Trade in a world with recyclable resources

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Abstract:

This paper examines the welfare-impact of trade from the premise that resources are limited and all goods in the long run consist of recyclable resources. It argues that export (import) of finished goods implies export (import) of the resources of which these goods exist. Trade affects the resource endowments and future production capacity of countries. It is shown that trade entails a voluntary sacrifice of future production capacity for resource-exporting countries.

1. Introduction

One of the most persistent insights in modern economics is that international trade leads to the factor price equalization (Ohlin 1933; Samuelson 1948, 1949) and is beneficial to countries engaging in it. Outside economics, there is a widespread popular view that trade impoverishes developing countries by bereaving them from their resources. Usually, these two perspectives have been seen as mutually exclusive, so that comparative advantage enters as argument against the latter, 'unenlightened' view. The two are not incompatible, however.

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One popular way of explaining factor-price equalization is by pointing out that international trade can be interpreted as the indirect exchange of production factors (e.g. Krugman and Obstfeld 1996; Leamer 1995, pp. 18). The export of labor intensive goods can be understood as an indirect way of exporting labor, while the import of capital intensive goods can be seen as the indirect import of capital. If production factors are thus allowed to move freely, they will flow to where their marginal returns are highest, increasing overall welfare and causing convergence of factor prices.

This paper argues that for one class of production factors, there is more to this interpretation than simply a well-working metaphor, however. Production factors can be classified into factors whose services are used in the production process, and factors that are physically embodied in the produced goods. Put differently, products are not only made by production factors (labor, capital), but also exist of them (resources). The resources of which commodities are made genuinely change hands when commodities are traded. By exporting finished goods, one also exports the resources of which they exist.

The total amount of resources in the world is fixed. Future products have to be made either from yet untouched resources, or from resources extracted from the finished goods one consumes in the present. In the long run production depends on the input of recycled resources, so that the export and import of goods embodying resources affects the future production possibilities of a country. Thus, the resource-intensity of one's consumption basket is determining one's future production capacity. Although improving welfare in the trade equilibrium, trade therefore negatively affects future consumption in resource-exporting countries.

The relation between trade and natural resources has been on the agenda of international economics for a long time. Papers by Singer (1950), Kemp and Ohyama (1978) and Proops (2004) analyze terms of trade and asymmetries in the gains of trade between resource-rich and resource-poor countries. Other segments of the literature focus on exhaustible resources, analyzing the effects of trade on resource depletion (Djajić 1984; Elbers and Withagen 1984; Lopez 1994; McRae 1978; Ferreira 2007) or renewable resources, analyzing the interaction effects of trade and market failures on management of such resources (Brander and Taylor 1997, 1998; Bulte and Barbier 2005; Jinji 2007). This paper's argument differs from these literatures in taking a perspective in which resources are neither exhaustible nor renewable, but recyclable. Our total stock of resources is in principle fixed; we cannot exhaust nor expand the amount of iron molecules we are given. In the long run, all we can do is to extract it from finished goods to make new products.

The paper presents this argument on basis of a simple, two-factor HO-model, which shows that resource exporting countries face a trade-off between current welfare and future consumption. In the absence of market failures, this trade-off will be made in a welfare optimizing way, depending on the time preferences of consumers in different countries.

2. Analysis

The assumptions behind the analytical model are analogous to Samuelson (1949). We assume two countries, Home and Foreign, producing two commodities, A and B. Each commodity is produced with resources and labor, which are both employed fully.

Resources are physically embodied in produced goods, whereas only the services of labor are embodied in goods[2]. As a consequence, resources reenter the economy at the location of consumption, while labor reenters the economy at the location of production of goods. The production function of each commodity shows constant returns to scale, so that an increase in both inputs results in a proportionate increase in output. Production is subject to diminishing marginal productivity, so that an increase of one input relative to the other causes a decrease in this factor's marginal productivity. There are no barriers or costs to trade in final goods, so that commodity prices are equalized. Production factors are not mobile (except as embodied in final goods). Finally, we assume technologies, qualities of inputs, and preferences to be the same in the two countries.

We can write the production side of our model as follows, following Leamer (1995). Let p denote a vector of final goods prices, v denote a vector of resource supplies, w denote a vector of factor prices, and q denote a vector of outputs, with $w = f(p,v); q = g(p,v)$. A is the input-output matrix, so that

$$A = A(w) \ , \tag{1}$$

$A(w)$ being the cost-minimizing choice of input intensities using the technologies available. Equilibrium in the market for factor goods requires:

$$q^h = \frac{v^h}{A} \ , \tag{2}$$

[2] For labor, we could also read capital or any other production factor that is not physically incorporated in traded goods.

with the superscript h denoting Home. The zero-profit condition in the final goods market requires final goods prices (p) to be equal to production costs, implying:

$$w^h = \frac{p^h}{A'} \quad . \tag{3}$$

By assuming identical homothetic tastes and an absence of all barriers of trade the demand side of the model is neutralized. The fact that the resources embodied in consumption are the inputs for future production gives a boost to demand for resource intensive goods relative to labor intensive goods, depending on the time preference of consumers. However, because we are assuming identical preferences (tastes and time preferences), this does not affect the point that factor prices and, hence, consumption proportions are equal in both countries. Thus,

$$c^h = s^h c^w = s^h \frac{v^w}{A} \quad , \tag{4}$$

in which s^h denotes the consumption share of country H, c^w gives the vector of world consumption, and v^w the vector of world resource supplies. On basis of this, we can write the vector of trade flows as

$$T = q^h - c^h = \frac{v^h - s^h v^w}{A} \quad . \tag{5}$$

The factors not indirectly consumed in the country itself are exported, and the factors indirectly consumed in excess of domestic availability are imported. In other words, in the two-factor case, (5) implies that:

$$L^h_{traded} = L^h - s^h L^w \ , \tag{6}$$

$$R^h_{traded} = R^h - s^h R^w \ , \tag{7}$$

with L denoting labor, R denoting resources, and L^h_{traded}, R^h_{traded} being the labor and resources respectively embodied in traded goods. For Foreign, all equations are the same. Upon trade, the relatively labor abundant country consumes less labor than it owns ($L - sL^w > 0$) and exports its excess labor in the form of labor intensive goods. Likewise, the relatively resource abundant country consumes more labor than it owns ($L - sL^w < 0$), and has to export resources in the form of resource intensive goods in order to cover excess labor consumption. As a result of these imports and exports both countries are better off; they can make use of each other's relative abundances, and are able to consume more when trading with each other than they were able to in autarky.

This is not the end of the story, however. The indirect import and export of resources brings about a change in factor endowments in both countries. Production in the next period in each country is a function of the resources embodied in the goods that have been consumed and the country's labor endowments, so that

$$q^h_{t+1} = g(R^h_{t+1}, L^h) = g(s^h_t R^w, L^h). \tag{8}$$

The country exporting resource-intensive goods has become less resource abundant as a result of trade, the country importing them less labor abundant. As countries thus become more alike, trade falls. This process goes on until in the long-run equilibrium factor endowment ratios are exactly the same in both countries and trade stops altogether:

$$\frac{R^w}{L^w} = \frac{R^h_{equilibrium}}{L^h} = \frac{R^f_{equilibrium}}{L^f} \quad . \tag{9}$$

This long-run equilibrium is caused by the indirect transfer of resources from the resource abundant country to the labor abundant country until factor endowment ratios are equal. If Home was the resource abundant country and Foreign the labor abundant country initially, this means that $R^h - R^h_{equilibrium} > 0$ and $R^f - R^f_{equilibrium} < 0$, implying that $q^h_{equilibrium} < q^h$ while $q^f_{equilibrium} > q^f$. Production and consumption in the initially resource abundant country has fallen due to trade, since it has exported part of its production factors. Production and consumption in the initially labor abundant country has been boosted by the import of extra production factors[3]. The resource-abundant country only gains from trade in the short run. The labor abundant country gains in the long run as well.

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[3] A informative way of writing (9) is $\frac{L^h}{L^f} = \frac{R^h_{equilibrium}}{R^f_{equilibrium}}$, emphasizing the fact that in the eventual distribution of ownership of resources follows the distribution of ownership of labor.

3. Discussion

This paper analyses the effects of trade on factor endowments when resources are recyclable. It starts out from the idea that trade in finished goods literally implies an exchange in production factors. When goods are traded, resources are traded indirectly, affecting the factor endowments of the economy. The analysis shows that while trade is welfare improving, it negatively affects future production and consumption of resource exporting countries. By contrast, trade increases the production capacity of resource importing countries.

In absence of market failures, we can expect individuals in both countries to take these long-run effects on production capacity into account when deciding to engage in trade. This implies that the relative price of resources will be higher as a result of the production capacity effect than in the Heckscher-Ohlin set-up without recycling. This price premium is a consequence of the fact that resource prices not only reflect the value attached to the goods that can be made out of them in the current period, but also the value of goods that can be made out of them in the future. The size of this price premium and the extent to which consumers are prepared to trade in future consumption for present welfare is dependent on the time preference of consumers. With increases in the importance attached to future consumption, consumers in both countries value the consumption of resource-intensive goods more, resulting in higher resource prices.

The fact that individuals take future production capacity effects into account when engaging in trade does not affect the standard results of trade theory. One of the characteristics of the Heckscher-Ohlin model is that the demand side is neutralized because preferences are assumed to be homogenous. The extra value attached to

resources due to future production capacity effects therefore does not alter the main insights of the theory. Trade is still driven by differences between factor endowments, countries export their abundant factors, and trade is beneficial to all countries. Although the resource-abundant country's real income and consumption eventually falls due to trade, the degree to which it does so is chosen by individual consumers making a trade-off between present and future consumption. Production capacity falls in the resource exporting country, but in the absence of market failures, it does so in an optimal way.

At the same time, the analysis lends some support to the popular view that trade tends to impoverish resource exporting countries. The fact that trade affects factor endowments, and thereby possibilities for future production, implies that trade is more of a zero-sum game than conventional trade theory portrays it to be, albeit only in the very long run. There is a limited amount of resources on Earth. Through trade, these resources are shifted from one place to the other. The increase in resources of one is the loss of the other. Resource abundant countries export resource intensive goods, depleting their resource base and harming future production possibilities. Labor abundant economies import resource intensive goods, adding to their resource base and boosting future production possibilities.

4. Conclusion

This paper looked at the effects of trade in a world harboring a fixed amount of recyclable resources. Its findings shed new light on the long-standing opposition between those who claim trade is welfare-enhancing, because of the use of comparative advantages, and those who claim that international trade implies a harmful transfer of

resources from developing countries to resource-processing, industrial economies. They might in fact both be right. Trade does imply a transfer of resources from resource-rich to resource-poor economies, and it does cause a long-run drop in consumption in the former. However, as long as agents involved in trade take these long-run production effects into account, the resource exporting country is compensated for its loss of production capacity by a higher immediate price for its resources. In absence of market failures, the depletion of the resource-abundant country's resources occurs in an optimal way.

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