Measuring the TFP costs of barriers to trade

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Abstract

This article performs output decompositions in order to measure the effect of trade restrictions on total factor productivity and labor productivity. It is assumed an economy with two tradable and non-storable intermediate goods, used in the production of a non-tradable final good. The solution of the static trade and factor allocation problem generates implicitly a mapping between factor endowments and final output, which is then used as an exogenous production function in the decomposition exercise. We find that for middle income economies with high tariff rates, the effects of trade restrictions are significant; in some cases, enough to attribute to protectionism one third of their TFP disadvantage, or more. For these economies, the impact of trade restrictions on GDP per worker is also relevant.

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1 Introduction

We study and measure the effects of international trade policy on total factor productivity and output levels. As opposed to the previous development accounting literature[1], we are not worried whether TFP or factors are more relevant in explaining output differences. Instead, we perform output decompositions from a distinctive perspective. We are interested to estimate in the first place the share of TFP difference that is due to distortions caused by barriers to trade. Our model is adequate to this task because in essence its trade portion is the standard Hecksher-Ohlin model. Tariffs distort domestic prices introducing an inefficiency in the allocation of factors between the production of intermediate goods, thus reducing the value of national product at international prices. In addition, the same price distortion causes an inefficiency in the choice of the mix of intermediate good by final-good producers.

Hence, policy instruments that increase the cost of international trade generate an inefficient equilibrium allocation of factors across industries. In the model, this inefficiency has an effect similar to a fall in total factor productivity. Under a conservative calibration of the parameters that determine the aggregate, static importance of trade, we find that barriers to trade can be very important for poor countries. Indeed, the model says that for a coun-

[1]For instance, Mankiw, Romer and Weil (1992) and Mankiw (1995) presented evidence that factors of production account for the bulk of income differences across countries. Others (e.g. Klenow and Rodriguez-Clare (1997), Prescott (1998) and Hall and Jones (1999),) however, have established what now seems to be a consensus that total factor productivity is more relevant than inputs in explaining output differences

try with 1/4 of US capital/labor ratio, the static difference between having tariff level of 10% or 100% can represent a loss of output of 8.7%. Applying the model to the data of some countries with a protectionist past - the main exercise of this article - we find that as much as one third of their TFP difference relative to the US can be attributed to restrictive trade policy. Although this is the most dramatic result, we found sizable productivity and output costs of barriers to trade in many cases.

We use as our main instrument a model that follows Ferreira and Trejos (2006). In this framework, it is assumed an economy with two tradable and non-storable intermediate goods, used in the production of a non-tradable final good. We focus on the case of a small, price-taking economy. The solution of the static trade and factor allocation problem generates implicitly a mapping between factor endowments and final output, which can then be used as an exogenous production function. This formulation is similar to Corden (1971), Trejos (1992) and Ventura (1997) that use a factor-endowments framework to introduce trade in a macro model.

This article has four sessions in addition to this introduction. The next session presents the model used in our development decomposition exercises, while session three discusses data and calibration. Session four presents the main results and session five concludes.

2 The model[2]

Time is discrete and unbounded. Our representative country is small (a price taker) 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, tradable intermediate products. They are only used to make the other good, called Y, a final product that can be consumed or invested, but that cannot be traded. There are also two factors of production in this economy: labor in efficient units H and physical capital K. The endowment of labor, measured in efficiency units, is given by:

$$H = Lh = Le^{\phi s},$$

where h represents efficiency-units of labor per worker and s stands for schooling. The production functions of A and B are:

$$\begin{aligned} A &= K_A^{\alpha_a} H_A^{1-\alpha_a} \\ B &= K_B^{\alpha_a} H_B^{1-\alpha_b}. \end{aligned}$$

Without loss of generality, A is labor-intensive: $\alpha_a < \alpha_b$. The production of the final good Y uses only the intermediate goods. Because these intermediate goods are tradable, the amounts of them that are used in the production of the final good (denoted by lowercase a and b) may differ from the amounts produced A and B. Total output of Y is given by:

$$Y = \Theta a^{\gamma} b^{1-\gamma}, \tag{1}$$

[2] The model follows closely Ferreira and Trejos (2006) and hence it will only be presented here a broad outline of its main components and the equilibrium solution

where Θ is total factor productivity.

We derive the allocation of capital K and labor H among the production of A and B, the quantities a and b of intermediate goods used domestically, and the amount of final output Y that is produced. Because intermediate goods are assumed to be non-storable, and the final good is not tradable, this is a static problem, which yields an equilibrium mapping

$$Y = F(K, H|\tau, p)$$

that relates final output with factor endowments. Second, because factors are not tradable, we can simply use that equilibrium mapping F as if it were an exogenously given technology.

To get $Y = F(K, H|\tau, p)$ in equilibrium notice that each period, the equilibrium solutions for $\{A, B, a, b, q, w, r, K_i, H_i\}$ must satisfy the following properties:

1. Producers of intermediate goods choose K_i, H_i in order to maximize the period's profits:

$$\begin{aligned}\Pi_A &= \max_{K_A, H_A} qK_A^{\alpha_a} H_A^{1-\alpha_a} - wH_A - rK_A \\ \Pi_B &= \max_{K_B, H_B} K_B^{\alpha_b} H_B^{1-\alpha_b} - wH_B - rK_B\end{aligned}$$

2. Producers of final goods maximize profits, taking domestic prices as given:

$$a, b = \arg\max_{a,b} \quad \pi a^{\gamma} b^{1-\gamma} - qa - b$$

3. Firms make zero profits,

$$
\begin{aligned}
\Theta a^{\gamma} b^{1-\gamma} &= qa + b \\
qA &= wH_A + rK_A \\
B &= wH_B + rK_B
\end{aligned}
$$

markets clear,

$$
\begin{aligned}
K &= K_A + K_B \\
H &= H_A + H_B
\end{aligned}
$$

and agents neither borrow from nor lend to the world economy,

$$pA + B = pa + b$$

4. Local prices of tradable goods satisfy an after-tariff law of one price:

$$q = \begin{cases} p/(1+\tau) & if \quad a < A \\ p \cdot (1+\tau) & if \quad b > B \end{cases}.$$

Based on these requisites, one can derive the equilibrium relationship F:

1. If K/H is much lower [much higher] than the world's ratio $(K/H)^*$, only the intermediate good A [B] will be produced, as its production uses more intensively the relatively abundant labor [capital]. There are critical levels $s_1 < (K/H)^*$ and $z_2 > (K/H)^*$ such that if $K/H \leq s_1$ then the country *only* produces A, and if $K/H \geq z_2$ then the country *only* produces B. Then, Y is a Cobb-Douglas function of K and H, with capital share α_a [α_b]. Furthermore, the critical values s_1 and z_2

are sensitive to τ. In particular, with higher tariffs the economy is less prone to specialize, so $\partial s_1/\partial\tau < 0$ [$\partial z_2/\partial\tau > 0$], with $s_1 \to 0$ [$z_2 \to \infty$] as $\tau \to \infty$.

2. If K/H is very close to $(K/H)^*$ a high enough tariff will make the economy not trade at all: There exist x_1 and x_2, where $s_1 < x_1 \leq (K/H)^*$ and $(K/H)^* \leq x_2 < z_2$ such that if $(K/H) \in (x_1, x_2)$ then there is no trade, so $a = A$, $b = B$. We have: $\partial x_1/\partial\tau < 0$ and $\partial x_2/\partial\tau > 0$. Also, $x_1 \to 0$ and $x_2 \to \infty$ as $\tau \to \infty$, while $x_1 = x_2$ if $\tau = 0$.

3. If K/H is neither too close nor too far from $(K/H)^*$, the economy will produce both intermediate goods, yet still trade. In those cases holds a result analogous to the Factor Price Equalization Theorem, which states that equilibrium marginal returns of capital and labor are not sensitive to small variations in the factor endowment. What that means is that final output Y is linear in K and H when $K/H \in [s_1, x_1]$ or when $K/H \in [x_2, z_2]$.

   Hence, the equilibrium relationship from K and H to Y takes the form

$$F(K,H|\tau,p) = \begin{cases} \Omega_1 K^{\alpha_a} H^{1-\alpha_a} \text{ if } K/H < s_1 \\ \Omega_2 K + \Omega_3 H \text{ if } K/H \in [s_1, x_1] \\ \Omega_4 K^{\overline{\alpha}} H^{1-\overline{\alpha}} \text{ if } K/H \in [x_1, x_2] \\ \Omega_5 K + \Omega_6 H \text{ if } K/H \in [x_2, z_2] \\ \Omega_7 K^{\alpha_b} H^{1-\alpha_b} \text{ if } K/H > z_2, \end{cases}$$

where the values Ω_i are functions of parameters, and are affected by p and τ. For a closed economy it is the case that $[x_1, x_2) = \Re_+$. Consequently, without trade our model simply collapses to one with the aggregate production function $F^*(K, H|\tau, p) = \Omega_4 K^{\overline{\alpha}} H^{1-\overline{\alpha}}$, $.\overline{\alpha}$ equal to $\gamma\alpha_a + (1-\gamma)\,\alpha_b$. For all values of p and τ, F is homogeneous of degree one and continuous in K and H. Generically, F is also locally concave and continuously differentiable.[3]. F is decreasing in τ (strictly decreasing if $k \notin [x_1, x_2]$) and also $\partial F_K/\partial\tau < 0$.

The fact that $\partial F_K/\partial\tau < 0$ implies that a protectionist trade policy carries as a consequence a loss in output, given inputs, and therefore a loss in measured productivity. The effect of τ on output is not because tariffs appear directly in any of the production functions, but rather because tariffs change domestic prices in a way that distorts the decisions of producers. There are two reasons why this is so. First, a distorted q introduces an inefficiency in the allocation of K and H between A and B, thus reducing the value of national product at international prices. Second, the same price distortion causes an inefficiency in the choice of a and b by Y-producers.

The theoretical effects of tariffs on output are illustrated in Figure 1, for the case where $\tau = 0$ and $\tau = 0.3$, respectively.

[3]If $\tau > 0$, global concavity and continuous differentiability is lost because F_K has discrete variations (up or down) at the critical values s_i and x_i. See Ferreira and Trejos (2006) for a proof of this result.

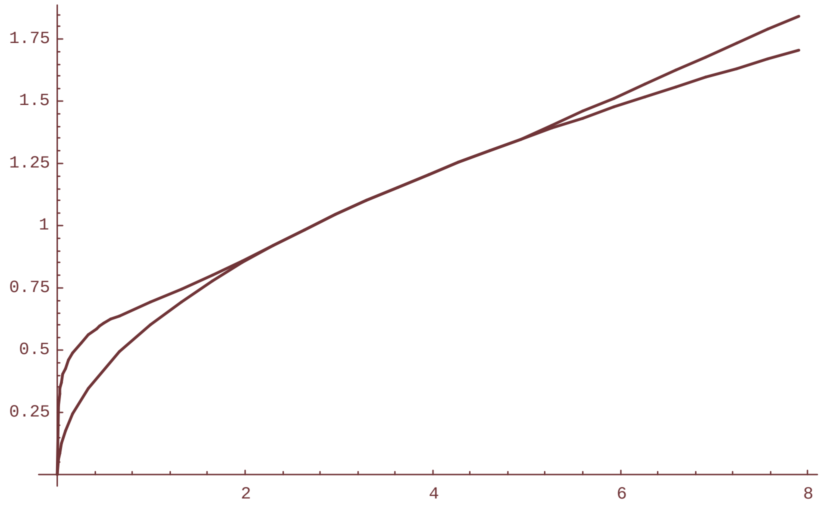

Figure 1: Production functions when τ=0 and $\tau = 0.3$

Note that, given K/H, the open economy unambiguously obtains more output as $F(K, H|\tau > 0)$ is everywhere below $F(K, H|\tau = 0)$. This means that in this model, everything else equals, larger barriers to trade imply smaller productivity. Moreover, the larger τ, the larger the distance between $F(K, H|\tau > 0)$ and $F(K, H|\tau = 0)$, given K and H. Note also that there is an interval $[x_1, x_2]$ where the curves coincide. In this sense, the model predicts that the costs of protectionism for economies close to the leaders is either null or very small, which is what one could expect from a model in which trade is driven by comparative advantage.

We perform level-accounting exercises for a variety of countries, to see what fraction of the total factor productivity residual that one measures using a closed-economy framework can actually be attributed to the inefficiencies associated with protectionist trade policy. In this sense ours is a static exercise of the costs of trade barriers. It is static because we ignore the impact of these barriers on capital accumulation and hence on growth and income levels in the future. As we have shown in our previous paper, this long run effect of protectionism policy can be sizable. However, we restrict ourselves to the following decomposition exercise:

$$\begin{aligned}
\ln(y_{US}/y_i) &= \ln\left(F(k_i, h_i|\tau_{US})\right)/\ln(F(k_i, h_i|\tau_i)) + \\
&\quad \ln\left(F(k_i, h_{US}|\tau_{US})\right)/\ln(F(k_i, h_i|\tau_{US})) + \\
&\quad \ln\left(F(k_{US}, h_{US}|\tau_{US})\right)/\ln(F(k_i, h_{US}|\tau_{US})) + \\
&\quad \ln((y_{US}/F(k_{US}, h_{US}|\tau_{US}))/(y_i/F(k_i, h_i|\tau_i))),
\end{aligned}$$

where y and k stand for output per worker and capital per worker, respectively. By construction, the sum in the right hand size has to be equal to the left hand size. The latter is the ratio of US GDP per worker to country i‘s GDP per worker. The first expression to the right is the portion of GDP difference explained only by tariffs. We use our production function to measure output, with the respective factors of production, but we give to country i the tariffs observed in the US. The second expression gives the residual difference of output - after accounting for trade policy - explained by human capital disparities. The third expression gives the residual difference - after accounting for trade and educational disparities - explained by physical capital. The expression in the very bottom is the residual TFP difference, it is that part of TFP disparity which is not explained by trade policy.

3 Data and calibration

To assess h, we use a standard Mincer function of schooling, of the form $h = e^{\phi s}$. Following Psacharopoulos (1994), we set the return of schooling to $\phi = 0.099$. We used data on the average educational attainment of the population aged 15 years and over, taken from Barro and Lee (2000)[4].

We use the Penn-World Tables (PWT) data for output per worker. The physical capital series is constructed with real investment data from the PWT using the Perpetual Inventory Method. The initial capital stock, K_0, was approximated by $K_0 = I_0/[(1+g)(1+n) - (1-\delta)]$, where I_0 is the initial investment expenditure, g is the rate of technological progress and n is the growth rate of the population. In this calculation it is assumed that all economies were in a balanced growth path at time zero, so that $I_{-j} = (1+n)^{-j}(1+g)^{-j} I_0$.

We use the same depreciation rate for all economies, which was calculated from US data. We employed the capital stock at market prices, investment at market prices, I, as well as the law of motion of capital to estimate the implicit depreciation rate according to:

$$\delta = 1 - \frac{K_{t+1} - I_t}{K_t}.$$

From this calculation, we obtained $\delta = 3.5\%$ per year (average of the 1950-2000 period). To minimize the impact of economic fluctuations we used the average investment of the first five years as a measure of I_0. When data was available we started this procedure taking 1950 as the initial year in order to reduce the effect of K_0 in the capital stock series.

[4]Data were interpolated (in levels) to fit an annual frequency when necessary.

Trade policy is assessed with many alternative data sources. We first used, for the mid 1960's and mid 1980's, data from individual country studies. In the first case we used data from Balassa (1971) which constructed, for a very limited number of countries, series of effective rate of protection. For the second period we used data from Ferreira and Rossi (2001) for Brazil, Gonzalez-Vega and Monge (1995) for Costa Rica, Harrison (1994) for Ivory Coast, and World Bank (1993) for Thailand. In all cases these measures of protectionism were converted into τ-equivalent terms. We also used World Bank(2005) data on average tariff rates (unweighted). Although nominal tariff is a worse measure of protectionism than effective rate of protection, in the present case it has the advantage of being available for a large number of countries.

We interpret the large economy in steady state to be the US; hence, we replicate the standard calibration of the American economy in closed RBC models using $f(k) = \Omega_4 k^{\overline{\alpha}}$. Following NIPA figures for capital's share in national income, we also match $\overline{\alpha} = 1/3$ This pins down the average $\overline{\alpha}$, but leaves freedom in choosing γ, α_a and α_b. These parameters are particularly important, as the quantitative effects of all trade-related phenomena, for low k, are bound to be larger with a big spread $\alpha_b - \alpha_a$, and with a lower γ, given $\overline{\alpha}$. If both industries require very different capital labor ratios, there is much to be gained from trade, as each country can specialize strongly on the industry whose demand is closest to their endowment. We choose α_a, α_b and γ so that exports cannot amount to more than half of output, and so that, for any one of the 20 richest countries in the world in 1985, the total gains from trade (the difference between $\tau = \infty$ and $\tau = 0$) are at most 1%

of total output. This leads to $\gamma = 1/2$, $\alpha_a = 0.258$ and $\alpha_b = 0.408$. Results are robust to variations of these values within reasonable bounds.

4 Results

We find that for many countries the effect of trade policy is negligible, because they have low tariffs, or because they are relatively wealthy compared to the US. Similarly, for many extremely poor countries, the effects of tariffs are large compared to their own low income, but only a very small fraction of their productivity difference with respect to the US, which is also very large. Nevertheless, for some middle income economies with high tariff rates, the effects are significant; in some cases, enough to attribute to protectionism one third of their TFP disadvantage, or more.

Tables 1 and 2 show comparisons with the US for some countries in the mid 1960's and mid 1980's. The column labelled y shows log-differences in output relative to the US, and the columns labelled s, k, τ and Θ are the portion of those log-differences that can be attributed to schooling, capital, protectionism and productivity, respectively. They should, of course, add up to the value shown in column y, as said before. The last column measures the proportion of total residual $(\tau + \Theta)$ explained by tariff distortions alone.

Table 1: Differences in output relative to the US, mid 1960's

	y	s	k	τ	Θ	$\tau/(\tau+\Theta)$
Chile	1.15	0.207	0.336	0.068	0.542	11.1%
Brazil	1.18	0.326	0.497	0.058	0.299	16.3%
Pakistan	2.79	0.431	1.461	0.027	0.870	3.1%
Philippines	1.13	0.249	0.914	0.022	0.604	3.5%

Table 2: Differences in output relative to the US, mid 1980's

	y	s	k	τ	Θ	$\tau/(\tau+\Theta)$
Costa Rica	1.25	0.329	0.66	0.043	0.216	16.5%
Brazil	1.07	0.435	0.438	0.077	0.121	38.8%
Ivory Coast	2.62	0.46	1.81	0.061	0.287	17.0%
Thailand	2.04	0.339	0.793	0.032	0.871	1.7%

We can see that productivity loss due to tariffs is significant in some cases, especially for the middle-income countries. In Brazil in the 1980's, τ explains almost 40% of the TFP difference with respect to the US, which is not surprising as Brazil in the period was one of the closest economy in the world. In other cases as Costa Rica, Ivory Coast and Chile in the 1960's, protection also have relatively large effects on productivity gap. Of course, it cannot explain the bulk of per worker income difference in a given moment, but the effect on TFP is sizable.

Table 3 below presents results also for mid 1980's now using World Bank data on average tariff rates. As said before, this series has the advantage of being available for a large number of countries.

Table 3: Differences in output relative to the US, mid 1980's (World Bank tariff data)

	y	s	k	τ	Θ	$\tau/(\tau+\Theta)$
Argentina	0.66	0.240	0.244	0.007	0.172	4.1%
Bangladesh	2.44	0.506	1.001	0.054	0.885	5.8%
Brazil	1.07	0.431	0.438	0.018	0.184	9.1%
Colombia	1.24	0.372	0.512	0.012	0.345	3.2%
India	2.59	0.426	1.069	0.052	1.041	4.7%
Mauritius	1.36	0.330	0.575	0.012	0.440	2.6%
Mexico	0.70	0.340	0.287	0.004	0.074	5.1%
Pakistan	2.27	0.505	0.943	0.036	0.785	4.4%
Tunisia	1.12	0.442	0.474	0.007	0.203	3.1%
Venezuela	0.85	0.319	0.339	0.009	0.187	4.5%

The countries above were purposely chosen due to the larger effect of τ. However, even in these cases the impact of trade barriers were not too sizable. Only in Brazil it explains something close to 10% of the TFP gap. In other cases, such as Bangladesh, Mexico and India, the observed average tariffs were the cause of 5% of the TFP difference. Most of the relevant cases were midle-income economies in Latin America and Asia, in which measured tariffs were higher. In all OECD countries, as expected, the impact was close to zero: trade due to comparative advantage is not the main reason for them to trade, so that our model cannot capture the cost of trade barriers. In very poor economies the measured impact was also small.

There are two reasons we can conjecture for the impact of τ to be relative small in the above table, although not irrelevant in many cases. One is that this measure under-estimate the degree of protection. For instance, it does not take into account the fact that in the mid 1980's non trade barriers such as cotas, licensing or outright ban on the import of specific products were widely used and most probably were more important for trade protection than tariffs. In the first two tables those factors were taken into account, at least partially. Moreover, even the tariffs in the World Bank data set seems too low. Ferreira and Rossi (2003) show that in Brazil, in this period, average tariff was closer to 100% than 47%, the number in the World Bank database. If we redo the above exercise using the former value instead of the later, we find that τ is able to explain almost 30% of the TFP gap. Moreover, instead of only explaining 2.2% of the output per worker difference with respect to the U.S., it now explains 5.8%. If this is a general pattern of tariff under-measurement, results in Table 3 would be very different.

A second possible reason for this result is the fact that we were using very conservative calibration, one that tends to reduce the gains from trade. So it might be the case that for different values of α_a and α_b - particularly those that increase the difference between them - we came up with larger TFP losses. This, however, is not the case unless we use very unreasonable parameter values. For instance, with α_a and α_b equal to 0.2 and 0.467 (values that still generate ($\overline{\alpha} = 1/3$)), τ would explain 4.4%, 6.4% and 10.1% of TFP difference of Argentina, Bangladesh and Brazil, respectively. Those values are very close to those displayed on Table 3.

Finally, results when using 2000 data found that in almost no case the effect of τ is far from zero. In this case barriers to trade were found to be irrelevant as most countries experienced major trade liberalization after the mid 1980's. Currently, protection is focused in few, albeit key, sectors but this does not show up in the data among other reasons because tariff is not the main instrument used. This is in accord with Rodrik (??) that argues that the gains from the current trade negotiations, in terms of output, are probably small as most economies are now relatively open.

We can also estimate the output cost of barriers to trade. We use the following formula:

$$y_{i\tau *} = \frac{F(k_i, h_i|\tau_{US})}{F(k_i, h_i|\tau_i)}$$

In this expression, we re-estimate country i output with US tariff in place of its own. It gives the measured gain of output if country i had its observed factors of production but American tariffs. The gains, in percentage terms, are presented below

Table 4: Output gains from "trade" reform

Mid 1960's	$y_{i\tau*}$	Mid 1980's	$y_{i\tau*}$
Chile	6.9%	Costa Rica	4.3%
Brazil	5.8%	Brazil	7.6%
Pakistan	2.7%	Ivory Coast	6.2%
Philippines	2.1%	Thailand	3.2%

According to Table 4, Brazil in the eighties would be 8 percent richer if its effective rate of protection were considerably smaller. Although not enough to close the gap to the US output - GDP per worker of Brazil was one third of that of the US in the period - this is no small number. Likewise, figures for Chile, Ivory Coast and Costa Rica were relevant. In these cases the static gain of eliminating barriers to trade would increase by 5% or more output per worker. Of course, as we could expect given results of Table 3, the measure gains using World Bank data are smaller. For the OECD countries - as a matter of fact, for a majority of countries - the estimated gains are close to zero. However, in those cases were average tariffs were relatively large, such as Bangladesh and India, their reduction to US tariff levels would imply gains of 5% of per worker GDP.

5 Conclusion

In this paper we presented evidence that barriers to trade were important factor impairing the productivity of less developed countries in the recent past. In some cases it explained a sizable part of TFP difference with respect to the leading economy. Moreover, the output cost may also be relevant.

The fact that in many cases the cost of trade barriers were estimated to be small may be either an indication of data problems, which are well know in the trade field - tariff is not always a precise measure of barriers to trade - or may reflect the fact that protectionism is not too harmful nowadays. Or that an aggregate model such as ours are not able to capture the full effect of sophisticate protection measures widely used today, such as export subsidy or anti-duping measures.

The methodology we use does not capture the fact that barriers to trade do affect investment decisions and so capital stocks, something we have shown in our previous paper (Ferreira and Trejos (2006)). In this sense, the current exercise is limited as it takes stocks as given but does not consider that, if it were not for trade restrictions, they would be considerably larger. Hence, results here can be seen as a lower bound of the costs of barrires to trade.

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