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An Appraisal of Alternative Ricardian Trade Models

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An appraisal of alternative Ricardian trade models

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Abstract. A prevalent feature of the global economy is the relevance of trade in intermediates due to production fragmentation. This phenomenon has led to the revival and development of trade models that include inter-industry relations. A wide variety of Ricardian trade models cope with this feature. In this article, we develop a Sraffa-Leontief framework to compare and appraise these models. The models are distinguished by their underlying theory of distribution and the assumptions about the degree of international capital mobility. We compare the predicted effects on employment and the distribution of national income. Moreover, we assess if the model assures the existence of a complete trade pattern, i.e. if it can assure that all countries engage in trade (like the principle of comparative advantage predicts). It follows from our appraisal that it is not warranted that all countries can engage in international trade, even if they want to. In other words, if allowed to work, the "strong balancing forces" may not make a country internationally competitive when there is production fragmentation.

Resumen. Un rasgo prevaleciente de la economía global es la relevancia del comercio de insumos intermedios debido a la fragmentación de la producción. Este fenómeno ha conducido al resurgimiento y desarrollo de modelos de comercio internacional que incluyen relaciones interindustriales. Una gran variedad de modelos Ricardianos lidian con esta característica. En este articulo, desarrollamos un marco Sraffa-Leontief para comparar y evaluar estos modelos. Los modelos se distinguen según la teoría de la distribución subyacente y los supuestos acerca del grado de movilidad internacional del capital. Comparamos sus predicciones sobre los efectos del comercio internacional sobre el empleo y la distribución del ingreso. Asimismo, evaluamos si el modelo garantiza la existencia de un patrón de especialización completo, es decir, si puede asegurar que todos los países participen del comercio (tal como predice el principio de las ventajas comparativas). A partir de nuestra valoración concluimos que esto no está asegurado, incluso si un país lo desee. En otras palabras, si se permite que funcionen, las "poderosas fuerzas de equilibrio" pueden no hacer que un país sea competitivo internacionalmente en el contexto actual de fragmentación de la producción.

An appraisal of alternative Ricardian trade models

1. Introduction

The geographical landscape of production has changed in recent years. Technological progress and institutional changes have contributed to reducing artificial and natural trade barriers, increasing the type and quantity of products that countries can exchange. Firms now source inputs from different locations or relocate abroad production stages to minimise costs and compete in global markets. Trade patterns are now more complex than exchanges in finished products. Since there is increasing specialisation in the different tasks and stages of producing goods and services, international trade in intermediate inputs has become increasingly relevant.

The awareness of the growing role of intermediate input trade led to the revival and development of trade models that include inter-industry relations (Jones 2000, Deardorff 2001). An advantage of linear input-output technology is that it is the basis of alternative economic theories. Therefore, it constitutes a bridge, a common language, on which to establish a dialogue between them.[1]

A fruitful dialogue is a crucial first step in assessing the effects of trade in what we may call the "age of global supply chains". For a broad group of scholars, outsourcing and offshoring continue to be essentially trade phenomena, and standard theory—i.e., the comparative advantage principle—continues to be relevant for justifying the gains of trade and determining trade patterns (see Brondino 2021).

In mainstream trade theory, international commerce affects the national income and its distribution. It does not affect factors' employment levels. Colloquially, it does not lead to permanent losses of jobs. However, job loss due to growing international competition is a major concern in public opinion. For example, Paul Kennedy asks, 'What

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[1] In this regard, in his preface to András Bródy's 'Proportions, Prices and Planning', Leontief comments:

> While the driving and the steering mechanisms of centrally planned socialist and quasi-competitive free-enterprise economics are, in principle at least, entirely different, the basic structures of both systems can be described in terms of the same kind of parameters. (Bródy 1970, p. 7)

Also, Backhouse (2014) argues that using linear models by Cambridge UK economists in their critique of capital theory played a crucial role in engaging MIT economists like Samuelson and Solow in the debates.

if there is nothing you can produce more cheaply or efficiently than elsewhere, except by constantly cutting labor costs?' (quoted in Krugman 1996, p. 79).

Mainstream economists always rebut this argument by recurring the principle of comparative advantage.[2] According to Krugman, Kennedy's question is based on a false analogy between countries and business. It is false because 'international competition does not put countries out of business' (Krugman 1996, p. 89). He continues arguing that

> There are strong equilibrating forces that normally ensure that any country remains able to sell a range of goods in world markets, and to balance its trade on average over the long run, even if its productivity, technology, and product quality are inferior to those of other nations. (Krugman 1996, p. 89)

Krugman recalls David Hume's price-specie flow mechanism as the basic explanation of how balance may be restored. As is well-known, Hume's mechanism is based on a case where currencies are backed by gold. An uncompetitive country would suffer a drain of gold, decreasing its money supply. This fall would lead to lower prices and wages, cheapening the goods and services produced in that country and restoring competitiveness.

Alternatively, Bertil Ohlin (1967, p. 7) describes the mechanism in the case of paper currency. In that case, if a country cannot export, there is no supply of foreign currency (Ohlin assumes away international borrowing/lending), and it cannot pay for its imports. The country's exchange rate would be forced up, raising foreign prices in terms of the home currency. Eventually, the country would be able to export sufficiently to pay for its imports.

Whichever analysis of the equilibrating forces is considered, it is usually discussed within exceedingly simple trade models, like the pure-labour Ricardian model or the two-primary factor Heckscher-Ohlin-Samuelson model. However, given the growing recognition of the role of intermediate inputs, it is natural to question the extent to which these propositions hold in the general case.

This paper develops a theoretical structure that can fit alternative Ricardian trade models, put them into dialogue and compare their predictions about the effect of trade.

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[2] To Kennedy's question, Krugman (1996, p. 80) replies that '[the] concern that your country may have nothing it can produce more efficiently than anyone else is the classic fallacy of confusing *comparative* advantage with *absolute* advantage'.

We pay special attention to the possibility of desertification or exclusion, a very extreme case in which a country is out-competed in all markets and has zero output and employment levels with free trade.

The term "Ricardian" is used to circumscribe the analysis to models that focus on differences in technology as the primary source of international trade. Labour is the only primary, non-produced input in the economic system. Countries have different methods of production and productivity levels. We employ two dimensions for classifying the models: whether the model assumes fixed or variable wages and whether it assumes capital mobility. The classification is inspired by Brewer's (1985) pioneering work. Unlike Brewer, we consider a production model with labour and produced means of production from the outset.

It follows from our appraisal that it is not warranted that all countries can engage in international trade, even if they want to. In other words, if allowed to work, the "strong balancing forces" may not make a country internationally competitive when there is production fragmentation.

After this introduction, the following section discusses the differences between national and international competition. Section 3 presents the basic linear production model and some relevant definitions. Section 4 analyses the structure of the alternative closures of the model; Subsection 4.1 is devoted to neoclassical models, while Subsection 4.2 analyses classical models. Section 5 discusses the likelihood of desertification in the case of variable wages. The last section provides some concluding remarks.

2. National versus international competition

Most economic theories, including the neoclassical one, envision free competition within a single market or nation as a process in which selling prices tend to equal production costs. In the words of Adam Smith, as a process in which market prices gravitate toward natural prices (Smith 1904, I.7.IV). The natural price is sufficient to pay each primary input their normal rental.[3]

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[3] This definition implies that the competition process also leads the owners of primary inputs of the same quality to earn a similar rental. The forces determining these normal rentals depend on the theory we consider.

This tendency results from the action of self-interest individuals, especially from firms seeking to maximise their return rate over the value of invested capital. In the absence of severe entry and exit barriers, firms reinvest their capital in activities that pay the highest profit rate. However, incumbent firms will not be willing to give up their market shares. Instead, they are constantly seeking to increase it. Therefore, there is fierce competition within industries among firms to extend their market shares.

Firms increase their market shares by selling at lower prices than contestants in a competitive setting.[4] To do so, they need to reduce production costs. Costs break down into wages, raw materials and capital goods. Individual firms cannot diminish the wage rate and the prices of inputs.[5] Instead, they must continually increase the efficiency of these inputs. Technically, that means reducing the inputs (labour, materials, capital goods) required per output unit by introducing new production processes. Firms unable to improve efficiency are driven out of the market.

As long as we deal with domestic markets, economic theories agree that absolute costs regulate competition. Consider a country with two separate regions, one more efficient than the other.[6] Suppose that development in infrastructure allows exchanges between regions. Without any protection, firms from the high-cost region face a declining share in the national market. Their lower efficiency levels make it difficult to sell outside their region, and the regional market is more vulnerable to products from low-cost firms. The high-cost region tends to have declining production and increasing "imports" relative to the low-cost one.

The competition process would lead to increasing unemployment in the high-cost region. In neoclassical theory, involuntary unemployment cannot persist over time if the labour market is perfectly competitive. However, unemployed workers would not accept real wage reductions. Instead, they would migrate to the low-cost region where the labour demand is growing. Likewise, high-cost firms would not allow a profit rate reduction and would reinvest their capital in the low-cost region.

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[4] Another strategy could be product differentiation, by improving quality or with advertising.

[5] Firms with market power could exert some pressure to reduce wages and the prices paid for inputs, but in the absence of entry and exit barriers, workers and suppliers will take their business elsewhere.

[6] The example is based on Shaikh (1996).

Without a public policy to correct regional imbalances, the final result is a shift in employment and output distribution. Employment nationwide remains unchanged. The low-cost area absorbs all of the unemployed. The high-cost region ends up deserted.

Disagreements emerge when we move the discussion toward international markets. The nature of competition and its effects are different. The reason is that the cultural-institutional division of countries restricts the movement of labour and capital. Ricardo (1951) was one of those who best articulated this idea, and it has become the foundational stone of trade theory.[7] In Ricardo's analysis, differences in technology among countries are the primary source of international trade. Indeed, a wide variety of models share this "Ricardian" feature. However, the effects of international competition differ according to which theory of distribution is adopted; more precisely, whether the real wage is fixed or variable.

For neoclassical theory, the wage rate—the labour rental—is determined by demand and supply, like any other commodity price. Therefore, it is (and should be) variable.[8] Resuming the example, assume that we are now dealing with countries instead of regions. With free trade, a country with initial absolute disadvantages would have increasing unemployment that cannot reduce by forcing the migration of workers. Involuntary unemployed workers exert downward pressure on the wage rate, strengthening international competitiveness and reducing unemployment.[9] Alternatively, if money wages are "sticky", the country with an absolute disadvantage would initially have a trade deficit. The increase in demand for foreign currency to pay for imports depreciates the domestic currency against the foreign currency. Exchange rate depreciation discourages imports, promotes exports, and closes the trade deficit. The decline in money wages or currency devaluation increases the *real* exchange rate and improves competitiveness. These are the "strong equilibrating forces" to which Krugman refers.

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[7] If all factors are internationally mobile, there would be no need for a theory of international value.

[8] Formally, it is an endogenous variable in general equilibrium theory. Income distribution given equilibrium prices is a subsidiary outcome. It merely reflects endowments, consumer preferences, and technology of a country at a given period.

[9] If the economy is small and takes international prices as given, real wages also fall. Lowering production costs allows firms to compete and increase their output and labour demand—the usual assumption is that firms from small economies face an infinitely elastic demand at the prevailing international price. Conversely, suppose the economy is large enough to affect international prices. In that case, reductions in money wages may leave unaffected the real wage, but reduce home wages in terms of foreign wages and selling prices, increasing real wages abroad.

In opposition, based on the insights of classical political economy, a strand of literature argues that the wage rate does not serve as an adjustment variable. It is an institutionally given variable relatively unresponsive to demand and supply imbalances. If the wage remains more or less invariant, international competition leads to persistent changes in employment and output levels. In the case of a country with an absolute disadvantage, international competition leads to higher unemployment and lower output.

As we stated above, Ricardo thought that capital was also internationally immobile. Capitalists are insecure and hesitant to invest in foreign countries. In the words of Ricardo:

> Experience, however, shews, that the fancied or real insecurity of capital, when not under the immediate control of its owner, together with the natural disinclination which every man has to quit the country of his birth and connexions, and intrust himself with all his habits fixed, to a strange government and new laws, check the emigration of capital. These feelings, which I should be sorry to see weakened, induce most men of property to be satisfied with a low rate of profits in their own country, rather than seek a more advantageous employment for their wealth in foreign nations (Ricardo 1951, pp. 136–137)

Although this opinion might have had a sense at the beginning of the nineteenth century, there is broad consensus that capital funds have long been and are now increasingly moving among countries seeking the maximum possible return rate. Several Ricardian models accept this state of affairs and analyse the effects of trade in the context of capital mobility.

Crossing these two dimensions, we can classify the alternative Ricardian models. To compare the predictions of each model, we will develop a basic linear model with the following premises:

(1) All commodities (finished, intermediate and capital goods) are tradable.
(2) There are no trade barriers of any kind (free trade).
(3) Labour is internationally immobile.

3. A basic linear production model

§1. Let us start by establishing the basic features of a national production system. First, every industry produces a single commodity. That is, there is no joint production. Second,

the production of commodities requires themselves as inputs and labour, which is the sole primary, non-produced input. Third, produced inputs are consumed entirely within the production cycle (which is the same for all commodities). In other words, all capital is circulating. Fourth and final, there is only one production process for each commodity.

The system is represented by the following objects. Firstly, the "national" make table lists all the commodity output by each production process or method. We consider a *pure* make table where every production process delivers one unit of any commodity, and every commodity is produced by some production method. If there are N commodities—and because we assume single production, the pure make table is square, with dimension $N \times N$ and indistinguishable from the identity matrix, $\mathbf{I}$.

Secondly, the "national" use table lists the commodities required as inputs for each production process. It is also square, of dimension $N \times N$, and it is represented by $\mathbf{A} = [a_{ij}]$, where a_{ij} be the quantity of commodity i used as an input in the production process of one unit of commodity j.

Finally, the labour coefficients vector lists the labour required by each production process. We may represent it by $\mathbf{l} = [l_j]$, with l_j being the amount of labour required for producing one unit of commodity j.[10]

National income is distributed between wages and profits. The wage bill is allocated proportionally to the contributed quantity of labour, while profits are distributed in proportion to the value of produced inputs advanced as capital. Domestic competition leads to uniform wage and profit/interest rates.[11]

Letting $\mathbf{p} = [p_j]$ be the vector of prices, where p_j is the money value or nominal price of one unit of commodity j; w be the money wage rate; and r be the profit/interest rate, we can represent the national "equilibrium" or "natural" price system as:

$$\mathbf{p}^\top = w\mathbf{l}^\top + \mathbf{p}^\top \mathbf{A}(1 + r) \tag{1}$$

[10] All vectors are column vectors. Transposition is indicated with the sign ⊤, and diagonalisation with the circumflex accent above the vector.

[11] As Petri (2021, p. 157) comments, the interest rate in neoclassical theory has a similar meaning to the profit rate in classical analysis. In the former, "profits" are the remainder after paying all costs, including interest on the capital employed, and are temporary. Thus, the zero-profit equilibrium condition is what, based on the classical approach, we could consider the case where the interest and profit rates are equal.

This price system is *undetermined* because, after defining the numéraire, the number of unknowns exceeds the number of equations by one. However, note that the process of commodity price formation is the same in neoclassical and classical theories (see Petri 1989). The difference lies in the circumstances involved in determining wage and profit rates. In other words, in the theory of distribution adopted. Formally, this consists in discussing alternative closures of system (1).

§2. When looking at the global economy, there is more than one method to produce each commodity. Specifically, if the number of countries is G, the number of available production processes is NG. We may unambiguously call them geo-industries. The *global* use table has a dimension of $N \times NG$, and it is built by binding the national use tables:

$$\widetilde{\mathbf{A}} = [\mathbf{A}^1 \quad \cdots \quad \mathbf{A}^G]$$

Additionally, we can define the *global* labour employment table. Its construction differs from the global use table since labour is not homogeneous across countries; the *quality* changes depending on the nationality of workers. Thus, the table has G rows according to each type of labour, and NG columns. Finally, each production method uses only workers from its location. Then, we may represent the global labour employment table as:

$$\tilde{\mathbf{L}} = \begin{bmatrix} \mathbf{l}^{1\top} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \mathbf{l}^{G\top} \end{bmatrix}$$

The main challenge of trade theory is determining the trade pattern (i.e., the location of economic activities) and the global price ratios at which commodities are exchanged. As it is well-acknowledged, this problem can be approached as a problem of choice of technique (Mainwaring 1974). In the analysis of the choice of technique,[12] the set of all production methods is called the *technology*. Moreover, a *technique* is a grouping of production methods, one for each commodity. In our setting, there are G methods to obtain each commodity; thus, the number of alternative techniques in the global economy is $\prod_{j=1}^{N} G = G^N$.

The criterion of choice is *profitability*, and it is consistent with the competition process discussed above. International competition leads to a global technique that

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[12] See Pasinetti (1977, chap. VI) or Kurz and Salvadori (1997, chap. 5).

produces each commodity at minimum cost. This technique is referred to as the dominant technique.

Letting $\bar{\mathbf{p}} = [\bar{p}_j]$, $\bar{\mathbf{w}} = [\bar{w}^h]$ and $\bar{\mathbf{r}} = [\bar{r}^h]$ denote the ruling prices, wage and profit rates in the efficient global technique, all measured in a common international currency. The subscript h stands for "country h", with $h = 1, \ldots, G$. The following conditions are met for each commodity j:

$$\begin{cases} \bar{p}_j = \bar{w}^h l_j^h + \sum_i \bar{p}_i a_{ij}^h (1 + \bar{r}^h), & \text{for some country } h. \\ \bar{p}_j \leq \bar{w}^g l_j^g + \sum_i \bar{p}_i a_{ij}^g (1 + \bar{r}^g), & \text{for all other countries.} \end{cases}$$

The condition states that, at the ruling prices, wages and profit rates, the j-producing activity from country h does not incur extra costs; therefore, commodity j is produced in country h.

The resemblance between trade analysis and the choice of technique only goes this far. Trade theory is more circumscribed. The interest lies in finding a global distributive configuration that allows *all* countries to participate in international trade. It is here where the contrasting views about the effects of international competition precisely lie. The profitability criterion is based on absolute advantage. Thus, the dominant technique may exclude one or more regions from production, leading to *desertification*. For most scholars, the trade story does not end here. As we have seen, in those regions, income distribution will change endogenously so that some industries become internationally competitive. This adjustment process underlies the notion of comparative advantage. Thus, trade theory is interested in finding *complete* or *shared* trade patterns.

A complete trade pattern satisfies the following conditions (Shiozawa 2007, p. 151):[13]

(i)   Each country has at least one competitive process.

(ii)   Each competitive process belongs to one country only.

Condition (i) establishes that each country can compete in at least one sector, and condition (ii) tells that if so, the country will be the exclusive producer and exporter.

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[13] Actually, Shiozawa (2007) speaks of a "strongly-shared" pattern of specialisation. A "shared" pattern would be the case where only condition (i) is verified. This distinction does not affect the development of our argument.

Once a country specialises, the national make table is no longer the same as the identity matrix. Only the industries whose production method is part of the global technique remain operational. Since the trade pattern is complete, all after-trade national make tables have at least one positive element. By binding them row-wise, a global *activity* table is obtained. Its dimension is $NG \times N$; the rows list the geo-industries, and the columns represent the commodities.

Let $\mathbf{X} = [x_{kj}]$, where $x_{kj} = 1$ if the kth geo-industry produces commodity j, and zero if not. Then, the complete trade pattern has the following elements:

$$\widetilde{\mathbf{A}}\mathbf{X} = \bar{\mathbf{A}}$$
$$\tilde{\mathbf{L}}\mathbf{X} = \bar{\mathbf{L}}$$

Where $\bar{\mathbf{A}}$ and $\bar{\mathbf{L}}$ are the *shared* use and labour coefficients tables, respectively. They represent the resulting efficient trade pattern.

The last element we need to represent the global equilibrium price system is the vector of sectoral profit rates. This vector lists the profit rates paid in each sector in the complete trade pattern. Many profit rates in this vector will be repeated in the realistic scenario that the number of commodities is larger than the number of countries. If any country produces more than one commodity, the rate of profit in these sectors must be the same due to nationwide competition. The number of unique profit rates in the complete trade pattern is G. Letting $\mathbf{r}_n = [r_j]$, we can now represent the global equilibrium price system as:

$$\bar{\mathbf{p}}^\top = \bar{\mathbf{w}}^\top \bar{\mathbf{L}} + \bar{\mathbf{p}}^\top \bar{\mathbf{A}}(\mathbf{I} + \hat{\mathbf{r}}_n) \tag{2}$$

Like system (1), system (2) has N equations. However, the number of unknowns is N prices plus G money wages plus G interest/profit rates. Therefore, it is undetermined. In what follows, we will discuss the alternative theoretical closures of this system.

We will not follow a historical timeline. Indeed, our starting point will not be the analysis of Ricardo but what we can call the *neoclassical-Ricardian* model. The reason for this choice is straightforward: most scholars associate the Ricardian trade theory with the starting models taught in most international trade textbooks, whether introductory or intermediate/advanced. Therefore, it is natural to start the discussion with the most familiar version, which is also the simplest.

4. Alternative closures

4.1.   Neoclassical theory

§1. The canonical neoclassical-Ricardian model assumes that the production of goods requires labour exclusively, without any assistance of intermediate and capital products, and has constant returns to scale. Additionally, the interest rate is assumed to be zero.[14] Thus, national income consists exclusively of wages. Based on these assumptions, the national price system becomes:

$$\mathbf{p}^\mathsf{T} = w\mathbf{l}^\mathsf{T}$$

Likewise, the system of international values is:

$$\bar{\mathbf{p}}^\mathsf{T} = \bar{\mathbf{w}}^\mathsf{T}\bar{\mathbf{L}} \tag{3}$$

System (3) has N equations and $N + G$ unknowns. There is an eloquent way to interpret this underdetermination. Suppose that the pair $(\bar{\mathbf{p}}^*, \bar{\mathbf{w}}^*)$ ensure a shared trade pattern. However, given these values, one or more countries run a trade deficit. In that case, unemployment emerges, the wage falls, and, consequently, so does the price of their exports. Given import prices, the trade balance is worsened if the quantities traded remain fixed. Therefore, it is not enough to determine the prices; the quantities traded must also be determined. This indeterminacy led John Stuart Mill to introduce the notion of "reciprocal demand" and later the problem was transformed into a fully-fledged general equilibrium analysis.

The way to close the model is the following. Firstly, we add an extra set of G equations representing the clearing of national labour markets. The supplies of labour of each country are taken as given. Secondly, we include an extra set of N equations that represent the clearing of global commodity markets. The number of equations now becomes $2N + G$, and the number of unknowns increases by N (the commodity outputs). Finally, defining a numéraire eliminates one variable, and Walras' Law eliminates one

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[14] Adopting these assumptions implies excluding capital and the discussion of its degree of mobility.

equation. Therefore, we end up having $2N + G - 1$ equations to determine $2N + G - 1$ unknowns.[15]

§2. The first step in making the analysis more complex is to lift the assumption that production requires only labour and to bring reproducible intermediate and capital goods into the picture. Let us first note that if we were to assume that produced inputs are non-tradable, then we are back to the pure labour case, but instead we should speak of total or vertically integrated labour coefficients. Because of this equivalence, this assumption is not relevant. At the same time, it is unrealistic if products can have intermediate and final uses. In the case where all products are traded, the system of international values becomes:

$$\mathbf{\bar{p}}^\top = \mathbf{\bar{w}}^\top \mathbf{\bar{L}} + \mathbf{\bar{p}}^\top \mathbf{\bar{A}}$$

As can be seen, the number of unknowns and equations does not change. Therefore, the problem of the existence and determination of a shared trade pattern is similar to the pure labour case. The strong equilibrating forces, specifically wage flexibility, still ensure that all countries specialise and participate in the shared trade pattern.[16] However, unlike the canonical model, the case with intermediate inputs introduces some complications that deserve to be highlighted.

In the pure labour model, it is possible to rank the degree of competitiveness of industries according to their relative labour productivity. Such a ranking has predictive power: if industry j in country h is competitive in the international market, then industries with higher labour productivity must also be competitive. Introducing tradable intermediates undermines the possibility of ranking industries strictly based on labour productivity: one must also consider the price of these intermediate products, and the price one must consider is the international price,[17] which is only known after trade takes place. Thus, any type of ranking before trade is bound to fail and ranking commodities after trade is trivial. The problem was originally noted by McKenzie (1953), Jones (1961) and Amano (1966). Jones (1980) sums up the problem succinctly: there is no way to eliminate relative prices from the definition of comparative advantage. The discussion

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[15] Counting equations and unknowns is simply a consistency check. The proof of existence of equilibrium requires further analysis that will not be addressed in the paper since it is out of its scope.

[16] We leave the discussion of this proposition for later.

[17] Or the price that firms pay after taking into account natural and artificial trade barriers.

was recently taken up by Deardorff (2005), Baldone *et al.* (2007), Dvoskin and Ianni (2021) and Brondino and Dvoskin (2021, sec. 5).

§3. The last step we take to conclude the exposition of the neoclassical interpretation of Ricardo is to admit a rate of interest greater than zero. The justification is that there is a time lag between the transformation of inputs into outputs. For neoclassical theory, this implies introducing the dimension of time and discussing the problem of capital accumulation. For this reason, this case is also known as a time-phased Ricardian system (Samuelson 1975).

The Ricardian time-phased system differs from the standard Heckscher-Ohlin model concerning the specification of capital. In the latter, capital is a primary factor; it is a single, malleable and indestructible good whose endowment is given. Conversely, capital goods are "produced means of production" in time-phased Ricardian systems. The optimal "quantity" of capital is endogenously determined (Chacholiades 1985).

The national price system is formally the same as (1)—however, its interpretation changes. A uniform interest rate implies that all capital goods pay the same net rate of return. Such a case can only happen in the steady state, where the stock of capital goods is adequate to reproduce the net output, and both grow at the same rate (usually equal to the population's growth rate). Society is satisfied with the per capita consumption and capital levels when the interest rate equals the subjective discount rate (or rate of time preference), δ. Therefore, we may write:

$$\mathbf{p}^\top = w\mathbf{l}^\top + \mathbf{p}^\top \mathbf{A}(1 + \delta)$$

Contrary to the previous cases, countries' relative prices may now differ for an additional reason: consumer preferences. The neoclassical theory usually prefers to focus on and separately analyse the various trade sources. To follow this approach in this context, we have two options. The first is assuming that countries have equal subjective discount rates. In that case, $\delta^h = \delta$ for all $h = 1, \dots, G$. This option is like assuming unrestricted international capital mobility. The second is assuming that countries have the same technology, like in the standard Heckscher-Ohlin model. However, this option strips the analysis from a fundamental Ricardian feature, leaving only the idea of labour as the sole primary factor. Nevertheless, it was the preferred path since one of the purposes of these models was to provide an answer to the unsatisfactory treatment of capital in the

Heckscher-Ohlin model, which was subject to harsh criticism during the 1970s.[18] Notably, Samuelson (1965, p. 35) confesses that in his works on the Heckscher-Ohlin model, he 'quietly replaced the venerable pair labor and capital by labor and land, hoping thereby to sidestep some of the intricacies involved in any discussion of capital'.[19]

After following the second option, the international price system becomes:

$$\bar{\mathbf{p}}^\top = \bar{\mathbf{w}}^\top \bar{\mathbf{L}} + \bar{\mathbf{p}}^\top \bar{\mathbf{A}} \left(\mathbf{I} + \widehat{\boldsymbol{\delta}}_n \right)$$

The interpretation of $\boldsymbol{\delta}_n$ is the same as $\mathbf{r}_n$. The number of unknowns and equations does not change concerning the previous cases because the time preference rates are given. As before, wage flexibility ensures that all countries participate in international markets and are part of the shared trade pattern.[20]

In all cases of the neoclassical-Ricardian analysis that we have reviewed, wage flexibility plays a key role. Backward economies can compensate for their higher labour and intermediate input requirements by reducing wages. If the balancing forces of supply and demand work properly, the country will enjoy full employment and participate in international markets. However, the latter does not mean the free-trade wage is lower than in the autarky case in real terms. On the contrary, the analysis predicts that it will increase with trade (Samuelson 2001, Deardorff 2005). Moreover, if the wage can command a larger share of net output after specialisation, the wage share in national income will also increase.

4.2.   *Classical theory*

§1. Inspired by the works of Sraffa (1951, 1960), a group of authors suggest an alternative reading of the classics and object to the supply-and-demand theory of distribution. In this reading, the wage rate is an institutionally determined variable. Emmanuel (1975) provides some empirical arguments against the neoclassical view of competitive wage-setting that are worth recalling:

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[18] Steedman (1979) brings together most of the critical articles.

[19] See Smith (1984) for a review of these models.

[20] There will also be capital accumulation and decumulation in the traverse to the new equilibrium position (see Chacholiades 1985). Incidentally, Mainwaring (1974) has shown that if there are productivity differences between countries, in some cases, free trade may lead to lower consumption per worker in the new steady state (see also Gram, 2010). This curious result does not contradict the fact that the dominant trade pattern (technique) minimises costs.

(1) The reasoning implies an infinitely flexible wage, susceptible to fluctuation without limits in both directions. However, there is a lower bound, absolute and exogenous, which is the physiological wage.

(2) The wage rate cannot result from the balance between demand and supply, like the price of any commodity. Such a balance presumes symmetry between buyers and sellers and freedom to celebrate the contract if the price is reasonable or not. However, workers cannot stock their labour services. Therefore, they have less bargaining power. To quote Adam Smith,

> A landlord, a farmer, a master manufacturer, or merchant, though they did not employ a single workman, could generally live a year or two upon the stocks which they have already acquired. Many workmen could not subsist a week, few could subsist a month, and scarce any a year without employment. In the long-run the workman may be as necessary to his master as his master is to him; but the necessity is not so immediate (Smith 1904, p. I.8.XII)

> The bargaining between workers and firms depends more on formal and informal norms than the market environment. Such conventions reflect the power relations between productive classes.

(3) The wage rate is negotiated and fixed on a national scale and usually on a professional basis. A supply-and-demand determination of the wage rate is only conceivable in the very-short run, on a sectoral scale, and within reduced geographical boundaries.

In the classical theory of prices, income distribution and technology are the starting points for determining relative values (Garegnani 1984). Analytically, the wage rate has logical precedence over other prices.

Classical economists classify the circumstances that intervene in the wage rate determination on a national scale into two groups.[21] The first includes institutional and cultural factors that define a consumption pattern society considers necessary for the subsistence of workers and their families, beyond physiological survival. The value of this basket constitutes a reference to money wage claims. It also defines a lower bound below which the real wage cannot persistently stay (Marshall 1980).

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[21] See Stirati (1991) or Petri (2021, chap. 1) for a thorough discussion.

The second group comprises the circumstances influencing the relative wage-bargaining power between employers and employees. As the quote from Adam Smith reveals, employers have a stronger position than workers under normal circumstances. If the economy is near full employment or growing fast, wages may rise above subsistence. Nevertheless, as Kalecki (1943) warns, employers can petition adjustment policies that increase unemployment to discipline workers' claims. Other authors suggest that profit squeezes reduce investment, leading to a slump and unemployment.

Since the subsistence wage has, so to speak, a moral meaning, employers do not have an incentive to set the wage rate below this level as it could lead to social disruption. Also, unemployment does not exert downward pressure on wages unless it is massive. Even so, the reduction would be slow and not indefinite.[22]

These considerations led classical authors to suppose that the wage rate gravitates around its subsistence level.[23] Formally, let d_j be the amount of commodity j consumed by a worker and $\mathbf{d} = [d_j]$. The money wage must be sufficient to purchase the worker's consumption basket $\mathbf{d}$:

$$w = \mathbf{p}^\mathsf{T}\mathbf{d}$$

Introducing this definition in equation (1) and following the classical conception that wages are part of the capital advanced in production, we get:

$$\mathbf{p}^\mathsf{T} = \mathbf{p}^\mathsf{T}(\mathbf{d}\mathbf{l}^\mathsf{T} + \mathbf{A})(1 + r)$$

As we can see, taking the workers' consumption basket as given removes an unknown from the national price system and becomes determined. Relative prices and the rate of profit are determined interdependently. Because of this way of closing the system, it can be said that the wage has logical precedence.

§2. Let us define $\mathbf{B} \equiv \mathbf{d}\mathbf{l}^\mathsf{T} + \mathbf{A}$ as the *extended* national use table, which lists the total amount of commodities required as inputs by each production method and workers' consumption. Likewise, we can define $\bar{\mathbf{B}}$ as the extended shared use table.[24] Based on this definition, the international price system in this setting becomes:

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[22] Drastic wage cuts may happen in exceptional circumstances that involve radical political changes, such as a military coup accompanied by harsh repression of the working class.

[23] Another prevalent argument in the time of the classics was that based on Malthus' population theory.

[24] Note that $\widetilde{\mathbf{B}}$ is the extended global use table. Post-multiplying it by $\mathbf{X}$ gives $\bar{\mathbf{B}}$.

$$\bar{\mathbf{p}}^{\mathsf{T}} = \bar{\mathbf{p}}^{\mathsf{T}}\bar{\mathbf{B}}(\mathbf{I} + \hat{\mathbf{r}}_n) \qquad (4)$$

System (4) has N equations and $N + G - 1$ unknowns (after defining the numéraire). Here again, a problem of underdetermination arises. Ricardo does not offer a solution to this problem. Despite this, part of Ricardo's interest is to analyse the effect of international trade on the national profit rate. Therefore, system (4) offers a more faithful interpretation of Ricardo's analysis than the neoclassical interpretation. The national profit rates will adjust to determine a complete trade pattern in this setting. Moreover, if the commodities traded enter the wage basket, the rate of profit increases with trade and specialisation because their prices fall.

Let us consider a simple example to grasp the idea.[25] Assume a global economy of two countries, say Germany and Poland, and two commodities, say corn and iron. Taking corn as the numéraire, suppose that the price of iron is 8 in Germany and 15 in Poland under autarky. Given these differences, German merchants could ship one ton of iron to Poland in exchange for fifteen bushels of corn. Then, sell this corn at home and get 1.875 tons of iron. The return rate of this operation would be 87.5% (ignoring transport and transaction costs). The same arbitrage opportunity is open to Polish merchants.

These opportunities eventually vanish as the relative prices converge to a single international commodity price ratio. Relative prices are bound to change because of the merchants' behaviour. With free trade, corn producers from Poland can import iron from Germany and raise their profit rate. Polish capital and workers flow to the corn industry, making Poland exclusively produce and export corn. A same story can be told for the iron industry in Germany.

To sum up, two main propositions follow from this analysis. First, the international commodity price ratio will lie between the range of autarky relative prices, although it is impossible to determine its exact value without further information. Second, within this range, only the corn-producing industry in Poland and the iron-producing industry in Germany are profitable. Additionally, the profit rate after trade rises in each country.

A visual aid may help understand these propositions. Figure 1 shows the profit rate in each sector as the relative price varies. Since corn is the numéraire, as the price of

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[25] See also Kurz (2017).

iron increases, the corn-producing industry gets a lower rate of profit. Conversely, the profit rate in the iron-producing industry rises. The blue lines correspond to Poland, and the red lines to Germany. The intersection of the same colour lines gives the equilibrium relative price and profit rate under autarky. A relative price higher than the equilibrium one would lead producers to specialise in iron. Contrariwise, if it is below, producers specialise in corn. As seen in the figure, if the international commodity price ratio lies between 8 and 15, German producers earn a higher profit rate by investing in iron production. Polish producers are equally lucky by investing in corn.
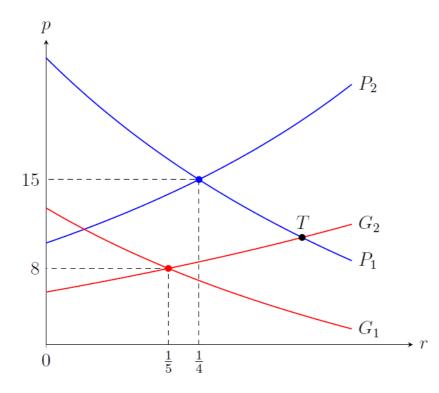

Figure 1. Sectoral relative price-profit rate curves. Source: Own elaboration based on Gibson (1980).

§3. There is an extensive discussion about the indeterminacy of the terms of trade in Ricardo's theory and how to solve it. As we have claimed, the neoclassical interpretation implies a radical departure from Ricardo's theory of distribution. We now proceed to discuss alternative closures within the classical analysis.

The first extension is due to Parrinello (1979). The author considers the two-industry model extensively used in the 1960s during the capital controversies to discuss growth and distribution in a closed economy. However, the insight of the analysis can be

extended to a general case. Parrinello respects all of Ricardo's assumptions:[26] real wages are given, and there is no (financial) capital mobility. The main addition is introducing a classical savings function: workers do not save, and capitalists save a fraction of their profits. Given the macroeconomic equilibrium condition that savings equal net investment, he derives the well-known relationship between the rates of profit and growth:

$$s_c r = g$$

Where s_c is the capitalists' savings rate, and g is the rate of growth. The national price system is the same as before. Under autarky, the profit rate determines the growth rate, given capitalists' savings rate.

In the global setting, the global growth rate will be uniform within a complete trade pattern. Since there are alternative complete trade patterns, the ruling one is that which maximises the growth rate. This is because such a trade pattern pays the highest rate of profit in each economy. The profitability criterion, consistent with the competition process, assures producing each commodity at the lowest possible cost. Given real wages and capitalists' propensity to save, this is equivalent to maximising national profit rates.

Thus, the price system of the efficient complete trade pattern is:

$$\bar{\mathbf{p}}^\top = \bar{\mathbf{p}}^\top \bar{\mathbf{B}}(\mathbf{I} + \hat{\mathbf{s}}_n^{-1}\bar{g})$$

Where $\mathbf{s}_n$ has the same interpretation as $\mathbf{r}_n$, and $\bar{g}$ is the maximum rate of growth of all the alternative trade patterns. The system has N equations to determine $N-1$ relative prices plus the uniform rate of growth. Ricardo's indeterminacy is, therefore, solved. The cost of Parinello's closure is the need to introduce the quantity system and—although exogenous and not micro-founded—preferences into the analysis, like in the neoclassical approach.

An alternative closure, developed contemporaneously to Parrinello (1979), is Emmanuel's theory of unequal exchange (Emmanuel 1972). Emmanuel (1975) also follows the classical approach of considering wages fixed at their subsistence level. The difference with Parrinello is that Emmanuel assumes international capital mobility. The assumption implies a single uniform rate of profit in the global economy. Thus, the

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[26] One minor difference is that the former assumes wages paid post factum.

number of unknowns in system (4) is reduced by $G - 1$. The international price system is:

$$\bar{\mathbf{p}}^{\top} = \bar{\mathbf{p}}^{\top}\bar{\mathbf{B}}(1 + \bar{r})$$

Defining the numéraire closes the system.

Emmanuel based his analysis on a given trade pattern and focused exclusively on determining international relative prices. Later, Gibson (1980) developed a simple graphical device to show how the dominant shared trade pattern obtains.[27] International capital mobility bridges the gap between the analysis of the choice of technique and the explanation of the trade pattern (Bellino and Fratini 2021). Notably, Parrinello highlighted the formal equivalence of his model with this approach. According to this author, the problem of choosing alternative trade patterns

> is identical to the problem of the choice of techniques in the case in which the two countries were integrated as a single world economic system, where capital is completely mobile and g would be the uniform rate of profit. (Parrinello 1979, p. 168)

Under Emmanuel's assumption, the problem of determining the trade pattern is formally equivalent to von Neumann's analysis (Brewer 1985). The competition among producers will lead to the trade pattern that produces the commodities at the lowest cost and pays the highest profit rate.[28] However, under the given circumstances, it is very likely that the competitive process will not establish a complete trade pattern.

The reason is that condition (i) above-mentioned, i.e. each country has at least one competitive process, is not warranted. The admittance of condition (i) presumes the working of an adjustment process that may allow any country to become competitive. However, if the real wage is fixed, the country has no alternative (at least in the medium term) to increase competitiveness. To quote Brewer (1985, p. 183), 'there is nothing to prevent any particular country from having higher costs than others in all lines of production; it then has zero output and employment'.

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[27] See Bellino and Fratini (2021) for an analytical and historical reconstruction.
[28] In determining international prices and the ruling profit rate that minimises costs, the global activity matrix is endogenously determined.

Indeed, the country will restrict trade or refrain from trading altogether before reaching this situation.[29] Therefore, the notion of a complete trade pattern is not helpful in this scenario. In other words, the strong equilibrating forces cannot ensure that any country is able to sell at least one good in world markets.

5. Desertification with variable wages

§1. Readers learned in neoclassical theory would hardly disagree with the latter conclusion. However, they would say that the result is contingent on the assumption of fixed wages. In other words, it is a result derived from conceiving imperfections in the labour market. The usual consideration is that trade union activity or stringent labour regulations interfere with the proper functioning of the market and impede its clearing.

The relevant question, a neoclassical scholar would argue, is whether desertification is possible had wages been variable (or market-determined)? In this case, the argument would be more challenging to sustain. As we have discussed, wage cuts reduce unit costs and make the economy regain competitiveness in neoclassical analysis. Notably, this idea is also present in heterodox analyses. For example, Vasudevan sustains that

> downward wage flexibility could play a role in transforming absolute cost disadvantage into a competitive cost advantage. Where technological conditions are unfavorable to a country in all sectors it can hope to compete in the international market only through a "race to the bottom" in terms of wage cutting. (Vasudevan 2012, p. 191)

However, if production requires intermediate inputs, it is not so evident that this mechanism works. As Deardorff holds,

> if sufficiently extreme, high input requirements may cause the value added in one or more sectors to be negative at world prices, so that no reduction in the wage will be enough to create comparative advantage in those particular sectors.
> It may seem (as it seemed to me, briefly) that this could happen in all sectors, making it impossible for a country to compete in any of them. If so, that would be an important difference from the Ricardian model without intermediate inputs, where a

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[29] Bellino and Fratini (2021) refer to it as "desertification", while Vasudevan (2012) speaks of an "empty production economy".

country must always have a comparative advantage in at least one good, which it can exploit if its wage is low enough. (Deardorff 2005, p. 23)

Deardorff quickly discards this possibility. The argument depends on the definition of a "productive" economy. An economy is "productive" if the entries of matrix $(\mathbf{I} - \mathbf{A})^{-1}$ are all non-negative. Also, Deardorff's analysis is framed in the case of production through labour and intermediate inputs and zero interest rate (see §2 of Section 4.1). Thus, let λ_j be the unit cost of producing good j with intermediate inputs valued at international prices and $\boldsymbol{\lambda} = [\lambda_j]$. Any industry is in operation in the international market if it does not pay extra profits. This condition may be represented as:

$$\bar{\mathbf{p}}^\top \leq \boldsymbol{\lambda}^\top$$
$$\bar{\mathbf{p}}^\top \leq w\mathbf{l}^\top + \bar{\mathbf{p}}^\top \mathbf{A}$$

If the strict inequality holds, the industry incurs extra costs and is not in operation. Let σ_j represent the extra cost incurred in the industry producing good j and $\boldsymbol{\sigma} = [\sigma_j]$. Introducing this definition, we can transform the latter system into a system of equalities:

$$\bar{\mathbf{p}}^\top = w\mathbf{l}^\top + \bar{\mathbf{p}}^\top \mathbf{A} + \boldsymbol{\sigma}^\top \tag{5}$$

For a wage rate greater than zero, if the constraint is non-binding in all sectors, then $\boldsymbol{\sigma}$ must be a negative vector. In that case, the wage should fall until any $\sigma_j = 0$, and the constraint in the industry producing good j becomes binding. However, let us conduct the thought experiment that the wage rate falls to zero, and still, no industry is in operation. We must assess whether this experiment is plausible. In that case, system (5) becomes:

$$\bar{\mathbf{p}}^\top = \bar{\mathbf{p}}^\top \mathbf{A} + \boldsymbol{\sigma}^\top$$

If we define value added as $\mathbf{v}^\top = \bar{\mathbf{p}}^\top (\mathbf{I} - \mathbf{A})$ then we must conclude that value added will be negative in all sectors, as Deardorff argues at the beginning of the quote. However, the definition of a productive economy comes into play here to prove how this conclusion is misleading. An alternative way to write equation (5) is:

$$\bar{\mathbf{p}}^\top = \boldsymbol{\sigma}^\top (\mathbf{I} - \mathbf{A})^{-1} \tag{6}$$

Since $\bar{\mathbf{p}}$ is positive, and the economy is "productive", it must be that $\boldsymbol{\sigma}$ is non-negative. This result contradicts the initial premise that all industries incur extra costs when wages

are zero. On the contrary, the expression indicates that all industries pay extra benefits in such a case. Therefore, there is a wage rate greater than zero for which at least one industry can compete in international markets. In other words, the process of lowering wages stops at a value of the wage rate that is positive, and the country can compete in at least one sector.

§2. Deardorff does not address, however, the case where the rate of profit is greater than zero.[30] We can discuss it under two alternative scenarios, with and without international capital mobility. In the first scenario, let us note that desertification is impossible if production requires only labour, and capital advances consist entirely of wages (Brewer 1985). However, Crespo et al. (2021) have recently shown that there can be desertification when production requires labour and intermediate inputs. We can discuss this result following Deardorff's reasoning. The unit cost for producing good j now includes interests paid on the value of advanced capital. Letting $\bar{r}$ be the ruling interest rate in the shared trade pattern, the condition of no extra costs becomes:

$$\bar{\mathbf{p}}^\top \leq w\mathbf{l}^\top + \bar{\mathbf{p}}^\top \mathbf{A}(\mathbf{I} + \bar{r})$$

Instead of introducing the vector of extra costs, let us transform the inequality constraints into equality by making the interest rate vary in each sector so as to eliminate extra costs. Additionally, assume that the wage rate is zero. Letting $\boldsymbol{\rho} = [\rho_j]$, equation (6) becomes:

$$\bar{\mathbf{p}}^\top = \bar{\mathbf{p}}^\top \mathbf{A}(\mathbf{I} + \hat{\boldsymbol{\rho}})$$
$$\bar{\mathbf{p}}^\top (\mathbf{I} - \mathbf{A}) = \bar{\mathbf{p}}^\top \mathbf{A}\hat{\boldsymbol{\rho}} \tag{7}$$

As can be seen by comparing equation (6) with equation (7), $\bar{\mathbf{p}}^\top \mathbf{A}\hat{\boldsymbol{\rho}}$ is non-negative. This result suggests that all the interest rates required by each industry to operate in the global economy are equal to or greater than zero. However, this is a necessary but not a sufficient condition. With international capital mobility, the sufficient condition is that at least one of these interest rates is equal to or higher than the ruling interest rate in the shared trade pattern. Otherwise, producers would have incentives to abandon local production and move abroad.

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[30] Copeland and Kotwul (1994) show in a two-country, two-good Ricardian model that trade may break down when one of the goods is quality-differentiated, and there are substantial income differences between countries. However, there are critical differences between desertification and a trade breakdown. Notably, the latter is voluntary. There is no country willing but unable to trade. Desertification occurs when a country opens to trade but finds no outlet for its products.

Thus, if $\max_j\{\rho_j\} < \bar{r}$, no industry can operate in the global economy—*even when the wage rate is zero*, and to quote Deardorff (2005, p. 23), 'cutting itself off from free trade would be the only way to survive'. In other words, the economy still cannot compete if the wage rate reaches zero.

An alternative way to pose this result is to claim that the payment of a uniform interest rate on invested capital imposes a positive lower bound on unit production costs, even when the wage is zero. Let us assume that a country's autarky normal prices are greater than international prices. When the country joins the global economy, it saves costs by importing capital goods, raising the interest rate that activities pay. Nevertheless, the raise may not be sufficient to reach the international interest rate. In that case, there would be a capital outflow. The domestic rate rises to parity with the international rate to avoid it. Capital costs now increase, reducing competitiveness. Also, with capital mobility, they become rigid. The only way to reduce costs would be to decrease wages; if these reach zero, the capital costs are still positive. In that case, unit costs would be:

$$\boldsymbol{\lambda} = \bar{\mathbf{p}}^{\mathsf{T}}\mathbf{A}(1 + \bar{r}).$$

Since the right-hand side consists of parameters only (from the point of view of the isolated country), nothing prevents that $\bar{p}_j < \lambda_j$ for all $j = 1, \dots, N$.

Now let us consider two scenarios without capital mobility. The first is based on Parrinello's (2010) analysis. The author poses the discussion in the context of fixed wages, but the argument can be extended to consider variable wages, as we have done in this section. Previously, we arrived at equation (7) and concluded that all interest rates are greater than zero. If producers cannot relocate their capital abroad, they will be content with investing in the industry that pays the highest interest rate. Assuming balanced growth, the rate of expansion will then be $\gamma = s_c \cdot \max_j\{\rho_j\}$. However, this growth rate could be lower than that of countries that are part of the shared specialisation pattern, say $\bar{g}$. In this case, the country would become smaller and smaller to the point of disappearing from the global economy.

If we impose the condition that the rate of profit ensures the growth rate $\bar{g}$, this will lead to all industries having unit costs above international prices. Let $\tilde{\rho} = \frac{\bar{g}}{s_c}$. In that case, if $\max_j\{\rho_j\} < \tilde{\rho}$, then no industry will be in operation, as we deduced previously.

In conclusion, although desertification is impossible, the country will tend to disappear if it cannot grow at the same pace as its trading partners. Moreover, any attempt

to grow at the same pace leads to the loss of competitiveness of home industries. This last result is crucial as it opposes the view that the growth rate can be increased by redistributing income in favour of profits. When the economy faces international competition, this would be counterproductive because the resulting higher prices do not reduce the real wage but overall competitiveness.

The second alternative involves assuming that there are indispensable goods that are not produced domestically. Throughout this article, we have assumed that countries produce the same goods. This assumption is not realistic. Many countries do not have capital goods-producing industries and must import them to produce final goods. Latin American structuralist authors thoroughly examined this case for different purposes. It is commonly known as "technical dependency". Dvoskin and Feldman (2018a, 2018b) develop a linear model to discuss how the trade pattern is determined in a price-taker economy that needs to import a capital good that cannot produce internally. The model allows focusing on the role of this dependency on the interaction between income distribution and balance of payments dynamics. Additionally, the model helps assess exchange rate policies to promote output growth (e.g. Dvoskin et al. 2020).

A country may be dependent on any input, whether an energy resource, a capital good, or raw materials. In a hardly noticed analysis, Beretta (1992) addresses—although briefly—the implications of "technical dependency" for desertification (see also Crespo et al. 2021). Let $\bar{q}_k$ be the international price of the imported input k and $\bar{\mathbf{q}} = [q_k]$. Furthermore, let m_{kj} designate the quantity of input k required for the production of one unit of good j; $\mathbf{M} = [m_{kj}]$ is the imports table. If we add the value of imported inputs to the unit cost equation, the lower bound when wages and interests are zero is:

$$\boldsymbol{\lambda}^\top = \bar{\mathbf{p}}^\top \mathbf{A} + \bar{\mathbf{q}}^\top \mathbf{M}$$

In both cases, the right-hand side of the expression consists only of parameters; again, nothing prevents $\bar{p}_j < \lambda_j$ for all $j = 1, \dots, N$. Therefore, desertification is possible without capital mobility but when the country has an input dependency.[31]

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[31] Beretta (1992, p. 68) develops a useful graphical analysis.

6. Concluding remarks

Comparing alternative "Ricardian" trade models has allowed us to obtain the following conclusions. Firstly, introducing intermediate inputs and capital goods into trade analysis is, conversely to the mainstream view, not trivial. In addition to the well-known problem of trade pattern reversals, it increases the likelihood of desertification. Another way to put it is that complete trade patterns (underlying the principle of comparative advantage) are an exception rather than the rule.

The requirement to pay a profit rate over the value of inputs advanced as capital sets a lower limit below which production costs, and therefore prices, cannot fall. In such a case, cutting wages may not transform an absolute cost disadvantage into a competitive advantage. Backward economies would be excluded from the pattern of efficient trade. The practical implications follow naturally: trade regulation policies may help preserve employment and production levels in the short- and medium-run; deregulating the labour market (a race to the bottom) does not ensure international competitiveness. The preferred long-term alternative is to adopt more advanced production methods and imitate best practices.

It should be noted that the analysis considers an economy with a lower absolute level of technology. However, most countries actively participate in international trade. This fact reveals that competitive cost advantages in the activities where the country specialises were likely already present before trading.

Secondly, the answer to the question of who gains from trade depends on the distribution theory we adopt. In neoclassical theory, the real wage rises relative to its pre-trade level if the economy can specialise in international trade. On the other hand, we can reach the opposite conclusion based on the classical approach. If real wages are relatively fixed, specialisation in global markets increases the profit rate relative to their pre-trade level. The evidence of a rising profit share in many countries in recent years seems to support the latter hypothesis.

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