each country in our sample for 1970,
relative to the US. and assign the same proportion of steady-state capital for a hypothetical counterpart in our model. Then, for each country, we generate three paths: one for a perpetually closed economy, one for an economy that runs for four years in autarchy and then liberalizes trade, and one for an economy that opens permanently in year one. We compare, at year 8, how much growth has been accumulated in each of the economies that liberalized trade, relative to the closed economy.

The following tables summarize the results for the case $\alpha_a = 0.35$:

<table>
<thead>
<tr>
<th>For $\alpha_a = 0.35$</th>
<th>$Y_{opt}/Y_{cl}$</th>
<th>$Y_{opt0}/Y_{cl}$</th>
<th>$C_{opt}/C_{cl}$</th>
<th>$C_{opt0}/C_{cl}$</th>
<th>$K_{opt}/K_{cl}$</th>
<th>$K_{opt0}/K_{cl}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>1.13</td>
<td>1.12</td>
<td>1.30</td>
<td>1.30</td>
<td>1.03</td>
<td>1.05</td>
</tr>
<tr>
<td>Max</td>
<td>1.42</td>
<td>1.49</td>
<td>1.67</td>
<td>1.79</td>
<td>1.24</td>
<td>1.44</td>
</tr>
<tr>
<td>Min</td>
<td>0.98</td>
<td>0.94</td>
<td>0.99</td>
<td>1</td>
<td>0.93</td>
<td>0.86</td>
</tr>
<tr>
<td>1-quartile</td>
<td>1.02</td>
<td>1.00</td>
<td>1.19</td>
<td>1.14</td>
<td>0.96</td>
<td>0.94</td>
</tr>
<tr>
<td>2-quartile</td>
<td>1.12</td>
<td>1.10</td>
<td>1.30</td>
<td>1.29</td>
<td>1</td>
<td>1.01</td>
</tr>
<tr>
<td>3-quartile</td>
<td>1.23</td>
<td>1.24</td>
<td>1.43</td>
<td>1.46</td>
<td>1.08</td>
<td>1.15</td>
</tr>
<tr>
<td>st dev</td>
<td>0.13</td>
<td>0.16</td>
<td>0.18</td>
<td>0.22</td>
<td>0.08</td>
<td>0.16</td>
</tr>
</tbody>
</table>

As can be seen from the tables, while for some countries the open path leads to less growth in inputs (and even to less output 8 years down the road), for most countries that is not the case. Under the more conservative value of $\alpha_a = 0.45$, we find that over 80% of the economies are wealthier if they have opened. and practically all are consuming more along an open growth path.

5 Differences in Trend

5.1 The data

Of the 124 countries for which there is Summers-Heston data on GDP for both 1960 and 1985, exactly half have grown faster than the US, while the other half have grown more slowly. Of the 62 nations that have fallen behind relative to the world leader, a good number are from Africa; more than a few have been in war for much of the period. Many, while being relatively poor, have not only fallen behind for those 25 years, but they have done it at a roughly steady pace, without a long war or other such event in that interval. We list 31 such countries (13 from Africa) that follow that description most clearly, in Table 6. For example, while the world as a whole has cut the lead of the US by, on average, five percentage points, the non-African countries
in our list have seen the lead expanded slightly, and the whole list has fallen behind considerably.

The fact that so many countries, most of them fairly poor, seem to behave as if they were on a lower-level balanced-growth path, have led researchers to seek for "development traps." That is, for other steady states to which poorer economies would be converging. One problem with this notion is that these traps seem not to be infallible: many countries have avoided the trap, started out much poorer and yet ended up much wealthier than those that have fallen in the trap. A "selective" trap, that would only catch those countries that display a particular feature or enforce a particular policy, would be a more appropriate concept given the evidence.

Can bad trade policy be such selective trap? Before we consider the model, notice the second part of Table 6. Trade barriers for this group of countries are significantly higher than for the world as a whole. For example, the Swage-Wagner tariffs, which are 18% in the average country, are 30% in the average country for our "development trap list." The incidence of non-tariff restrictions, according to Sachs-Warner, is twice as much among the list than in the whole sample. The mean OPEN residual, by construction equal to zero for the whole world, averages -0.30 (a whole standard deviation) for these countries.

5.2 What the Model Says

The model we consider in this paper has such selective development traps. We have seen that, for tariffs that are either 0 or \( \infty \), there is a unique, globally stable steady state. That is also the case for tariffs that are positive but low. However, as it turns out, given other parameters there is a positive tariff level, call it \( \tilde{T} \), such that if \( T > \tilde{T} \) there is a second steady state, lower than \( k^* \) (and decreasing in \( \tau \)). The reason is that, for positive \( \tau \), the map \( y(k) \) is no longer concave, as there is a level of \( k \) at which its first derivative jumps up (that is the level of \( k \) at which the economy switches from trade to autarchy; that is, where \( \kappa(\tau) = k \)). For a large enough \( \tau \), the discontinuity is large enough that it makes the steady-state Euler equation have two solutions: there are two steady states (the one shared with the large price-setting economy, and another one strictly lower).\(^8\)

\(^8\)The higher \( \tau \), also, the lower the \( k \) at which the discontinuity occurs. That is why for \( \tau = \infty \) there is only one steady state: the lower one collapses to the origin. For \( \tau = 0 \), the
5.3 The Results

We have calculated the value of $\tilde{\tau}$, the tariff level at which the development traps occur, for alternative values of $\alpha_a$. Those are presented in the following table:

<table>
<thead>
<tr>
<th>$\alpha_a$</th>
<th>$\tilde{\tau}$</th>
<th>$k/k^*$</th>
<th>$f(k)/f(k^*)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>0.202</td>
<td>0.159</td>
<td>0.294</td>
</tr>
<tr>
<td>0.40</td>
<td>0.461</td>
<td>0.150</td>
<td>0.282</td>
</tr>
<tr>
<td>0.35</td>
<td>0.832</td>
<td>0.133</td>
<td>0.260</td>
</tr>
<tr>
<td>0.30</td>
<td>1.465</td>
<td>0.105</td>
<td>0.222</td>
</tr>
<tr>
<td>0.25</td>
<td>3.265</td>
<td>0.056</td>
<td>0.146</td>
</tr>
</tbody>
</table>

Unlike the high steady state, the lower steady state $\hat{k}$ is decreasing in $\tau$. Figure 3 presents the values of $k$ and output at the lower steady state, as a function of tariffs, as they increase beyond $\tilde{\tau}$.

6 Conclusion

References


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economy shifts into autarky only at what would be the autarkic steady state, and hence the steady state is also unique.

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## TABLE 6
Contribution to growth in productivity from changes in trade policy and in inputs (1970-1985, $\alpha_1 = 0.45$)

<table>
<thead>
<tr>
<th>Country</th>
<th>$g_Y$</th>
<th>$g_H$</th>
<th>$g_K$</th>
<th>$\delta t$</th>
<th>$g_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Togo</td>
<td>-0.272</td>
<td>0.446</td>
<td>0.153</td>
<td>-0.116</td>
<td>-0.761</td>
</tr>
<tr>
<td>Kenya</td>
<td>-0.056</td>
<td>0.236</td>
<td>-0.102</td>
<td>-0.095</td>
<td>-0.095</td>
</tr>
<tr>
<td>Jordan</td>
<td>0.680</td>
<td>0.273</td>
<td>0.376</td>
<td>-0.089</td>
<td>0.113</td>
</tr>
<tr>
<td>Uruguay</td>
<td>-0.296</td>
<td>0.049</td>
<td>0.073</td>
<td>-0.057</td>
<td>-0.361</td>
</tr>
<tr>
<td>Guyana</td>
<td>-0.662</td>
<td>0.034</td>
<td>-0.175</td>
<td>-0.055</td>
<td>-0.466</td>
</tr>
<tr>
<td>Cyprus</td>
<td>0.302</td>
<td>0.033</td>
<td>0.085</td>
<td>-0.036</td>
<td>0.221</td>
</tr>
<tr>
<td>Greece</td>
<td>0.163</td>
<td>0.036</td>
<td>0.118</td>
<td>-0.025</td>
<td>0.033</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.462</td>
<td>0.102</td>
<td>0.249</td>
<td>0.007</td>
<td>0.104</td>
</tr>
<tr>
<td>Canada</td>
<td>0.229</td>
<td>0.014</td>
<td>0.072</td>
<td>0.007</td>
<td>0.135</td>
</tr>
<tr>
<td>France</td>
<td>0.033</td>
<td>0.055</td>
<td>0.050</td>
<td>0.008</td>
<td>-0.080</td>
</tr>
<tr>
<td>Japan</td>
<td>0.212</td>
<td>0.023</td>
<td>0.186</td>
<td>0.010</td>
<td>-0.007</td>
</tr>
<tr>
<td>Iceland</td>
<td>0.368</td>
<td>0.021</td>
<td>0.091</td>
<td>0.013</td>
<td>0.242</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.045</td>
<td>0.007</td>
<td>0.017</td>
<td>0.014</td>
<td>0.007</td>
</tr>
<tr>
<td>Chile</td>
<td>-0.330</td>
<td>0.010</td>
<td>-0.089</td>
<td>0.023</td>
<td>-0.279</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.127</td>
<td>0.013</td>
<td>0.124</td>
<td>0.034</td>
<td>-0.049</td>
</tr>
<tr>
<td>Panama</td>
<td>0.049</td>
<td>0.057</td>
<td>0.027</td>
<td>0.050</td>
<td>-0.085</td>
</tr>
<tr>
<td>Iran</td>
<td>-0.050</td>
<td>0.279</td>
<td>0.075</td>
<td>0.055</td>
<td>-0.453</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.671</td>
<td>0.106</td>
<td>0.272</td>
<td>0.071</td>
<td>0.222</td>
</tr>
<tr>
<td>Korea</td>
<td>0.691</td>
<td>0.064</td>
<td>0.348</td>
<td>0.083</td>
<td>0.196</td>
</tr>
<tr>
<td>Tanzania</td>
<td>-0.159</td>
<td>-0.023</td>
<td>-0.036</td>
<td>0.097</td>
<td>-0.196</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.717</td>
<td>0.114</td>
<td>0.433</td>
<td>0.124</td>
<td>0.046</td>
</tr>
</tbody>
</table>
FIGURE 1: Output levels

FIGURE 2: Consumption Ratio
FIGURE 3: Next Period's Capital Level

FIGURE 4: Output Ratio
Autor: Ferreira, Pedro Cavalcanti.
Título: Barriers to trade: barriers to growth.