Monotonicity of Indices of "Revealed" Comparative Advantage: Empirical Evidence on Hillman's Condition

By

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I. Introduction

The proliferation of trade control measures (in terms of number and in terms of discriminatory impact in both developing and developed economies) makes the issue of comparative advantage and its proper measurement one of continuing interest. This is even more relevant given that nations are engaged again in another round of trade negotiations.

Since Balassa's [1965] paper proposing the criterion of "revealed" comparative advantage (RCA) to gauge the long-term effects of trade liberalization, many studies have asserted the shortcomings of the two measures originally suggested: export performance and export-import shares [UNIDO, 1982]. The net trade share measure was already criticized by Balassa as biased by the degree of skewness in the cross-country pattern of protection. The export performance measure of RCA is also affected by trade policy measures like export subsidization or other arrangements discriminating among suppliers.[1] Furthermore, Bowen [1983] has shown that, when used for comparisons across commodities, the export performance measure assumes that every country exports every commodity, if one interprets revealed comparative advantage above (below) unity as indicative of relative advantage (disadvantage).[2] Bowen proposes, instead, two indices that use production (or consumption) data.[3]

Remark: Data calculations were carried out in the context of the Global System of Trade Preferences Project of UNCTAD. This paper was written while one of the authors was a consultant at UNCTAD; the views expressed in the paper, however, do not neccessarily reflect those of UNCTAD. Comments from Henryk Kierzkowski and an anonymous referee are gratefully acknowledged. Errors remain our responsibility.

[1] The export performance measure of RCA is:

$$RCA = (X_{ij}/X_j)/(W_i/W),$$

where Xij are exports of good i by country j; X_j are total exports of country j; W_i are the world's exports of good i and W is the world's total trade.

[2] This could be true if one worked with aggregate categories of commodities, or if intra-industry trade existed for every commodity.

[3] Reliable trade statistics on commodities have proven to be very difficult to obtain; the lack of consistent statistical information on production or consumption at the level of disaggregation needed for any meaningful empirical analysis may preclude investigations involving countries with a poor record of national statistics but still important in international trade.

Hillman [1980] has proven diagrammatically that the export-performance index of RCA is not appropriate for cross-commodity comparisons of comparative advantage: in this case the value of the index is independent of comparative advantage in the Ricardian sense of pre-trade relative prices. Yeats [1985] provided empirical evidence in this connection showing that the index (as used in the country-industry approach) fails to provide a reliable cardinal or ordinal measure of a country's RCA.

Hillman [1980] developed the condition that has to be fulfilled for obtained the correspondence between RCA and pre-trade relative prices in cross-country comparisons with respect to a specific commodity: the transformation performed to the index of RCA has to be monotonic. In this paper we test the behaviour of the monotonicity condition as an indicator of the confidence that can be attached to the RCA index in comparisons across countries. We have used a sample of 118 developing economies' trade figures at the most disaggregated level for which statistics can be collected.[4] We conclude that Hillman's condition is less restrictive than thought to be in the literature we surveyed: it only fails to hold for commodities representing 9.5 percent of the exports of 118 developing economies in 1985.

II. Hillman's Index

Hillman [1980] has shown that comparative advantage according to pretrade relative prices for country i in commodity j requires the following necessary and sufficient condition to hold:

$$1 - \frac{X_{ij}}{W_i} > \frac{X_{ij}}{X_j}\left(1 - \frac{X_j}{W}\right).$$

Assuming identical homothetic preferences across countries, Hillman's condition is necessary and sufficient to guarantee that changes in the RCA index are consistent with changes in countries' relative factor endowments; that is to say, if pre-trade relative prices in a two-country two-good world were $P_{i1} > P_{i2}$ (or $P_{i1} < P_{i2}$), then it would be true that $RCA_{i1} < RCA_{i2}$ (or $RCA_{i1} > RCA_{i2}$). In other terms, the change in exports of the labour intensive good i in country j, given a change in the country's labour endowment, should be positive. Hillman's condition can also be seen as the necessary and sufficient condition for the scaling of a country's exports by a measure of its size and by a measure of commodity size to be a monotonic transformation.[5] If fulfilled, the

[4] See list of countries in the Appendix.

[5] We owe this point to an anonymous referee.

condition guarantees that an increase in the level of a country's exports of a good will result in an increase in the index of RCA.

In empirical work, an interesting issue is related to the behaviour of the ratios X_{ij}/W_i and X_{ij}/X_j as the level of commodity aggregation changes. Aggregation of commodities into groups has two effects on those ratios. Firstly, W_i becomes larger because it includes exports of more commodities; X_{ij} is also likely to rise but less than W_i unless, for instance, a country j has a monopoly power for all the commodities of the group. In the latter case the ratio X_{ij}/W_i would equal 1. So, aggregation is likely to increase the left-hand term of Hillman's condition. Secondly, as we aggregate data, X_j increases because, in principle, we include more products; also, as aggregation takes place, the change in X_{ij} will be small if country j is highly specialized. In any case, we expect the right-hand term of the equation to rise as we aggregate commodities. The ratio X_{ij}/X_j reaches a value of 1 more quickly the more specialized exports are. We conclude that a reduction in the number of cases where Hillman's condition does not hold bears a negative relationship with commodity aggregation. This is contrary to Hillman's conclusion.[6] We have checked the fulfillment of Hillman's condition at three different levels of commodity aggregation.

For empirical purposes, we have transformed Hillman's condition into an index. The index (HI) takes the following form:

$$HI = \left(1 - \frac{X_{ij}}{W_i}\right) / \frac{X_{ij}}{X_j} \left(1 - \frac{X_j}{W}\right) .$$

Whenever HI is larger than one, the index of RCA used in cross-country comparisons will be a good indicator of comparative advantage. If economy j has a monopoly in the world market of good i ($X_{ij} = W_i$), the value of the HI approaches to zero. If economy j specializes in the production of good i ($X_{ij} = X_j$), the value of HI is smaller than one because, by definition, the value of the world's exports of i is smaller than or at most equal to total world exports.[7]

The HI values have been calculated for 118 developing countries' exports using trade figures for 1985. These trade figures have been estimated by the United Nations Statistical Office (UNSO) at the most detailed level of the Standard International Trade Classification (SITC), Revision 2 in October-

[6] Hillman's negative relationship between data aggregation and the likelihood that his condition will hold true occurs when aggregation of X_{ij} takes place across commodities *and* countries.

[7] If country j does not export good i, the index is not well-behaved, and it tends to infinity. Presumably, ex-post absence of exports is not consistent with pre-trade relative prices indicating the presence of comparative advantage.

Table 1 – *Categories of Commodities with HI < 1 at the 5- and 4-digit level (1985 Trade Data)*

SITC	Description	Country	Rank[a]	X_{ij}/W_i	X_{ij}/X_j	RCA	HI
0019	Live animals for human food, n.e.s.	Sudan	1	0.931	0.238	719.4	0.289
07113	Coffee substitutes containing coffee	Ethiopia	1	0.945	0.155	1044.2	0.354
0412	Other wheat, unmilled	Argentina	2	0.989	0.135	43.9	0.087
4236	Sunflower seed oil	Argentina	5	0.972	0.062	43.1	0.473
08131	Oil cake of soya beans	Brazil	2	0.971	0.063	14.3	0.486
28731	Aluminium ore, concentr.	Guinea	1	0.574	0.841	463.7	0.507
2860	Uranium and thorium, ores and concentrates	Malaysia	1	1.0	(*)	23.2	0.0
3330	Petroleum oils, crude	Iran, Nigeria	15 4	0.092 0.095	0.961 0.956	2.5 2.5	0.981 0.984
3414	Petroleum and other hydrocarbons' gases	Algeria	1	0.898	0.347	33.0	0.301
5241	Radioactive elements and isotopes	Niger	1	0.766	0.907	1397.7	0.258
2714	Potassium salts, natural crude	Jordan	1	0.991	0.381	570.2	0.024
2640	Jute and other textile bast fibers	Bangladesh	2	0.924	0.127	354.9	0.605
68122	Rolled platinum, unworked or semi-manufactured	Yugoslavia	1	1.0	(*)	51.1	0.0
68212	Refined copper	Zambia	4	0.197	0.816	115.8	0.986
68721	Bars, rods, etc, wrought of tin	Bolivia	1	0.940	0.202	521.0	0.295

[a] Rank of the SITC in which the country shows the largest RCA across commodities. – (*) the item accounts for less than 0.001 of the country's total exports.

November 1987.[8] The exports considered in the sample account for 80 percent of the total exports of developing countries.

The empirical results at 5-digit, 4-digit, 3-digit and 1-digit levels are reported in Tables 1 and 2. Table 1 shows that 14 countries have a "commodity" with an HI smaller than one (and larger than zero), while only one country (Argen-

[8] The SITC, Revision 2 classification includes 1,832 elementary items, i.e. not further subdivided. There is a virtual one-to-one correspondence between elementary items of the SITC Revision 2 and those of the Customs Co-operation Council Nomenclature (CCCN).

Table 2 – Categories of Commodities with HI < 1 at the 3-digit and 1-digit level (1985 Trade Data)

SITC	Description	Country	Rank[a]	X_{ij}/W_i	X_{ij}/X_j	RCA	HI
		a. 3-digit level					
041	Wheat (including spelt) and meslin, unmilled	Argentina	1	0.972	0.135	43.1	0.212
264	Jute and other textile bast fibers, not spun	Bangladesh	1	0.924	0.127	354.9	0.605
286	Ores and concentrates of uranium and thorium	Malaysia	1	1.0	(*)	23.2	0.0
287	Ores and concentrates of base metals, n.e.s.	Guinea	1	0.121	0.947	97.5	0.930
333	Petroleum oils, crude, from bituminous minerals	Iran,	4	0.092	0.961	2.5	0.981
		Nigeria	1	0.095	0.956	2.5	0.984
524	Radioactive and associated material	Niger	1	0.735	0.907	1340.3	0.293
		b. 1-digit level					
3	Mineral fuels, lubricants and related materials	Iraq	1	0.055	0.985	1.89	0.988
3	Mineral fuels, lubricants and related materials	Libyan Arab Republic	1	0.055	0.983	1.89	0.991
3	Mineral fuels, lubricants and related materials	Nigeria	1	0.071	0.968	1.86	0.998
3	Mineral fuels, lubricants and related materials	Saudi Arabia	1	0.144	0.961	1.85	0.966

[a] Rank of the SITC in which the country shows the largest RCA across commodities. – (*) The item accounts for less than 0.001 of the country's total exports.

tina) was found with two "commodities" with HI smaller than one;[9] with 1830 SITCs this group represents 33,804 observations. This is approximately 9.5 percent of the total exports of the sample considered. We can see that for 11 products out of 15 (73 percent) the value of the HI is smaller than one due to the fact that the countries concerned have a market power in the commodity (X_{ij}/W_i close to one); this accounts for 2 percent of the exports of all the economies. In Table 2 panel (a), the number of commodities for which the HI is below one is reduced to 6 and the number of exporters to 7. This represents about 7.7 percent of the total exports of our sample. The number of cases in which Hillman's condition is not fulfilled due to market power drops to 3 out

[9] We have not included in the group of commodities 8 SITC for which exports of the country are below $ 1,000,000; the total of these exports is $ 1,733,000.

of 7 (43 percent); this reflects 0.3 percent of total exports. The share of cases due to export specialization remains stable as we aggregate data across commodities: 7.5 percent at the most disaggregated level and 7.4 percent at the 3-digit level. Table 2 panel (b) shows that the mineral fuels, lubricants and related materials constitute the only group where there are, at the highest level of commodity aggregation, 4 economies that have an HI below one although the value of the index is admittedly almost one. The share of the exports concerned in the total for the developing economies is higher than at the more disaggregated levels: 16.9 percent. The countries singled out are all largely specialized in the group of commodities; as expected, there are no cases of HI lower than one due to market power.

The results show that: *(i)* commodity aggregation is likely to affect the number of cases in which Hillman's condition does not hold because the exporter enjoys some market power, and *(ii)* the number of cases due to the lack of export diversification is probably less sensitive to the level of commodity aggregation.

The distributions per country of the commodities (SITC) included in the Tables are as follows: in Table 1, 2 SITC for Argentina and 1 for Algeria, Bangladesh, Bolivia, Brazil, Ethiopia, Guinea, Iran, Jordan, Malaysia, Niger, Nigeria, Sudan, Yugoslavia, and Zambia; in Table 2 panel (a), Argentina, Bangladesh, Guinea, Iran, Niger, Nigeria and Malaysia; in Table 2 panel (b), four economies, out of which three are new: Iraq, Libya and Saudi Arabia are added to Nigeria. These samples include a total of 15 economies at a 5-digit level, 7 at a 3-digit level and 4 at a 1-digit level which show at least one SITC for which Hillman's condition does not hold.

Hillman's index behaves as expected taking always a value of zero when the economy has a monopoly power in the world market of the "commodity": these are SITCs 2860 and 68122 in Table 1 and SITC 286 in Table 2 panel (a). These "commodities" happen to represent a low percentage of the countries' exports; but this is not necessary. Furthermore, the index is, as expected, close to zero when the economy tends to specialize in few exports and simultaneously has a monopoly power in them; this is the case of Jordan in the export of potassium salts in Table 1.

As stated in Table 1, in all but 5 cases the exporting country supplies more than 90 percent of the developing countries' exports. In Table 2 panel (a), that number drops to 3. As Hillman said [1980, p. 320], his condition does not hold when the economy has a monopoly power in the commodity.

In SITCs 68212 and 3330, in Table 1, we have the other extreme case in which the HI is expected to be lower than 1: refined copper represents 82 percent of Zambia's exports and petroleum oils cover 96 percent of exports of Iran and Nigeria. In Table 2 panel (a), petroleum oils and crude oils obtained from bituminous mineral, SITC 333, is the only group; this accounts for a large

share of Iran and Nigeria's exports. Group 3, mineral fuels, lubricants and related materials, is also the only one that remains at the most aggregated level displayed in Table 2 panel (b); in all the cases exports of the group of commodities represent more than 96 percent of the exports of the countries involved.

SITCs 5241 and 28731 of Table 1 are due to cases of high market share and low degree of export diversification: Niger supplies 77 percent of the developing countries' exports of radioactive elements and isotopes, representing 91 percent of its exports; Guinea supplies 57 percent of the developing countries' exports of aluminium ore which accounts for 84 percent of its exports. When we aggregate to the 3-digit level we still have Niger supplying 73 percent of the developing countries' exports of radioactive and associated material, but Guinea's market share of ores and concentrates of base metals drops to 12 percent; those exports represent, on the contrary, a larger proportion of the country's exports, 95 percent.

All the economies in Table 1 are those that have the highest RCA index of the group (per commodity) except in the case of SITC 3414 in which Algeria occupies the second place in the ranking after Bolivia. The economies of Table 2 are, without exception, those reporting the highest RCA index of the group, per commodity.

We have also included in our tables a column that displays the rank of the commodities in terms of RCA (across industries) for each respective country. Our evidence confirms Yeats' [1985] finding that the country-industry approach fails to flag countries' comparative advantage due to the different distributions of indices of RCA across industries; this is less pronounced when using more aggregated data. But in our context, we cannot conclude either that the ranking in the cross-country comparison is adequate. Research along Yeats' lines should first discard cases that have an HI smaller than one to be conclusive.

Finally, if we compare the country composition of the World Bank's research on trade policy and industrialization [World Bank, 1987, Ch. 5] with that of our Table 1, we note that 7 out of 10 countries that are included in both studies belong to the group that the World Bank has categorized as strongly inward-oriented, 1 belongs to the group of moderately inward-oriented and the other 2 to the group of moderately outward-oriented.[10] Therefore, the majority

[10] See World Bank [1987, pp. 82–83] for the exact definitions. Let us say here that the classification takes into account four indicators: the effective rate of protection, the degree of use of direct controls, the degree of exchange rate overvaluation and the use of export incentives. The first three are positively correlated with the degree of inward-orientation and the last one is negatively correlated. Our study excludes only 2 countries out of the 41 included in the World Bank's research.

of products that we have identified as having an HI smaller than one are those representing the traditional exportables of countries considered strongly inward-oriented; those are countries that, according to the World Bank, apply frequent direct controls to the traditional export sector and in which incentives to non-traditional export sectors are non-existent. We can conclude that the ranking of countries per commodity provided by the index of RCA, at least at a very disaggregated level, seems to be little affected by the actual level of effective protection and direct controls.

III. Conclusions

The necessary and sufficient condition suggested by Hillman [1980] for the index of RCA, when used in cross-country comparisons, to provide a one-to-one relationship between pre-trade comparative advantage and revealed comparative advantage is fulfilled for the great majority of the "commodities" traded in 1985 by 118 developing economies. Given the low level of data aggregation (the lowest for which statistical information is currently available), the large sample of countries and the high percentage of developing economies' total exports captured in this research, we can conclude that Balassa's export-performance index, for cross-country comparisons, is a good indicator of comparative advantage as reflected by pre-trade prices. In other words, Hillman's condition is a useful indicator of the presence of monotonicity in indices of RCA: we have observed that at a 5-digit level of commodity aggregation, increases in Balassa's export performance index of RCA are likely to correspond to increases in export levels. Aggregation of commodities at a 3-digit and at a 1-digit level suggests that Hillman's condition is unlikely to be violated if the cause for values of the Hillman's Index less than one is due to export specialization; on the contrary, the number of cases of a Hillman Index smaller than one due to a large share of world markets is expected to be negatively related to the level of aggregation. Our results suggest that Hillman's index should be calculated in any empirical investigation trying to assess the long-term implications of trade liberalization negotiations using an export-performance index of RCA. There is evidence that, if used at a disaggregated level, the HI is a tool that may help flag cases in which the RCA index can be a misleading indicator of countries' comparative advantage, even in cross-country comparisons. It may also help reduce disagreements regarding the most appropriate coefficient of RCA.

Further research should be directed toward enlarging the sample of countries to include the entire world and to incorporate at least three years of trade so as to be able to eliminate the possible influence of cycles.

Appendix

List of Countries

Afghanistan	Algeria	Angola
Antigua	Argentina	Bahamas
Bahrain	Bangladesh	Barbados
Benin	Bhutan	Bolivia
Brazil	Belize	Brunei
Burkina Faso	Burma	Burundi
Cameroon	Cape Verde	Central African Rep.
Chad	Chile	Colombia
Comoros	Congo	Costa Rica
Côte d'Ivoire	Cyprus	Democratic Yemen
Djibouti	Dominica	Dominican Rep.
Ecuador	Egypt	El Salvador
Equatorial Guinea	Ethiopia	Fiji
Gabon	Gambia	Ghana
Grenada	Guatemala	Guinea
Guinea Bissau	Guyana	Haiti
Honduras	India	Indonesia
Iran	Iraq	Jamaica
Jordan	Kenya	Korean Rep.
Kuwait	Lebanon	Liberia
Libyan Arab Rep.	Madagascar	Malawi
Malaysia	Maldives	Mali
Malta	Mauritania	Mauritius
Mexico	Morocco	Mozambique
Nepal	Nicaragua	Niger
Nigeria	Oman	Pakistan
Panama	Papua New Guinea	Paraguay
Peru	Philippines	Qatar
Rwanda	St. Christop. & Nev.	St. Lucia
St. Vincent	Samoa	São Tomé & Príncipe
Saudi Arabia	Senegal	Seychelles
Sierra Leone	Singapore	Socialist Vietnam
Solomons	Somalia	Sri Lanka
Sudan	Suriname	Syrian Arab Rep.
Thailand	Togo	Tonga
Trinidad	Tunisia	Uganda
United Arab Emirat.	United Rep. Tanzan.	Uruguay
Vanuatu	Venezuela	Yemen
Yugoslavia	Zaire	Zambia
Zimbabwe		

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