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Composite Revealed Comparative Advantage Index: A Non-parametric Approach

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Abstract

The composition and share of export items from a country change over time. Individual exporting companies take firm-level actions to keep up their market share. A relative (to the point of reference) and comparative (compared to other exportable goods) advantage index for an export item can aid decision-making at the country and company levels. Present literature shows less reference to the existence of such an index. The popular Balassa's revealed comparative advantage (B-RCA) index measures the comparative strength of a product at any given period. However, this method and its variants are time stationary and not directly applicable for sectors, i.e., groups of commodities with the same first four digits of the HS Code. Sector-level RCA aids in identifying the country's comparative advantage over the sector over time. For a given set of products, the paper uses many partner countries and a many-product trade approach. This paper suggests two indices to reflect the dynamic RCA. It suggests calculating the ratio of the Balassa index for each product for the current period and reference period – the relative revealed comparative advantage (RRCA); proposes geometric aggregation of these ratios to get a composite RCA (CRCA) index for a country.

Keywords: *Revealed comparative advantage (RCA), dynamic RCA, relative revealed comparative advantage (RRCA), composite RCA (CRCA), Export competitiveness*

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1. Introduction

A country's total exports and the item basket to another country vary over time. For example, the US exports to India increased manifold over the years (Figure 1) not deterred by the geographical distance between the countries. However, the export compositions changed over time. The top five commodities exported by the US in 2015 to the world were - petroleum (excluding crude) oils, integrated circuits, automobiles with reciprocating piston engines, and medicaments. In 2020, the US was the biggest exporter of refined petroleum, petroleum gas, medical instruments, gas turbines, and aircraft parts (OECD, 2022).

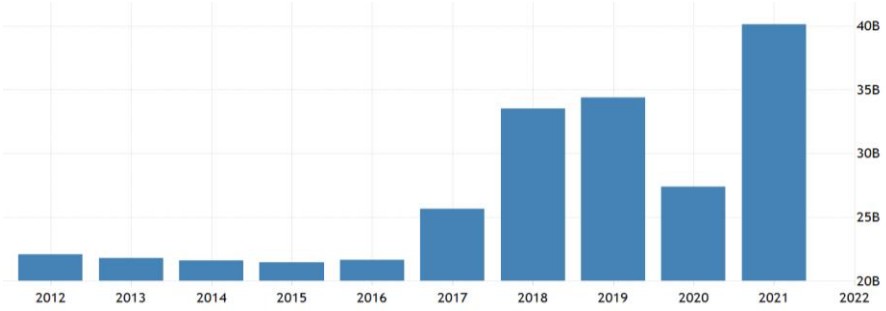

Figure 1. US total exports to India – 2012 to 2021 (in Billion USD)
Source: TradeEconomics (2022)

The law of comparative advantage (LCA) advocates countries to produce and export those goods whose resource requirements are less than other products. This condition holds even if the country can make all goods at less cost than other exporting countries (Ricardo, 1951). The comparative advantage can be swaying due to other factors like cost of production, logistic facilities, differences in quality, tastes, goodwill, etc., A country's exports may increase by government incentives increasing competitiveness but not a comparative advantage (Proudman & Redding, 2000). However, accounting for such factors to understand the relative benefits seems challenging in a multi-criteria scenario.

Based on post-trade data, the Revealed Comparative Advantage (RCA) measured as B-index by Balassa, (1965) is a popular method to determine the comparative advantage of a country's goods at a given period. The extant indices do not provide the means to understand the changing export composition and markets. The Balassa RCA Index is a time-period-specific method and does not reveal the growth path of the RCA of an export item. This formulation does not indicate the composite or aggregated RCA of a country to know the country's comparative advantage of all the export items taken together as a function of trade flows relative to the point of reference, i.e., a base period.

The growth (decline) path of the RCA of an export item reflects the goods' acceptance (rejection) in the global market. A country's policy may be directed

towards such items that exhibit increasing trends and or may explore the plausibility of enhancing exports of goods with a declining trend. Similarly, a firm exporting goods may analyze its future strategies based on a relative index. Thus, the development of a relative (to the point of reference) and comparative (compared to other exportable goods) advantage index of an export item demands merit. Present literature shows a scanty reference to the existence of such an index.

The RCA for a group of similar commodities constituting a sector (with the common first two or four digits of HS codes of items) can also aid in identifying the fluctuations in the export of the group across time. For example, the RCA of goods under chapter 10, i.e., cereals, or against HS code 1006, i.e., rice, can be determined to decide on policies for the entire sector or specific goods. However, a drop in an industry's RCA may be due to the comparative advantage gained in another industry. This gain may be due to the diversion of capital and resources in these sectors. These variations are predominant for goods that are higher in the value chain.

The Major Limitations of the B-Index are:

- The index is asymmetric. While comparative advantages are in the infinite interval (1, ∞), comparative disadvantages ≥0 but <1. Thus, the comparative advantages and disadvantages are not measured at the same interval (Laursen, 2015).
- The index is not additive. For example, the sum of B-Index separately for BRIC (Brazil, Russia, India, and China) countries ≠ RCA of all BRIC countries. Need felt for RCA measure satisfying meaningful addition across products and countries (Yu et al., 2009)
- The B-index is subject to a size bias. It does not distinguish between exports, imports, and sector-specific factors affecting export flows. RCA based on export as well as import data was felt desirable from productivity differentials and product differentiation (Stellian & Danna-Buitrago, 2019).
- The time stationarity of the B-index is associated with doubts regarding its empirical distribution (Leromain & Orefice, 2014).
- High values of the B-index indicate strong comparative advantages, but the converse may not be true. A high value of the index for a country may happen even for a relatively small share of total exports (Leromain & Orefice, 2014).
- Classification of products and countries may influence the B-index (Yu et al., 2009).
- An increase in the export of a product by say 10% affects differently the share of the country, share in world export, and the B- index.
- The pattern of comparative advantage varies at different levels of disaggregation of products (Maryam et al., 2018).
- Comparison of the B-index for several product categories of countries A and B is problematic since both the nominator and denominator of the B-index vary.

An appropriate method of aggregating RCA of all commodities of a country reflecting the overall export potential of the country satisfying desired properties including tracking of the growth path of the aggregated index over time is felt needed.

The paper provides a method enabling evaluation of RCA across products and time, through composite RCA of i-th country at the t-th period by combining the relative RCAs of each commodity/sector under export. Such index facilitates the assessment of the progress or decline of RCA in successive periods i.e., $RCA_{ij(t+1)}$ over $RCA_{ij(t)}$ which may help to investigate the progress path of the RCA index (RCAI) with other trade-related indices.

The article has five sections. The following section discusses the Revealed Comparative Advantage (RCA) and its variants. Section 3 gives the proposed method, followed by properties, benefits of the proposed method, and an empirical illustration. The last section concludes the findings of the paper.

2. Literature Review

A country and a company aim at increasing their export market share that is changing from the goods as well market perspectives. Medium and small firms face challenges in their internationalization effort losing out to global firms (Ruzzier et al., 2006). Over time export barriers, i.e., restrictions imposed by importing countries change – leading to the closure and opening of markets. The export quantum can vary due to a drop in the global economy, global requirement for the particular product, or due to export barriers or loss of competitiveness.

Constant Market Share (CMS) analysis provides a means to analyze the reason for changing market share. It distinguishes the change in market share due to total world export growth, global growth in commodity, growth in market share of the importing country, and competitiveness of the product (Milana, 1988); Dieter & Englert, 2007). However, this method does not account for changes in export market share due to tariff and non-tariff barriers. Prior to CMS analysis, Balassa's RCAI can lead to the identification of export items with a high comparative advantage.

Balassa's (1965) RCA-index (RCAI) to measure the comparative advantages of an export item is the most widely used index. It is easy to understand and compute. RCAI is computed based on the share of the country's export of an item over the global exports of the same commodity. However, this index does not capture the import data and the deficiency was made good by the works of Stellian and Danna-Buitrago (2019). The index suffers from other demerits, namely, it has size bias, it is asymmetric, and it does not possess additivity (Stellian & Danna-Buitrago, 2022).

Revealed comparative advantages (RCA) using trade flow data is a major issue for trade policy (Costinot et al., 2015). However, fluctuations in exchange rates, trade barriers (formal/informal), etc. may distort trade flows, which in turn results in biased RCA. Moreover, RCA based on trade flows fails to provide information on the

factor endowments, institutions, infrastructures, etc. Thus, trade flow-based RCA does not throw light on the ex-ante origin (Amoroso, et al. 2011; Marconi, 2012; Nyahoho, 2010). French (2017) observed that commonly used indexes are generally not consistent with theoretical notions of comparative advantage. An alternate index – Contribution to Trade Balance (CTB) was suggested by Stellian and Danna-Buitrago (2022). However, neither of these methods gives the growth trend of the export products over time to understand whether the exporters are operating in a favorable environment or not. A single firm may have their exports rising but the country of export may be losing an advantage over other countries in the particular export item over time. Similarly, export firms may currently have lower returns from global sales but can expect to grow if the RCA shows an increasing trend relative to the base year.

A methodological extension can enable one to overcome the time stationary limitation of RCAI. In this paper, relative RCA and a composite RCA computation have been proposed. RRCA helps identify the growth path of comparative advantage of an export item and a CRCA is the total advantage of the commodity cluster of the country as a whole.

The methodological details of Balassa's RCA and its variants are given in the ensuing sections.

2.1. Balassa RCA Index

Among the measures of export advantages, the Balassa index is frequently used in the literature on international trade. Let X_{ij} be the export of product j by the i-th country at a time period. Here, $\sum_j X_{ij}$ indicates total export of the i-th country; $\sum_i X_{ij}$ gives world export for the j-th commodity; and $\sum_i \sum_j X_{ij}$ denotes world export of all commodities. Balasa's RCA Index for the j-th commodity exported by the i-th country is given by

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

= (Proportion of j-th commodity to total export of the i-th country) × (Reciprocal of the proportion of world export for the j-th commodity)

For a country, RCA_{ij} is positively related to the proportion of export of the j-th commodity to the country's total export and is inversely associated with the proportion of world export for the j-th item. Thus, the relative measure RCA_{ij} can be computed from trade-related data of the country and the world. RCA_{ij} also indicates the relative importance of the destinations of the product exported by a country at a particular commodity at a specific time.

RCA_{ij} for the i-th country gets increased if $\frac{X_{ij}}{\sum_j X_{ij}}$ increases or the proportion of world export for the j-th commodity is decreased. $\frac{X_{ij}}{\sum_j X_{ij}}$ lies between zero and 1 ($0 \leq \frac{X_{ij}}{\sum_j X_{ij}}$

≤ 1) and $\frac{\sum_i \sum_j X_{ij}}{\sum_i X_{ij}}$ >1. Thus, RC$A_{ij} \geq 0$ where equality is attained if $X_{ij} = 0$, i.e., the country does not export the j-th commodity. RCA_{ij}> 1 indicates that country i has a comparative advantage and can be taken as a degree of 'export specialization' of the i-th country in the j-th sector. The higher the value, the higher the advantage. Theoretically, a country can increase its aggregated RCA by two-fold approaches, viz. increasing the export of each commodity being exported by the country and increasing the number of commodities in the export leg by various export diversifications, including identification of new countries for export. However, the aggregated RCA of a country needs to be defined and measured.

RCA by (1) is based on static export data without representing dynamics of comparative advantage over time and ignores import data. High values of the Balassa index suggest strong comparative advantages, but a country may show high values of the index even if it represents a relatively small share of exports (Leromain & Orefice, 2014). Similarly, the index reveals comparative advantages if its value exceeds one and relative disadvantages if it belongs to [0, 1). Thus, comparative advantages and disadvantages are not measured on the same numerical basis by the Balassa index. This "asymmetry" is an econometric issue (Laursen, 2015) and also matters in measuring the consistency of comparative advantage measurements. Empirical distribution of the Balassa index tends to exhibit fat tails even though observations suggest that strong comparative (dis)advantages are relatively rare. The measure of revealed comparative advantage (RCA), with multiplicative specification and dependency on many countries and export items, is incomparable across time and places. In addition, the assessment of the effect of policy changes is not straightforward.

2.2. B-RCA Index Variants

In order to overcome the limitations of Balassa's RCA index, primarily relating to incomparability and inconsistency issues, other indices were suggested like symmetric RCA index (SI) (Dalum et al., 1998) considering only export variables; Lafay index (LI) (Lafay, 1992) considering trade and production variables; weighted RCA index (WI) (Proudman and Redding, 2000); additive RCA index (AI) (Hoen & Oosterhaven, 2006); normalized RCA (NI) (Yu et al., 2009) using comparative-advantage-neutral point, etc. However, Balassa's RCA index and its variants are not directly applicable for sectors, i.e., groups of commodities with the same first four digits of the HS Code. The time-period-specific approach does not reveal the dynamic behavior of export performance, the growth path of the RCA of an export item, and aggregated RCA of a country.

The RCA index by Costinot et al. (2012) is an econometrically based measure that fits the ex-ante nature of Ricardian comparative advantage. RCA index by Hoen and Oosterhaven (2006) involves the difference between normalized exports of that country for a given product or between the weighted share of that product in total

exports into some trade area, where weights are based on total exports of a country. Yu et al. (2009) suggested the normalization variable as the total exports into the trade area under consideration. The Normalized revealed comparative advantage (NRCA) index by Yu et al (2009) is a more precise and consistent estimate and is comparable across commodity, country, and time. But NRCA does not adjust trade flows. The index has some similarities with the Contribution-to-the-Trade-Balance (CTB) index in the sense that the treatment of exports by the NRCA index is analogous to the treatment of trade balance by the CTB index. The "regression-based" RCA index by Leromain and Orefice (2014) assumes a linear relationship and fits ordinary linear regression.

Proudman and Redding (2000), and Hinloopen and Van Marrewijk (2001) considered the empirical distribution of RCA over time using transition probability matrices to find the dynamics of comparative advantage by classifying the data into several categories like quartiles, quintiles, deciles, etc. The number of categories is usually determined in an ad hoc manner, depending on data availability. The authors provided structural analysis to decide the number of categories using the entire data set covering all countries, years, and sectors for different levels of aggregations. Transition probability indicates the probability that the j-th sector of the i-th country is moved to the k-th decile of the distribution in the (t+k)-th year. However, researchers differed in methods of estimating transition probabilities and also the most suitable lag period. For the USA and several countries of Europe, Proudman and Redding (2000) observed that RCAs of manufacturing industries changed little between 1970–74 and 1990–93. However, relative productivity across countries may decrease over time, implying a decrease in trade (Evenett & Yeung, 1998).

Nowadays, a country may export and import a particular commodity. For example, India typically exports onion, but in recent years, it imported onion when there was an increase in domestic price. The popular convention of equivalency of comparative advantage with a trade surplus resulted in the consideration of indices based on the trade balance. The difference between the trade balance and the theoretical trade balance is normalized by the GDP to obtain the Contribution to Trade Balance (CTB) Index (Stellian & Danna-Buitrago, 2019). If countries A and B show the same positive difference, CTB is higher for those with lower GDP. Thus, CTB also considers the size of the economy. CTB indices consider the normalized difference between the actual trade balance and the expected level, where the total trade or GDP of a country is used as the normalization variable. CTB indices address a number of shortcomings of the B index and are more robust. However, the conceptualization and computation, normalization process of the CTB index are not unique. Thus, the calculation of RCA indexes as CTB indexes involves a number of methodological issues. Stellian and Danna-Buitrago (2019) observed that the CTB index fails to avoid ordinal ranking bias but performs well in terms of time stationarity. Stellian and Danna-Buitrago (2022) considered 11 CTB indices and through empirical investigation found higher

empirical accuracy when normalization is done by total trade only and the multiplicative CTB indices had low empirical accuracy

Riedel and Donges (1977) defined RCA_{ij} considering both export and import as

$$RCA_{ij} = \frac{(X_{ij}-M_{ij})/(\sum_i X_{ij}+M_{ij})}{(\sum_j X_{ij}-\sum_j M_{ij})/(\sum_i X_{ij}+\sum_j M_{ij})} \quad (2)$$

where M_{ij} represent country i's export and import of product j.

A country exports a part of the total production of a commodity. For the i-th country, Bowen (1983) defined RCA_{ij} in terms of the total output of the j-th commodity (Q_{ij}) and net trade (production minus consumption) of the j-th commodity (T_{ij}) by

$$A_{ij} = \frac{\frac{T_{ij}}{Y_i}}{\frac{\sum_i Q_{ij}}{Y_w}} \quad (3)$$

Combining the above, Vollrath (1991) suggested the following RCA indices (RCAIs) considering exports and imports in relation to the rest of the world.

$$RCA_{ij} = \frac{X_{ij}/X_{ik}}{X_{nj}/X_{nk}} - \frac{M_{ij}/M_{ik}}{M_{nj}/M_{nk}} \quad (4)$$

$$RCA_{ij} = \ln\left[\frac{X_{ij}/X_{ik}}{X_{nj}/X_{nk}}\right] \quad (5)$$

$$RCA_{ij} = \ln\left[\frac{M_{ij}/M_{ik}}{M_{nj}/M_{nk}}\right. \quad (6)$$

Where,

X_{ik} : Country i's total exports of other products; X_{nj} and X_{nk}
X_{nj} : Exports of product j by the rest of the world
X_{nk}: Total export of other products by the rest of the world
M_{ij}: Country i's import of product j
M_{nk}: Total imports of other products by the rest of the world

Leromain and Orefice (2014) did not favor mixing the factors influencing trade flow. Different measures of RCA may be appropriate for other purposes (French, 2017). Each RCAI has advantages and disadvantages. No RCAI follows a known distribution, and there is no perfect RCAI (Sanidas and Shin, 2010). For the i-th country, RCA_{ij} differs from year to year. Thus, changes of RCA_{ij} across time for a country may be considered by redefining RC$A_{ij} = f(t)$ to facilitate better comparisons across time and space, including statistical tests of significance of the change in two successive time periods like H_0: $RCA_{ij(t+1)} = RCA_{ij(t)}$

The values of RCAs for a country are specific to the commodities and country of export. Jain (2020) found that India has positive RCA in different product categories

for countries. RCA was positive for six product categories with Vietnam and Singapore, four product categories with Brunei and Cambodia, three product categories with Myanmar and Thailand, and over eight product categories for Australia, New Zealand, Japan, South Korea, China, Indonesia, Malaysia, and the Philippines.

A significant component of RCA_{ij} is $\frac{X_{ij}}{\sum_j X_{ij}}$ which may be influenced by a host of factors. These are trade barriers, export-oriented strategies, the concentration of high-technology-based manufactured items for export (Kowalski and Bottini, 2011), logistic efficiencies of the j-th commodity at the i-th country (Devlin and Yee, 2005), and similar.

Often arithmetic average of RCA's is taken. If the export of the j-th commodity to countries A, B, C, and D by the i-th country are X_{Aj}, X_{Bj}, X_{Cj} and X_{Dj} respectively, then the arithmetic average of RCA_{Kj} for K= A, B, C, and D are well-defined. However, in general, the Geometric mean of RCAs as a product of two positive ratios is equivalent to the Costinot et al. (2012) measure and preferred for averaging across all types of commodities.

A high value of RCA_{ij} does not always indicate high export from i-th to j-th country. For example, between 2018 to 2020, the RCA of India with Australia for hides and skin was as high as 6.40, but the commodity constituted only 2.35% of India's exports to Australia in 2018 (Jain, 2020).

Hinloopen and Van Marrewijk (2001) compared multiplicative RCAs (MRCAs) for 12 EU countries and found that about one-third of all MRCAs exceed unity, implying values of the median of the MRCAs are less than one. Thus, the distribution of the MRCA depends on several factors, including the number of countries and sectors considered in the analysis. Theoretical derivation of the dynamic standard MRCA distribution may not be possible due to its dependence on the number of countries and sectors with unstable mean exceeding the theoretically expected value of one (Hoen & Oosterhaven, 2006). The authors suggested additive RCA. However, if the logarithm is taken on both sides of (1), MRCA gets converted to an additive model. Yu et al. (2009) considered the deviation of actual exports of the commodity exported by that country from the expected exports of the same commodity in a world of no comparative advantages and proposed a Normalized RCA index (NRCA). It appears to have similarities with CTB to a certain extent, but the NI does not adjust trade flows. Normalization procedures also differ. Empirically, Deb and Hauk (2017) found that the Log of Balassa index performed best, despite deficiencies of the index for cross-country or cross-commodity comparisons, and the performance of NI was relatively poor, raising questions about the consistency of NI with the Ricardian theory of comparative advantage. Despite limitations, the Balassa RCA index is the most popular and is reported by the International Trade Centre (ITC), World Integrated Trade Solutions (WITS), and UN COMTRADE for various countries.

3. Proposed method

The methodology suggested includes a two-stage approach:

- Computation of Relative Revealed Comparative Advantage (RRCA) for a commodity group (sector): This stage involves two steps. The first step: Computation of RCAs of the individual sector over years. The second step: measuring the ratio of RCAs and the base year RCA. Say, the RCA of a commodity or product for the year - 2016 is 1.8 (A) and that of the base year (2015) (B) is 1.5, then the ratio of A and B (A: B) is computed. Similarly, such ratios for the period - 2017 to 2022 are determined. This is termed the **Relative Revealed Comparative Advantage (RRCA**). This computation aids in identifying the growth path of a specific commodity compared to others compared to a base year.

  The plot of RRCA over time gives the growth (decline) path of the comparative advantage of the product over years. Section 3.1 describes this stage.

- **Computation of Composite RCA (CRCA)** of a country i.e., revealed comparative advantage index for n-group of commodities. In this stage products of RRCA for each year for different sectors are computed. This step is based on the concept of geometric aggregation. Say, RRCA for chemicals, pharma products, and cosmetics for the year 2016 to 2022 (with 2015 as the base year) are computed. That is, say $\mathrm{RRCA}_{2016}^{\mathrm{chemical}}$, $\mathrm{RRCA}_{2016}^{\mathrm{Pharmal}}$, and $\mathrm{RRCA}_{2016}^{\mathrm{cosmetics}}$ are calculated. The product of these RRCAs constitutes the CRCA per year.

  Such aggregating method satisfies the principles of monotonicity, and time reversal and enables the formation of chain indices. Section 3.2 explains this stage.

3.1. RCA of a sector

RCA for a commodity-group (sector) exported by i-th country ($RCA_{i,j-th\ sector}$) can be presented in tabular fashion given in Table 1.

Table 1. Calculation of RCA of a sector for a particular country in a specific year

Commodity-group	Export of the commodity by *i*-th country to other countries	Total export of the commodity by *i*-th country	Total export of the *i*-th country	Proportion of world export (W_j) of the commodity	RCA of the commodity for the *i*-th country across countries
j	$X_{j1}, X_{j2}, \ldots \ldots, X_{jn}$	$\sum_{c=1}^{n_1} X_{jc} = T_{ij}$	TE_i	$\frac{T_{ij}}{W_j} = P_j$	$\frac{T_{ij}}{TE_i} \cdot \frac{1}{P_j}$

The procedure is illustrated with a hypothetical example given in Table 2.

Table 2: India's export of Chemicals

	China	USA	UAE	Germany	Rest of world (ROW)	Total
India's export of chemicals	166.47	150.34	55.46	47.73	223	643
World export of chemicals						30,000
Total of World export						19,015,285
Share of India's chemical export to her total trade					643 ÷30000	0.021433
Proportion of chemical in world trade					30,000 ÷ 19,015,285	0.001578
RCA of India for chemicals					0.021433 ÷ 0.001578	13.58536

Observations:

- For the i-th country, the procedure helps to find the RCA of one commodity or a group of commodities (RCA_{ij}) across the countries to which the j-th product is being exported.
- The method of computing RCA_{ij} is admissible, even if the number of destination countries for the j-th product is increased or decreased.
- However, the procedure does not help combine the RCA of two different commodities, say, chemicals and marine products. This is primarily because of different denominators like total export of j-th and k-th commodities exported by the i-th country and different values of the proportion of world export of j-th and k-th commodities.
- The sectors of the i-th country can be ranked with respect to RCA_{ij} values.
- Progress path of RCA_{ij} in terms of $\frac{RCA_{ij_{(t+1)}}}{RCA_{ij_t}}$ or $\frac{RCA_{ij_{(t+1)}} - RCA_{ij_t}}{RCA_{ij_t}}$ may quantify the progress or decline of RCA_{ij} in successive periods, where $RCA_{ij_{(t+1)}} > RCA_{ij_t}$ implies progress and $RCA_{ij_{(t+1)}} < RCA_{ij_t}$ implies decline.

Thus, the gain in comparative advantage (or comparative disadvantage) of a commodity or a commodity group for a country during the period of interest can be assessed. The sectors showing an increasing RCA trend could be important signals for the economy.

3.3. Composite RCA of a country

Suppose a country exports an n-group of commodities. RCA of each commodity group (sector) for the current year can be presented as an n-dimensional vector

$$\boldsymbol{RCA_c} = \begin{pmatrix} RCA_{c1} \\ RCA_{c2} \\ \cdots \\ \vdots \\ RCA_{cn} \end{pmatrix}$$

Similarly, the RCA vector for the base period is

$$\boldsymbol{RCA_0} = \begin{pmatrix} RCA_{01} \\ RCA_{02} \\ \cdots \\ \vdots \\ RCA_{0n} \end{pmatrix}$$

The ratio $\frac{RCA_{cj}}{RCA_{0j}}$ defines the dynamic nature of the RCA of the j-th sector in the current period over the base year.

Progress is indicated if $\frac{RCA_{cj}}{RCA_{0j}} > 1$ and decline if $\frac{RCA_{cj}}{RCA_{0j}} < 1$.

By aggregating the ratios over the sectors, the composite RCA (CRCA) of the i-th country in the current year can be defined as the geometric mean of such ratios, i.e.,

$$RCA^i_{C0} = \sqrt[n]{\prod_{j=1}^{n} \frac{RCA_{cj}}{RCA_{0j}}}$$

or equivalently avoiding the n-th root,

$$RCA^i_{C0} = \prod_{j=1}^{n} \frac{RCA_{cj}}{RCA_{0j}} \qquad (7)$$

Properties:

RCA^i_{C0} of the i-th country in the current period as per equation (7) has the following properties:

- Simple geometric aggregation without considering correlation or association between exports of a pair of sectors.
- Represents a continuous, monotonically increasing function.
- Symmetric over its arguments, i.e., independent of the order of chosen sectors.
- Independent of change in scale, i.e., measurements in dollars or euros.
- A small gain in RCA of a sector and growth in RCA^i is constant i.e., RCA^i has constant elasticity.

- $RCA^i_{C0} > 1$ implies improvement from the base year considering all export commodities
- Satisfies time-reversal test, i.e., $RCA^i_{C0} * RCA^i_{0C}$ = 1
- Facilitates the formation of chain indices, i.e., RCA^i_{20} = (RCA^i_{21}) * (RCA^i_{10})
- Have a symmetric index making equal use of the export values and destination in both the current period and base period and treating them in a symmetric manner.
- zero-valued trade flows are excluded.

Benefits:

The proposed method of finding the CRCA of a country as a function of time helps to:

- Draw the $RCA^i_t -$ graph over a long period to reflect the zigzag path of improvement or decline over time.
- Find the relative importance of the sectors in terms of the values of $\frac{RCA_{cj}}{RCA_{0j}}$
- Classify the sectors. The sectors with $\frac{RCA_{cj}}{RCA_{0j}} > 1$ are "Stars" or "Cash Cows" (Joubert et al., 2011) and the sectors for which $\frac{RCA_{cj}}{RCA_{0j}} < 1$ but ≥0.5 have the potentiality to improve and become a "Star" if appropriate corrective actions are implemented and the sectors with $\frac{RCA_{cj}}{RCA_{0j}} < 0.5$ are critical and require immediate managerial attentions.
- Similarities of trends of RCA-curves of two countries may be found by correlation. Better could be to use non-parametric trend tests like the Modified Mann-Kendall trend test, which is robust in the presence of autocorrelation (Hamed and Rao, 1998).
- May help to evaluate the effects of changes in policies on trade barriers, tariffs, etc. on a country's export.
- Facilitate undertaking correlation analysis and finding the empirical relationship of the RCA of a country with other trade indicators, like Trade intensity index, trade Competitiveness, Normalized Trade Balance, Trade openness ratio, HH Market concentration index, HH Product Concentration index, etc.

4. Limitations

- RCA^i_{C0} of the i-th country considering base periods is an index that is a function of time and generates time-series data where computations of the index are done at adjacent time periods with potential for correlation between observations and structural breaks.

- The time series may not always be stationary.
- The introduction of a new commodity in the export leg will increase the dimension of the vector RCA_c. If the corresponding value of the component in RCA_0 vector is taken as zero, the method fails. Remedial action is to take the corresponding value as one.
- If for the k-th sector, $RCA_{ck} = RCA_{0k}$, the sector does not contribute to the country-level RCA for the c-th time-period i.e., RCA^i_{C0}.

5. Empirical Illustration

Commodity-wise RCA of India for various export items was obtained from WITS from 1999 to 2019. The ratio of RCA (RRCA) of a product or product group at the t-th year and the same for 2019 are shown in Table 3. Each such ratio was greater than zero. The value of the ratio exceeding one indicates improvement with respect to the base year 1999. Graph of values of such ratios for product/product-group reflects its growth path with respect to the base year (1999).

Several product groups exhibited RRCA greater than one, implying an improvement of comparative advantage of the product over the base year. The relative importance of the product, sectors in terms of the values of $\frac{RCA_{cj}}{RCA_{0j}}$ varied over time. Products with RRCA > 1 from 2000 to 2019 include fuels, chemicals, plastics or rubbers, woods, mechanical & electrical items, capital goods, and metals (except for 2010 and 2011). These item groups may be listed under "Stars" or "Cash Cows." Critical products such as Vegetables and Minerals need immediate managerial attention as the ratio $\frac{RCA_{cj}}{RCA_{0j}}$ fell below 0.5 in 2019. Products with RRCA between zero and one have the potential to become a "Star" if appropriate actions are initiated.

Figure 2 shows fluctuations of commodity-wise RRCA of India, i.e., RCA, compared to the base year 1999. The fuel products group appears to be the outlier compared to other products, exhibiting substantial growth compared to 1999.

Figure 3 shows the RRCA for all product groups except Fuels. The figures indicate India's decline in exports of commodities such as hides and skins, animals, vegetables, minerals, stones, and glasses compared to finished products such as capital goods, mechanical and electrical products, consumer goods, miscellaneous items, metals, plastics, rubber, and chemicals. This trend indicates India's growth in the export value chain. However, the concern is with food products that decreased from high growth (above 1) to an RRCA of 0.67 in 2019. This drop could be due to growing stringency in sanitary and phytosanitary (SPS) requirements across countries and India's inability to meet such needs. India could not leverage the potential to gain a comparative advantage in textiles, clothing, and footwear, and as such, the growth remained below one.

Table 3: Ratio of RCA (RRCA) of a product/product group with respect to 1999

Sectors	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Animal	1	1.21	1.05	0.98	0.81	0.75	0.69	0.70	0.63	0.61	0.58	0.57	0.56	0.62	0.70	0.82	0.84	0.81	0.83	0.80	0.89
Vegetable	1	1.01	0.90	0.86	0.78	0.71	0.61	0.61	0.57	0.59	0.51	0.49	0.51	0.71	0.73	0.70	0.62	0.53	0.52	0.51	0.47
Food Products	1	1.14	1.12	0.95	0.84	1.00	0.78	1.11	1.12	1.40	0.89	0.89	1.08	1.07	1.05	0.89	0.84	0.80	0.76	0.71	0.67
Minerals	1	1.09	1.14	1.07	1.30	1.92	1.58	1.20	1.23	1.31	1.04	0.88	0.59	0.37	0.25	0.24	0.24	0.30	0.31	0.22	0.26
Fuels	1	2.00	3.89	4.00	5.22	4.78	5.11	7.11	8.11	7.00	7.33	10.11	9.89	9.44	10.22	9.22	9.22	9.44	9.67	8.56	8.33
Chemicals	1	1.14	1.12	1.09	1.12	1.02	1.04	1.12	1.11	1.12	1.11	1.09	1.10	1.27	1.32	1.35	1.41	1.49	1.40	1.49	1.55
Plastic or Rubber	1	1.23	1.43	1.55	1.55	1.59	1.68	1.66	1.41	1.34	1.32	1.25	1.34	1.43	1.48	1.45	1.43	1.43	1.48	1.73	1.68
Food Products	1	1.14	1.12	0.95	0.84	1.00	0.78	1.11	1.12	1.40	0.89	0.89	1.08	1.07	1.05	0.89	0.84	0.80	0.76	0.71	0.67
Hides and Skins	1	1.03	1.05	0.97	0.89	0.83	0.79	0.76	0.73	0.72	0.71	0.62	0.58	0.62	0.62	0.65	0.63	0.62	0.58	0.59	0.57
Wood	1	1.17	1.28	1.44	1.39	1.28	1.22	1.39	1.28	1.28	1.39	1.50	1.28	1.39	1.39	1.44	1.50	1.67	1.61	1.72	1.78
Textiles and Clothing	1	1.01	0.96	0.92	0.88	0.85	0.87	0.91	0.86	0.83	0.81	0.80	0.78	0.79	0.81	0.79	0.80	0.74	0.73	0.76	0.69
Footwear	1	1.00	1.08	0.95	0.92	0.98	0.91	0.96	0.97	0.93	0.93	0.87	0.85	0.83	0.87	0.92	0.91	0.87	0.82	0.83	0.80
Stone and Glass	1	1.00	0.91	0.96	0.99	1.06	1.14	0.92	0.90	0.78	0.87	0.82	0.75	0.57	0.53	0.60	0.56	0.59	0.58	0.63	0.58
Metals	1	1.12	1.04	1.25	1.36	1.25	1.25	1.31	1.25	1.24	1.17	1.00	0.99	1.09	1.18	1.22	1.23	1.17	1.52	1.33	1.22
Mach and Elec	1	1.10	1.30	1.20	1.25	1.25	1.35	1.65	1.70	2.00	2.05	1.85	1.80	1.95	1.80	1.80	1.70	1.70	1.70	1.95	2.20
Transportation	1	0.70	0.63	0.63	0.74	0.93	1.04	1.15	1.11	1.22	1.78	1.70	1.93	2.04	1.85	2.04	2.04	2.00	2.04	2.11	2.07
Miscellaneous	1	0.87	0.81	0.84	0.77	0.81	0.81	0.74	0.87	0.87	0.84	0.77	0.90	1.10	0.87	0.94	1.06	1.10	1.19	1.23	1.61
Raw materials	1	0.86	0.92	0.85	0.83	0.94	0.85	0.72	0.80	0.79	0.71	0.70	0.57	0.59	0.55	0.53	0.62	0.62	0.60	0.49	0.51
Intermediate goods	1	1.07	0.98	1.02	0.98	0.91	1.02	0.86	0.92	0.90	0.76	0.72	0.71	0.84	0.88	0.87	0.87	0.87	0.91	0.88	0.82
Consumer goods	1	0.98	0.98	0.97	0.98	0.92	1.00	1.05	1.05	1.02	0.99	1.06	1.08	1.15	1.18	1.18	1.13	1.14	1.13	1.16	1.16
Capital goods	1	1.05	1.25	1.15	1.20	1.20	1.40	1.60	1.75	1.95	1.95	1.90	1.90	2.10	1.90	1.95	1.90	1.90	1.90	2.10	2.45
CRCA	**1**	**4.27**	**8.12**	**5.02**	**4.94**	**8.24**	**5.41**	**13.48**	**13.66**	**19.87**	**6.22**	**3.54**	**2.77**	**5.94**	**3.22**	**3.60**	**3.30**	**3.36**	**3.54**	**2.89**	**3.66**

Source: Authors Compilation (RCA data compiled from WITS database)

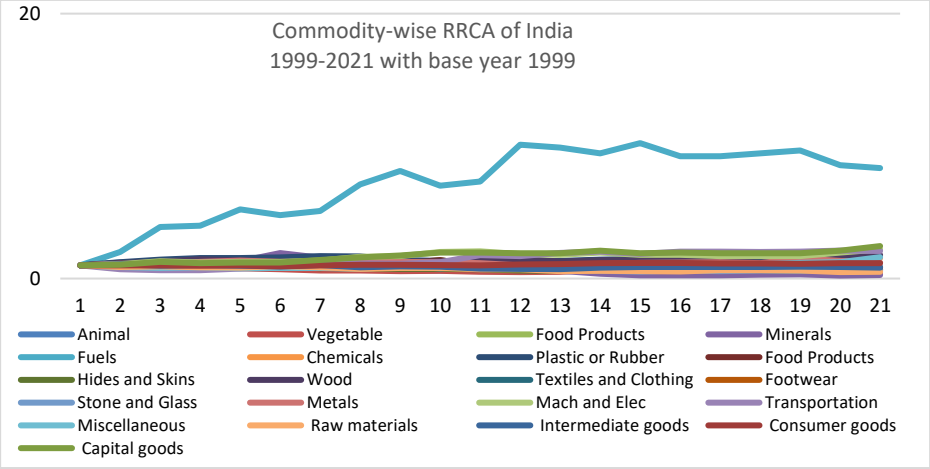

Figure 2. Commodity-wise RRCA of India from 1999 to 2021~~2019~~

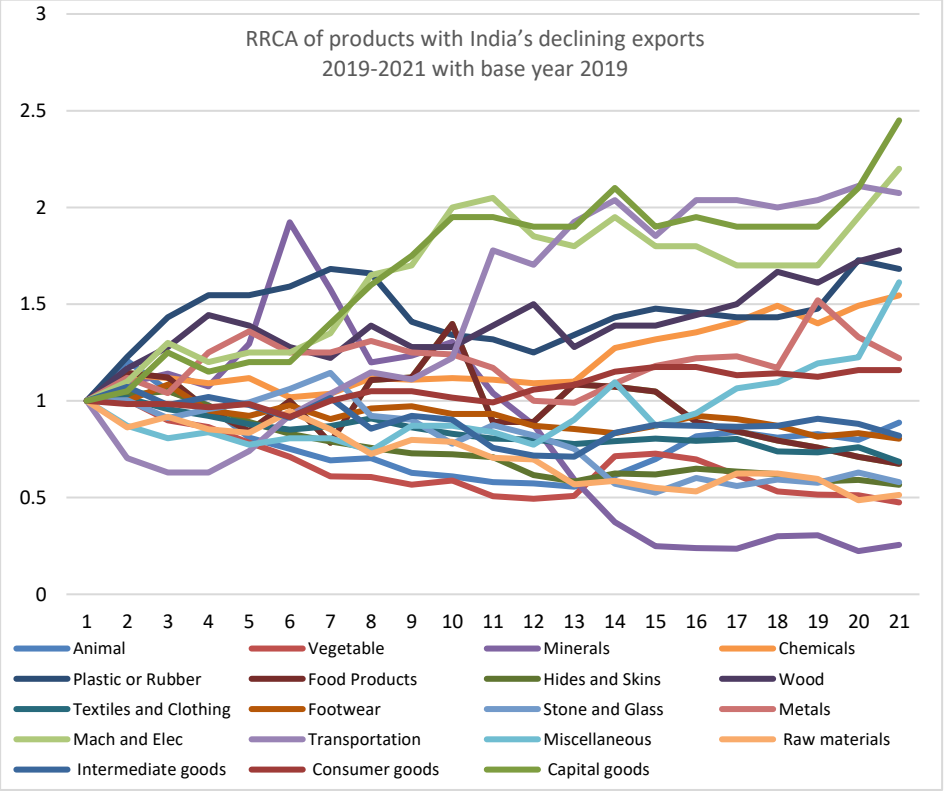

Figure 3. RRCA for all product groups except fuels

India's composite RCA (CRCA) showed a zigzag pattern attaining its peak in 2008, as can be seen in Figure 4. India's export competitiveness during the period 2013-2019 remained below the period 2000-2008. The reasons for the sharp decline from 2009 onwards need to be analyzed and reorientation of policies done.

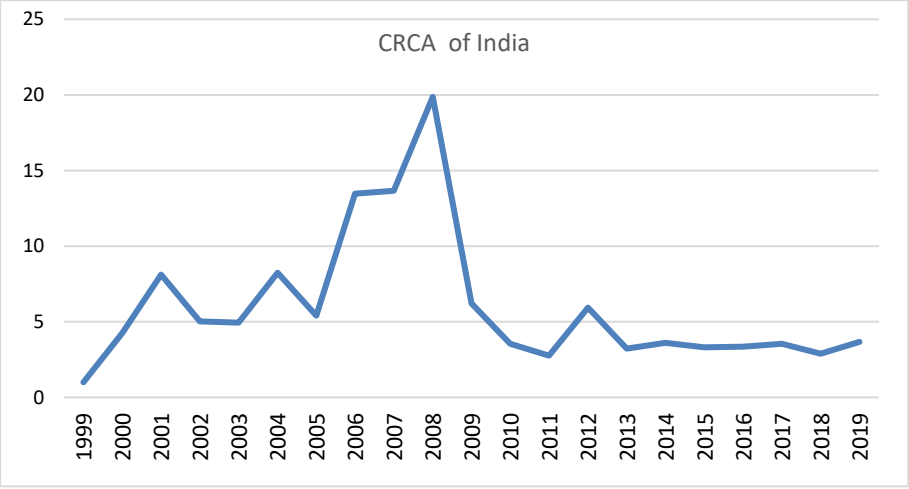

Figure 4. Composite RCA of India (1999 – 2019)

6. Conclusions

This paper introduces two indices – relative RCA (RRCA) and the Composite RCA (CRCA). These indices are based on the traditional Balassa RCA index but overcome its primary limitation of time stationarity. The proposed indices are simple to compute and interpret. The method is non-parametric, avoids the relevance of weights, and allows the drawing of the path of the index to reflect its dynamic frontier.

RRCA of individual products over years shows the growth (decline) of comparative advantage of different export sectors. The decline in relative RCA demands examination for a such drop. Several factors affect the competitiveness of export goods - such as a drop in quality, increase in price, availability of substitutes, shift in labor markets, weakening of buyer's country currency, and similar. The sectors with $\frac{RCA_{cj}}{RCA_{0j}}$ < 0.5 are critical and require immediate policy and managerial attention. Individual firms may assess the strengths, opportunities, and weaknesses of their country's export goods and their markets. Products with an increasing trend are opportunities while those with a declining trend are weak products in global markets.

CRCA over time shows the trend of the country's export strength. The growth of export volume is dynamic in nature and varied goods may experience varied

changes. If the overall competitiveness, i.e., CRCA, increases the country's direction of a trade can be said to be adaptive to changing environment. Else, it calls for a policy relook.

The results indicate that RCA computation is necessary but not sufficient to decide on a country's policies. The proposed method of geometric aggregation is a suitable measure of aggregated comparative advantages, although the Contribution-to-the-Trade-Balance (CTB) measure involving arithmetic aggregation should not be dismissed. Future studies may be undertaken to evaluate country-specific relationships of composite RCA with other trade indicators of the country. It may be compared with the constant-market-share (CMS) analysis to reveal the reason for the increase or decrease and its correlations with measures like income, employment, and welfare.

References

Amoroso, N., Chiquiar, D., & Ramos-Francia, M. (2011). Technology and endowments as determinants of comparative advantage: Evidence from Mexico. *The North American Journal of Economics and Finance,* 22(2), 164-196. https://doi.org/10.1016/j.najef.2011.01.004

Balassa, B. (1965). Trade liberalisation and "revealed" comparative advantage. *The Manchester School of Economic and Social Studies,* 33, 99-123. https://doi.org/10.1111/j.1467-9957.1965.tb00050.x

Bowen, H. P. (1983). On the Theoretical Interpretation of Indices of Trade Intensity and Revealed Comparative Advantage, *Weltwirtschaftliches Archiv,* 119(3), 464-472. https://doi.org/10.1007/BF02706520

Costinot, A., Dave D., & Ivana K. (2012). What Goods Do Countries Trade? A Quantitative Exploration of Ricardo's Ideas. *Review of Economic Studies*, 79(2), 581-608. https://doi.org/10.1093/restud/rdr033

Costinot, A., Donaldson, D., Vogel, J. & Werning, I. (2015). Comparative Advantage and Optimal Trade Policy. *The Quarterly Journal of Economics,* 130(2), 659-702. https://doi.org/10.1093/qje/qjv007

Dalum, B., Laursen, K. & Villumsen, G. (1998). Structural change in OECD export specialisation patterns: de-specialisation and 'stickiness'. *International Review of Applied Economics*, 12, 423-443. https://doi.org/10.1080/02692179800000017

Deb, K., & Hauk, W. R., Jr. (2017). RCA indices, multinational production and the Ricardian trade model. *International Economics and Economic Policy*, 14(1), 1-25. https://doi.org/10.1007/s10368-015-0317-z

Devlin, J., & Yee, P. (2005). Trade logistics in developing countries: The case of the Middle East and North Africa. *The World Economy*, 28, 435-456. https://doi.org/10.1111/j.1467-9701.2005.00620.x

Dieter, M., & Englert, H. (2007). Competitiveness in the global forest industry sector: an empirical study with special emphasis on Germany. *European Journal of Forest Research,* 126(3), 401-412. https://doi.org/10.1007/s10342-006-0159-x

Evenett, S. J., & Yeung, B. Y. (1998). *Willingness to Pay for Tariff Liberalization*. Manuscript. New Brunswick, N.J.: Rutgers Univ.; Ann Arbor: Univ. Michigan, https://www.alexandria.unisg.ch/publications/22181.

French, S. (2017). Revealed Comparative Advantage. What is it Good for? *Journal of International Economics,* 106, 83-103. https://doi.org/10.1016/j.jinteco.2017.02.002

Hamed, K. H., &Rao, A. R. (1998). A modified Mann-Kendall trend test for autocorrelated data. *Journal of Hydrology*, 204, 182 196. https://doi.org/10.1016/S0022-1694(97)00125-X

Hinloopen, J. & Van Marrewijk, C. (2001). On the empirical distribution of the RCA. *Weltwirtschaftliches Archiv,* 137, 1-35. https://doi.org/10.1007/BF02707598

Hoen, A. & Oosterhaven, J. (2006). On the measurement of comparative advantage. *Annals of Regional Science, 40*, 677-691. https://doi.org/10.1007/s00168-006-0076-4

Jain, M. (2020). Review of ASEAN-India Free Trade Agreement Using Revealed Comparative Advantage Index. *International Journal of Business and Economics*, 5(2), 56-65.

Joubert, J. C. N., Jooste, A., & Lotriet, R. (2011). The Cash Cows, Dogs, Stars and Problem Children of the South African Agricultural Sector1. *International Journal of Agricultural Management,* 1(1), 18-23.

Kowalski, P. & Bottini, N. (2011). *Comparative advantage and export specialisation mobility. Globalisation, Comparative Advantage and the Changing Dynamics of Trade*. OECD Publishing.

Lafay, G. (1992). The measurement of revealed comparative advantages. In: Dagenais, M. G. & Muet, P.A. (eds.) *International Trade Modelling*. London: Chapman & Hall. https://doi.org/10.1007/978-1-4757-2150-8_10

Laursen, K. (2015). Revealed comparative advantage and the alternatives as measures of international specialization. *Eurasian Business Review*, 5(1), 99-115. https://doi.org/10.1007/s40821-015-0017-1

Leromain, E. & Orefice, G. (2014). New Revealed Comparative Advantage Index. Dataset and Empirical Distribution. *International Economics,* 139, 48-70. https://doi.org/10.1016/j.inteco.2014.03.003

Marconi, D. (2012). Environmental regulation and revealed comparative advantages in Europe: Is China a pollution haven? *Review of International Economics,* 20(3), 616–635.

Maryam, J., Banday, U. J. & Mittal, A. (2018). Trade Intensity and Revealed Comparative Advantage: An Analysis of Intra-BRICS Trade. *International Journal of Emerging Markets,* 13(5), 1182-1195. https://doi.org/10.1108/IJoEM-09-2017-0365

Milana C (1988). Constant-market-share analysis and index number theory. *European Journal of Political Economy,* 4, 453-478. https://doi.org/10.1016/0176-2680(88)90011-0

Nyahoho, E. (2010). Determinants of comparative advantage in the international trade of services: An empirical study of the Hecksher-Ohlin approach. *Global Economy Journal,* 10 (1), 1–22. https://doi.org/10.2202/1524-5861.1495

OECD (2022). United States- Country Profile. https://oec.world/en/profile/country/usa

Proudman, J. & Redding, S. (2000). Evolving patterns of international trade. *Review of International Economics*, 8, 373-396. https://doi.org/10.1111/1467-9396.00229

Ricardo, D. (1951). On the principles of political economy and taxation. In: Sraffa, P. (ed.) *The works and correspondence of David Ricardo*, Vol.1. Cambridge, UK: Cambridge University Press, 1951.

Riedel, J. & Donges, J. (1977). The Expansion of Manufactured Exports in Developing Countries: An Empirical Assessment of Supply and Demand Issues. *Review of World Economics (Weltwirtschaftliches Archiv).* 113. 58-87. https://doi.org/10.1007/BF02696566

Ruzzier, M., Hisrich, R. D., & Antoncic, B. (2006). SME internationalization research: past, present, and future. *Journal of Small Business and Enterprise Development*, 13(4), 476-497. https://doi.org/10.1108/14626000610705705

Sanidas E. & Shin Y. (2010). Comparison of Revealed Comparative Advantage Indices with Application to Trade Tendencies of East Asian Countries. *9th Korea and the World Economy Conference, New Economic Order after the Global Financial Crisis,* Incheon, Korea. http://www.akes.or.kr.

Stellian, R. & Danna-Buitrago, J. (2019). Revealed comparative advantages and regional specialization: Evidence from Colombia in the Pacific Alliance. *Journal of Applied Economics*, 22(1), 349-379. https://doi.org/10.1080/15140326.2019.1627722

Stellian, R. & Danna-Buitrago, J. (2022). Revealed comparative advantages and contribution-to-the-Trade-Balace Indexes. *International Economics*, 170, 129-155 https://doi.org/10.1016/j.inteco.2022.02.007

TradeEconomics (2022) *United States Exports to India*. https://tradingeconomics.com/united-states/exports/india

Vollrath, T.L. (1991). A Theoretical Evaluation of Alternative Trade Intensity Measures of Revealed Comparative Advantage. *Weltwirtschaftliches Archiv*, 127(2), 265-280. https://doi.org/10.1007/BF02707986

Yu, R., Cai, J. & Leung, P. (2009). The normalized revealed comparative advantage index. *Annals of Regional Science,* 43, 267-282. https://doi.org/10.1007/s00168-008-0213-3