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Exclusion in "Ricardian" Trade Models

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Abstract

The paper discusses the following result of the so-called 'Ricardian' models of international trade: the impossibility of exclusion from trade. We show that this result holds due to the very restrictive assumptions behind these models: (i) commodities are produced by unassisted labour alone under (ii) complete factor immobility. The moment these assumptions are relaxed, the likelihood of exclusion can no longer be neglected. The reason is the following: even if there were no limits to the fall in the rate of domestic real wages, production costs would reach a *positive lower bound* due to the presence of *imported* capital goods. Exclusion is therefore the result of this lower bound being higher than the prevailing international price, for both capital and consumption-goods sectors.

Keywords: Absolute advantage; Comparative advantage; Exclusion from trade; Pattern of specialization; Ricardian models of trade.

JEL Codes: B27; B51; F11.

1. Introduction[1]

Since David Ricardo (1951) introduced the notion of comparative advantage (henceforth, CA) for the first time with the sufficient analytical rigor, the vision has established itself that differences in productivity across countries do not constitute an unsurmountable obstacle to international trade. Irrespectively of the absolute degree of its technological backwardness, it is argued, a country will always be able to compensate this deficiency

[1] We wish to thank Saverio Fratini, Antonella Palumbo and one anonymous referee for the comments and suggestions to a previous version of this article. The usual disclaimer applies.

with *sufficiently low wages*. In other words, that there *necessarily* exists a distributive configuration that prevents exclusion from trade[2].

The claim has been adopted as its own by the neoclassical approach, and formalized in what are currently known as 'Ricardian Models of Trade' (cf. Dornbusch et al, 1977). Baptized this way precisely because, unlike the other 'traditional' class of trade-models within this approach, which highlight the role played by factor endowments (Heckscher, 1919; Ohlin, 1933; Samuelson, 1948, 1949), the former emphasize – as Ricardo himself did – the role of productivity differences across countries to explain the pattern of specialization[3]. As an expression of their current relevance, most neoclassical trade theorists recognize that, by themselves, differences in factor endowments do not accurately fit with the actually observed patterns of trade (cf. Trefler,1995). In what we can safely consider as one of '*the*' current graduate textbooks in mainstream international trade theory, we find Feenstra arguing that:

> the Heckscher-Ohlin model is hopelessly inadequate as an explanation for historical or modern trade patterns unless we allow for technological differences across countries. For this reason, the Ricardian model is as relevant today as it has always been (Feenstra, 2014, p. 1)[4].

Now, besides the emphasis on countries' technological differences, the other peculiarity of the neoclassical Ricardian models is that, since they conceive distribution as a strictly market phenomenon, the required adjustment in distributive variables to avoid exclusion is *automatically* triggered every time that, due to its lack of international competitiveness, a country exhibits (at least some) persistent unemployment[5,6]. And while due to this reason the neoclassical theory presents itself as the 'natural environment', so to

[2] In the words of an authoritative scholar in the subject, "A country that is less productive than its trading partners across the board will be forced to compete on the basis of low wages rather than superior productivity. But it will not suffer catastrophe, and indeed will normally still benefit from international trade"(Krugman, 1991, p. 812).

[3] To avoid any misunderstandings, it is worth noting that the term 'Ricardian models' is actually misleading. Indeed, beyond the mentioned similarity between these models and Ricardo's own contribution, there are irreconcilable differences between the two. In particular, while in the latter distribution is determined by non-economic factors, in the former the real wage necessarily adjusts to ensure both internal (i.e. full-employment) and external (i.e. balance of payments) equilibria. (For a detailed analysis of Ricardo's own contribution to trade theory, see Gehrke (2015).

[4] As Gandolfo (2014) notes, among the causes that explain the different levels of productivity across countries, technological differences need not be considered in the strictest engineering sense. Recent literature has additionally emphasized the role of institutions and even cultural traits as causes of CA (see, e.g. Belloc and Bowles, 2013).

[5] "The reason that it is still possible for the home country [the country that has absolute disadvantages in all commodities] to export", explains Feenstra, "is that its *wages will adjust* to reflect its productivities: under free trade, its wages are lower than those abroad" (Feenstra, 2014, p. 3, Emphasis added).

[6] Even those models that, by emphasizing the importance of increasing returns to scale – what is currently known as 'New Trade Theory' – seem to be able to do without CA as an explanation of trade – need that distributive variables adjust to compensate potential differences in productivity caused, for instance, by countries' significantly different sizes (cf. Krugman, 1980, p. 958). This helps understanding why the proponents of New Trade Theory still accept the validity of CA (see Krugman, 1991).

speak, to develop these models, the fact is that they can also be complemented, in principle, by an alternative theory of prices and distribution. Little wonder then that, scholars that do not necessarily adhere to this approach to value and distribution, nonetheless have explicit recourse to the Ricardian models (cf. e.g. Cimoli and Porcile, 2010; Razmi, 2012) or at least to the general message they transmit (cf. e.g. Frenkel and Ros, 2006; Bresser-Pereira, 2008[7]), to justify why the fall in real wages can contribute to *diversify* the productive structure of a particular nation, by allowing the addition of new sectors that were not profitable at a higher real wage. The difference with respect to the marginalist models being that the fall in real wages is, in this case, conceived as the outcome of *deliberate* economic policy (e.g. a real devaluation).

The plurality of schools that continue to rely on Ricardian models, strongly suggests that their critical examination is relevant even beyond their implications for the neoclassical theory of international trade. In this respect, it is true that a group of authors, on the basis of the revival of the classical approach after Sraffa's (1960) seminal contribution, has convincingly argued against the spontaneous adjustment in income distribution through the action of the supply-and-demand forces, either because distribution is 'exogenous' to the market (cf. Brewer, 1985; Gibson, 1981; Shaikh, 1980; Parrinello, 1979, 2010), or because the forces of supply and demand may not work in the 'right' direction (Metcalfe and Steedman, 1972; Steedman and Metcalfe, 1977). However, these objections alone do not exclude the possibility that, if the change in distribution were the outcome of economic policy, specialization might actually take place.

In this work we critically face this issue. And we show that, *independently* of its cause (either unemployment, as it is argued by the marginal approach, or the outcome of deliberate economic policy, as some non-orthodox scholars suggest), the fall in the real wage may not be able to compensate productivity differences and avoid the exclusion from trade; even if, for the sake of argument, we allow wages to fall to arbitrarily low levels, even zero.

Within what we can identify as the *canonical* Ricardian model of trade (cf. Matsuyama, 2008), exclusion is not possible essentially because production is assumed to require *unassisted labour alone*. Therefore, conveniently enough, when wages fall, production costs can be *arbitrarily* reduced relative to the rest of the world, and compensate any possible technological backwardness. But this outcome ceases to hold the moment that, realistically enough, we consider that production employs *capital goods* and, moreover, we also allow for – thanks to the mobility of capital across countries (hypothesis not less realistic, given the actual conditions of global production) – at least some tendency to *equalization of profit rates across countries*. We argue therefore, that, under these two premises – production with capital goods and free capital mobility–, exclusion from trade *can indeed happen*. We therefore develop an argument firstly presented in Parrinello (2010, Section 4, p. 55), where the possibility of exclusion is considered, but not sufficiently explored in its causes as the issue deserves.

[7] For a critical assessment to Frenkel and Ros's (2006) contribution, and more generally, to what is currently known as the 'New structural approach', see Dvoskin et al. (2019); for a critical reconstruction of Bresser's contribution, see Dvoskin and Feldman (2018).

The argument to be developed in the article can be summarized by the following three propositions: (a) the moment production requires, besides labour, the employment of *imported* capital goods, there is a *lower bound* to the fall in production costs, even if domestic wages fall to zero; (b) when the available technology is sufficiently backward, it may well happen that this lower bound is *higher* than the corresponding international price; and finally, (c) the impossibility to domestically produce these capital goods is the result of the international profit rate being higher than the *maximum rate* affordable by its domestic production.

The thread of the argument is developed as follows. In Section 2 we present the no-trade-exclusion condition, both for the 2 and the N consumption-goods cases, under the standard assumptions of Ricardian models; specifically, that commodities are produced by unassisted labour alone that is paid at the end of the production cycle. In Section 3, we partially relax these assumptions: we allow for the existence of capital, although it consists entirely of anticipated wages. We show that in this case, capital mobility is not enough for exclusion, but it may happen that a country is excluded from trade if labour is the mobile factor. And while this is a rather implausible assumption, this 'laboratory' example will be useful to grasp why, when production costs cannot be arbitrarily reduced, trade-exclusion becomes a possibility. Section 4 finally considers the truly relevant case of production of capital goods under capital mobility, where the main result of the paper is shown, both for 2 and N consumption goods. The article concludes in Section 5 with a brief summary of the argument and some implications of our results.

2. Comparative advantage in canonical Ricardian trade models

2.1. Two commodities

To settle the grounds of the discussion, it is enough to consider the production side of a canonical Ricardian model of two countries $i = \{A; B\}$ that produce two different consumption goods $z = \{0; 1\}$, by unassisted labour alone under constant returns to scale. We further keep the standard assumptions of these models of labour immobility across countries and one common currency to abstract from exchange-rate considerations.

If l_z^i and w^i stand, respectively, for the unitary labour requirement of commodity z and for the level of *money* wages in country $i = A, B$ in terms of the common monetary unit; then, the money cost of production of z in i is determined by:

$$c_z^i = w^i l_z^i \qquad [1]$$

Notice from [1] that costs of production can be *arbitrarily* reduced with appropriate reductions in the wage rate. In other words, c_z^i goes to zero when w^i goes to zero.

Under international trade, due to the action of competition, commodity z will be produced in the country that can supply it at the minimum average costs, c_z^i. Therefore p_z, the price of commodity z, is:

$$p_z = min\{c_z^A; c_z^B\} \qquad [2]$$

2.2. Impossibility of exclusion from trade

We can proceed to examine why *exclusion from trade is not possible.* To see this, let us follow the standard procedure (see Dornbusch et al. 1977, Section 2, Gandolfo, 2014, Section, 2.4.2), and define the relative wage between the two countries, $\omega \equiv w^A/w^B$. Suppose now that country A has absolute cost disadvantages in the production of *both* commodities ($c_z^B < c_z^A \Rightarrow p_z = c_z^B \ \forall z$). Consider next a notional decrease in w^A, and therefore, in the relative wage ω. Since the cost of production of z in country A can be arbitrarily reduced by reductions in its own wage rate, this will eventually ensure that the condition $c_z^A < c_z^B$ will hold for at least one z. As a result, country A will not be excluded from trade.

It is convenient to notice that as long as the productive structure does not change, the fall in ω necessarily implies that real wages in country A are falling in terms of any commodity. Since *all* commodities are being produced in country B, prices are proportional to w^B and, hence, w^A/p_z falls, for all z. The moment a particular commodity z starts being produced in country A, the fall in w^A causes the money price of this commodity to fall proportionally[8], hence the real wage no longer falls in terms of this particular commodity, but it will continue decreasing in terms of any imported commodity. Likewise, in the case that all commodities are being produced in country A, a fall in ω will only *rise* the real wage in country B, leaving real wages in country A unaffected. Consequently, a change in ω is tantamount to a change in the real wage either in country A or in country B, in terms of any commodity that is not being produced by this country [9]. Therefore, as it is usual in the literature, to examine the pattern of trade, for analytical convenience we will here consider variations in the relative wage, always having in mind that these variations imply changes in real wages.

2.3. The pattern of specialization

One can then proceed to determine the precise interval of ω that allows specialization in production. To do this, consider first the *comparative cost* of the same commodity in countries A and B, cc_z:

$$cc_z = \frac{c_z^A}{c_z^B} = \frac{w^A}{w^B}\frac{l_z^A}{l_z^B} = \omega\frac{l_z^A}{l_z^B} \qquad [3]$$

The value of ω that would be necessary to equalize production costs of commodity z in both countries ($cc_z = 1$), is given by:

[8] As we will see in Section 4 below, when production includes *imported* capital goods, since money prices are no longer proportional to money wages, a fall in w^A will also cause a fall in the real wage even in terms of those commodities that are being produced in country A, provided that these commodities use, either directly or indirectly, imported commodities.

[9] As can be inferred from the previous note, with imported capital goods the fall in ω will also cause a fall in real wages in country A (and a rise in country B) even in terms of any commodity, provided that it employs imported inputs.

$$L(z) = \frac{l_z^B}{l_z^A} \qquad [4]$$

Function $L(z)$, which has been extensively used in the literature (see for instance Dornbusch et al., 1977, and more recently, Matsuyama, 2008 and Razmi, 2012), presents however two important properties that are not always sufficiently stressed: (i) it depends on technical coefficients alone, and (ii) it can be determined independently from other production methods besides the one(s) employed in the production of commodity z. We will come to these properties in the following sections.

The comparison between the actual value of ω and the value of $L(z)$ allows determining whether commodity z can be (profitably) produced in country A. In particular, $c_z^A \leq c_z^B$ requires that:

$$\omega \leq L(z) \qquad [5]$$

Without loss of generality, the two commodities can always be numbered so that $L(z)$ is *decreasing* in z, namely that $L(1) < L(0)$. And this means that whenever $L(0) < \omega$ both commodities are produced *only* in country B, while when $\omega < L(1)$ both commodities are produced only in country A. Finally, there is (full) specialization (A produces commodity 0 and B produces 1)[10], if the relative wage falls within the following interval:

$$0 < L(1) \leq \omega \leq L(0) \qquad [6]$$

In Figure 1 we represent the shape of function $L(z)$ for the simple two-commodity case.

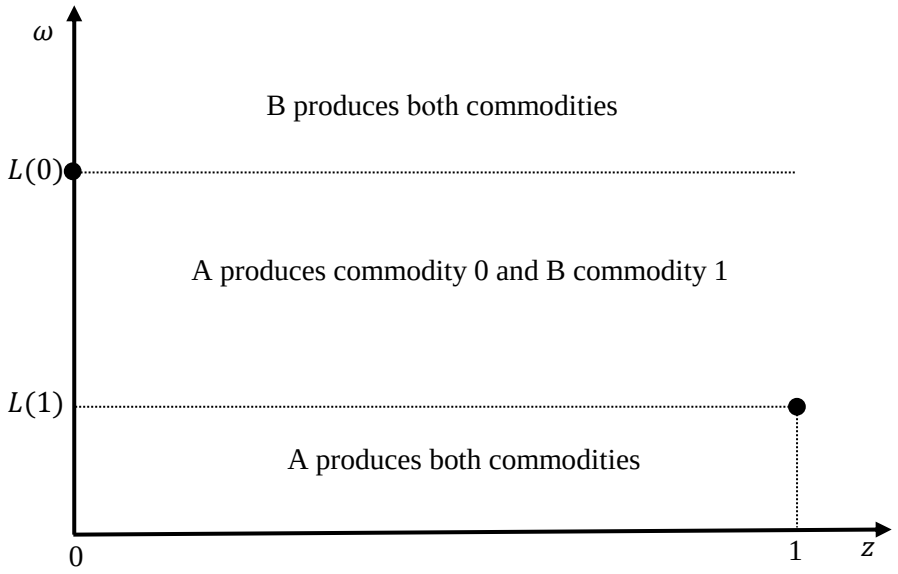

Figure 1- The pattern of specialization in the two-commodity case.

Of the three possible cases depicted in Figure 1, sufficient flexibility in the relative wage ensures that condition [6] will eventually hold and therefore specialization will prevail.

[10] Notice that the opposite pattern of specialization is not possible since it would simultaneously require that $\omega \leq L(1)$ and $\omega \geq L(0)$, which cannot happen since, by assumption, $L(0) > L(1)$.

2.4.Many commodities

The extension of the previous result to the production of many (*N*) commodities is rather straightforward. Provided that all goods are produced by unassisted labour alone, it is still possible to order commodities such that:

$$0 < L(N-1) \leq L(N-2) \leq \cdots \leq L(0) \qquad [7]$$

Then, for the existence of specialization – partial, in this case –, it is enough that the relative wage, ω, falls in the following interval:

$$0 < L(N-1) \leq \omega \leq L(0) \qquad [8]$$

Condition [8] therefore excludes a situation in which all commodities are only produced in one country [either in country B, when $\omega > L(0)$, or in country A, if $\omega < L(N-1)$]. Condition [8] will hold if relative wages are determined by market forces but it may also be the outcome of deliberate public policy. Hence, commodity 0 will be produced by country A and commodity $N-1$ by country B, while the location of production of the remaining commodities $1, \ldots, N-2$, can be ascertained by condition [5], once the precise level of ω is determined[11]. In Figure 2, a possible pattern of trade is represented when $\omega = \bar{\omega}$.

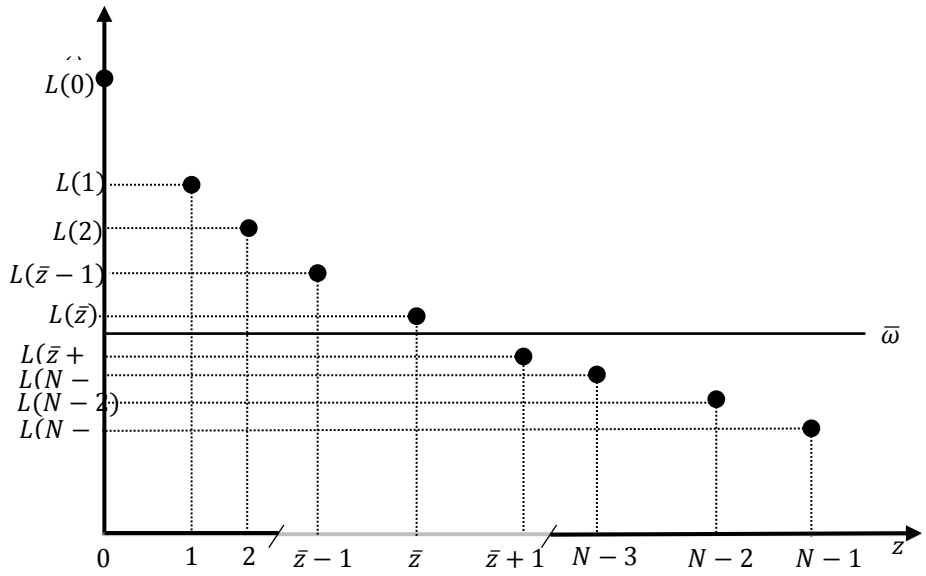

Figure 2- The pattern of trade with many commodities.

The figure shows that for the given relative wage $\bar{\omega}$, country A produces commodities 0,1... up to $\bar{z}$, while the remaining commodities are produced by B.

[11] The determination of this level of ω is beyond the scope of this article. If, for instance, one develops the argument *internally* to the neoclassical approach, it will generally depend, besides technology, on the other data of neoclassical theory – the preference structure of consumers and labour endowments (on this point see e.g. Dornbusch et al, 1977). But, as argued in the introduction, nothing prevents us from assuming that the precise level of ω is the outcome of public policy, as in Razmi (2012).

3. Capital as anticipated wages

In this section we reconsider the possibility of exclusion from trade when capital consists *entirely* in anticipated wages. We continue assuming that there are N consumption goods, still produced by unassisted labour alone. However, since wages are paid at the *beginning* of the production cycle, a positive rate of profits is included in normal production costs. The cost of production of a generic commodity z in country i is now determined by:

$$c_z^i = w^i l_z^i (1 + r^i) \qquad [9]$$

where r^i is the rate of profits earned in country i. As before, due to the action of competition, under international trade the price of z will be determined by condition [2]:

$$p_z^i = min\{c_z^A; c_z^B\} \qquad [2]$$

And, therefore, commodity z can be simultaneously produced by the two countries only when $cc_z = 1$, that is:

$$w^A l_z^A (1 + r^A) = w^B l_z^B (1 + r^B) \qquad [10]$$

Let us define the relative (gross) profit rate, $\equiv \frac{1+r^A}{1+r^B}$. Condition [10] can be expressed in terms of a modified L function, which we will call T. This function takes the following form:

$$\omega = T(z, \rho) = \frac{L(z)}{\rho} \qquad [11]$$

Like $L(z)$ in the previous section, $T(z, \rho)$ gives the relative wage that allows commodity z to be produced by the two countries at the same costs (the difference being that, differently from $L(.)$, $T(.)$ also depends on income distribution; see the next paragraph). This means that when $\omega < T(z, \rho)$ commodity z is produced only in country A, while it is produced only in country B when $\omega > T(z, \rho)$. Therefore, the prevailing pattern of trade is again simultaneously determined with income distribution. Consequently, country A will produce and export *all* commodities z satisfying $\omega \leq T(z, \rho)$.

We can now proceed to examine the condition that ensures the existence of trade and the possibility of specialization. This can be done by applying the same logic as before. Although, now, the relative wage that equalizes costs does depend on the relative profit rate, ρ – $T(.)$ does not inherit property (ii) from $L(.)$ (see Section 2.3) – the difference between functions $L(.)$ and $T(.)$ is more apparent than real: from [11] it is immediate that ρ only *rescales function* $L(z)$ *without affecting its original shape*[12]. Then, $L(N-1) \leq \cdots \leq L(0)$ implies $T(\mathrm{N}-1; \rho) \leq \cdots \leq T(0, \rho)$ for any feasible level of ρ. Furthermore, for feasible values of $\rho(> 0)$, $L(.) > 0$ implies $T(.) > 0$. In words, the ranking of commodities in terms of comparative costs is preserved and the relative wage that prevents exclusion from trade is necessarily positive.

With these remarks, the no-exclusion-from-trade condition can be written as:

[12] In the following section we will see that when there is production of capital goods, the absence of this property does become relevant for exclusion.

$$0 < T(N-1;\rho) \leq \omega \leq T(0,\rho) \qquad [12]$$

which due to [11] can be expressed as:

$$\frac{L(N-1)}{\rho} \leq \omega \leq \frac{L(0)}{\rho} \qquad [12']$$

Or alternatively, as:

$$L(N-1) \leq \rho\omega \leq L(0) \qquad [13]$$

3.1. Factor mobility

So far, we have presented function $T(z,\rho)$ in its general form, namely neglecting the possibility of 'factor' mobility across countries. When capital is internationally mobile, then profit rates are equalized across countries and the following condition must hold:

$$\rho = 1 \qquad [14][13]$$

Notice that, when [14] is duly considered, [13] boils down to [8] (the no-exclusion-condition when there was no capital). And we already know that if the relative wage is flexible enough, [13] will eventually hold, and therefore there will be specialization under conditions of trade.

To see why the consideration of capital as anticipated wages poses no particular difficulties when there is capital mobility and labour immobility across countries, it is useful to consider the *opposite*, although empirically implausible, situation of full labour mobility ($\omega = 1$) and capital immobility ($\rho \neq 1$, in general). Under these conditions, the no-trade-exclusion condition [13] becomes:

$$L(N-1) \leq \rho \leq L(0) \qquad [15]$$

And the fact is that [15] may not hold because, when, for instance, $L(0) < \rho$ and therefore country A happens to be excluded from trade, the necessary fall in ρ to ensure specialization may require a *negative* net profit rate in country A. To see this, we have recourse to Figure 3, which illustrates the argument in graphical terms.

[13] The moment the mobility of capital is considered, one could wonder why differences in production methods across countries still prevail. This is due both to technical and institutional reasons. As to the former, some methods of production employ specific kinds of labour – well trained engineers, for instance – that may not be available in some countries. Moreover, due to economies of agglomeration, indivisibilities and even irreversibilities that arise in production, but also due to differences in infrastructure, some countries may not be able to employ the most 'advanced' methods of production, independently of the price system. Regarding the institutional reasons, as argued in Parrinello (2010), methods of production also reflect the different functions performed by the National Government. Different national institutions, which include public organizations, the rule of law but also informal social norms, may constrain the choice of available techniques, even when capital is freely mobile, and technical knowledge is evenly diffused.

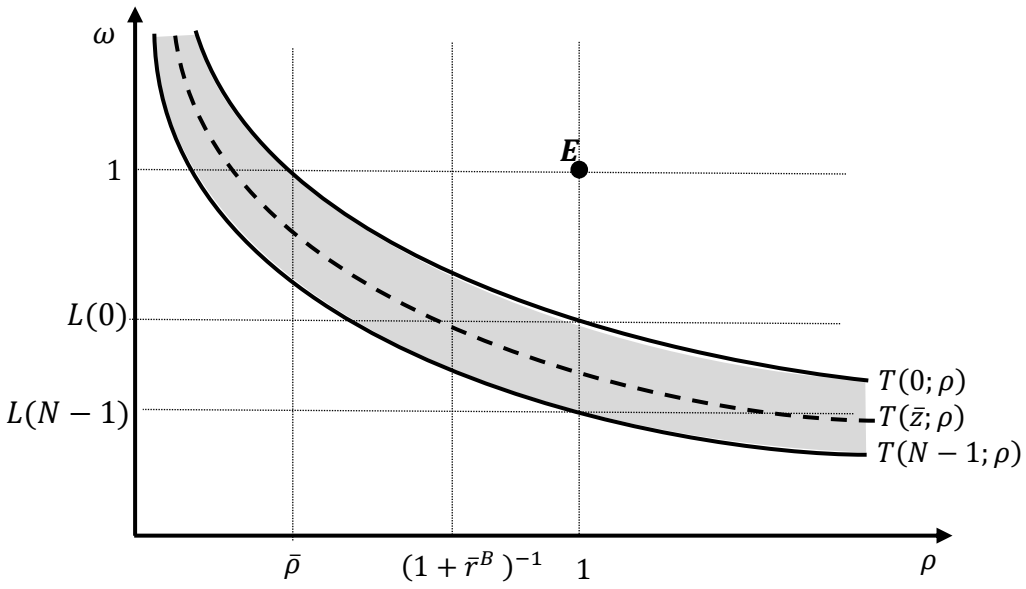

Figure 3 - $T(Z,\rho)=\omega$ in the $\rho-\omega$ space.

Condition [13] is represented in the figure by the grey area within the solid black curves. Its upper limit represents the different $\rho-\omega$ configurations that allow commodity 0 to be produced in both countries, while its lower limit shows the same thing for commodity $N-1$. Note that, due to [11], for any level of ρ, $T(N-1,\rho)$ is always below $T(0,\rho)$ in the $\rho-\omega$ space. In turn, the dashed curve in the figure illustrates the possible distributive configurations that would allow a specific commodity $\bar{z}$ to be produced by the two countries at the same costs. The dashed curve therefore supports a specific pattern of trade: country A specializes in the production of all $z\in[0;\bar{z}]$ and B in the production of $z\in[\bar{z};N-1]$[14]. This is because it also follows from [11] that all the possible $T(z,\rho)$ curves (one for each z) do not intersect each other, the curves $T(z,\rho)$ being always above $T(z+1;\rho)$ for any ρ. Hence if z is produced in country A, $z-1$ will be produced in this country, too.

We know that country A will be excluded from trade if $\omega>T(0,\rho)$ – namely when $\omega\rho>L(0)$ – like in point $E=(1;1)$ in the figure, which lays strictly above the grey area. Notice that point E also illustrates the distributive configuration when both labour and capital are fully mobile, and thus shows that in this case exclusion is possible. A necessary and sufficient condition for this result to hold is that $L(z)<1$ for all z. This case is rather trivial since, being all factors mobile, it limits itself to replicate the results of a closed economy, where, as is well known, competition does exclude the choice of technologically backward methods of production.

We now move to the truly interesting cases for international trade, in which at least one factor is not mobile. With capital mobility, ρ is the sole distributive variable that is constrained to be equal to unity. The figure shows that, for $\rho=1$, an economically relevant (non-negative) level of ω that prevents exclusion (i.e. $\omega\in[L(N-1);L(0)]$ in the

[14] Of course, with a finite number of commodities, only by fluke the actual distributive configuration will exactly verify $\omega=T(\bar{z};\rho)$. So, generally, $\bar{z}$ will be produced only in one country.

figure) *always* exists. Although now there is capital in production, exclusion is still not possible because, as capital consists entirely in anticipated wages, *any* level of the profit rate that could be imposed within a country by capital mobility, would still be realized if wages were appropriately reduced.

On the contrary, the figure shows that when labour is the mobile factor ($\omega = 1$), the necessary level of ρ that would prevent exclusion of country A, $\bar{\rho}$, may not be economically meaningful, since it may *require* a negative profit rate in this country. To see this, notice that, differently from ω – which tends to zero when w^A goes to zero –, ρ does not approach zero when r^A does. Recalling that $\rho \equiv \frac{1+r^A}{1+r^B}$, it is immediate that this variable could be reduced, either because of a higher r^B or of a lower r^A. Now, let us assume that all commodities are being produced in country B with a rate of profits equal to $\bar{r}^B$ (country A is being excluded from trade). It follows that there exists a lower bound to ρ, which corresponds to $r^A = 0$ and $r^B = \bar{r}^B$. And, as it is shown in the figure, since $\bar{\rho} < (1 + \bar{r}^B)^{-1}$, country A cannot avoid its exclusion from trade. Or, in other words, the only way the threshold, $\bar{\rho}$, can be achieved is by allowing r^A to be negative[15].

To conclude with this section, we could alternatively grasp the different implications of capital and labour mobilities, by inspecting the cost equation of commodity z – $c_z^i = w^i l_z^i (1 + r^i)$ – and considering whether this cost in country A could be reduced below the respective cost in country B, c_z^B. As it can be seen, regardless how small c_z^B is, when capital is the mobile factor, the cost of production of z in country A would eventually tend to zero if wages were sufficiently reduced in this country, therefore overcoming producers in country B.

On the contrary, with labour mobility, even if r^A were reduced to zero, production costs would remain positive and– since $w^A = w^B = w$ – they could not be further reduced below $w l_z^A$. In other words, labour mobility imposes a *lower bound* to production costs that may prevent competitiveness in every commodity.

4. Production with capital goods

In this section, we extend the analysis further and incorporate capital goods. As we have shown in the previous section, the possibility of trade-exclusion was the consequence of the existence of a *positive lower bound in production costs*. But with capital as anticipated

[15] That r^A cannot fall below zero is obvious enough to need justification. However, the reader may still wonder whether there are forces that would increase $\bar{r}^B$ sufficiently to promote the competiveness in country A. If, on the one hand, one develops the argument internally to the neoclassical theory, $\bar{r}^B$ is the rate of profit corresponding to the world endowment of labour being employed in country B (this due to the neoclassical full-employment condition coupled with the assumption of labour-mobility). Given the preference structure of consumers and technology, under these conditions capital in country B is as *scarce* as possible, and therefore its rate of remuneration is maximized at $\bar{r}^B$, and hence it cannot be further increased. If, on the other hand, we consider an alternative, 'non-mechanical' theory of distribution, the forces that determine the rate of profits may be so complex that there is simply no reason to expect a further increase in $\bar{r}^B$, much less as the outcome of an economic policy adopted in country A, aiming to promote its own competitiveness.

wages this could only happen when labour was the mobile factor, which was of course not a very realistic assumption. The aim of the present section is to show that under a more plausible framework of production with capital goods, the mobility of capital (or at least some mobility) can also give raise to such a lower bound.

4.1. Production with capital goods: two commodities

To that end, consider a simple economy that produces two commodities. We suppose that commodity 1 is a circulating capital good, while commodity 0 is a pure consumption good. The cost of production of a generic commodity z in country i, is now given by:

$$c_z^i = (w^i l_z^i + a_{1z}^i p_1)(1 + r) \qquad [16]$$

where a_{1z}^i is the unitary requirement of commodity 1 in the production of commodity z and r is the international profit rate under the assumption of capital mobility; while $p_1 = \min\{c_1^A; c_1^B\}$ is the normal price of the capital good employed in production (on this see immediately below).

4.1.1. Function T with capital goods

So far, the conditions that ensured the existence of trade were determined with the help of function T. The presence of capital goods entails, however, the following difficulty: since costs of production now depend on the price of the capital good employed, function T will vary with *the location* of production of the capital good. To see this, consider the comparative cost of the generic commodity z, which, recall, is the basis to derive function T:

$$cc_z = \frac{w^A l_z^A + a_{1z}^A p_1}{w^B l_z^B + a_{1z}^B p_1} \qquad [17]$$

with p_1 given by:

$$p_1 = \frac{(1 + r) l_1^A}{1 - a_{11}^A (1 + r)} w^A \qquad [18]$$

if $c_1^A < c_1^B$. Or by:

$$p_1 = \frac{(1 + r) l_1^B}{1 - a_{11}^B (1 + r)} w^B \qquad [18']$$

when $c_1^A \geq c_1^B$.

If, for the sake of argument, [18'] holds, the value of function T for the consumption good 0 – that, recall, gives the relative wage, ω, that renders $cc_0 = 1$ – would be given by:

$$T(0, r) = L(0) + (a_{10}^B - a_{10}^A) \frac{l_1^B}{l_0^A} \left[\frac{1 + r}{1 - a_{11}^B (1 + r)} \right] \qquad [19]$$

It is readily seen that function $T(0,r)$ in [19] does not inherit any of properties (i) and (ii) of function $L(z)$ derived when labour was the only input (see Section 2.2)[16]: neither the value of the function for commodity 0 is independent of income distribution (it depends on the *level* of r) nor is independent from the conditions of production of the other industries (it depends on the technical coefficients of the capital-good sector)[17]. The implications for the possibility of trade exclusion are discussed in the following subsection.

4.1.2. Exclusion in the production of the consumption good

We now proceed to examine the possibility of trade-exclusion. Since our aim is mainly negative, the argument is developed in the following way. First, we assume that condition [18'] holds – i.e. the capital good *is* produced in country B because $c_1^A > c_1^B$ – and identify a *sufficient* condition that ensures that the consumption good 0 can only be produced in country B. And then, in Section 4.1.3 we will identify a second sufficient condition that ensures that the capital good can only be produced in country B too, therefore justifying the recourse to condition [18'] in the first step.

Let us start with the first step. From [19], we know that country A will not be able to produce good 0 if the actual relative wage, ω, is higher than the level that allows production costs to be equalized across countries, given by $T(0,r)$. Namely, when:

$$T(0,r) < \omega \qquad [20]$$

In order to ensure exclusion, condition [20] must hold for *any* economically feasible value of the relative wage. This will be immediately ensured if the required relative wage is negative:

$$T(0,r) < 0 \qquad [21]$$

as $\omega \geq 0$ would immediately imply [20] holds. We will thus show that this possibility cannot be excluded a priori. To see it, notice that, differently from $L(z)$ in the canonical Ricardian model, function $T(0,r)$ has one additional term (compare [19] to [4]). This term is the analytical expression of the absence of property (ii) – the influence on $T(.)$ of production methods of other industries – when there are capital goods. And its relevance is evident the moment one notices that its *sign* depends on the sign of $(a_{10}^B - a_{10}^A)$. While the importance of the absence of property (i) – the influence on T of income distribution – is that the absolute magnitude of this term increases with the level of the profit rate[18].

Therefore, if productivity of the consumption-good sector in country A is sufficiently low, a_{10}^A is high enough, condition [21] may hold, therefore implying that the necessary

[16] Of course, that none of this two properties hold is independent of the fact that the capital good is produced in countries A or B.

[17] Under the very simple conditions of production assumed in this section, property (ii) still holds for the capital-good sector. Nevertheless, it would *immediately* cease to hold the moment more than two basic goods were used in production.

[18] Actually, a further implication of the absence of properties (i) and (ii) is that the *shape* of function T will change when income distribution changes. The deep consequences of this on the theory of comparative advantages cannot be examined here. We hope to do this in a future contribution.

level of the relative wage that would equalize production costs across countries is negative, which has of course no sense from an economic point of view.

An alternative, perhaps more intuitive, way to present the argument can be directly derived from [17] and considering whether $cc_0 > 1$ holds. That is:

$$(a_{10}^A - a_{10}^B)p_1 > w^B l_0^B - w^A l_0^A \qquad [22]$$

[22] shows that even if country A has lower wage-costs than B (the right-hand side is positive), it will have absolute cost disadvantages in the production of the consumption good (and therefore, provided $c_1^B < c_1^A$, in the production of the two commodities) when its 'capital-goods' costs relative to B, are 'sufficiently large' (the left hand side is positive and greater than the right hand side). And the fact is that this may happen *even* when the wage rate in country A goes to zero. In this case, country A may be unable to compensate with low wages its relative 'backwardness' in the *employment* of the capital good in the consumption-good industry[19].

Finally, the reason behind exclusion could also be grasped from a third angle that emphasizes the role of production costs in trade. As we already know, exclusion is caused by the existence of a lower bound in production costs. And this lower bound arises when there are capital goods because producers of the consumption good in country A find it convenient to *import* the capital good from country B, since it is more cheaply produced there. If this is the case, from [16] and [18'], the price (cost of production) of the consumption good in country A is given by:

[19] At first sight, exclusion in the production of some sector for any level of the real wage due to technological backwardness may seem too strong a result to hold in reality; however, a quick inspection on historical literature on the subject indicates that huge and increasing – productivity differences across countries have emerged since the Industrial Revolution, thus giving substantial plausibility to our theoretical claims. Two examples will suffice to strengthen our argument from an historical perspective. If before 1820 the differences in income levels – measured in purchasing power parity – by country between the richest regions of the world, such as England, Holland, or the lower Yangtze River Valley, compared to some regions of Africa or Central Asia did not exceed the proportion of 3 to 1, 150 years later these differences rose to more than 60 (cf. Bairoch et al.,1981; Maddison, 2003). Indeed, Williamson (2011, chapter, 5) documents that it is after the revolution of transport caused by railroads and steamboats – that is, when transcontinental trade acquired gigantic proportions and started to include subsistence (or basic) goods among merchandised commodities – that the jump in European productivity levels and the fall in transport costs led to a change in the terms of trade that drastically reduced the price of industrial products; this literally destroyed manufactures in the rest of the planet, especially in the most advanced areas of Asia. Hardly any distributive change could have reversed this trend in productivity levels per worker, which in the course of few decades went from a ratio 1:1 to 20:1, as it happened, for example, with textiles produced in Manchester and Bengal. Mazoyer and Roudart (2006) further document that, decades later, something similar happened when agriculture also began to industrialize with the introduction of machinery – e.g. tractors – and increasing inputs from the chemical industry – e.g. fertilizers, herbicides, fungicides – were introduced. Simultaneously, regions with abundant endowments of fertile lands of temperate or subtropical climate such as the US Midwest, Canada, Australia, New Zealand, Argentina and Uruguay were inserted into the world market by the new transports. These changes modified the terms of exchange of agricultural production throughout the planet making production for the market of peasants who worked with reduced levels of productivity in large regions of Latin America, Asia, Africa and even Europe, unfeasible. Of course, these are just two examples, but in any case they strongly suggest the divergent trends in countries productivities that have emerged in the last 200 years.

$$c_0^A = (1+r)\left(l_0^A w^A + a_{10}^A \frac{(1+r) l_1^B w^B}{1 - a_{11}^B (1+r)} \right) \quad [23]$$

which has the implication that $c_0^A > 0$ *even* when $w^A = 0$. In other words, since the capital good is imported form B, production costs do not go to zero even if w^A would fall arbitrarily close to zero.

4.1.3. Exclusion in the production of the capital good

Let us now move to the second step and justify that recourse to [18'] in the previous subsection (the condition that shows that the capital good is produced in country B). For this, notice that, since $a_{11}^i > 0$, there is a *maximum rate of profits* that the capital-good sector in each country can afford, R^i. This is the rate that would be obtained from [16] (with $z = 1$) if wages were zero in country i:

$$R^i = \frac{1 - a_{11}^i}{a_{11}^i} \quad [24]$$

Suppose then, without loss of generality, that $a_{11}^B < a_{11}^A$. It follows that $R^A < R^B$. It can be shown that, if the international profit rate belongs to the following interval:

$$R^A < r < R^B \quad [25]$$

then, the capital good will be produced in country B at lower costs than in country A for any feasible (*non-negative*) level of wages in the latter. (Actually, the profit rate need not be necessarily uniform across countries for the argument to hold. It is enough that, due the existence of *some mobility of capital*, the profit rate in country A bears some relationship with the one obtained in country B, provided that r^A satisfies [25]).

In fact, when the level of the international profit rate, r, is higher than the maximum level affordable by the capital good-sector in country A, R^A, then it follows from [24] that $(1+r)a_{11}^A > 1$. And this means that the capital-good sector in this country would not reach international competitiveness, even when $w^A = 0$. Formally, [16] (with $z = 1$ and $i = A$) and [25] both imply:

$$c_1^A = (1+r)w^A l_1^A + (1+r)a_{11}^A p_1 > (1+r)w^A l_1^A + p_1 \geq p_1 \quad [26]$$

where the equality follows from [16], the strict inequality from $(1+r)a_{11}^A > 1$ and the weak inequality from $w^A \geq 0$. Hence, $c_1^A > p_1$ even if $w^A = 0$. And therefore [18'] is justified[20].

If we further recall that condition [21] shows that this country may be also unable to compensate with low wages its backwardness in the *employment* of the capital good, the joint result is that, *even if* full wage flexibility allows real wages to drop to zero, country A may be excluded from trade. A numerical example is provided in Appendix A.

[20] Since $r < R^B$ and $w^B > 0$ then: $p_1 = \min\{c_1^A; c_1^B\} = c_1^B$ and [18'] holds.

4.2. Many consumption goods

The extension of the argument to economies that produce many consumption goods, as in the famous paper by Dornbusch et al. (1977), is rather straightforward. Since our purpose is to show that the (negative) result of the subsection 4.1 still holds, it is enough to assume that the production of all consumption goods z requires labour and *the same* capital good, commodity 1[21]. On this basis, condition [16] still determines the normal price of the generic commodity z in country i and condition [25] still ensures that the capital good can be profitably produced only in country B. Therefore, exclusion from trade of country A can be assessed by means of a generalized version of [21], which must now hold for every possible z. This is:

$$T(z,r) < 0, \forall z \qquad [21']$$

In appendix B we provide a numerical example of this case.

Clearly, while with many consumption goods complete exclusion from trade may not be empirically relevant for most countries, what this theoretical possibility does suggest is that policies that attempt to promote national competitiveness of *some* sectors by prompting a fall in real wages, may not be successful if the country only has at its disposal backward methods of production that employ imported means of production. We will return to this point in the conclusions of the article.

4.3. Trade-exclusion with no factor mobility

We conclude this section by showing why *even* under the presence of capital goods in production, exclusion from trade is impossible when both labour and capital are immobile across countries, provided that *both* distributive variables – wages and profit rates – are flexible enough.

Consider a hypothetical situation in which country A is excluded from trade and focus first on the conditions of production of the capital good. Specifically, let us examine the possible distributive configurations that would allow country A to overcome country B in the production of this commodity. This would happen if $c_1^A = p_1$ (with $p_1 = c_1^B$ because country B is producing both goods). In other words, [18] must hold:

$$c_1^A = \frac{(1+r)l_1^A}{1 - a_{11}^A(1+r)} w^A = p_1 \qquad [18]$$

However, if the profit rate was higher than the maximum profit rate in country A (condition [25] held), the production of the capital good was precluded in country A because the capital-good sector would earn the same profit rate as in country B only under a negative wage in country A. In other words: if $r > R^A$, then $1 < a_{11}^A(1+r)$ and therefore $c_1^A = p_1$ would require $w^A < 0$ (see also [26]).

[21] The assumption that all commodities are produced with the same capital good is of course highly restrictive. But since our purpose here is *negative*, it is enough to consider this case. If any, the allowance for more capital goods would strengthen our conclusions.

On the contrary, with the full immobility of capital, the constraint imposed by [25] vanishes. Therefore, if, for the sake of argument, *both* distributive variables in country A are free to adjust, it is to be expected that r^A falls, if *necessary* [22], below R^A. Then: $1 > a_{11}^A(1 + r^A)$ will eventually hold; from [18], it follows that there are non-negative combinations (r^A,w^A) that allow country A not to be excluded in the production of the capital good. Then, due to the assumed flexibility in distributive variables, one of these pairs will be achieved[23].

Although the previous argument is enough to avoid complete exclusion from trade, it is worth making some remarks about the consumption-goods industries. The first thing to be noticed is that the fall in distributive variables in country A could allow some of the consumptions goods to reach competitiveness *before* the capital good does. The price of the generic consumption good z would be given by $c_z^A = (1 + r^A)(\, l_z^A w^A + a_{1z}^A c_1^B)$ and, since the capital good is being produced in country B, in this case it is not even necessary that $r^A < R^A$.

At any rate, as it was the case with capital as anticipated wages, there is always a distributive configuration that allows *every* industry z to reach competitiveness. This is because, with appropriate reductions in distributive variables, the capital good will be eventually produced in country A and therefore, the cost of production of any consumption good could be arbitrarily reduced. In fact, with the capital good being domestically produced, the cost of production of every commodity z is determined by:

$$c_z^A = (1 + r^A)\left(l_z^A + \frac{(1 + r^A)a_{1z}^A l_1^A}{1 - a_{11}^A(1 + r^A)} \right) w^A \qquad [27]$$

which clearly tends to zero if both r^A and w^A are arbitrarily reduced, and therefore competitors in country B can be eventually overcome.

5. Conclusions

Within standard Ricardian models of trade, real wage flexibility ensures the possibility of specialization (every country has absolute advantage in the production of some good). We have shown, however, that this result crucially depends on the possibility that commodities are produced by *unassisted labour alone*. Or, when the presence of capital goods is admitted in production (and it should!), on the further – increasingly implausible, in the current era of globalization – assumption that not only labour, but especially capital, are *completely immobile* across countries. Although, in some way or another, either of the two assumptions was always present in the literature since David Ricardo (1951), any attempt to remove them, at least partially, as would be the case with the simple acceptance of production of capital goods with a limited mobility of capital, overturns conclusions

[22] If necessary because, as it is discussed in the following paragraph, it could be the case that some consumption good industries become competitive before the capital good does and it is not required that r^A keeps falling below R^A to prevent exclusion.

[23] Which particular distributive configuration will be reached cannot be determined a priori, and is beyond the scope of the present article.

of traditional Ricardian models that have become sort of 'common knowledge' for international trade theorists.

Our theoretical results show why, contrarily to what is often heard in both mainstream and heterodox academic circles, but also in the political arena, the adjustment mechanism in income distribution that should re-establish trade imbalances, or problems of financing in foreign currency, through its impact on the competitiveness of domestic production, cannot be accepted. For we have shown that when capital mobility is duly considered, competitiveness of domestic production may not be achieved for any distributive configuration that (reasonably) excludes negative values. It explains why in these peripheral economies the fall in real wages may be able to correct external deficits *only* by means of its impact on aggregate income, that precisely induces a decrease in the level of imports of capital goods. These results are in line with the numerous empirical studies that support the conclusions of the so-called 'elasticity pessimism'.

Now, while complete trade exclusion may be considered as an implausible result, our argument can also be interpreted in terms of *sectorial,* rather than *national,* competitiveness. Consider for example those (many) countries that only manage to produce and, fundamentally, export, goods within a single industry, usually natural-resource based. Among trade theorists, it would be 'natural' to conclude that, had these countries not been endowed with abundant natural resources (had not suffered, the so-called 'curse of natural resources'), they would have managed to produce some other commodity, anyway. "A country must always possess a comparative advantage in *something*" (Clarida and Findlay, 1991, p. 31, our italics), it is, indeed, often argued. On the contrary, our argument has shown that technological backwardness may imply that, besides these primary goods, other 'somethings' need not exist.

In fact, the argument developed in the paper has shown that, from a sectorial perspective**,** international competitiveness may be hindered by the inefficiency in the *employment* of capital goods (in the model considered in the article, depicted by the consumption-goods sector) or, alternatively, in the *production* of the capital goods themselves. On the one hand, we have argued that exclusion due to the former lays in the presence of *imported* inputs, since these set a positive lower bound to production costs, which, moreover, rise with the backwardness of the sector. Furthermore, if, for the sake of argument, one disregarded the reasons behind the presence of these imported inputs, this positive lower bound would exist *even* if the assumption of free capital mobility across countries were dropped. On the other hand, the moment that at least some capital mobility across countries is admitted, we have shown that exclusion in the production of capital goods arises when the *level* of the international profit rate is higher than the maximum level affordable by the domestic production of these goods. The validity of this condition may seem, at first glance, too restrictive – or even *ad hoc* – to hold in reality. On closer inspection, however, it is not. This could be more easily grasped if one considers its limiting case – that would appear almost evident for many developmentalist scholars – in which no method of production for the capital goods is available *at all,* as witnessed in many peripheral economies. Under these conditions, the domestic production of these goods would not be possible *even* at a zero profit rate. An interesting implication of this rather

limiting, but still plausible, situation, is that the mobility of capital across countries is not even a *necessary* assumption for the results of the paper to hold.

The consequences of all this can hardly be underestimated. They strongly suggest that different strategies, which much more actively involve the participation of the State than simply 'putting the prices right', should be taken both to embark backward economies into a process of sustained growth or to induce structural change.

Appendix A: Exclusion from trade under full wage flexibility, the two-commodities case

The present appendix gives a numeral example that shows that exclusion from trade is possible under full wage flexibility when production requires the employment of a capital good and capital is mobile across countries. The available production methods are shown in Table A1.

	Country A		Country B	
z	0	1	0	1
a_{1z}^i	5/3	4/5	1	½
l_z^i	1	1	2	1

Table A1- Available production methods

The maximum profit rate affordable by the capital-good sector in each country is:

$$R_1^A = 25\% \qquad R_1^B = 100\% \qquad \text{[A1]}$$

Assume the global profit rate is $r = 50\%$. Therefore, the capital good can only be produced in country B, regardless the wage rate.

If the capital good is taken as the numeraire ($p_1 = 1$), we have that:

$$1 = c_1^B = \frac{(1+r)w^B l_1^B}{1 - a_{11}^B(1+r)} = 6w^B \qquad \text{[A2]}$$

and hence:

$$w^B = \frac{1}{6} \qquad \text{[A3]}$$

We can now proceed to examine the conditions of production of commodity 0. We determine first, the cost of production of this commodity in country B,

$$c_0^B = (1+r)(a_{10}^B p_1 + w^B l_o^B) = 2 \qquad \text{[A4]}$$

next, we determine the cost of production in country A, under a zero-wage rate:

$$c_o^A = (1+r)a_{10}^A p_1 = 2.5 > 2 = c_o^B \qquad \text{[A5]}$$

The conclusion is that country A cannot profitably produce neither commodity 0 nor commodity 1, even after w^A has dropped to zero. Therefore, A is excluded from trade[24].

Appendix B: Exclusion with many consumption goods

The present appendix shows that exclusion from trade is still possible if there are many – actually an *infinite* number of – consumption goods; that is, the generic consumption good z is indexed within the interval $[0; 1)$ while commodity 1 is the capital good. The available production methods are shown in Table B1.

	Country A		Country B	
z	z (with $z \neq 1$)	1	z (with $z \neq 1$)	1
a_{1z}^i	$5(2-z)/3$	4/5	$2-z$	½
l_z^i	1	1	2	1

Table B1- Available production methods

Note that the methods of production available in the capital-goods industries are the same as those presented in table A1. Therefore, as before, the maximum profit rates affordable by each of these sectors are the ones presented in condition [A1]. If we still assume that $r = 50\%$, the capital good will be produced in country B alone.

Now, we can examine the conditions of production of the remaining z (with $z \neq 1$) commodities. To that end, we determine first, the cost of production of these commodities in country B:

$$c_z^B = (1+r)(a_{1z}^B p_1 + w^B l_z^B) = \frac{2-9z}{6} \qquad [B1]$$

Next, we can proceed to calculate these costs in country A:

$$c_o^A = (1+r)(a_{1z}^A p_1 + w^A l_z^A) = \frac{27+9z+w^A}{6} \qquad [B2]$$

Note that $c_o^A > c_o^B$ even if $w^A = 0$. In this latter case we would have:

$$c_o^A - c_o^B = 2.5 + 3z > 0 \quad \forall z \in [0; 1) \qquad [B3]$$

Therefore, country A cannot profitably produce any commodity even when its rate of wages arbitrarily decreases, with the implication that it will be excluded from trade.

It may be finally useful to construct our $T(z; 0.5)$ function for this case, as is shown in the graph below.

[24] Note that in this case, condition [24] from the text holds, since: $(a_{10}^A - a_{10}^B)p_1 = 2/3 > 1/3 = w^B l_0^B$

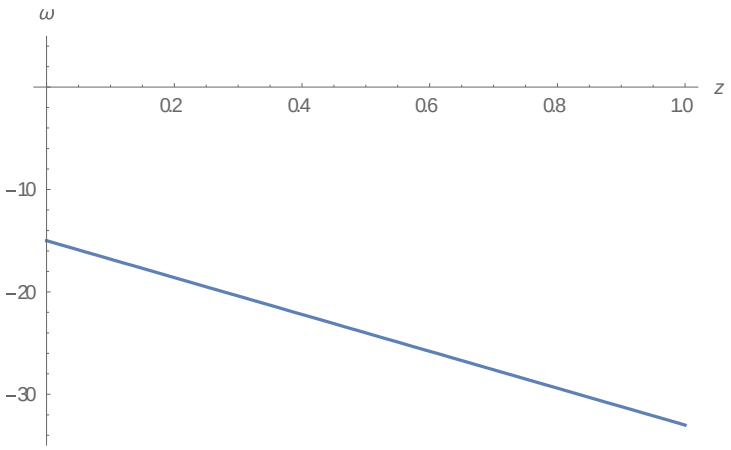

Figure B1- Exclusion from trade in the continuum-of-goods case

The graph shows that the maximum relative wage ω required for any of the infinite number of consumption goods to be produced less costly in country A than in country B, is *negative*, with the implication that for any (economically meaningful) level of the wage rate in country A, this country will be excluded from trade.

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