Gains from trade and measured total factor productivity

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July 13, 2009

Abstract

We develop and calibrate a model where differences in factor endowments lead countries to trade different goods, so that the existence of international trade changes the sectorial composition of output from one country to another. Gains from trade reflect in total factor productivity. We perform a development decomposition, to assess the impact of trade –and barriers to trade– on measured TFP. In our sample, the median size of that effect is about 6.5% of output, with a median of 17% and a maximum of 89%. Also, the model predicts that changes in the terms of trade cause a change of productivity, and that effect has an average elasticity of 0.71.

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1 Introduction

A large literature (e.g., Mankiw, Romer and Weil (1992), Prescott (1998), Klenow and Rodriguez-Clare (1997), Caselli (2005) among many) has studied the cross-country differences in total factor productivity, that is, those differences in output per-capita that cannot be explained by corresponding differences in available inputs. In these exercises, it is assumed that the technology that transforms inputs into output is the same across countries, except for a single TFP coefficient that changes the effectiveness of the overall production process, but does not change the way different inputs interact with each other. The functional forms used in these analyses are chosen assuming that countries do not trade with each other, and are calibrated using parameters that give a good fit to the data of developed nations.

In this paper, we quantify the impact of international trade on Total Factor Productivity (TFP). Trade leads to a more efficient allocation of resources across sectors, and thus may affect aggregate productivity even if sectorial productivities are not allowed to differ across countries. Since barriers to trade do vary significantly, the degree to which gains from trade are exploited may be a relevant component in explaining cross-country TFP differences.

We use a very similar model as Ferreira and Trejos (2006). The equilibrium of that model under autarky is homeomorphic to the standard model used in most development accounting exercises, so comparison is convenient. The simplest way of formulating this model is to interpret the traded goods as inputs in the production function of a final non-tradeable good, but it is not the fact that these are intermediate goods that matters, but rather that there is a sectorial allocation problem that trade barriers may distort. By construction, this model predicts that trade will be of little importance for rich countries, but for a poor country the model predicts that trade induces a sizeable gain in TFP, which increases with trade liberalization and with the terms of trade.

We calibrate this model and apply it to a large sample of developing countries, to assess the quantitative importance of the effects mentioned above. Because countries reap at least some of these benefits from trade, the TFP differences between rich and poor countries that are estimated with our model are larger than those emerging from more conventional output decompositions, which are performed assuming a closed economy. For the country in our database with the lowest capital endowment per worker, Uganda, our calibrated model estimates that free trade could increase output by 89.8% compared to autarky; in other words, the raw productivity difference relative to the US is much larger than conventional measurements (which would impute those gains from trade as productivity) would deliver. The assessed gains from trade for other African nations (Congo, Mozambique and Rwanda, among others) range between 50% and 62% of productivity; for several Asian countries, around 15%. Of course, many countries waste a good part of these gains through protectionism. We estimate that in 1985 Bangladesh and India, who should have enjoyed gains from trade to the tune of 1/3 of GDP due to their capital scarcity, wasted most or all those gains with average tariffs at prohibitive levels over 90%.

Because countries can pick very different trade policies, the model adds another dimension that can explain the behavior of TFP residuals. We do not have comparable cross-country data for transportation costs, non-tariff barriers, and other phenomena that reduce the incentives to international exchange. But looking at data on tariffs we find that for some poor nations, those barriers alone are large enough to account for large differences in productivity. Due to the nature of the trade problem, the same tariffs would have a different cost in different countries, because both the potential gains from trade and the distortionary effect of policy vary with the capital-labor ratio. For instance, in 1985 Brazil and Benin had similar nominal tariff rates, under which poorer Benin realized almost all its (large) potential gains from trade, while the wealthier Brazil lost most of its (proportionally smaller) benefits.

Other authors have pursued to quantify the relationship between trade and productivity, although emphasizing different transmission mechanisms. For instance, Eaton and Kortum (2002) develop a model where TFP is specific to each country and industry, so trade allows countries to allocate more resources to the industries that have drawn high productivities. Using a similar model, Lucas and Alvarez (2008) estimated that a country with 1% of world GDP would gain from openness to trade up to 41% in productivity. Using a similar model, Rodriguez-Clare (2007) obtains similar estimates, which become much higher if openness involves not only the possibility to exchange goods, but also fosters the diffusion of ideas.

An open economy with barriers to trade is one of the simplest examples of resource misallocation in a sectorial problem, and thus the mechanism described here is related to a recent literature that emphasizes inefficiencies in the composition of output as a means to explain differences in TFP. For instance, Restuccia and Rogerson (2008) show that policies that distort prices faced by individual producers can lead to 50 percent decreases in measured TFP. Likewise, Hsieh and Klenow (2007) use a standard model of monopolistic competition with heterogeneous firms to measure the impact on productivity of the resource misallocation caused by distortions across firms. They find that the removal of these distortions could boost TFP in India by as much as 60%.

Another issue that our model can address is the effect of changes in the terms of trade. Here, a change in the relative price of exported to imported goods alters the allocation of resources and degree of specialization among different sectors, in a way that affects not only welfare but also output and TFP. There is a literature (e.g., Easterly, Islam and Stiglitz (2001)) that describes an empirical link of this sort. Kehoe and Ruhl (2008) show that one can explain this empirical link with a standard macro model only under very limited specifications both of the theory and of the measurement, and thus pose that this strong empirical relationship is a puzzle. Our model can help explain this puzzle, since it predicts –in a manner that is quite natural within a Hecksher-Ohlin framework– that an improvement in terms of trade simply allows a better sectorial composition, that yields more final output out of the same inputs. Under our calibration, for a very capital-poor country a 10% gain in the terms of trade yields a 5.7% gain in TFP, and these effects can be larger depending on factor endowments and trade policies[1].

In Section 2 we describe and solve the model, and in Section 3 we describe the data and calibration. In Section 4, we present the results and Section 5 concludes.

2 The model

We model the world as a collection of small economies that trade with a much larger and wealthier country. The asymmetry in sizes is such that –for all practical purposes– the autarkic domestic prices in the big country are the international prices, and the small countries are price takers. The picture in our mind is that the big economy is the US (or perhaps the US plus the EU). We focus our attention on the equilibrium allocation in the other countries.

There are three goods in these economy: two non-storable, tradable intermediate products, A and B, and a final good, Y, which presumably can be consumed or invested (but we do not look at consumption or investment decisions here), and that cannot be traded. Each good is produced, by a large number of small, competitive firms, using technologies that have constant returns to scale.

There are also two factors of production in this economy: labor in efficient units L and physical capital K. Labor and capital are used in producing A and B, and these in turn are used to produce Y. The endowment of labor, measured in efficiency units, is given by:

$$L = Nh = Ne^{\phi s},$$

where N is the number of workers, h represents efficiency-units of labor per worker and s stands for schooling. The production functions of A and B are:

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[1] Other possible explanations are financial market frictions (Mendoza, 2006), labor hoarding and changes in capital utilization (Meza and Quintin, 2007) and costs in shifting resources across sectors (Kehoe and Ruhl, 2006).

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

Without loss of generality, A is labor-intensive: $\alpha_a < \alpha_b$. We use B as numeraire, and the relative prices of A and Y in terms of B are denoted p and π.

Because A and B are tradable, the amounts of them that are used in the production of the final good (denoted a and b) may differ from the amounts produced (denoted A and B). Total output of Y is given by:

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

All markets are perfectly competitive; in the case of A and B, these are not domestic but rather global markets, from which local Y producers can import provided they pay an ad-valorem tariff τ. The rate τ captures all the (policy or non-policy induced) costs of bringing goods into the local market.

We denote $k = K/L$ in general, and in particular define k^* as the capital-labor ratio of the large, developed country where international A and B prices are set, which we shall calibrate to be the US. We restrict our analysis to small countries where $k < k^*$.

To solve for an equilibrium, derive the allocation of capital K and labor L among the A and B industries, the quantities a and b used domestically, and the amount of final output Y.[2] We seek for a set of prices for all factors and goods, so that all firms maximize profits,

$$
\begin{aligned}
K_A, L_A &= \arg\max q K_A^{\alpha_a} L_A^{1-\alpha_a} - rK_A - wL_A \\
K_B, L_B &= \arg\max K_B^{\alpha_b} L_B^{1-\alpha_b} - rK_B - wL_B \\
a, b &= \arg\max \pi \Theta a^{\gamma} b^{1-\gamma} - qa - b
\end{aligned}
$$

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[2] This part of the model follows Corden (1971), Ventura (1992), Deardorff (2001) and, more closely, Ferreira and Trejos (2006).

given market clearing (that is, $K_A + K_B \leq K$, $L_A + L_B \leq L$), no arbitrage (that is, $q = (1+\tau)p$ if $A > a$, $q = p$ if $A = a$, and $q = p/(1+\tau)$ if $A < a$), free entry (that is, all firms have zero profits) and no international lending (that is, $pa + b = pA + B$). The relevant part of the solution, for our present purposes, can just be summarized as an equilibrium mapping

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

that relates final output with factor endowments. The mapping F is not a production function, in the sense that it does not describe an exogenously-imposed technological relationship. It describes an equilibrium relationship that takes into account the technologies and markets for all the products, and the equilibrium effects of trade in the optimal choice for final good producers. Notice then that Θ plays the role of Total Factor Productivity, but also that changes in τ or p, by affecting F without changing inputs, can also affect *measured* TFP.[3]

Of course, since we do not go into the problem here of how is Y used, and since no other inputs enter the production function for Y, this model where A and B are the intermediate products that are used to produce Y is homeomorphic to one in which A and B are just different consumption goods, and Y is utility rather than production. The effects of trade on welfare and productivity in this model do not emerge from the fact that the tradeable goods are intermediate inputs, but from the existence of a sectorial allocation problem that trade barriers can distort. It is still convenient to think about Y as final good production, and thus about A and B as intermediates, in one sense: in the absence of trade (say, when $\tau = \infty$), Y collapses into the standard, Cobb-Douglas production function on capital and labor that is used

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[3] One could get TFP differences across countries as if coming from TFP differences within sectors, rather than at the aggregate level. But our purpose here is to put forward how aggregate measures of TFP are affected by considering the effects of trade induced by factor endowment differences, and we would confuse that issue (and its comparison to previous closed-economy TFP decompositions) if we allowed sectorial production functions to vary across countries. We also lack a database of good quality sectorial outputs and resource allocations that would be comparable across countries.

in most development accounting exercises, so a comparable decomposition can be performed.

In the Appendix, we show that one can derive functions s, x, and Ω_i such that the equilibrium mapping F can be written as

$$F(K, L|\tau, p) = \begin{cases} \Omega_1(\tau, p)K^{\alpha_a}L^{1-\alpha_a} \text{ if } k < s(\tau, p) \\ \Omega_2(\tau, p)K + \Omega_3(\tau, p)L \text{ if } k \in [s(\tau, p), x(\tau, p)] \\ \Omega_4 K^{\overline{\alpha}}L^{1-\overline{\alpha}} \text{ if } k \in [x(\tau, p), k^*], \end{cases} \tag{2}$$

where $\overline{\alpha} = \gamma\alpha_a + (1-\gamma)\alpha_b$.[4]

Interpreting (2), if the economy has a very low capital-labor ratio, it will only produce the labor-intensive good A, export some of it, and import all the b that it uses to make final goods from the capital-richer country. In that case, the mapping F is just proportional to the value of A production, and thus takes the shape of a Cobb-Douglas with the lower capital share α_a. For higher k the economy diversifies –although the country is still an exporter of A and importer of B– and as a consequence of the Factor Price Equalization Theorem, F is linear in K and L for an interval.[5] Even higher k implies that the factor endowment is too close to that of the larger trading partner, so that the benefits from trade are not enough to compensate for the trading cost τ, and thus the economy is in autarky. In that case, F is a Cobb-Douglas, with a capital share equal to the weighted average $\overline{\alpha}$. One can show that for the large economy that is a price setter rather than a price taker, the equilibrium mapping is $Y = \Omega_4 K^{\overline{\alpha}}L^{1-\overline{\alpha}}$ for all values of k.

It is straightforward to show that Ω_1, Ω_2 and Ω_3 are decreasing in τ; in other words, increases in the cost of trade decrease output. The reason is that

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[4] We derive the function $F(K, H|\tau, p)$ only for values of $k < k^*$ because this is the relevant interval for the groups of countries we study. The derivation for values of $k > k^*$ is straightforward.

[5] When the factor endowment is inside the diversification cone, the capital intensity for each industry in the price-taking market becomes a constant, pinned down by international prices. Then, alternative values of K/H just change the mix across industries, but not within industries; factor prices are then set and production of Y is linear in K and H, a result analogous to the Factor Price Equalization Theorem.

τ induces a distortion on the relative price of A in terms of B, that makes the imported good more expensive domestically. Because we restrict our analysis to countries that are more labor abundant than the economy where prices are set (that is, $k < k^*$), the imported good is the capital intensive good B, and thus this distortion inefficiently shifts to the B industry resources that could be used more efficiently producing A, while also inducing the Y industry to use a higher a/b mixture as inputs. Furthermore, s and x are also decreasing in τ and, in the limit, $x \rightarrow 0$ as $\tau \rightarrow \infty$. In other words, under a high enough tariff there is no trade.

Similarly, Ω_1, Ω_2 and Ω_3 are increasing in p, the relative price of the labor intensive good A in which our labor-abundant small countries have comparative advantage. Hence, when terms of trade improve, output of final goods increases, a relationship that is further explored and interpreted below.

3 Data and calibration

We use the Penn-World Tables (PWT) data for national income accounts and for the size of the labor force. For schooling, we use the average education attainment of the population aged 15 years and over, from the database gathered by Barro and Lee (2000). For tariffs we use the sample gathered by the World Bank (2005). We perform our calculations for 1985, and restrict the analysis to the countries where the estimated k ratio is less than the US level.[6]

To construct the capital series, we use the Perpetual Inventory Method, estimating the capital stock in the first year, following Hall and Jones (1999), among many, by $K_0 = I_0/[(1+g)(1+n)-(1-\delta)]$, where depreciation is

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[6] Ideally we would have liked to use cross-country data that reflected the total cost of international trade, whether induced by policy, distance, logistics or other factors. Clearly, the World Bank tables are a lower bound, both because they include only tariffs, and because these are calculated as unweighted averages, which include very low tariffs reported for some non-tradeables.

As extensively documented in the survey by Anderson and van Wincoop (2004), non-tariff barriers and transportation costs can be quite expensive according to several estimates. However, we have not identified any database with an uniform measurement or estimation of these other costs for a large sample of countries.

$\delta = 3.5\%$ (as in Ferreira, Pessôa and Veloso (2008)), $g = 1.54\%$ is the trend-growth rate of output in the US, and n is the population growth for each country. To construct the data on human capital, we use a Mincer function of schooling, of the form $h = e^{\phi s}$, and set the return of schooling to $\phi = 0.099$, following Psacharopoulos (1994). For k^* we pick the level of capital that corresponds to steady state in a standard growth model, with 6.1% return on capital and a production function $Y = \Omega_4 K^{\overline{\alpha}} L^{1-\overline{\alpha}}$; for p we pick the autarkic relative price of A when $k = k^*$.

We were challenged by which object in our model should be identified as representing the measure of GDP that appears in the PWT. This is not a problem at domestic prices, since in the model necessarily $qA + B = qa + b = \pi Y$, as a consequence of profit maximization and zero deficit. But using international prices to correct for PPP differences, and especially for a poor country with high trade barriers (where in general $a \neq A$, $p \neq q$ and $\pi \neq \pi^*$), these inequalities do not hold, and in particular it is the case that the value of GDP measured by pricing the output of each good $(pA + B)$ is not necessarily the same as the GDP measured at an aggregate demand level $(\pi^* Y)$. In the model, just as in the data, these two definitions of GDP yield different numbers when using PPP.

Why is there a difference? As Feenstra, Heston, Timmer and Deng (2007) illustrate, because a measure of income that comes from making PPP corrections to the components of aggregate demand (consumption, investment, etc.) includes *all* the gains from trade as part of national income, while only part of those gains are included in a sum of the PPP-corrected levels of sectorial output. And, as described in Summers and Heston (1991), the PWT get GDP as a measure of real national income, from aggregate demand. In our model, Y includes all the gains from trade (those emerging from a better sectorial allocation of K and L, and those coming from an improvement in the mix of a and b that trade allows), while $pA + B$ does not. Hence, income relative to the US in the PWT is closer to Y/Y^* in our model than to $(pA + B)/Y^*$, and for reasons that are independent of whether or not one considers Y to be a final good industry instead of a measure of consumption. This measure has also the positive characteristic that it is useful for comparison, as in equilibrium for the autarkic large economy $Y = \Omega_4 K^{\overline{\alpha}} L^{1-\overline{\alpha}}$, which is a similar production function as the one *assumed* in other decomposition exercises in the literature. Hence, we will relate the GDP data with the variable Y/Y^* in our model.[7]

Using data from 18 different sectors in the U.S., Acemoglu and Guerrieri (2008) divide the economy into two subcomponents, whose capital shares average 0.268 and 0.496. We take those values for α_a and α_b. We pick $\overline{\alpha} = 0.4$ as used in Cooley and Prescott (1995), the capital share estimated for a developed (and, in our model, closed) economy[8]. This implies that $\gamma = 0.4211$ results from the choices of $\overline{\alpha}$, α_a and α_b. This number is important as the gains from trade are sensitive to γ (and maximized at $\gamma = 1/2$).

We find this calibration to be conservative, in the sense that it predicts that the *entire potential* gains from trade –that is, from autarky to free trade– for a country with Mexico´s GDP are 1.1% (about half the number estimated by Kehoe and Kehoe (1995) as the static gains from exploiting comparative advantage that Mexico would reap from joining NAFTA). As we shall see, even though under this calibration the gains from trade are modest for a middle-income country with comparatively high k like Mexico, it can also be very high for the world's poorest countries.

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[7] We checked in what way the calculation shown below would have differed if we had chosen to use $pA + B$ instead of Y as a measure of GDP. We found that it makes very little difference: using the former definition would have only shrunk the gains from trade by 0.4% in the median case, and by 1.8% in the average case. The main contrast between both concepts is not in the size of the gains from trade, but rather in the fact $pA + B$ is not, even under autarky, a Cobb-Douglas function of K and L.

[8] As in Cooley and Prescott (1995), the service flow of total capital in our economy includes those of public capital and durables, which is reflected in the calibrated value of the capital share $\overline{\alpha}$.

4 Results

4.1 Gains from trade

Trade increases output given the level of inputs, and ignoring this effect biases the measurement of total factor productivity. Define the size of the gains from trade by

$$\Gamma_\tau \equiv \frac{F(K, L|p, \tau)}{F(K, L|\tau = \infty)}. \tag{3}$$

Then, for a country with productivity Θ_i, if one uses the closed-economy production function $F(K, L|\tau = \infty) = \Omega_4 K L^{1-\overline{\alpha}}\Theta$ to perform the development decomposition, the resulting estimation of TFP will be $\widehat{\Theta}_i = \Gamma_\tau \Theta_i$, which will be biased upwards relative to Θ_i. The effect of ignoring the gains from trade would be larger for countries that are very poor or very open, as Γ_τ is decreasing in both τ and k. In fact, for a country with low enough capital that under trade it would specialize in the production of the labor intensive good A (that is, if $k < s(\tau, p)$), there is a constant χ such that

$$\Gamma_\tau = \chi \frac{p^{1-\gamma}(1+\tau)^\gamma}{1+\gamma\tau} k^{\alpha_a - \overline{\alpha}} > 1. \tag{4}$$

which is increasing in p and τ, and can become arbitrarily large as $k \to 0$.[9]

The following figure illustrates the size of Γ_τ as a function of k/k^* under our calibration, for values of $\tau = 0$ and $\tau = 0.28$, where this last value is the average tariff in our sample of 71 developing countries. Notice that around $k = 0.01k^*$ we observe $\Gamma_0 \sim 2$, so ignoring the gains for trade leads to an estimate of TFP that is twice as high. Notice also that under $\tau = 0$ the gains from trade fall smoothly with k, and still boost GDP over 10% for a relatively rich country with half the US capital-labor ratio. Meanwhile, under $\tau = 0.28$ gains from trade suddenly fall abruptly for $k > s(p^*, 0.28) \sim 0.2$ (as the economy ceases

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[9] The bigger the difference between the factor endowments between trading partners, the larger the gains from trade. Since by construction we have assumed that the large economy who sets international prices is capital-rich compared to its trading partners, the lower k is in these, the more they gain from trade.

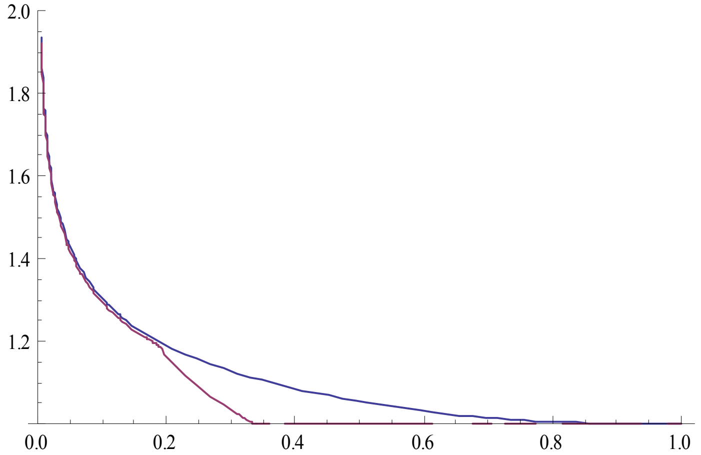

Figure 1: Γ_τ as a function of k/k^* for $\tau = 0$ and $\tau = 0.28$.

to be fully specialized) and $\Gamma_{0.28} = 0$ when $k > x(p^*, 0.28) \sim 0.33$ (as the economy ceases to trade.

Just how big are the gains from trade in the world? The following table shows the potential gains under free trade, Γ_0, for a representative sub-sample of economies (the full sample appears in the Appendix).

Table 1: Gains from openness

COUNTRY	Γ_0	COUNTRY	Γ_0
Bangladesh	1.30	Philippines	1.17
Brazil	1.01	Rwanda	1.61
China	1.39	South Africa	1.01
Haiti	1.49	Togo	1.43
India	1.34	Uganda	1.90
Malaysia	1.09	Zimbabwe	1.08

For the poorest nations, trade can almost double output (in the case of Uganda, the estimated increase in output under free trade is 89.8%), although Γ_0 is less than 2% for a dozen countries in our sample which, like South Africa and Brazil in this table, are relatively capital-rich.

Of course, it does not take very high barriers to trade to make much of these gains to go away. For the same countries (again, find the rest in the Appendix), we list in the next table the levels of τ that make the gains from trade Γ_τ to be a third of Γ_0, half of Γ_0, or disappear altogether.

Table 2: Loss from barriers to trade

COUNTRY	τ needed for Γ_0 to fall by			Actual τ	k/k^*
	1/3	1/2	100%		
Bangladesh	53.0	57.7	67.9	94.5	0.10
Brazil	4.7	5.8	8.2	47.1	0.71
China	71.0	75.6	88.5	49.5	0.06
Haiti	92.7	98.1	113.6	27.7	0.04
India	61.7	66.0	77.8	91.0	0.08
Malaysia	15.0	17.6	23.8	14.0	0.39
Philippines	28.1	31.2	40.7	29.2	0.22
Rwanda	119.3	125.8	144.4	33.0	0.02
South Africa	4.8	5.8	8.3	21.2	0.70
Togo	79.8	84.9	98.8	19.5	0.05
Uganda	185.6	195.3	342.1	25.0	0.01
Zimbabwe	12.8	15.3	21.2	9.4	0.43

Clearly, many countries in the list have high tariffs and waste most of the gains from trade. For instance, in the case of Bangladesh, the potential contribution to output from free trade would be a boost of 30%, and it would take $\tau = 53\%$ for a third of those gains to go away, and of $\tau = 68\%$ to wipe them out. The actual tariff rate of 94.5%, however, is enough to waste completely that boost in TFP. Similarly, Philippines is losing almost half its potential gains from trade because of restrictive commercial policy.

On the other hand, Uganda and Rwanda are so scarce in k that one needs tariffs above 340% and 144%, respectively, to shut them from trade. Are such rates completely unrealistic? Perhaps not. As Anderson and van Wincoop (2004) mention, measures of tariffs significantly underestimate the actual cost of doing trade, because they ignore transportation costs and many policy-induced non-tariff barriers. Recent direct measurement by Malherbe (2007) quantified the cost of shipping cargo in and out of Rwanda, a landlocked country whose trucks have to go through Uganda and Kenya before reaching an international port in Mombassa. They found that the land-shipping alone cost about 80% of the value of exports. For imports this percentage is much higher (since containers come full inwards and half-empty outwards), and it has been quoted that bringing cargo into Kigali (Rwanda) from Mombassa can cost upwards of $6.500 per container. After adding the shipping cost to Mombassa, plus tariffs, non-tariff barriers and the financial cost of nearly a month for the turnaround trip, the 144% prohibitive rate that appears in the previous table does not seem farfetched.

In contrast, in countries such as Brazil and South Africa, in which k is relatively high, the tariff necessary to shut them from trade is very small. In fact, in both cases the observed tariff in 1985 is well above this level, so that they lost all the potential gains from trade.

Labor-abundant countries would specialize in producing only the labor-intensive good with low $k < s(p, \tau)$. The country would acquire all the B it needs from the international market at a much lower opportunity cost, and hence the large gain from trade. In a less capital-poor country, where $s(p, \tau) < k < x(p, \tau)$, firms still find it profitable to produce more A than needed by the local market, yet some B gets produced domestically as well. In this case, the potential gains are smaller as the countries endowment is not that different from the one of its trading partner (that is, k and k^* are close). Finally, a rich enough country, where $k > x(p, \tau)$, will simply not trade. In that case, τ is bigger than the difference between the international prices and the local prices that prevail without trade.

The next figure shows the functions $s(p, \tau)/k^*$ and $x(p, \tau)/k^*$ as they vary with the tariff rate τ, for our calibration. One can verify that under free-trade, countries with less than 54% of the US levels for k would be fully specialized in A, and this means in 1985 every country below Ecuador's reported k ratio, or 55 out of the 71 members of the sample; the others would still be A-exporters,

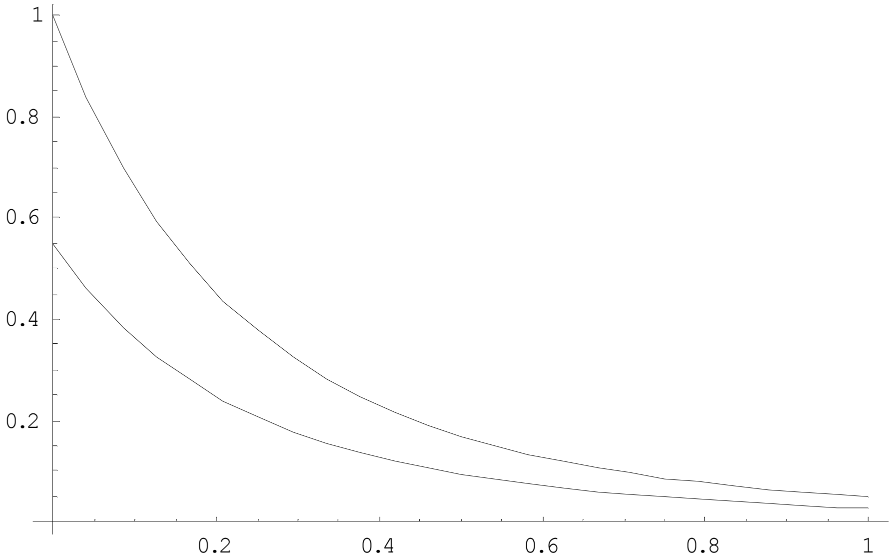

Figure 2: $s(p,\tau)$ and $x(p,\tau)$ as a function of τ

but their production would be diversified. As τ increases, trade –and the gains it yields– fall. For example, if $\tau = 0.28$, the average value of τ in our sample, the distortion towards allocating more resources in the B rather than A industry is strong enough that only 28 countries in the sample remain fully specialized, and 14 don´t trade at all.

4.2 Productivity decomposition

We proceed now to make the decomposition. The usual approach yields

$$Y = \widehat{\Theta} K^{\overline{\alpha}} L^{1-\overline{\alpha}}$$

where $\widehat{\Theta} = \Theta \Gamma_\tau$. If an economy is in autarky, then $\Gamma_\tau = \Gamma_\infty = 1$, and thus $\widehat{\Theta} = \Theta$. However, if tariffs are low enough, then $\Gamma_\tau > 1$, and thus one may overestimate the true TFP, Θ, if one ignores the impact of international trade.

Dividing by the number of workers, L, we get output per worker, or

$$\frac{Y}{N} = \widehat{\Theta}\left(\frac{K}{L}\right)^{\overline{\alpha}}\frac{L}{N} = \Gamma_\tau\Theta\left(\frac{K}{L}\right)^{\overline{\alpha}} h.$$

We use this expression in a otherwise standard level decomposition exercise, in which income difference with respect to the US is measured as

$$\frac{Y_i/N_i}{Y_{US}/N_{US}} = \left(\frac{K_i}{L_i}/\frac{K_{US}}{L_{US}}\right)^{\overline{\alpha}} \times (h_i/h_{US}) \times \Gamma_{i,\tau} \times \frac{\Theta_i}{\Theta_{US}}$$

The two first components in the right hand side are standard in level decomposition exercises; first comes the effect of different levels of capital per efficiency unit of labor, and then the amount of efficiency units of labor per worker. i.e., human capital. The product of the last two components is $\widehat{\Theta}$, what usually appears for productivity, which we separate in in two parts: the productivity *gain* from trade and the TFP residual. The decomposition for our highlighted countries appears in the next table, and again the numbers for the full sample are in the Appendix.

Table 3: Development accounting

COUNTRY	y	k	h	$\widehat{\Theta}$	$\boldsymbol{\Gamma}_\tau$	$\boldsymbol{\Theta}$
Bangladesh	0.087	0.402	0.425	0.506	1.000	0.506
Brazil	0.342	0.870	0.482	0.815	1.000	0.500
China	0.054	0.328	0.549	0.297	1.362	0.218
Haiti	0.048	0.264	0.457	0.397	1.482	0.267
India	0.075	0.364	0.487	0.424	1.000	0.424
Indonesia	0.127	0.412	0.505	0.609	1.278	0.476
Malaysia	0.291	0.687	0.578	0.734	1.064	0.689
Philippians	0.161	0.549	0.643	0.454	1.115	0.407
Rwanda	0.045	0.208	0.416	0.520	1.599	0.325
South Africa	0.497	0.869	0.567	1.001	1.000	1.001
Togo	0.066	0.299	0.449	0.487	1.427	0.341
Uganda	0.031	0.127	0.418	0.583	1.886	0.309
Zimbabwe	0.156	0.714	0.449	0.485	1.064	0.456

As expected, quite a few countries have $\Gamma_\tau \approx 1$, either because they are relatively high k and can expect little gains from trade (e.g., Brazil and Barbados), or because their tariffs are so high that they waste most of those gains (e.g., Bangladesh and Pakistan). In this case $\Theta \approx \widehat{\Theta}$. On the other hand, for many countries Γ_τ happens to be very large, so even though some of the potential gains from trade are wasted due to protectionism, most are realized. For instance, in the usual decomposition, TFP in Rwanda is 52% of TFP in the U.S. However, once we take into account the gains from trade that such a poor country can enjoy (estimated as a boost of 60% in output)– TFP is really much lower, 32%. Other noteworthy cases are those of Congo, Haiti, Mozambique, Rwanda and Sierra Leone. In these countries Θ is around or below 65% of $\widehat{\Theta.}$ On average, the trade-corrected TFP estimate Θ in our sample is around 88% of $\widehat{\Theta}$[10].

Is there a way in which one can say that our estimated Θ is a *better* number than the usual $\widehat{\Theta}$? In particular, is there any puzzling aspect of $\widehat{\Theta}$ as it is conventionally measured, that gets explained once we divide the trade and non-trade components of productivity? When we consider (by running a simple OLS regression, for instance) the relationship between income per capita and standard closed-model TFP, $\widehat{\Theta}$, we find high positive correlation, as expected, but a large number of outliers countries for which TFP is either much higher or smaller than expected for its income level. Some examples would be Sierra Leone, Jordan, Uganda and Mozambique and Guatemala. However, for the case of the trade-corrected measure of TFP, Θ, this phenomena is less pronounced and the relationship between y and Θ is much smoother. Hence, a large part of the relationship between y and $\widehat{\Theta}$ was due to international exchange, and once we correct for the gains from trade, estimated TFP falls. The R-squared of the regression of Θ on y (both relative to the U.S.) is higher

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[10] Note that in the case of $\widehat{\Theta}$ our results are not too distant from the literature. We redid our decomposition in a manner similar to Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997) BK5 decompositions and found, for instance, that in 1985 TFP of Uganda, Senegal and Niger was, respectively, 61%, 49% and 35% of the U.S. These numbers are very close to ours (58%, 48% and 29%).

and, more importantly, the sum of squared residual is 43% smaller than that of the regression of $\widehat{\Theta}$ on y, and indication of a better fit.

4.3 TFP effects of changes in terms of trade

Kehoe and Ruhl (2008) show that there is a strong link between the terms of trade and total factor productivity in the data of some countries (like the US and Mexico), and cite a number of other papers that have also pointed out this empirical fact.[11] They also illustrate through a variety of macro models that the standard approach cannot account for this relationship, which is a puzzle in need of an explanation. We believe that the model described in the previous sections provides one plausible mechanism to understand this puzzle: improvements in the terms of trade change the allocation of resources across sectors, inducing higher specialization in a way that increases productivity. To be precise, an increase in p induces a reallocation from K_B to K_A and from L_B to L_A, and simultaneously raises b at the expense of a, in a manner that is conducive to higher income and output. It is straightforward to see that as long as $k < k^*$ then $\frac{\partial Y}{\partial p} \geq 0$, as Ω_1, Ω_2 and Ω_3 in (2) are increasing in p.

Furthermore, as Kehoe and Ruhl also argue, this finding depends on how is output measured. Notice in particular that while in the model the sign of the effect of terms of trade on real income is unambiguous, this is not necessarily the case if, for example, output is measured using a Laspeyres method and no PPP correction (as many countries do), especially when tariffs are high. Measuring $qA + B$, using $q = p/(1+\tau)$, would be the equivalent to applying Laspeyres. After an increase in p, old prices (used in Laspeyres) put a premium on B over A, compared to new prices; similarly, domestic prices (which include the tariff) put a premium on the imported good over the exported good. The real gains from trade may not be enough to compensate both biases. On the other hand, if one uses PPP corrected rather than domestic prices, these biases

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[11] In the decade before the current financial crisis, several Latin American countries enjoyed very favorable terms of trade, as the raw materials on which they have comparative advantage hit record prices. In those countries, output and productivity increased very dramatically in the same period.

do not exist, and the positive link between terms of trade and productivity is then unambiguous.[12]

How big is the effect of changes in p on measured productivity? It depends on the level of income and the size of barriers to trade. In particular, recall from (4) that when the economy is poor enough to be specialized in the production of the labor intensive good –that is, when $k < s(p^*, \tau)$– then Γ_τ is proportional to $p^{1-\gamma}$ and thus the elasticity of $\widehat{\Theta}$ to p is just given by $1-\gamma = 0.57$. In fact, the elasticity maintains that value even for a diversified trading economy if $\tau = 0$. In our sample of 71 countries, as in a large number of them $k < s(p^*, \tau)$, the median response of the gains from trade to a hypothetical change in the terms of trade displays that same elasticity. However, the effects of p on $\widehat{\Theta}$ may be bigger or smaller if $\tau > 0$; in our sample, the elasticity averages about 0.73, and is above 1.0 in 10 cases.

The effect of p on $\widehat{\Theta}$, for the case in which $k = 0.375k^*$, is illustrated in the next figure. It shows the variation in output when $\tau = 0$ (the straight line above) and $\tau = 0.28$ as functions of p, both as a proportion of the respective output leves at the original price. For the case of $\tau = 0$, for instance, the straight line shows that when prices increase by 10%, output (i.e, $F(K, L|1.1 * p, \tau)$ will be 5.7% above its original figure (i.e, $F(K, L|p, \tau)$.

When $k = 0.375$ and $\tau = 0.28$, small variations of p from p^* are not enough to push the economy out of autarky. However, as p increases above certain level, it makes up for part of the negative impact of tariffs on output. The economy starts to do some trade, and in the process the sectorial composition of output changes in favor of the good where the economy has comparative advantage, so productivity grows. Further increases in terms of trade allow the economy to produce increasingly more efficient sectorial mix, both on the

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[12] Something similar happens when one considers the effects of trade liberalization. Rodriguez-Clare, Trejos and Sáenz (2005) describe how measured TFP in Costa Rica, performed using the local NPIA, calculated with a Laspeyres method and a base year before the opening of the economy, is biased downwards. The reason is that the price vector puts a premium precisely on imported goods (as they contain the old tariffs), while the liberalization shifts resources in the other direction, to the production of exportables. What is an increase in TFP after trade liberalization using PPP GDP, looks like a fall of measured TFP when using domestic statistics.

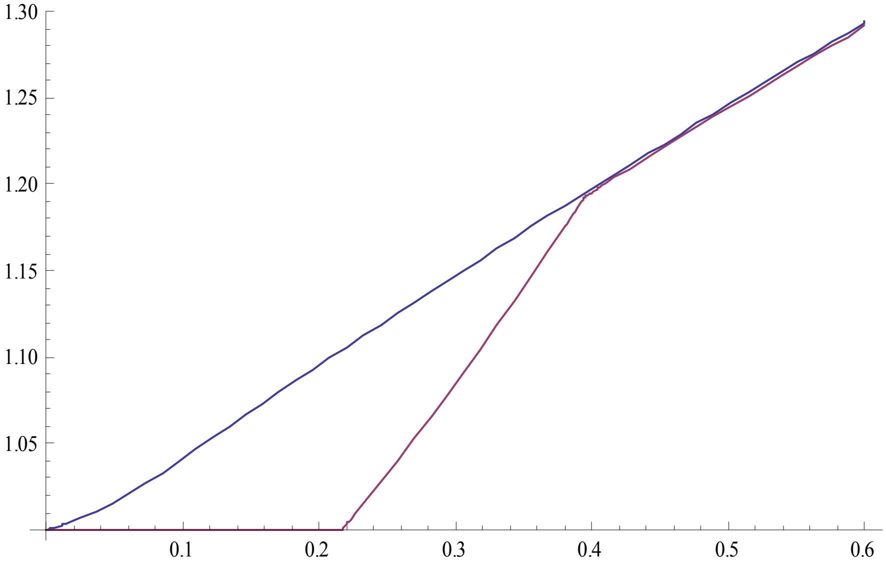

Figure 3: Change in $F(K, L/p, 0)$ and $F(K, L/p, 0.28)$ as p changes.

first production stage (exporting more A and producing less B), and on the second (acquiring the utilized b at a smaller opportunity cost). Notice that in this interval the elasticity of output to p is larger than 0.57. For large enough variations in p (in this case above 41%) the economy specializes in the production of good A and hence the response of output to variations in p is the same as in the economy with no tariff.

5 Conclusion

In this paper we presented evidence that gains from trade are relevant to measured productivity. We used a very simple version of the Hecksher-Ohlin model so that the only reason countries trade are factor differences, and tariffs, by changing the relative domestic prices of tradable goods, lead to inefficient sectorial allocations. This contrasts with Eaton and Kortum (2002) Ricardian trade model in which there is a continuum of goods and countries have differential access to technology. In that model efficiency varies across commodities and countries. As opposed to Rodriguez-Clare (2006), which builds on Eaton and Kurtum(2002), there is no diffusion in our model. Nonetheless, the model is able to capture some important features of the international commerce - poor countries do trade because of factor differences - and so our measured gains from trade may be seen as a (large) lower bound of the gains from openness. As a matter of fact, they are close to those Rodriguez-Clare (2007) obtained in the pure trade model.

Moreover, 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 a previous paper (Ferreira and Trejos (2006)). In this sense, the current exercise is also limited as it takes stocks as given but does not consider that, if it were not for trade restrictions, they would be considerably larger.

Of course, the fact that poor countries with high tariffs are still enjoying most of the gains from trade could be reverted if we have more realistic data, and not only nominal tariffs data. Anderson and van Wincoop (2004) survey the literature on trade costs and show that for the OECD economies they are quite large and well above nominal tariffs. We wanted, however, to use homogeneous data and the only source we know for this is the WorldBank database on nominal tariff. A natural extension of this work is to use (and construct in some cases) data of trade cost based on gravitation models for a large set of economies.

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A Appendix

We present in details the derivation of the production function used in the paper. The profit maximization problems in the definition of stationary equilibrium yield:

$$\begin{aligned}\frac{(1-\alpha_a)}{\alpha_a}k_A &= \frac{(1-\alpha_b)}{\alpha_b}k_B \\ q(1-\alpha_a)k_A^{\alpha_a} &= (1-\alpha_b)k_B^{\alpha_b} \\ \frac{\gamma b}{(1-\gamma)} &= qa,\end{aligned} \tag{5}$$

Similarly, the market clearing conditions for K and L can be transformed into:

$$\lambda k_A + (1-\lambda)\, k_B = k,$$

where $\lambda = L_A/L$ and the production functions are then written as

$$A = \lambda L k_A^{\alpha_a} \text{ and } B = (1-\lambda)\, L k_B^{\alpha_b}.$$

In the case of an economy that do not trade the condition $pa + b = pA + B$ is substituted instead for the conditions $a = A, b = B$. In that case, the above solves into

$$\lambda = \gamma \frac{(1-\alpha_a)}{1-\bar{\alpha}},$$

where $\bar{\alpha} = \gamma\alpha_a + (1-\gamma)\,\alpha_b$. Then, more algebra yields the solutions:

$$k_A = \frac{\alpha_a}{(1-\alpha_a)}\frac{1-\bar{\alpha}}{\bar{\alpha}}k \text{ and } k_B = \frac{\alpha_b}{(1-\alpha_b)}\frac{1-\bar{\alpha}}{\bar{\alpha}}k.$$

These imply that total output Y (under $a = A, b = B$) is:

$$Y = \Omega_4 K^{\overline{\alpha}} L^{1-\overline{\alpha}}, \tag{6}$$

where

$$\Omega_4 = \frac{\gamma^{\gamma}(1-\gamma)^{1-\gamma}\left[\alpha_a^{\alpha_a}(1-\alpha_a)^{1-\alpha_a}\right]^{\gamma}\left[\alpha_b^{\alpha_b}(1-\alpha_b)^{1-\alpha_b}\right]^{1-\gamma}}{\bar{\alpha}^{\bar{\alpha}}\left(1-\bar{\alpha}\right)^{1-\bar{\alpha}}}.$$

From 5 and the expression of q one can derive:

$$x = \frac{\bar{\alpha}}{1-\bar{\alpha}}\left[\left(\frac{p}{1+\tau}\right)\frac{{\alpha_a}^{\alpha_a}\left(1-\alpha_a\right)^{1-\alpha_a}}{{\alpha_b}^{\alpha_b}\left(1-\alpha_b\right)^{1-\alpha_b}}\right]^{\frac{1}{\alpha_b-\alpha_a}}$$

where x is the minimal capital level for the economy not to trade (i.e, $x(\tau,p)$ in (2)). Likewise, following similar steps one can derive:

$$\begin{array}{rcl} s_1 & = & \left[\dfrac{p}{1+\tau}\left(\dfrac{\alpha_a}{\alpha_b}\right)^{\alpha_b}\left(\dfrac{1-\alpha_a}{1-\alpha_b}\right)^{1-\alpha_b}\right]^{\frac{1}{\alpha_b-\alpha_a}} \\ s_2 & = & \left[\dfrac{p}{1+\tau}\left(\dfrac{\alpha_a}{\alpha_b}\right)^{\alpha_a}\left(\dfrac{1-\alpha_a}{1-\alpha_b}\right)^{1-\alpha_a}\right]^{\frac{1}{\alpha_b-\alpha_a}}, \end{array} \qquad (7)$$

where s_1 corresponds to $s(\tau,p)$ in (2)

In the case that the economy is diversified and export A and import B, the solution of the factor allocation problem is:

$$\begin{array}{ll} L_A = \frac{s_2L-K}{s_2-s_1} & L_B = \frac{K-s_1L}{s_2-s_1} \\ K_A = s_1\frac{s_2L-K}{s_2-s_1} & K_B = s_2\frac{K-s_1L}{s_2-s_1} \end{array}. \qquad (8)$$

From the expression above and (7) the equilibrium expression of Y in this case is:

$$Y = \Omega_2 K + \Omega_3 L \qquad (9)$$

where:

$$\begin{aligned}\Omega_2 &= \gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}p^{-\gamma}\frac{\left(1+\tau\right)^{\gamma}}{1+\gamma\tau}\frac{s_2^{\alpha_b}-ps_1^{\alpha_a}}{s_2-s_1}\\ \Omega_3 &= \gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}p^{-\gamma}\frac{\left(1+\tau\right)^{\gamma}}{1+\gamma\tau}\frac{ps_1^{\alpha_a}s_2-s_2^{\alpha_b}s_1}{s_2-s_1}\end{aligned} \tag{10}$$

Finally, when the economy is fully specialized in A (so that $k < s_1$), one can derive (after imposing $K_B = L_B = B = 0$) from (5), (8) and the expression for the equilibrium in the market for intermediate goods:

$$Y = \Omega_1 K^{\alpha_a} L^{1-\alpha_a}, \tag{11}$$

where:

$$\Omega_1 = \gamma^{\gamma}\left(1-\gamma\right)^{1-\gamma}p^{1-\gamma}\frac{\left(1+\tau\right)^{\gamma}}{1+\gamma\tau}.$$

Table A.1: Gains from openness

COUNTRY	Γ_0	COUNTRY	Γ_0
Benin	1.43	Jordan	1.04
Botswana	1.15	Korea	1.08
Cameroon	1.28	Malaysia	1.09
Cent. Afric. Rep.	1.41	Nepal	1.39
Congo	1.50	Pakistan	1.27
Egypt	1.21	Papua New	1.16
Ghana	1.31	Philippines	1.17
Guinea Bisseau	1.35	Sri Lanka	1.30
Kenya	1.33	Syria	1.12
Lesotho	1.43	Taiwan	1.12
Malawi	1.41	Thailand	1.15
Mali	1.36	Turkey	1.13
Mauritius	1.14	Barbados	1.01
Mozambique	1.64	Bolivia	1.17
Niger	1.37	Brazil	1.01
Rwanda	1.61	Chile	1.08
Senegal	1.36	Colombia	1.12
Sierra Leone	1.57	Costa Rica	1.10
South Africa	1.01	Dominican	1.15
Tanzania	1.32	Ecuador	1.06
Togo	1.43	El Salvador	1.17
Tunisia	1.03	Guatemala	1.14
Uganda	1.89	Guyana	1.08
Zambia	1.18	Haiti	1.50
Zimbabwe	1.07	Honduras	1.21
Bangladesh	1.30	Jamaica	1.07
China	1.39	Mexico	1.01
Fiji	1.08	Nicaragua	1.13
Hong Kong	1.02	Panama	1.06
India	1.34	Paraguay	1.15
Indonesia	1.30	Peru	1.02
Iran	1.01	Uruguay	1.02

Table A.2: Loss from barriers to trade

COUNTRY	τ needed for Γ_0 to fall by			Actual τ	k/k^*
	1/3	1/2	100%		
Benin	80.2	85.2	99.2	48.3	0.05
Botswana	25.1	28.2	36.0	30	0.26
Cameroon	50.6	54.5	65.2	30.2	0.11
Cent. Afric. Rep.	75.3	80.1	93.5	32	0.06
Congo	94.6	100.1	115.7	22.6	0.03
Egypt	36.0	39.4	48.4	47.4	0.18
Ghana	56.9	61.1	72.4	26.3	0.09
Guinea Bisseau	64.8	69.2	81.4	27.8	0.07
Kenya	59.3	63.5	75.1	39.9	0.09
Lesotho	79.6	84.5	98.4	17.4	0.05
Malawi	75.5	80.3	93.8	31.6	0.05
Mali	65.1	69.5	81.8	17	0.07
Mauritius	23.5	26.4	34.0	36.2	0.28
Mozambique	126.2	133.0	152.5	15.6	0.02
Niger	67.9	72.4	85.0	18.5	0.07
Rwanda	119.3	125.7	144.4	33	0.02
Senegal	65.0	69.4	81.7	13.2	0.07
Sierra Leone	109.4	115.4	132.9	25.8	0.02
South Africa	4.7	5.8	8.2	21.2	0.70
Tanzania	58.5	62.6	74.2	28.5	0.09
Togo	79.9	84.8	98.8	19.5	0.05
Tunisia	7.6	9.4	13.4	25.9	0.57
Uganda	185.8	195.2	342.0	25	0.01
Zambia	30.7	34.0	42.4	29.9	0.21
Zimbabwe	12.8	15.3	21.1	9.4	0.43
Bangladesh	53.0	57.0	67.9	94.5	0.10
China	70.9	75.5	88.5	49.5	0.06
Fiji	14.2	16.8	23.0	12.4	0.40
Hong Kong	6.7	8.2	11.8	0	0.61
India	61.6	65.9	77.8	91	0.08
Indonesia	51.0	54.9	65.6	30.2	0.11

Table A.2 (cont.): Loss from barriers to trade

COUNTRY	τ needed for Γ_0 to fall by			Actual τ	k/k^*
	1/3	1/2	100%		
Iran	4.3	5.3	7.6	20.7	072
Jordan	17.3	20.0	26.7	15.2	0.35
Korea	14.1	16.6	22.7	21	0.41
Malasya	14.9	17.5	23.8	14	0.39
Nepal	72.2	76.8	89.9	21.9	0.06
Pakistan	48.8	52.6	63.1	72.2	0.12
Papua NewGuine	28.4	31.5	39.7	14.2	0.23
Philippines	29.2	32.4	40.7	29.2	0.22
SriLanka	53.3	57.3	68.3	36.2	0.10
Syria	19.8	22.7	29.7	14.8	0.32
Taiwan	20.3	23.1	30.3	23.3	0.31
Thailand	25.6	28.6	36.5	38.1	0.26
Turkey	22.9	25.8	33.3	27.9	0.28
Barbados	4.0	4.9	7.0	17.3	0.74
Bolivia	29.5	32.7	41.0	17.6	0.22
Brazil	4.7	5.7	8.1	47	0.71
Chile	14.3	16.8	23.0	20.8	0.40
Colombia	20.2	23.0	30.1	36.7	0.31
Costa Rica	17.7	20.4	27.2	19.5	0.35
Dominican Rep	25.6	28.7	36.5	27.8	0.25
Ecuador	11.0	13.3	18.7	34.3	0.47
El Salvador	30.0	33.2	41.6	20	0.22
Guatemala	24.2	27.2	34.8	19.4	0.27
Guyana	14.0	16.5	22.6	18.7	0.41
Haiti	92.7	98.1	113.5	27.7	0.04
Honduras	36.9	40.4	49.5	51.3	0.17
Jamaica	13.1	15.6	21.5	17.9	0.43
Mexico	4.2	5.1	7.3	19.7	0.73
Nicaragua	22.6	25.5	32.9	22.1	0.29
Panamá	11.5	13.9	19.4	12.8	0.49
Paraguay	25.2	28.2	36.0	11	0.26
Peru	6.2	7.6	10.8	37.6	0.64
Uruguay	6.6	8.1	11.5	36.3	0.62

Table 3: Development accounting

COUNTRY	y	k	h	$\widehat{\Theta}$	Γ_τ	Θ
Benin	0.053	0.298	0.401	0.447	1.407	0.318
Botswana	0.253	0.582	0.486	0.894	1.059	0.843
Cameroon	0.154	0.414	0.448	0.829	1.276	0.649
CentAfrican Rep.	0.066	0.313	0.402	0.524	1.397	0.375
Congo	0.034	0.259	0.444	0.301	1.497	0.201
Egypt	0.214	0.499	0.485	0.885	1.013	0.873
Ghana	0.067	0.384	0.486	0.361	1.310	0.275
GuineaBisseau	0.023	0.351	0.368	0.184	1.349	0.137
Kenya	0.061	0.373	0.473	0.349	1.313	0.265
Lesotho	0.057	0.300	0.495	0.388	1.426	0.272
Malawi	0.031	0.313	0.452	0.219	1.398	0.157
Mali	0.057	0.350	0.372	0.443	1.356	0.326
Mauritius	0.257	0.597	0.572	0.751	1.	0.751
Mozambique	0.031	0.196	0.378	0.418	1.641	0.254
Niger	0.037	0.339	0.374	0.292	1.369	0.213
Rwanda	0.045	0.208	0.416	0.520	1.598	0.325
Senegal	0.073	0.350	0.429	0.485	1.357	0.357
Sierra Leone	0.068	0.226	0.416	0.723	1.560	0.463
South Africa	0.496	0.869	0.567	1.006	1.	1.006
Tanzania	0.027	0.377	0.457	0.160	1.317	0.121
Togo	0.065	0.299	0.448	0.487	1.427	0.341
Tunisia	0.323	0.800	0.473	0.853	1.	0.853
Uganda	0.031	0.127	0.417	0.583	1.886	0.309
Zambia	0.068	0.537	0.504	0.253	1.128	0.224
Zimbabwe	0.155	0.714	0.448	0.485	1.064	0.455
Bangladesh	0.086	0.402	0.425	0.505	1.	0.505
China	0.053	0.328	0.549	0.297	1.361	0.218
Fiji	0.275	0.695	0.691	0.572	1.065	0.537
Hong Kong	0.498	0.822	0.749	0.808	1.027	0.786
India	0.075	0.364	0.486	0.424	1.	0.424
Indonesia	0.126	0.412	0.504	0.609	1.278	0.476
Iran	0.322	0.879	0.478	0.766	1.	0.766

Table 3 (cont.): Development accounting

COUNTRY	y	k	h	$\widehat{\Theta}$	Γ_τ	Θ
Jordan	0.414	0.660	0.562	1.118	1.081	1.034
Korea	0.342	0.697	0.770	0.636	1.013	0.628
Malasya	0.291	0.687	0.577	0.734	1.064	0.689
Nepal	0.050	0.324	0.392	0.399	1.388	0.287
Pakistan	0.103	0.423	0.425	0.572	1.	0.572
PapuaNewGuine	0.135	0.555	0.421	0.578	1.165	0.496
Philippines	0.160	0.549	0.643	0.454	1.115	0.407
Sri Lanka	0.115	0.400	0.597	0.481	1.286	0.374
Syria	0.263	0.632	0.527	0.788	1.109	0.710
Taiwan	0.371	0.628	0.697	0.846	1.059	0.798
Thailand	0.133	0.579	0.562	0.410	1.	0.410
Turkey	0.238	0.603	0.491	0.805	1.051	0.766
Barbados	0.438	0.887	0.691	0.714	1.	0.714
Bolivia	0.172	0.546	0.542	0.582	1.170	0.497
Brazil	0.342	0.970	0.482	0.815	1.	0.815
Chile	0.297	0.695	0.643	0.666	1.016	0.655
Colombia	0.288	0.629	0.532	0.859	1.	0.859
Costa Rica	0.282	0.655	0.572	0.754	1.059	0.711
Dominican Rep.	0.219	0.578	0.509	0.746	1.084	0.687
Ecuador	0.275	0.739	0.598	0.621	1.	0.621
El Salvador	0.232	0.543	0.486	0.879	1.172	0.749
Guatemala	0.267	0.591	0.452	0.996	1.130	0.881
Guyana	0.133	0.698	0.577	0.331	1.028	0.321
Haiti	0.047	0.264	0.456	0.396	1.482	0.267
Honduras	0.161	0.493	0.509	0.641	1.	0.641
Jamaica	0.149	0.710	0.523	0.401	1.025	0.391
Mexico	0.493	0.883	0.562	0.992	1.	0.992
Nicaragua	0.208	0.606	0.478	0.720	1.093	0.659
Panama	0.355	0.731	0.637	0.761	1.039	0.733
Paraguay	0.277	0.582	0.562	0.847	1.148	0.737
Peru	0.294	0.834	0.604	0.583	1.	0.583
Uruguay	0.338	0.824	0.655	0.626	1.	0.626