

# MEASURING COMPETITIVENESS OF TRANSITION ECONOMIES WITH RICARDO AND HECKSCHER-OHLIN

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To measure competitive trade advantage of an economy trade performance indicators (TPIs) are used. Current TPIs do not measure trade performance of transition economies properly due to their unrealistic assumptions. First, the current TPIs underestimate the potential of transition economies, since they are based on ex post data, i.e. before transition, and not on the current or future figures (of to-be-exported goods). Second, current TPIs do not reflect the Ricardian model of comparative advantage or Heckscher-Ohlin's theory of factor endowments. They merely assess the export or import shares worldwide. As such the purpose of this paper is to propose new TPIs that resolve both deficiencies: the factor prices (or unrevealed) comparative advantage indicator and the Heckscher-Ohlin indicators.

**Keywords:** *Comparative advantage, International trade, Balassa, Ricardo, Heckscher-Ohlin, Transition economies.*

## 1. INTRODUCTION

Governments are frequently changing their international competition policy to protect their local markets. To measure the impact of their policy so-called trade performance indicators (TPIs) are used. Common measures, like the Balassa, Michaely and Lafay indicators for example, use somehow a ratio between the export and import of a country to show the degree of trade specialization. Given the impact of their results, it is of high importance that those calculi can be relied on. But many authors like Marsh and Tokarick (1994), Daskapan (2008a), and Scott (2005) are sceptical. Especially governments of transition economies would be misled by those unreliable TPIs.

Daskapan (2008b) has presented six lacks in the current TPIs based on two leading trade theories: the Ricardian model of comparative advantage and Heckscher-Ohlin theory of factor endowments. From all the indicators the Balassa indicator appeared to be best but was still lacking (Balassa 1965). The deficiencies they have exposed in the current TPIs are the following. The first concern is symmetry of the TPI, i.e. the indicator turns out to produce an output, which cannot be compared on both sides of 1. Secondly, a more disturbing issue is the effect of intra industry trade. As such a distorted over-positive result will be given. Thirdly, another serious problem is the lack in the current TPIs to include not-yet-exported goods. The TPIs measure only the exported goods ex post; based on that outcome a conclusion is drawn about the country's trade specialization. Other specializations of a country, leading to goods with high trade potential, but which are not exported (yet), are as such not exposed. Consequently, the goal of Ricardo to find out a country's trade comparative advantage is missed. An alternative solution to this problem does not exist yet. Fifth, the given TPIs do not indicate trade specialization, but rather the relative export share. This relative export share can be the consequence of numerous factors other than trade specialization, like politics and trade barriers. Sixth, measuring trade

performance according to the Heckscher-Ohlin theory (Heckscher 1949, Ohlin 1933) lacks an appropriate method. Due to this fact, we are not able to measure and compare differences in factor endowments between nations.

Especially the third, fifth and sixth lacks are affecting the measurement of transition economies. Regarding the third lack, transition economies are per definition evolving and have not reached yet their maturity stage. As such many potential trade sectors, with no ex-post data on trade yet, are excluded in the current calculations. The competitive power of a transition economy would be underestimated. As for the fifth lack, governments are misled by (only) presenting export/import shares, since those are in a transition economy yet low, whereas their unmeasured potential is high. Regarding the sixth lack, transition economies have abundance in several (natural) resources that would cause according to the Heckscher-Ohlin theory an export impulse. Unfortunately, a TPI based on Heckscher-Ohlin theory is lacking to measure this potential. Therefore, we expect that the current TPIs will give incomplete and/or distorted results when applied to measure the trade performance of transition economies (see figure 1). *As such the purpose of this paper is to propose two new indicators to resolve both shortcomings in the context of transition economies.*

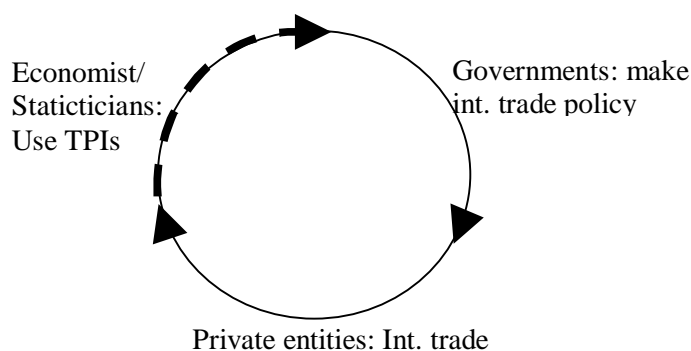


Figure 1. Actors in a trade process

The structure of this paper is as follows. In section 2 we will introduce the concept of unrevealed comparative advantage and propose its indicator. In section 3 this indicator is compared with the Balassa indicator by applying both on the same dataset. In section 4 we will explain the need of an indicator that is based on the Heckscher-Ohlin theory. In section 5 we will propose alternative indicators that are based on the Heckscher-Ohlin theory. Finally in section 6 a conclusion and future work is given.

## 2. Unrevealed comparative advantage

David Ricardo opposed the theory of absolute advantage, by developing the theory of comparative advantage, which states that (Mahoney et al 1998) a country should produce and export those goods and services for which it is relatively more productive than other countries and import those goods and services for which other countries are relatively more productive. The term comparative advantage refers to the opportunity cost of two producers. The Ricardian model is based on technological differences across countries, which result in differences in the productivity .

The revealed comparative advantage can be considered as the first method to measure comparative advantage of international trade specialization (Balassa 1965). Since it is one of the oldest TPIs, it has as such been used in many economic analysis. Over all the years some shortcomings have been noticed in this indicator and many alternatives have been proposed (Daskapan 2008a). The Revealed Comparative Advantage (RCA) or Balassa indicator is defined as

$$RCA_{ij} = \frac{X_{ij} / \sum_i X_{ij}}{\sum_j X_{ij} / \sum_i \sum_j X_{ij}} \quad (1)$$

where  $X_{ij}$  is the export of sector  $i$  from country  $j$ . Here the numerator represents the percentage of share of one given sector  $i$  in the total national exports of country  $j$ , whereas the denominator represents the percentage share of a given sector in world exports. The  $RCA$  indicator is thus a comparison of national export structure with the world export structure. When  $RCA$  equals 1 for a given sector in a given country, the percentage share of that sector is identical with the world average. If  $RCA$  is above 1 the country is considered to be specialized in that sector and vice versa, where  $RCA$  is below 1.

One of the concerns of  $RCA$  and many other current TPIs, i.e the lack of an indicator for non-exported goods (Daskapan 2008b) Since an indicator, which is only based on the export numbers, like the Balassa index a.o., gives an uncomplete outcome, it is necessary to derive the comparative advantage on the basis of other figures than export data. This part of non-exported domestic goods that is not included in the current indicators is called the unrevealed comparative advantage. Given the factor price equalization proposition and Stolper/Samuelson (see section 4), the here proposed alternative is based on the production costs of a good in a country in relation to the average costs of the total production in the world. This alternative indicator is labelled the factor prices or unrevealed comparative advantage (FPCA). It is based on the costs of required resources for the production of the goods in the considered sector. We will call those costs factor prices  $FP$ .

$$FPCA_{ij} = \frac{FP_{ij} / \sum_i FP_{ij}}{\left( \sum_j FP_{ij} / \sum_i \sum_j FP_{ij} \right)} \quad (2)$$

In order to compare this indicator we will introduce in the next section first a fictitious case of four countries. The normalized data will enable us to compare the FPCA with the Balassa indicator.

### 3. COMPARING INDICATORS IN A FICTIVE WORLD OF FOUR COUNTRIES

A common approach in economics is to use a fictive or hypothetic case (Pasteels and Kirchbach 2005). Our purpose is after all not to measure the actual current trade specializations of the different countries, but rather to compare and discuss the TPIs for trade specialization. Assume then a world that comprises four countries: I, E, N and T, where I represents a country with an economy in transition. Assume further that those countries produce three types of goods, which can also to some extent be exported, namely a. Food, b. Textile and c. Wood. In order to make comparisons between the countries and their goods we need also to define a standard unit for all goods:

*One trade unit is the standardized quantity of one good for a certain fixed amount of money (say in \$).*

For example: 1 unit of food is defined as a nutritious good with an energy of 1000 Kcal and one unit of wood is a piece of 1 kg of wood and so on, such that

$$1 \text{ unit food} = 1 \text{ unit of wood} = 1 \text{ unit of textile} = 10\$.$$

In the next tables the production and exports of those units of goods per country are shown. In table 1 the export of goods per country per sector (in units  $\times 10^3$ ) is depicted. It is obvious that Country T has the highest and Country I the lowest export rate. On a total (global) scale all the three goods are exported almost at the same rate ( $7 \times 10^3$  and  $8 \times 10^3$ ).

**Table 1 Export of goods per country per sector (in units x10<sup>3</sup>)**

Sector \ Country	a. Food	b. Textile	c. Wood	Total
I.	1	0	1	2
E.	1	3	2	6
N.	2	1	1	4
T.	4	4	3	11
<b>Total</b>	<b>8</b>	<b>8</b>	<b>7</b>	<b>23</b>

**Table 2 Production of goods per country per sector (in units x10<sup>3</sup>)**

Sector \ Country	a. Food	b. Textile	c. Wood	Total
I.	10	8	8	26
E.	2	5	4	11
N.	6	3	3	12
T.	7	7	4	18
<b>Total</b>	<b>25</b>	<b>23</b>	<b>19</b>	<b>67</b>

Whereas in Table 1 Country T has the most exported units (11) and Country I the least (2), in Table 2 we can see that Country I has the highest production of units. The world export of all goods consists of 23 units in Table 1 and the world production of goods consists of 67 units in Table 2. This means that a total of  $67-23 = 44 \times 10^3$  units is meant for domestic consumption.

**Table 3 Resources (labor + capital) for production of one unit in \$**

Sector \ Country	a. Food	b. Textile	c. Wood	Total
I.	1	1	1	3
E.	4	6	5	15
N.	2	2	2	6
T.	3	3	3	9
<b>Total</b>	<b>10</b>	<b>12</b>	<b>11</b>	<b>33</b>

Low trade performance

high trade performance

From Table 3 we see that Country I needs the least resources to produce one unit of any of the three goods. Country E on the other side has the highest costs of production. According to the theory of *absolute advantage* Country I has compared to the other countries an absolute advantage and Country E has an absolute disadvantage for all the goods. As such, Country I will gain when exporting all its products whereas Country E will lose. However, this statement does not hold, since the theory of absolute advantage has been overruled by the Ricardian comparative advantage and Heckscher-Ohlin theory.

When we apply the FPCA indicator of expression 3 by using the data from Table 3, we see in table Table 4 some differences with the conventional Balassa indicator (from table 1). For example,

$$RCA(I,a) = (1/2)/(8/23) = 1.44$$

$$FPCA(I,a) = (1/3)/(10/33) = 1,10$$

**Table 4 The FPCA indicator compared with Balassa**

Sector \ Country	a. Food	b. Textile	c. Wood	a. Food	b. Textile	c. Wood
I.	1,10	0,92	1,00	1,44	0,00	1,64
E.	0,88	1,10	1,00	0,48	1,44	1,10
N.	1,10	0,92	1,00	1,44	0,72	0,82
T.	1,10	0,92	1,00	1,05	1,05	0,90

a. FPCA indicator

b. Balassa indicator

In contradiction to the Balassa indicator we see now that Country I with a transition economy has also a (unrevealed) comparative advantage for textile (I,b). The Balassa index would not have revealed this

opportunity. Also the other combinations differ somehow: some, like (N,c) and (T,c) improved and some, like (I,c) and (N,a), deteriorated.

*Lemma 1: The unrevealed comparative advantage indicator indulges to the non-exporting country problem for transition economies.*

#### 4. Consequences of the HO model for transition economies

The Heckscher-Ohlin (H-O) theory presents the issue that interregional differences in production costs occur because of the differences in the supply of production factors (McCulloch 1999). Those goods that require much of the abundant, thus less costly factor, will have lower production costs, so that they can be sold for less in international markets (Salvatore and Dominic 1995). This theory of factor endowments states thus that: *a region should export products that use intensively its relatively abundant factors and import products that use intensively its scarce factors.* We define abundance as the positive difference when the supply exceeds the demand of factors.

A fundamental distinction between the H-O model and the Ricardian model is that the Ricardian model assumes that production technologies (only labor) differ between countries, whereas the H-O model assumes that production technologies (labor and capital) between countries are the same. Trade performance indicators should embrace both theories. However, that is currently not the case, since all TPIs are now based on the Ricardian model. This is a deficiency for transition economies, since many transition economies, a.o. many of the new countries of the former Soviet Republic, are already technologically advanced. According to the Ricardian model, the technological small difference between them and the developed countries would not give them much impulse to trade. On the other hand, transition economies do have abundance in several (natural) resources that would cause according to the H-O theory a trade impulse. Unfortunately, a TPI based on H-O theory is lacking. Before proposing an H-O TPI in the next section, we will show in this section the effect of H-O on trade flow between transition economies and developed economies.

The H-O model has led to the formulation of certain named conclusions arising from the assumptions inherent to the H-O model:

- The Rybczynski theorem says that an increase in a country's endowment of a factor will cause an increase in output of the good, which uses that factor intensively, and a decrease in the output of the other good (Amano 1963).
- The Stolper-Samuelson theorem says that relative changes in output goods prices will drive the relative prices of the factors used to produce them. If the world price of capital-intensive goods increases relative to the price of labour intensive goods the rental rate will increase relative to the wage rate (Stolper 1941).
- The factor-price equalization theorem says that when the prices of the output goods are equalized between countries, as when countries move to free trade, then the prices of the factors (capital and labor) will also be equalized between countries (Kuga 1972).

Based on those theories we can pose two lemmas:

**Lemma 2:** *price of factors and of their produced goods decreases when abundance of the factors increases.*

**Lemma 3:** *Given a one country closed economy, this change in price is linearly related to the change of the abundance of factors.*

The basic assumptions for those lemma's are that in this economy there is one country in the world, labour and capital are the only factors of production, only one good is produced in each country, the supply of factors is fixed in each country, the productivity is fixed, perfect competition prevails in all markets, factors are not mobile across the two countries, but within each country, there are no other costs involved (transportation costs, etc.).

So, when the quantity  $Q$  of factors increases by  $\Delta Q = m$ , while demand remains the same, its price  $P$  will decrease by  $\Delta P = n = am+b$ , with  $a$  and  $b$  as constants, such that the national value  $V$  of all those goods remains the same:  $V = (P \times Q)_{\text{before}} = (P \times Q)_{\text{after}}$ .

Assume for example that before the change the total quantity of apples in a country is 100 whereas the price per apple is 10, so that the total national value is  $100 \times 10 = 500$ . If in the next period the number of harvested apples in the country increases by 25 (i.e.  $100+25$ ), whereas the number of consumers remains the same, then lemma 2 says that the price will decrease by  $n$  (i.e.  $10 - n$ ), such that  $(10-n) \times 125 = 500$ . In this case this will result in  $n = 6$ .

Given the previous lemmas and the price equalization theory we pose the next lemma.

**Lemma 4:** *Assuming different but constant demands in different countries, perfect competition and free trade of goods in and between the countries, differences in factor endowments will lead to differences in prices between the countries. Given then the price equalization theory countries trade until a new equilibrium is reached.*

Differences in factor endowments between the transition economies and mature economies will thus lead to trade until a certain equilibrium is reached. This can be explained as follows. Given those 3 lemmas this means that any distortion in prices or quantity in a free trade relation between countries will lead to a new equilibrium. For example, in a two country economy with only America (A) and Moldavia (M) that trade with each other this equilibrium will be derived. There is free trade of goods, but not of consumers, so that both demands remain constant.

$$V_A = (P_{A,\text{before}} \times Q_{A,\text{before}}) = (P_{A,\text{after}} \times Q_{A,\text{after}}) \quad (3)$$

$$V_M = (P_{M,\text{before}} \times Q_{M,\text{before}}) = (P_{M,\text{after}} \times Q_{M,\text{after}}) \quad (4)$$

We know now that  $P_{A,\text{before}} = P_{M,\text{before}} = P_{\text{before}}$ , since there was a trade balance before the distortion. The distortion of the equilibrium will lead to different prices and thus initiates trade. This trade will continue until  $P_{A,\text{after}} = P_{M,\text{after}} = P_{\text{after}}$ .

$$V_A = (P_{\text{before}} \times Q_{A,\text{before}}) = (P_{\text{after}} \times Q_{A,\text{after}}) \quad \Rightarrow P_{\text{before}} / P_{\text{after}} = Q_{A,\text{after}} / Q_{A,\text{before}} \quad (5)$$

$$V_M = (P_{\text{before}} \times Q_{M,\text{before}}) = (P_{\text{after}} \times Q_{M,\text{after}}) \quad \Rightarrow P_{\text{before}} / P_{\text{after}} = Q_{M,\text{after}} / Q_{M,\text{before}} \quad (6)$$

The price equalization theory between both countries enables (5) in (6), which gives

$$Q_{A,\text{after}} / Q_{A,\text{before}} = Q_{M,\text{after}} / Q_{M,\text{before}} \quad (qed.) \quad (7)$$

This means that trade will stabilize when the relative increase of factors between the developed economy and the economy in transition becomes equal.

## 5. The Heckscher-Ohlin indicator

Another concern is the lack of an appropriate TPI based on the Heckscher-Ohlin theory. Whereas the other trade theories can lean on well developed and used indicators, as we have seen in the previous sections, measuring trade differentiation according to the Heckscher-Ohlin theory lacks an appropriate indicator. As such we propose alternative Heckscher-Ohlin indicators (HOI) to measure factor endowments. Instead of only presenting the final expressions, we will describe our considerations during this quest for HOIs.

### 5.1. Heckscher-Ohlin Indicator based directly on factor prices

A country is abundant in a factor relative to another country if it has more endowment in that factor than the other country. If we want to capture this abundance in an indicator such that a comparison between countries/sectors becomes possible, one way is to express it relatively to those other sectors and countries. We assume further that lower factor prices represent higher factor endowments. As such, if we could measure an aggregated factor price directly the initial composition of HOI is

$$HOI_{ij} = \frac{\ddot{F}_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} \quad (8)$$

where the umlaut represents the average value.  $\ddot{F}_{ij}$  depicts the average factor price in sector  $i$  of country  $j$ ,  $\ddot{F}_j$  gives the average factor price in country  $j$ . Here the numerator represents the ratio between the average factor price in sector  $i$  of country  $j$  and the average factor price for all sectors in country  $j$ . The denominator represents the ratio between the average factor price of sector  $i$  in the world and the average factor price in the world. The HOI is thus here a comparison of the average national factor price compared with the average world the factor price. When  $HOI$  equals 1 for a given sector in a given country, the endowment of that sector is identical with the world average. Where  $HOI$  is above 1 the country is considered to be factor abundant in that sector and vice versa where  $HOI$  is below 1.

Although this indicator measures directly the aggregated factor endowment per sector and per country, it is not practical since it does not distinguish between the different specific factors. As such it is then not possible to draw conclusions about a country's comparative advantage per factor per sector. The 2x2x2 model only assumes the factors labour (L) and capital (K). The factor land or property (D) is not included, although this also an accepted factor in economics (Fetter 1977; Ryan 2002). Recall that in the neo-classical model country A is considered capital abundant relative to B if:

$$\frac{K_A}{L_A} > \frac{K_B}{L_B} \Rightarrow \frac{K_A}{K_B} \cdot \frac{L_B}{L_A} > 1$$

That means that with a 2x3x2 model A is considered capital abundant relative to B if:

$$\frac{K_A}{D_A \cdot L_A} > \frac{K_B}{D_B \cdot L_B} \Rightarrow \frac{K_A}{K_B} \cdot \frac{D_B \cdot L_B}{D_A \cdot L_A} > 1$$

Therefore, we can substitute the aggregated factor  $\ddot{F}_{ij}$  with the specific factors  $\ddot{F}_l$ ,  $\ddot{F}_r$ ,  $\ddot{F}_t$ :

$$F = Fl + Fr + Ft, \quad (9)$$

where  $\ddot{F}_l$  is the factor price of labor,  $\ddot{F}_r$  the factor price of land and  $\ddot{F}_t$  the factor price of capital. This gives after substitution in expression (8):

$$HOI_{ij} = \frac{(\ddot{F}_w + \ddot{F}_r + \ddot{F}_t)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} = \frac{(\ddot{F}_w)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} + \frac{(\ddot{F}_r)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} + \frac{(\ddot{F}_t)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} \quad (10)$$

where each term represents one of the following specific Heckscher-Ohlin indicators.

- Labor endowment is represented in the first term of the previous equation:

$$HOI_{ij}^{(w)} = \frac{(\ddot{F}_w)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} \quad (11)$$

However, unlike the other specific HOI, labor endowment can be measured directly, and not necessarily as a derivative from the factor prices, when using the unemployment rate. The assumption here is that unemployment is the result of a negative balance between demand and supply of the factor labor.

$$HOI_{ij}^{(w)} = \frac{\ddot{U}_{ij} / \ddot{U}_j}{\ddot{U}_i / \ddot{U}} \quad (12)$$

where  $\ddot{U}_{ij}$  is the unemployment rate in sector  $i$  of country  $j$ . Here the numerator represents the ratio between the unemployment rate in sector  $i$  of country  $j$  and the unemployment rate for all sectors in country  $j$ . The denominator represents the ratio between the unemployment rate of sector  $i$  in the world and the unemployment rate in the world. The HOI is thus here a comparison of the national unemployment rate compared with the world unemployment rate. When  $HOI$  equals 1 for a given

sector in a given country, the endowment of that sector is identical with the world average. Where  $HOI$  is above 1 the country is considered to be factor abundant in that sector and vice versa where  $HOI$  is below 1.

- For capital endowment we suggest the second term of the previous equation.

$$HOI_{ij}^{(r)} = \frac{(\ddot{F}_r)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} \quad (13)$$

- and for land endowment

$$HOI_{ij}^{(t)} = \frac{(\ddot{F}_t)_{ij} / \ddot{F}_j}{\ddot{F}_i / \ddot{F}} \quad (14)$$

**Lemma 5:** *The Heckscher-Ohlin indicator to measure the factor endowments can be based directly on factor prices*

## 5.2. Heckscher-Ohlin Indicator based indirectly on final goods

Based on Stolper-Samuelson theorem and the Factor-Price Equalization theorem we assume that factor abundance can also be measured by the prices of the final goods. We assume that lower factor prices represent higher factor endowments. As such, factor endowments lead to lower factor prices and thus to lower prices of the final goods. The  $HOI$  for the average aggregated price  $\ddot{P}_{ij}$  of a good in sector  $i$  of country  $j$  is then:

$$HOI_{ij} = \frac{\ddot{P}_{ij} / \ddot{P}_j}{\ddot{P}_i / \ddot{P}} \quad (15)$$

where the umlaut represents the average value.  $\ddot{P}_{ij}$ ,  $\ddot{P}_j$ ,  $\ddot{P}_i$  and  $\ddot{P}$  represent then respectively the average price of a good in country  $j$  and in sector  $i$ , of all goods in country  $j$ , of a good in all sectors  $i$ , of all goods in the world. Like the previous indicator this one does not distinguish between the different factor endowments. It is also not a workable indicator, since  $\ddot{P}_j$ ,  $\ddot{P}_i$  and  $\ddot{P}$  are unrealistic variables to calculate. As such it is then also not possible to draw conclusions about a country's comparative advantage per factor per sector. The first attempt to reach a workable  $HOI$  is by using the CPI for  $\ddot{P}_j$  and  $\ddot{P}$ , so that

$$HOI_{ij} = \frac{\ddot{P}_{ij} / CPI_j}{\ddot{P}_i / \ddot{CPI}} \quad (16)$$

where  $\ddot{CPI}_j$  represents the consumer price indicator in country  $j$  and  $\ddot{CPI}$  the average consumer price indicator in the world.

Another option is to decompose the aggregated price  $\ddot{P}_{ij}$  in to the specific prices  $\ddot{P}_l$ ,  $\ddot{P}_r$ ,  $\ddot{P}_t$ , which are expressed in terms of factor prices. As for labor, we use the indicator real wage ( $w$ ). For land we propose rent ( $r$ ) and for capital interest ( $t$ ). The expression for the aggregate price  $\ddot{P}_{ij}$  of a good in sector  $i$  of country  $j$  is then:

$$\ddot{P}_{ij} = (a.t + b.w + c.r)_{ij} (1+m)_{ij}$$

with  $a, b, c$  as the quantities and  $m$  as a prefixed constant for profit or loss margin. We will make a simplification by assuming that for this case the profit margin for each product in each country is equal to  $1+m$ :

$$\ddot{P}_{ij} = (a.t + b.w + c.r)_{ij} (1+m) \quad (17)$$

The HOI becomes now

$$\text{HOI}_{xy} = \frac{\ddot{P}_{xy} / \ddot{P}_j}{\ddot{P}_i / \ddot{P}} = \frac{(a.\dot{i} + b.\dot{w} + c.\dot{r})_{xy} / (a.\dot{i} + b.\dot{w} + c.\dot{r})_j}{(a.\dot{i} + b.\dot{w} + c.\dot{r})_i / (a.\dot{i} + b.\dot{w} + c.\dot{r})} \wedge (x, y) \notin \{[1, j], [1, i]\} \quad (18)$$

Furthermore, we define three categories of goods. In the first category,  $b$  and  $c$  are that relatively small compared to  $a$  that we assume  $c = b \approx 0$ . In the second category, we assume  $a$  and  $c$  to be zero and in the third category,  $a$  and  $b$  are assumed to be equal to zero, so that

$$\begin{aligned} P_{ij}(\text{cat1}) &= (a.t)_{ij} (1+m) & \wedge c = b \approx 0, \\ P_{ij}(\text{cat2}) &= (b.w)_{ij} (1+m) & \wedge a = c \approx 0, \\ P_{ij}(\text{cat3}) &= (c.r)_{ij} (1+m) & \wedge a = b \approx 0. \end{aligned}$$

The HOI can now be defined separately for each factor now. We suggest

- for capital endowment:

$$\text{HOI}_{xy}(t) = \frac{\ddot{P}_{xy} / \ddot{P}_j}{\ddot{P}_i / \ddot{P}} = \frac{(a.\dot{i})_{xy} / (a.\dot{i})_j}{(a.\dot{i})_i / (a.\dot{i})} \wedge (x, y) \notin \{[1, j], [1, i]\} \quad (19)$$

- for labor endowment:

$$\text{HOI}_{xy}(w) = \frac{\ddot{P}_{xy} / \ddot{P}_j}{\ddot{P}_i / \ddot{P}} = \frac{(b.\dot{w})_{xy} / (b.\dot{w})_j}{(b.\dot{w})_i / (b.\dot{w})} \wedge (x, y) \notin \{[1, j], [1, i]\} \quad (20)$$

- for land endowment:

$$\text{HOI}_{xy}(r) = \frac{\ddot{P}_{xy} / \ddot{P}_j}{\ddot{P}_i / \ddot{P}} = \frac{(c.\dot{r})_{xy} / (c.\dot{r})_j}{(c.\dot{r})_i / (c.\dot{r})} \wedge (x, y) \notin \{[1, j], [1, i]\} \quad (21)$$

If we also assume that the production function is equal, so that the productivity is equal, the HOI's can be simplified into:

$$\text{HOI}_{xy}(t) = \frac{\dot{i}_{xy} / \dot{i}_j}{\dot{i}_i / \dot{i}} \wedge (x, y) \notin \{[1, j], [1, i]\}$$

$$\text{HOI}_{xy}(w) = \frac{\dot{w}_{xy} / \dot{w}_j}{\dot{w}_i / \dot{w}} \wedge (x, y) \notin \{[1, j], [1, i]\}$$

$$\text{HOI}_{xy}(r) = \frac{\dot{r}_{xy} / \dot{r}_j}{\dot{r}_i / \dot{r}} \wedge (x, y) \notin \{[1, j], [1, i]\}$$

This enables us to distinguish the effect of the different factor endowments for a specific good.

**Lemma 6:** *The Heckscher-Ohlin indicator to measure the factor endowments can be based indirectly on final goods*

## 6. Conclusions and Future work

In this paper we proposed alternative indicators to overcome the shortcomings of the current trade performance indicators (TPIs) to measure the trade potential of transition economies properly. We have focussed on three types of shortcomings. First, many potential trade sectors are excluded in the current calculations, since no ex-post trade data exists yet about them. Second, the given TPIs do not

represent trade specialization or comparative advantage, but rather the relative export share. Third, a TPI based on Heckscher-Ohlin (H-O) theory is lacking to measure the trade potential based on factor abundance. To overcome the first and second shortcomings the unrevealed comparative advantage indicator that is based on factor prices is introduced. To meet the third shortcoming two alternative H-O indicators are derived: the H-O indicator that is based directly on factor prices and the H-O indicator that is based *indirectly* on factor prices.

In future work we intend to test both H-O indicators and the unrevealed comparative advantage indicator with real data. In this test we will use data from developed countries and data from transition economies. Both datasets will be used according to the 'old' TPIs and according to the here new proposed TPIs. Our expectation is that when the results of both, i.e. old vs. new TPIs, are compared the new TPIs will reveal more sectors with trade potential than the old TPIs.

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