Specific Factors Model When Countries Have Different Technologies: Why Inefficient Industry is Better Than no Industry at All

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Abstract

One of the main questions of specific factors theory is whether it is possible to achieve a redistribution of gains from trade such that everybody in both trading countries win. This theory explicitly assumes that the trading partners possess identical technologies, and the difference in the amount of goods produced is solely due to the differences in factor endowments. In effect, opening to trade between two countries with different factor endowments is an optimization problem that redistributes labor between the types of goods produced given the available capital. In this optimization problem both trade participants benefit from free trade, and it is possible to make everybody win. But if the two countries possess different technologies, the result is quite the opposite. The optimization problem leads to the destruction of capital in the country with less efficient technology. While the main conclusions of the theory – the owners of export-oriented factor of production win and capital-abundant country will export capital-intensive goods and vice versa – will hold, the country with less efficient pre-trade technology will lose the technology altogether, and the total output of that country will fall as a result of free trade.

Introduction

Intuitive non-expert view is that trade liberalization should lead to convergence in terms of economic development. Take, for example, the expectation and the enthusiasm of the start of the economic reform and transition from planned to market economy in Eastern Europe in the late Eighties. The layman thinking would be "Eastern Europe produces the whole range of advanced products, and while these products may be less efficient and less reliable than their Western counterparts, they are cheaper too due to lower incomes in the East. Upon removal of trade barriers with the West, they have a good chance due to lower price. With time, quality, reliability, and, therefore, incomes, should converge." But this hasn't happened in over thirty years since the start

of economic reforms. In fact, the whole eight former-planned economy new European Union members with combined pre-reform population of over 100 million people have failed to create even a single world-recognizable brand since the start of the economic transition and the integration with the European Union. And even the local brands they had before have now disappeared, or, like Skoda in the Czech Republic, have become subsidiaries of Western brands, positioned as poor-man's versions of consumer goods.

The reason, as is taught in the first lecture to first-year economics students, is that resources are limited, and specialization is key. The world economy is a giant optimization problem – the resources must be utilized in the most efficient way. And if we look at resources as being of two types – skilled labor or high-technology resources, and unskilled labor – it turns out that the developed countries have relative (comparative) advantage in the former, and the developing countries – in the latter. In other words, the technology products in Eastern Europe are less expensive than in the West, but unskilled labor is even cheaper! And any optimization will redistribute the use of resources in such a way that high-technology economy will shift to the West, and low-technology, unskilled economy will shift to the East.

In our previous publications we considered two simple illustrations which show how optimization constrained by limited resources leads to a redistribution of production – high-technology goods are produced by advanced countries, and developing countries are left to specialize in low-added value manual labor.[1,2] These results were mainly based on Ricardian comparative advantage – the first economics optimization principle. We modified the Ricardian model to include two types of products – high-technology and low-technology. The output of the high-technology industry per unit of labor was higher than that of low-technology, and the advanced country had comparative advantage in high tech. Given the difference in output per

hour, the result of that model was that the developing country lost from trade while the advanced country gained disproportionately.

One could argue that the modified Ricardo model of the previous publication, where high-technology output per unit labor is higher than low-technology output, implicitly assumes, or is analogous to, some form of knowledge or capital employed. It is indeed possible to recast that model as a form of a model that employs both capital and labor, and attribute higher productivity in the high-tech industry to the difference in the capital endowment between the two countries. This would be largely equivalent to the other fundamental model of trade – the specific factors model.[3,4] With one exception – in the canonical specific factors model the technology that the trading partners employ is the same. But the cornerstone of the modern economy is the fact that advanced countries possess vastly superior technologies than developing countries. Therefore, one need to consider the analysis of labor-capital model when technologies in the two trading partners are different. In this paper we will show that when that is the case, while each country still exports the good in which it has endowment advantage, there are fundamental differences with the classical model's results. First, the less advanced country loses the technology altogether. Second, the less advanced country loses from trade. These conclusions are consistent with modified Ricardian model from our previous work.

Results

There is a crucial difference between the situation when technologies are different and when technology is less abundant in one country or another. When technologies are the same, in the absence of trade the capital-abundant country from the optimization standpoint is overutilizing labor, while labor-abundant country is overutilizing capital. Free trade results in a more efficient utilization of available labor and capital in both countries and leads to gains by both participants.

When technologies are different, the capital is not overutilized in the capital-scarce economy, and free trade does *not* benefit the country with less advanced technology.

To demonstrate these conclusions, we will proceed in two steps. First, we will consider a classical specific factors model starting with autarky production of two goods and demonstrate the main results of this model when technology is the same – trade benefits the export-oriented factors, the capital-abundant country exports capital-intensive goods and vice-versa, and both countries gain. Then we will consider the case of different technologies. We will start with the same autarky production of two goods by two countries and demonstrate the crucial difference in the production possibilities frontier. We will show that there is no free-trade optimum that will benefit the country with less advanced technology.

Also, we will recall the Ricardian model with the same autarky production when the prices of goods are set to reflect high-technology versus low-technology output. We will argue that that model is identical to the specific factors model with different technologies.

Specific factors model. Case 1: same technology, scarce versus abundant capital

Consider the following autarky two-country two-commodity production table.

Products	**American workers**	**American output**	**Russian workers**	**Russian output**	**World output**
Chairs	200	100,000	200	100,000	200,000
Laptop PCs	300	60,000	300	18,000	78,000

Table 1. Before specialization, two countries, the United States and Russia, produce laptop PCs and chairs.

Instead of deriving the results in terms of abstract relative prices, we will start from assuming specific world prices in dollars for the two goods that would be established in a free-trade regime. Suppose that in the world market the price of a laptop PC is $1000, and the price of a chair is $100. In dollar terms we get:

Products	**American workers**	**American output**	**Russian workers**	**Russian output**
Chairs	200	$10,000,000	200	$10,000,000
Laptop PCs	300	$60,000,000	300	$18,000,000
Total	500	$70,000,000	500	$28,000,000

Table 2. Dollar value of the commodities produced by the two countries before the establishment of a free trade regime under a specific assumption regarding the world price of the goods.

Further, assume that furniture production requires very little capital, which we will set to zero for the sake of model simplicity. Electronics is the only product that requires capital.

If technology is the same, then given the same amount of capital, 300 workers in Russia would produce the same 60,000 laptops as 300 US workers. What does it mean in this case that 300 workers in Russia produce only 18,000 laptops per year? If the capital endowment in Russia is smaller, that would mean that most of these 300 Russian workers are required to compensate for the shortage of necessary machine tools, due to a diminishing return on the available capital. To fix ideas, suppose the capital used in the US allows all the 300 workers to be efficiently employed and to produce the 60,000 laptops, while the capital employed in Russia is four times smaller, allowing to efficiently utilize only 75 workers. With the same technology as in the US, these 75

workers would produce 15,000 laptops per year. If Russia is producing 18,000 laptops with 300 workers, it means that the extra 225 workers are very inefficiently compensating for scarceness of capital and are only able to increase the laptop production from 15,000 to 18,000, given the diminishing return.

Also, for the sake of simplicity, assume that the US has enough capital to employ all 500 workers in electronics if needed. The production possibilities frontiers for the two countries are as follows:

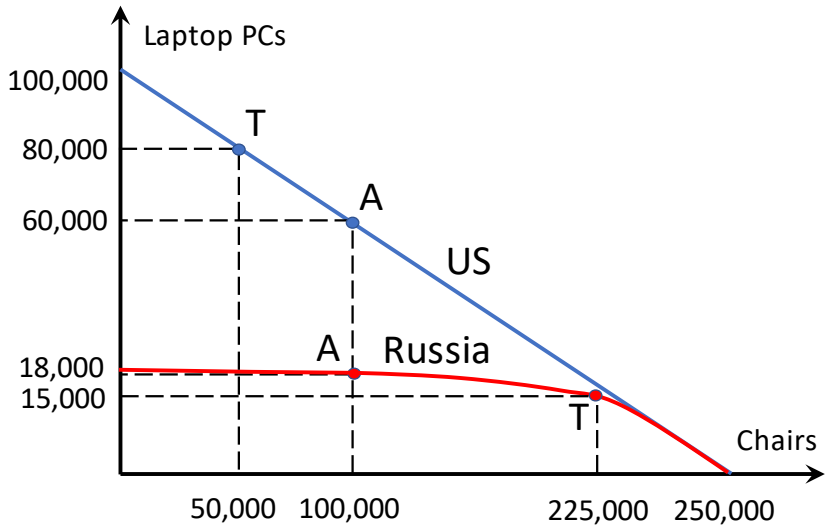

Figure 1. Production possibilities frontiers for the US and Russia. The technology in the two countries is the same. The autarky production numbers are denoted by points A for the US (blue) and Russia (red). The *crucial* difference in the case of the same versus different technologies is the behavior of the PPF for Russia in the rightmost part of the plot. When technology is the same, part of the Russia's PPF and the US PPF (segments of the red and blue lines near the 250,000 chairs) overlap (more precisely, *have the same slope*). In the case of different technologies, the red line would *always* have a smaller slope than the blue line, as in Figure 2 below.

Now consider what happens if a free-trade regime is established between the two countries. If we were to move 225 Russian workers from laptops to chairs, the laptop production in Russia would shrink by only 3000, while the production of chairs would increase by, respectively, 112,500. The US, on the other hand, would move, say, 100 workers from chairs to laptops, losing 50,000 chairs in furniture, but these workers in electronics could produce extra 20,000 laptops. In the above scenario the technologies are the same, the capital-abundant country increases the production of capital-intensive goods that more than compensates for the shortfall of laptops from Russia. The labor-abundant country disproportionately increases the production of labor-intensive goods, and there is a mutual gain from trade.

The free-trade production table is as follows:

Products	**American workers**	**American output**	**Russian workers**	**Russian output**	**World output**
Chairs	100	50,000	425	212,500	262,500
Laptop PCs	400	80,000	75	15,000	95,000

Table 3. Free-trade output of the two commodities by the two countries corresponding to the PPF from Figure 1.

In dollar terms, under the stated earlier assumption of a $1,000 laptop and a $100 chair:

Products	**American workers**	**American output**	**Russian workers**	**Russian output**
Chairs	100	$5,000,000	425	$21,250,000

Laptop PCs	400	$80,000,000	75	$15,000,000
Total	500	$85,000,000	500	$36,250,000

Table 4. The dollar value of the output under free trade and under the assumption of a $1,000 laptop and a $100 chair.

The main conclusions of the specific factors model obviously hold. Trade benefits factors of production in the exporting country – technology in the US – but hurts the technology capitalists in Russia. But also, Russian economy wins as a whole, therefore there is a way to redistribute gains such that everybody wins.

Specific factors model. Case 2: different technologies

Start with the same autarky two-country two-commodity production table.

Products	**American workers**	**American output**	**Russian workers**	**Russian output**	**World output**
Chairs	200	100,000	200	100,000	200,000
Laptop PCs	300	60,000	300	18,000	78,000

Table 5. This table is identical to Table 1 and is reproduced here for convenience.

What does it mean that technologies are different? It means that the 300 electronics workers in Russia *are* efficiently employed *given the amount of machinery available* for laptop production. Or that essentially all the 300 workers are necessary to efficiently operate the available tools. And reducing the number of workers in electronics industry from 300 to 75, like in the previous section, will make three-quarters of the machinery sit idle, and reduce the laptop production from 18,000 not to 15,000, but to approximately 4,500.

The production possibilities frontier for Russia is in this case very different from what it was in the case of equivalent technologies (Figure 2).

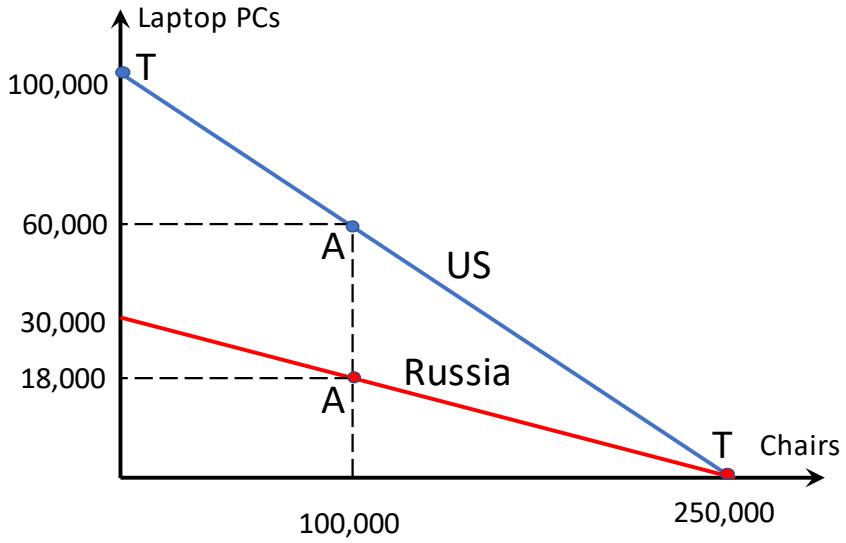

Figure 2. Production possibilities frontiers for the case of different technologies. The pre-trade production is denoted by points A (autarky) on Russia's (red) and US (blue) PPFs. The free-trade production is denoted, respectively, by a red T for Russia and a blue T for the US.

The only free-trade equilibrium solution in this case is complete specialization – with the US producing only electronics and Russia producing only furniture (Table 6)

Products	**American workers**	**American output**	**Russian workers**	**Russian output**	**World output**
Chairs	0	0	500	250,000	250,000
Laptop PCs	500	100,000	0	0	100,000

Table 6. Complete specialization corresponding to the PPFs in Figure 2.

In dollar terms:

Products	American workers	American output	Russian workers	Russian output
Chairs	0	$0	500	$25,000,000
Laptop PCs	500	$100,000,000	0	$0
Total	500	$100,000,000	500	$25,000,000

Table 7. The dollar values of the output from Table 6.

The most important consequence of complete specialization is the loss of all technology by Russia altogether. This is the well-known Vanek-Reinert effect[5] – the destruction of the most advanced industries and primitivization of economic activities in the less developed countries upon opening to trade with the developed world.

From the specific factors model perspective, trade benefits the owners of capital in the exporting country – electronics in the US – while obviously hurting capital owners in the developing country. Also, capital-abundant country exports capital-intensive good and vice versa. But what is important in this case is that the developing country loses as a whole, and there is no way to redistribute "gains" from trade to make everybody win.

The (almost) classical Ricardian model

In our previous publication[1] we considered the following production table in the framework of a simple Ricardian two-country two-commodity model. The US and Russia both produce laptop

PCs and chairs. The productivity in chairs was taken as being similar or the same in the two countries, while the US had comparative advantage in high-technology electronics.

Products	**American workers**	**American output**	**Russian workers**	**Russian output**	**World output**
Chairs	200	100,000	200	100,000	200,000
Laptop PCs	300	60,000	300	18,000	78,000

Table 8. An illustration of Ricardian two-country two-commodity model.

In a free trade regime, the two countries specialize in their respective products as follows:

Products	**American workers**	**American output**	**Russian workers**	**Russian output**	**World output**
Chairs	0	0	500	250,000	250,000
Laptop PCs	500	100,000	0	0	100,000

Table 9. Specialization under the classical Ricardian two-country two-commodity model from Table 8.

What we suggested was to consider a trivial question that would be the first to come to mind to a person unfamiliar with the field of economics. A laptop PC is an expensive piece of technology with a typical price of $1,000, while a chair is a relatively simple product worth about $100. How would this free-trade specialization benefit both participants, particularly the developing country? Indeed, under this assumption, the autarky output in Russia (Table 10)

Products	American workers	American output	Russian workers	Russian output
Chairs	200	$10,000,000	200	$10,000,000
Laptop PCs	300	$60,000,000	300	$18,000,000
Total	500	$70,000,000	500	$28,000,000

Table 10. The dollar values of the autarky output in the "almost classical" Ricardian model of Table 8.

is much higher than Russia's free-trade output (Table 11).

Products	American workers	American output	Russian workers	Russian output
Chairs	0	$0	500	$25,000,000
Laptop PCs	500	$100,000,000	0	$0
Total	500	$100,000,000	500	$25,000,000

Table 11. The dollar values of the free-trade output in the "almost classical" Ricardian model of Table 9.

We can call this model a modified Ricardian model. While we are considering labor as the only input, the value of labor output is differentiated between high-technology and low-technology products. We implied that labor in the electronics industry was more productive than in furniture. This is due to the higher collective skill required for producing a laptop as opposed to a chair.

But comparing the Tables 5 and 6 on the one hand and Tables 8 and 9 on the other, we see that the modified Ricardian model is exactly equivalent to our illustration of specific factors model

when countries have different technologies. There are the same production possibilities frontiers for the two trading partners. And the same conclusions about winners and losers from free trade.

A generalization on production possibilities frontier

Technically speaking, the countries have different technologies when the maximum (in absolute value) slope of the red line is smaller than the minimum (in absolute value) slope of the blue line (Figure 3). In this case the only optimal solution, as we have already mentioned, is a complete specialization of the country with less advanced technology on primitive commodity, and autarky is more favorable for the developing country. The constant return to capital assumption for the US electronics industry, as in Figure 1, is not necessary.

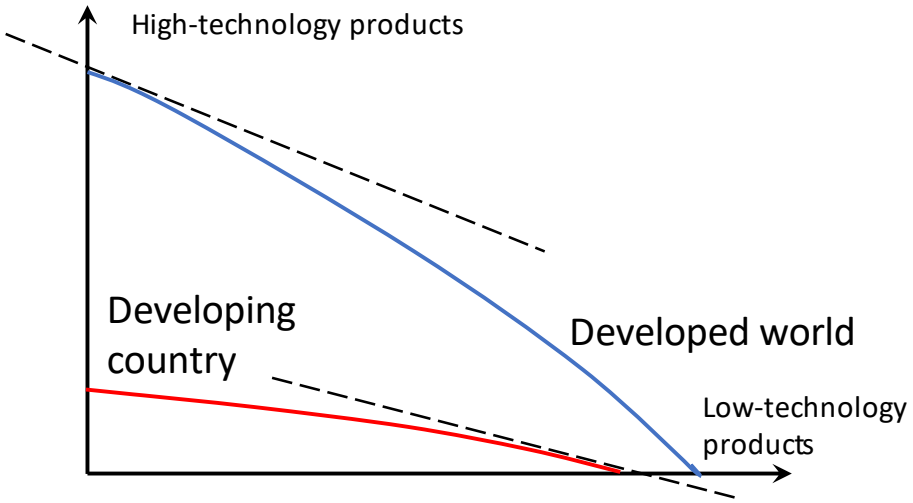

Figure 3. Production Possibilities Frontiers with diminishing return on capital. Dashed lines represent the slopes of the PPFs – the minimum slope for the advanced country (top) and the maximum slope for the developing country (bottom). The dashed line for the advanced country along its PPF is always steeper than the dashed line for the developing country. The only equilibrium is complete specialization (in this case, the Vanek-Reinert effect).

The only scenario under which free trade can be mutually beneficial is when there is a segment of the red line that is steeper than the least steep segment of the blue line. In this case the optimum will be partial specialization.

Also, the assumption that the blue line has a constant slope in Figures 1 and 2 means that the US in our example has unlimited capital or at least enough capital to employ all its furniture workers in the high-technology industry. This assumption is more so valid if we are considering a developing country against the developed world. The world always has sufficient capital to increase production by more than the entire high-technology industry in the developing country.

Real world examples

The specific factors theory when countries have different technologies has only one optimization solution, a solution that implies that the capital stock in the developing country shrinks to zero. This cannot be right!

But wait! The capital stock in the developing countries, such as the countries in Eastern Europe, *is* ZERO!

Consider, for example, the German conglomerate B/S/H/ opening a dishwasher assembly line in Poland.[6] The geographical location of the tools and machinery (the capital) is in Poland, next to the German border. Would anything change for the capital owners if this location was a few miles to the west, in German proper? Nothing! The capital rent is still paid to the German owners. Calling this assembly line "investment in Poland" only because the line is geographically located in Poland is the biggest misnomer of modern economics. In fact, if we reclassified investment by the geographic destination of the capital rent, everything would become a lot more logical. Dishwasher assembly line would be called investment in Germany (where the capital

owners receive the rent). And what was called "Foreign Direct Investment" in Poland should be reclassified as Purchase of Cheap Labor in Poland. It is nothing more than that!

The situation doesn't change if the machinery is purchased by a developing country rather than employed by a foreign owner. As an example, the Russian government has agreed to purchase $12 billion worth of foreign equipment for the construction of a liquefied natural gas complex.[7] In this case the rent is paid to the foreign (not Russian) owners of the technology, even though it is a lump sum upfront, since this lump sum is obviously just the present value of the capital rent over the life of the equipment.

Another posit of the economic convergence theory is an infinite mobility of capital. In fact, the mobility of capital is zero as well. No Western company has ever transferred any knowledge or technology to a developing country. In fact, it only may be the other way around as in the case of the sale of Czech automaker Skoda to Volkswagen of Germany. All the Skoda technology belongs to German owners, who receive virtually all the capital rent, while Czech employees are essentially just contract laborers.

Conclusions

This study aims to provide the simplest possible illustration of specific factors model to demonstrate that when technologies that the trading partners possess are sufficiently different, free trade benefits only the advanced country. The country with less advanced technology loses the technology altogether, which results in a decreasing output and a lack of technological development.

In our study we also illustrate the conditions under which free trade in the specific factors model benefits both participants. These conditions are consistent with our earlier study and correspond to trade between two equally advanced nations.

The example shown in this paper is another illustration of the Vanek-Reinert effect.[5] Free trade between a developing and a developed nation destroys the most advanced industries in the developing country, leading to a loss of national income, lack of technological development and a widened gap with the developed world.

A very important point is that the nomenclature in modern economics distorts the real-world business process. "Newly Industrializing Economies" are not "industrializing" or "exporting manufactured goods" if the value added of their exports is just manual assembly and all advanced tools and components used by these economies are imported. The capital does not flow across borders – in fact it's protected by numerous laws and patents. As a result, the "foreign investment in the developing world" is a wrong concept from the development perspective if the owner of the capital is in an advanced nation and all the capital rent is flowing to the developed nations as well.

The further developments of the standard trade theories, such as factor price equalization, need to be considered through the light of different technologies as well. This is a topic of further research.

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