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**Herfindahl-Hirschman
meets international trade and development theories**

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Abstract

To date there does not exist one a generally acceptable measure or index of Specialization in International Trade. Development Economic Theory embraces the expectation of a direct relationship between economic growth and export diversification. However, International Trade Theory supports the association of export expansion with increased specialization. The paper proposes a Specialization Index and applies it to six small developing countries: Singapore, South Korea, Malaysia, Mexico, Tunisia and Morocco, during the years of their take offs. Additionally, the index is applied to the two large fast growing economies of China and India.

JEL Classifications: O1, O14, F1, F14

Key words: Trade Specialization Indices; Development Theory; Developing Country Export Compositions; International Trade Theory; Trade in Manufactures; Trade and Transformation; Singapore; South Korea; Malaysia; Mexico; Tunisia; Morocco; China; India.

Herfindahl-Hirschman Meets International Trade and Development Theories

I. Introduction

Economic Development literature generally agrees that increasing export diversification is a concomitant to economic development. An accepted explanation for Africa's export stagnation in recent decades is its dependence on mono-culture, and on a single or small number of commodities. The fact that African countries lag behind other Less Developed Countries (LDCs) is often explained by its *inability to diversify* into manufacturing (Otobo, 2004). The "over-specialization" of a Less Developed Country's dual economy is often identified as a major cause of its failure to climb the Newly Developed Countries' (NIC's) development-ladder. The claim is that their economic base cannot provide the diversified and sophisticated manufactured exports demanded by the market. A common characteristic observed in the export compositions of successfully developing countries is a broadening of their productive base, and a diversification in their export offerings. Hence, development economics tends to lead to the expectation of an inverse relationship between economic growth and trade specialization.

Moreover, the Development literature suggests that during the first half of the 20th Century, many if not most Less Developing Countries followed the Prebisch (1959) and Singer (1950) model of import-competing industrialization. Since this model of growth explicitly called for an increasingly diversified LDC production base, it similarly would have supported the hypotheses of an inverse relationship between economic growth and specialization.

Paradoxically, the generally accepted theoretical association between economic growth and specialization (in production, as well as in exports), derived from Trade Theory is just the opposite. A mainstream theme developed as early as Adam Smith's *Wealth of Nations* (1776) links higher productivity and economic growth with an increased degree of specialization. This is notably true in the tradition associated with Ricardo's Classical Comparative Advantage model of trade. Successful expansion of exports requires relatively high levels of productivity, either as determinant, or as the result of an increased specialization. Hence, one would expect to find a positive relationship between increased exports and production specialization. The direct relationship between export driven economic growth and specialization is given an additional theoretical foundation when explicit consideration is given to scale economies.

This paper examines the degree and presence of specialization of exports in the context of LDC takeoff scenarios by analyzing an index of "trade specialization" for developing countries. Developing countries in Asia, Africa and Latin America are undergoing significant export spurts and observable transformations of their export compositions.

Aizenman and Lee (2010) assert that foreign reserve hoarding is a trend that started in China as a means of controlling the real exchange rate as well as promoting exports. This trend is picked up by LDCs to also enhance their exports. However, Aizenman and Lee dismiss this strategy as a way to increase exports because of the possibility of "competitive hoarding" in order to preserve their market share in the USA and other OECD countries. Only a single country can "win" in such a situation, with all others continuing to hoard reserves in order to minimize losses.

In reality, it is clear that much of the observed LDC export spurts are associated with the development of fragmentation (see Hayakawa 2007). This is further developed by Choi and Choi (2010) who show that LDC export spurts are better associated with North-South fragmentable processes, and hence are associated with varying degrees of specialization within product groups. The main obstacle facing any study that attempts to undertake such an analysis is the weakness of empirical measurements. In short, there does not exist one generally acceptable measure or index for the concept of “Specialization in International Trade”. In the following section, one such measure for specialization and its theoretical and conceptual framework are developed and used in the empirical section following the presentation of the data.

II. Conceptual Framework

Recently a large body of literature focuses on the relationship between economic growth and export specialization, e.g., Petsas (2010) that constructs a model of Schumpeterian growth in which economic growth lowers the range of goods exported, and hence increases the degree of specialization.

In order to construct an empirical measure of specialization in international trade, it is necessary to conceptualize what needs to be measured. A recent survey (Krugman, 2009) discusses the issue of geographic specialization of exports of developing countries located in Asia, Africa and Latin America, but does not explore detailed disaggregated export vectors as is done in this paper. Imagine a country producing n goods and exporting an identical amount of each of the n products. Define this situation as the total absence of specialization in trade.¹ If over time, starting from a zero-specialization

¹ Note that the classic autarky is one possible case in the general set of the specialization spectrum, where $n=0$.

situation, the amount of one product exported increases while exports of other products remain unchanged, then this process is defined as constituting a growing degree of specialization in export composition. If such a country becomes completely specialized, e.g., reaching the Ricardo Point (RP) in the classical model, then only one product is being exported.

This illustration identifies growing specialization as coinciding with, or consisting of, an increased dispersion between the volumes exported. In the case identified above as a zero-specialization situation, the export vector has a rectangular distribution, and no dispersion exists between the elements (products) of the export vector. The dispersion among the elements in the export vector is at a maximum in the RP, representing full specialization. Hence, in seeking some empirical measure of the degree of specialization at the country level, some measure of a statistical dispersion of the country's export vector is needed. The starting point is recognizing that this issue—the identification and measurement of specialization in international trade—is comparable in context to a similar issue in Industrial Organization (IO), namely, the need for a theoretically sensible and empirically tractable measure of market power. A promising indicator used in the IO context is the Herfindahl-Hirschman Index (HHI).

Recently, there has appeared a new tendency for empirical work in International Trade to adopt measures from the IO literature. Some examples of this tendency are Magee and Magee 2008, Krugman, 2009, and Kydland and Prescott, 1992. Just as a comparison of HHI indices between industries allows for measurements of relative levels of monopoly power between industries, so comparisons of (HHI-based) Trade

Specialization Indices (TSIs) allow for an identification of relative levels of trade specialization among countries.²

The Trade Specialization Index (TSI), for an industry with n firms, is defined as:

$$(1) \quad \text{TSI} = \sum_{i=1}^N s_i^2$$

where s_i is the sectoral share³ of the i -th commodity or product. The TSI is the sum of the squares of the market shares of all N firms in the industry. Note that in our context the $\sum_{i=1}^N s_i^2$ are the proportional share of commodity i in the total export bundle of a country. In its typical IO interpretation, the HHI measures the relative market shares of individual firms in a given industry. Similarly, in our context, the SRI measures the relative trade volumes of individual commodities.

The HHI is routinely used by Industrial Organization economists and by the U.S. Federal Trade Commission (FTC). As noted, it is only recently that international trade theorists have begun to adopt this industrial organization tool for empirical evaluations in such issues as the determination of whether an entity is a “small” or “large” country in optimal tariff context (for example, Magee and Magee, 2008). The Federal Trade Commission defines the range above an (arbitrarily chosen) benchmark of 1,800 as indicating a significant departure from industry competitiveness. Following suit, one may consider the existence of some benchmark for the TSI index as developed in this paper, such that any value above some hypothetical value may be interpreted as

² Interestingly, the use of this concept in our context overcomes a potential problem found in its traditional IO context. Measures such as HHI must perforce use industry shipment data, and hence must deal with the well known difficulty in defining an industry, since most industries produce multiple and joint products. However, the usual data used in trade studies are product, rather than industry based, and thus avoids this source of ambiguity in its interpretation.

³ “Sectoral” may include all commodity exports, or perhaps some subset such as food, or perhaps machinery exports.

indicating some significant degree of specialization, although not necessarily a value of 1,800.

In the section below following the introduction of the data sources, this paper explores the issue of what actually is the pattern of specialization that is typical or descriptive of developing country export compositions as they undergo rapid “takeoff” in their manufactured exports. The following section presents the TSI measure for a sample of typical developing countries in the process of an export takeoff.⁴ The sample includes three South East Asian countries, two North African countries and one Latin American country. Each of these countries experienced both rapid expansion and a significant compositional shift in their exports in favor of relatively sophisticated machinery.

The Development literature suggests that the second half of the last Century witnessed a widespread departure from the Import Substitution protectionist paradigm in favor of export promotion “liberalization”. The working hypothesis in this paper is that this liberalization phase, like that of the “takeoff” phase should be systematically associated with an increased degree of specialization in its respective export compositions. In the empirical examination of the TSI proxies, a validation for, or rejection of this hypothesis is examined.

Although the empirical sample includes only a small number of Newly Industrialized Countries (NICs), the phenomenon of a relatively massive shift both quantitatively and qualitatively toward manufactured products, is today recognized as a

⁴ “Takeoff” periods are identified by observing actual values of exports (total, and then separately Machinery) of the respective sample countries, and noting periods of both relatively rapid growth, and relatively large transformation in the makeup of the exports (the percentage of Machinery) in the total export composition. The authors will gladly provide an appendix in which appear clear depictions of the rapid and sustained growth in export volumes, as well the growth of the proportion of relatively sophisticated exports of machinery and transport equipment (“Machinery”), as well as several significant “out of sample” developing countries.

generally typical phenomenon. The recent review by Paul Krugman (2009) of major recent theoretical trends in trade theory posits that this phenomenon may indicate a paradigmatic shift, adding validity to the “old” trade theories that focused on comparative advantage (Krugman 2009, pp 569-570).

This study concentrates on a subset of manufactures that has been noted in the literature to play a key role in international trade, namely Machinery. The values of each of the (HHI-based) Trade Specialization Indices (TSI’s) are calculated for similar time periods (decades) during “takeoff”. These take off periods may occur at different historical periods for respective countries. They are calculated for each of the two commodity groupings - all commodity exports, and machinery exports - at the disaggregated 4-digit level of aggregation of the Standard International Trade Classification (SITC).

Next, calculations of the same indices are computed for the *Import* vectors of the same trade vectors. If the TSI indeed provide measures consistent with the conceptual definition of specialization, then one expects to find the indices associated with exports to have higher values than those associated with the respective imports.

III. Data

The commodity coverage consists of 4-digit Standard International Trade Classification (SITC) for total and for Machinery exports. The Machinery sector includes Transportation equipment. Machinery exports are products classified as Standard International Trade Classification (SITC) 7, either Revision 1 or 2 from the United Nations Commodity Trade Statistical Database (COMTRADE) maintained by the United Nations Statistical Office. Although Revision 1 is somewhat archaic, it is used in

order to examine the takeoff years of the 1960s and 1970s for the East Asian Newly Industrialized Countries (NICs).⁵ The years covered consist of one decade for each country. The sample includes a “take-off” period in which each country experienced both a relatively large quantitative increase in its exports, as well as a notable compositional shift to relatively more sophisticated products.

The respective country/year coverage is:

Singapore	1970-1980
South Korea	1965-1975
Malaysia	1970-1980
Mexico	1970-1980
Tunisia	1985-1995
Morocco	1985-1995 ⁶

The first sets of data employed in this paper cover All Exports. These data include all products classified as SITC categories 0 to 9 inclusive for each year. Then the indices are recalculated for Machinery exports, for the same countries and time periods. These include exports of all machinery and transportation equipment products classified as SITC Category 7. This category of products has been identified in a large and influential branch of trade theory literature as especially critical and key in understanding recent trends in trade flows (including those of North South). See Section IV.2 below.

In each case, TSIs are calculated for time periods in which the country experienced a period of trade liberalization followed by notable increases in total exports, along with a compositional transformation as measured by the ratio of Machinery to total exports. Each of the three TSI candidates is calculated over time, one for each year, for

⁵ These were years of rapid expansion in exports for each of the sampled countries. See Kellman and Chow (1993) for extensive discussion of earliest NIC takeoff.

⁶ The sample focuses on small open economies (certainly small as compared to their major trade partners). In order to gain an insight as to whether the results are specific to “small” countries, we added two “out of sample” countries which both clearly experienced takeoffs in recent decades, and which are also clearly “large” countries. These are India and China. Their takeoff period occurred in the first decade of the 21st Century.

each of the 12 cases 6 countries x 2 trade vectors – All Exports, and then Machinery exports). Next, the calculations of the TSIs are performed for total machinery imports. Finally, two additional sets of TSIs were calculated for Machinery exports of India and China. For the results of these last two “out of sample” countries, see Table 3 below and the discussion following this table.

IV.1 Time Trends During Takeoff Periods – All Commodity Exports

The following coefficients are calculated for each of the six trade vectors. In Table 1, the Specialization Indices [TSI] are depicted for each of the trade vectors - total commodity exports to the world from the six countries: South Korea, Singapore, Malaysia, Tunisia, Morocco and Mexico. Each of the resultant indices is regressed on time (year). Since the time period covered for each vector is identified as one of relatively rapid export growth, a significantly positive slope coefficient (β) would support the inference that the respective index is a reasonable measure of export specialization.

Table 1: Time Trends for the Trade Specialization Index* - All Exports

Country	TSI
Singapore 1970-1980	-27.98
	0.0051
South Korea 1965-1975	-9.088
	0.435
Malaysia 1970-1980	-59.19
	0.0022
Morocco 1985-1995	-34.82
	0.0033
Tunisia 1985-1995	-91.11
	.0079
Mexico 1970-1980	0.251.6
	0.0063

* The Coefficient of each TSI trend regression coefficient is followed by each one’s corresponding p-value.

The entries in Table 1 are the respective trend coefficients β obtained from a bilateral regression of:

$$(3) \quad [\text{TSI}] = a + \beta \text{ Year}$$

The relevant information needed for inferences are the sign and the statistical significance of the trend coefficient. Each trend coefficient is accompanied by its respective p-value.

For most of the export vectors, the estimated coefficients are non-positive. Of the six export vectors, one (South Korea) is not significantly related to time, and one (Mexico) has a positive time trend for the TSI indices. The TSI indices of four of the six have (significant) negative time trends. We interpret this as supporting the tendency to greater diversification in the export compositions of rapidly growing developing countries. Four of the six are negatively significant and all but one are negative while the remaining one is not significantly related to time (South Korea). The estimated results in Table 1 above are consistent with the common expectation derived from the Economic Development literature, namely that a substantial takeoff in the exports of LDCs is found to be associated with a broadening of the export base, and hence a lessening of specialization in one or few exported products.

These results also support the applicability of the “new trade theories” pioneered by Krugman in which underlying models of imperfect or monopolistic competition replace the dominant “perfect competition” assumptions of classic and neoclassic models of comparative advantage. Though not initially designed for LDC-developed country trade, these newer models support the scenario wherein expansion of trade will involve a broader mix of products as consumers increasingly seek greater variety.

IV.2 Time Trends During Takeoff Periods –Machinery Exports

This section reports results for a more narrowly defined product category – exports of Machinery. These are all of the products classified within SITC 7 (“Machinery”). These include all machinery, transport equipment, telecommunications equipment, and computer-related products. Much empirical work follows the pioneering work of Kravis and Lipsey in identifying this group of products as having an especially key role in international trade. Kravis and Lipsey (1982) noted in several places that this group of products is especially important in international trade.⁷ Subsequent to the work of Kravis and Lipsey, a voluminous international trade literature has focused on essentially the same (“Machinery”) subset of products. Examples are Vollrath and Johnston (1991) who identify the key role of “Finished Capital Goods” (as defined in Vollrath and Johnston, 1991), and Richardson and Zhang (2001) who focus on the product “Producer Goods” in the same context.⁸

As noted above, one way to explain the findings in Table 1, is that as a developing country takes off, its exports become more diversified and thus less specialized. However, if one examines the degree of specialization describing not **all** commodity exports, but rather a narrower subset of exports, one might expect to find increased specialization. For example, if a country’s exports were initially confined to agricultural products and it subsequently added substantial manufactured exports, its total export composition would be found to be more diversified or less specialized. However, there would be no reason to expect a lesser degree of specialization within the subsets of

⁷ E.g., Kravis, I.B and Lipsey, R. “Prices and Market Shares in the International Machinery Trade,” *Review of Economics and Statistics*, vol. 64, no. 1, Feb. 1982, pp. 110-116.

Lipsey Robert Price Competitiveness in World Trade, published by the NBER in 1971.

⁸ See footnote 25, on page 205 in Richardson and Zhang (2001).

agricultural (or machinery) exports. The results for Machinery Exports are presented in Table2.

Table 2: Time Trends for Trade Specialization Index - Machinery Exports*

Country	TSI
Singapore 1970-1980	34.52382
	0.0236
South Korea 1965-1975	85.1
	0.2167
Malaysia 1970-1980	547.5
	<0.0001
Morocco 1985-1995	23.15
	0.6831
Tunisia 1985-1995	24.8
	0.0855
Mexico 1970-1980	-39.6
	0.1328

* Coefficient of each TSI regressed on year and its corresponding p-value.

Table 2 presents the trend slopes of the TSI for each of the six country exports of those products classified under SITC 7, at a 4-digit level of aggregation for Machinery. Unlike the results in Table 1, not one of the six TSI time trends is significantly negative.⁹Hence, we find no support for a systematic degree of diversification within the key sophisticated category “Machinery.” On the other hand, we do find several cases that support the hypothesis that rapid export growth are associated with a measurable increase in specialization. Positive slopes are found for one half of the sample (three positively significant time trends at 10%). These findings support the inference of increased

⁹ At the four digit level of aggregation, SITC 7 includes over 150 different products. This is not a statistically small sample of commodities, and gives no theoretical presumption or bias to the probability that increased specialization will likely characterize changes over time.

specialization during periods of relatively large increases in export volume and transformation (takeoff periods).

The findings in Table 1 support the general presumption in the Development literature that such periods tend to be associated with growing diversification of the overall export base. The findings in Table 2 support the general presumption in the Trade literature of a positive relationship between export growth and specialization. This latter expectation is consistent both with classic theories of comparative advantage, and with “new” theories based on scale economies that lead to expectations of “specialization in narrower ranges of machinery [that] permit the exploitation of economies of scale through the lengthening of production runs” (Krugman, 2009, page 562).

An additional finding that supports our identification of the TSI index as a revealed measure of specialization is found when we add several “out of sample” countries. We repeat the exercise with two additional countries, India and China. These countries tend to differ from the original sample of developing countries. Both are large countries. Trade literature leads us to expect that such large countries should be expected to take advantage of scale economies inherent in their large domestic markets, and hence demonstrate a relatively large propensity to specialize within the relatively differentiable and sophisticated category of machinery exports. The results for these large countries are presented in Table 3. Both India and China have experienced notable takeoffs in their manufactured exports in the recent decade. The findings in table 3 supports the Trade Theory presumption that export expansion and a growing level of specialization are expected correlates in the context of rapid growth in the foreign trade sector, a “takeoff” scenario, for both “large” and “small” countries.

Table 3: Specialization for Machinery Exports of Large Rapidly Growing Developing Countries

Country	TSI
India 1998-2008	6.01
	0.0029
China 1997-2007	10.55
	0.0093

Coefficient of each TSI regressed on year and its corresponding p-value.

Both countries summarized here are as noted relatively large and both have recently experienced notable export “takeoffs”. The results are similar to those found in Table 2. Within the Machinery category, clear positive time trends signaled systematic increasing degrees of specialization in both. In fact, the Trade Theory underlying these calculations makes no significant distinction between large and small countries. Recent research argues that China has succeeded in promoting its “natural comparative advantage” by focusing on relatively sophisticated product categories, such as those found in the “Machinery” (SITC 7) category, see Petsas (2010). In addition, studies demonstrate that India’s noted recent explosion into the international manufactured trade markets have followed its trade liberalization in 1991, and followed the pattern of other countries in other continents with no noted excess supply in unskilled labor (e.g., Sen, 2009).

IV.3: Trade Index Comparisons for Machinery Exports Versus Imports

A minimal “necessary” finding that one would expect to be satisfied for any proper empirical index of trade specialization is that the exports of any (both LDC and developed) country be more specialized than its imports. It is a broadly accepted precept that countries tend to specialize in their exports but tend to import a little of everything.

While, this is considered to be a “stylized fact” in International Trade literature, it is of interest that recent research notes that countries joining the WTO do so not to promote balance or liberalization in world trade, but rather for the old fashioned Commercialist motive of promoting exports, e.g., see Balding (2010).

Since this paper provides for an empirically tractable measure of specialization, one is capable of testing this generalization. Accordingly, the TSI is recalculated after replacing exports with imports (from the World) for each of the six - Asian, African and Latin American - LDCs. Next, the value of each index is compared with its corresponding index calculated from exports. A finding that the import related indices are systematically smaller than those associated with exports would support the use of this index as a reasonable measure of specialization in trade.

Table 4 presents the mean values of the estimated TSI for exports, imports and the results of a dependent-sample means test comparing the values for exports with imports for each country and time period. The following are results pertain to **Machinery** exports and imports.

Table 4: Average Trade Specialization Index of Machinery Exports vs. Imports

Country	Variable	Mean	t Value	Pr > t
South Korea	TSIx	1411.18	15.77	<.0001
	TSIm	719.395	13.18	<.0001
	diffTSI	695.991	6.46	<.0001
Malaysia	TSIx	2353.21	8.81	<.0001
	TSIm	1036.37	10.74	<.0001
	diffTSI	1316.84	4.86	<.0001
Singapore	TSIx	1072.8	15.99	<.0001
	TSIm	728.879	13.62	<.0001
	diffTSI	343.923	12.75	<.0001
Morocco	TSIx	2581.79	15.41	<.0001
	TSIm	299.825	22.28	<.0001
	diffTSI	2281.96	13.45	<.0001
Tunisia	TSIx	1237.82	23.43	<.0001
	TSIm	264.853	25.1	<.0001
	diffTSI	972.969	20.82	<.0001
Mexico	TSIx	1045.26	15.5	<.0001
	TSIm	420.934	20.16	<.0001
	diffTSI	733.15	8.58	<.0001

TSIx is the Herfindahl-Hirschman (based) Index for all machinery exports.
 TSIm is the Herfindahl-Hirschman (based) Index for all machinery imports.
 diffTSI equals TSIx – TSIm.

The findings summarized in Table 4 show that each TSI calculated for exports is statistically significantly larger than those calculated for imports. Note that a larger value for a TSI denotes a greater level of specialization. These findings support the appropriateness of the indices as measures of international trade specialization.

V. Conclusions

This paper applies, for the first time, an explicit measure of the degree of specialization in international trade of developing countries. The Trade Specialization Index is applied to data for developing countries in a broad geographical and historical

representation. All indices utilize trade data representing periods of rapid growth and structural transformation of trade. The paper examines the patterns of specialization of total and of Machinery exports for Mexico, Morocco, Tunisia, South Korea, Singapore and Malaysia.

The indices calculated from All Commodity exports fail to support a general tendency to greater degree of specialization. This finding is consistent with both theoretical work in Development Economics and with “new trade theories” focusing on the effects of imperfect or monopolistic competition. It is also supported by casual observation that in recent decades, Less Developed Countries (LDC) exports are largely characterized by a broadening of their export product base, away from monoculture or some predominating mineral export to manufactured products.

However, when the analysis focused on a subset of products (“Machinery”) that has been identified as a key sector for international trade patterns in a voluminous literature, the results support the proposition that recent rapid expansions in LDC trade quantities as well as rapid transformations in the composition of these exports have been accompanied by systematically increased degree of specialization. This finding is affirmed for all cases of LDC Machinery export.

A second test of the trade specialization index confirms that, as expected, exports are more specialized than imports for every sampled country. The finding that countries specialize in exports but not in imports may be considered intuitive. However, hitherto, it has never been empirically demonstrated in an empirically tractable manner.

This paper resolves a paradox in which development economic theory leads to expectations of greater diversity while international trade theory leads to expectations of

increased specialization. To our knowledge this has not been empirically demonstrated in the literature.

The development of a trade specialization index opens the door for an extensive array of further research. For example, were extensively studied cases of external sector liberalization, e.g., the Chicago School's impact on Chile's trade, associated with, generally welfare enhancing, increases in specialization? Was the imposition or the removal of trade sanctions, e.g., for post 1994 South Africa, associated with gains in specialization? How do financial crises affect the degree of specialization in the export compositions of affected Asian countries? Has the relative degree of specialization in country exports affected the impact of the world wide recession in the past three years?

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