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TRADE COMPETITION MEASUREMENT AND THE CHOICE OF MEASUREMENT INDEXES

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Abstract. The aim of this paper is to bring a methodological and empirical contribution to the measurement of trade competition. Globalization and the emergence of new poles in the world economy brought changes to the global landscape and consequent increase in international trade. There is a debate in the literature with regard the indexes that are better fit to be applied in empirical examples for the acquirement of relevant results for measurement of trade competition. This measurement will be achieved by observing the levels of structural similarity in distinct areas and at different moments in time. A higher degree of similarity between the export structures implies a stronger competition in destination markets. The values obtained for this measurement are highly relevant for the trade competition topic. Through this study we further explore the measurement of trade competition and comparatively discuss several indexes used in this area of research.

JEL classification: B17, B27;

Keywords: trade competition; structural similarity; export structures; trade competition indexes; competition measurement; Krugman index

1. Introduction

The concept of measuring the levels of structural similarity in distinct areas and at different moments in time to observe a higher degree of similarity between the export structures has already been studied. A high similarity implies a stronger competition in destination markets in correlation with the trade competition topic.

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What we propose to do in this study is to further explore the measurement of trade competition and present several indexes that have already been used in this area of research. Alongside the measurement of trade competition through sector shares we explore structural similarity as an intra-sector dimension in order to measure the quality in product specialization. Moreover we measure inter-sector similarity to reflect the degree of similarity between sectors. All of these approaches are based on trade competition being measured through the exports of two countries (a,b) for a given destination market (m). The indexes used to measure the above types of competition are variations of the Krugman index as in Lopes et al. (2014) all starting from the traditional Krugman index as in Krugman (1991). For our study in the empirical section the estimation of the specialization levels will be done focusing on the evolution of export structures over time.

Furthermore, this paper explores other types of perspectives of analysis: the competition in a block of countries, the competition between two countries in all the markets, competition that a country faces in a specific destination market, competition that a country faces in all markets, competition in a given market among all the countries, and finally competition between all countries in all markets.

2. Literature review

International trade and the measurement of trade competition have been intensely researched and debated in the recent years (Palan and Schmiedeberg, 2010, Crespo and Simoes, 2012). The aim of this paper is to bring a methodological and empirical contribution to trade competition measurement. As stated “Globalization is neither inevitable nor irreversible” (World Trade Economy, 2013, p. 5), alongside with the emergence of new poles in the world economy consequently making the global landscape modify. Globalization is a driver in the geographical reconfiguration facilitating the shift in economic power for numerous nations (Head and Mayer, 2013; Riad et al., 2012). All these factors have contributed to the high-powered increase of international trade (Berthelon and Freund, 2008). With all the changes in the worldwide trade the concept of trade competition should be granted a higher attentiveness. Furthermore the conclusions of this paper will show what is left to be researched in this area in order to have a complete review on measuring trade competition.

Based on the research that has been done so far there is a debate among the indexes more applicable in empirical examples for the acquirement of relevant results. According to Palan (2010, p. 3) “Due to the increasing interest on the effects of economic integration on the specialization of countries, the necessity to measure heterogeneity across countries as well as its effects on the competitiveness of individual countries has risen Yet there seems to have been no agreement on which index is best to capture specialization, although the empirical results depend heavily on the statistical methods and measures employed.”

Even more, analysing trade structural similarity is an important subject to be researched in international economics (Wacziarg, 2004). Several empirical analyses have measured the levels of structural similarity in distinct areas and years to observe that if the export structures have a higher degree of similarity that implies a stronger competition in destination markets (Midelfart-Knarvik et al., 2003; Crespo and Fontoura, 2007; Palan and Schmiedeberg, 2010).

There are multiple ways to evaluate the phenomenon but most studies on this subject have focused on the structural similarity to weight trade competition (Crespo and Simoes, 2012). In this study we further explore the measurement of trade competition. Several indexes that have already been used in this area of research will also be presented.

There are a lot of researchers that have studied the topic of trade competition measurement while further emphasising the perspective of competition of two countries in a given market m (Crespo and Simoes, 2012). The following phase of research was based on exploring the existence of various typologies of competition between countries (Moreira et al., 2017, Lopes et al., 2014). Jenkins' paper (2008) is focused on one specific type of competition; the one faced by all exporters by one market *m*. Also Krugman's study (1991) became the foundation for this research and is the most used index for this field.

The remainder of the paper focuses on the choice of Krugman index and the description of its modified version in order to measure trade competition between two countries to one destination market. This section also elaborates different approaches to measure this kind of competition, such as inter-sector and intra-sector similarity. The empirical part of this article analyses trade competition in a block of countries and presents other useful perspectives of analysis that can be involved. Lastly, some final remarks are being presented.

3. Methodology

The first perspective of approach for trade competition is the situation where two countries *a* and *b* compete in market *m*. The modified Krugman index is the baseline index which only considers sectoral shares.

Crespo and Simoes (2012) propose the consideration of an average of the Krugman Index calculated at different levels of sectoral disaggregation in order to evaluate not only the level of actual competition (traditionally evaluated through the Krugman Index) but also the potential one.

In order to calculate sectoral shares similarity Crespo and Simoes (2012) propose a modified Krugman index that can be expressed as:

$$E_{abm} = 1-\beta\sum_{i=1}^{I} | v_{iam} - v_{ihm} |$$

The authors have chosen to use β as it is commonly used in studies as β=1/2; with values between 0 and 1. When E_{abm} =1 it means that there is a maximum similarity with the weights of each sector being equal in the exports of countries *a* and *b* to market *m*.

To further explore the perspective of competition between countries *a* and *b* that face competition in market *m* and to obtain a broader view the inclusion of inter-sectoral similarity and intra-sectoral similarity is fundamental Moreira et al. (2017). After having the base for index for the sectoral share competition measurement, the inter-sectoral similarity approach is introduced to consider the degree of dissimilarity between sectors and the intra-sectoral approach in order to introduce the quality factor.

Index E_{abm} could be enlarged to reflect the degree of dissimilarity between sectors for a better analysis of the difference in specialization thus obtaining a stronger measure of trade competition. Moreover we could take a hypothetical example of three countries R(Romania), H(Hungary) and B(Bulgaria) that are totally specialized in one sector. If R would be specialized in curtains, H in bed covers and B in pharmaceuticals; after testing E_{abm} we would obtain the value 0 which would indicate a maximum level of structural dissimilarity between all country pairs as the sectors in discussion are different. On the other hand we can say that the sectors of curtains and bed covers are very similar from the point of view production materials and obtaining processes as opposed to the pharmaceutical sector. Therefore it would be useful to have an index that could measure the similarity between R and H and lower structural similarity between R, H and B. In order to measure this difference a criteria to distinguish how distinct the sectors are from each other must be set. Furthermore to empirically measure this inter-sectoral similarity the index must develop even more. It can be obtained calculating the average of the structural similarity indices obtained at each level of sectoral disaggregation considered in the empirical analysis (g = 1, 2, . . . , G; where G is the most disaggregated level). The best suggestion is to use a predefined sectoral nomenclature that has different levels of disaggregation. The nomenclature used in the methodological and empirical study of Moreira et al. (2017) was the Standard International Trade Classification (SITC). The SITC is a classification of goods used to classify the exports and imports of a country to enable comparing different countries and years. The classification system is maintained by the United Nations. The data is used for analytical purposes applied in economy and are given by trading partners, with products classified according to each level of the Combined Nomenclature (CN8, HS6, HS4 and HS2). I will be used in this study to use the predefined sectors and subsectors of export.

$$F_{abm}=\frac{\sum_{g=1}^{G} E_{abm}^{g}}{G}$$

We can calculate E_{abm}^{g} as for sectoral shares for each level *g*.

While Crespo and Simoes (2012) consider equal weights for all levels of sectoral disaggregation and calculate the index through a simple average in the

study of Moreira et al. (2017) the development is that they generalise that measure by allowing the weights to be defined according to the objectives of each specific research.

The new index being:

$$S_{abm} = \sum_{g=1}^{G} \alpha^{g} E_{abm}^{g}$$

Where $\sum_{g=1}^{G} \alpha^{g}$=1, and E_{abm}^{g} is calculated as E_{abm} (from sectoral shares) for each level of *g*. Depending on the purpose of each study the weights for each level of disaggregation may vary depending on the importance of structural similarity in the discussed research. This index was designed to be applied in studies based mainly on the level of potential competition instead of present competition.

In order to get a complete view on structural similarity an intra-sectoral dimension should be included to measure the quality in product specialization. However measuring quality empirically can be challenging so considering using unit export values as a quality proxy (Stiglitz, 1987) may modify the index into the following form:

T_{abm}=$Z_{abm}E_{abm}$ that can be obtained through the formulas

$$Z_{abm} = \sum_{i=1}^{I} U_{iabm}\, \varepsilon_{iabm}$$

Where $U_{iabm} = \frac{Min[UV(x_{iam}), UV(x_{ibm})]}{Max[UV(x_{iam}), UV(x_{ibm})]}$

And $\varepsilon_{iabm} = \frac{v_{iam} + v_{ibm}}{2}$

Z_{abm} is used to reduce the level of structural similarity between countries *a* and *b* and be a function of the average degree of intra-sectoral dissimilarity. This can be calculated through a weighted average of the differences in terms of quality levels in each sector; ε_{iabm} are the average share of *i* in the exports of *a* and *b* to *m*. The value U_{iabm}=1 can be obtained when the unit export values of *a* and *b* to *m* ($UV(x_{iam})$, $UV(x_{ibm})$) are the same. Furthermore if the values are the same for all products Z_{abm}=1 and in conclusion T_{abm}=E_{abm}. If the difference in the unit export values is grater it implicitly means bigger penalization on E_{abm} that would suggest a lower degree of trade structural similarity between the two countries.

4. Measurement Indexes

In the study of Jenkins (2008) several types of index are reviewed that can be used to measure trade competition based on export values. One of them is called the Export Similarity Index and it is one of the most well-known index since it was presented by Finger and Kreinin (1979) in a research where they were measuring the similarity of the exports of two countries to a third market. So mainly it was an index to measure the similarity of exports of country *a* and *b* to market *m*.

$$ESI = 100 * \sum_{i} (x_{ia}, x_{ib})$$

What we use to calculate the index is the share of each product in each country's total exports and is the sum of the smaller value for each product. In the formula above *x* is a share of a certain commodity in exports, *I* is the product, and *a* and *b* are the two countries for which the index is being calculated. The value of the index ranges between 0 and 100 (meaning no overlap between the product that the two countries export when it equals 0 to an identical export habit when it equals 100).

Another index that has been used to measure competition was Coefficient of Conformity (CC) by Blazquez-Lidoy et al. (2006). The CC index is based yet again on two countries but this time on the product of the market shares of these countries:

$$CC = \frac{100 * (\sum_i x_{ia} x_{ib})}{\sqrt{(\sum_i x_{ia}^2 \sum_i x_{ib}^2)}}$$

There are also other indexes used to measure market concentration, such as the Hirschman-Herfindahl Index, even though it was mainly used in industrial economics to determine if there is a presence of monopoly. The index works through attributing higher weight to larger firms (by giving α different values). If the value of α is higher more weight is given to the largest industries and the emphasis on small industries is lower. The may be calculated in the following way:

$$HHI = \sum_{i=1}^{I} b_i^{\alpha}$$

As said above the value of α is arbitrary and the industries/countries are noted with i=1,… I. The b_i^{α} represents the share of industry *i* in the total industries of country *n*. We could use the HHI index in our study to try to measure the intra-sectoral similarity and to see how strongly a country is specialized.

Other indexes can only be used to measure specialization in particular situations, such as the Shannon Entropy Index (SEI) in the way it was adjusted by several authors

(Attaran and Zwic, 1987, Smith and Gibson, 1988, Aiginger and Davies, 2004 or Aiginger and Pfaffermayr, 2004). The SEI can be defined as the negative sum of the shares of country *a* multiplied by the natural logarithm of shares of each single country *i*.

$$SEI = -\sum_{i=1}^{I} b_i \ln(b_i)$$

If we compare the SEI with the HHI we might notice that the logarithm form brings some differences: the relative weights of big countries are reduced compared to the HHI, also the SEI is an inverse measure of specialization. For the values obtained for the SEI that are closer to 0 we can say they indicate absolute specialization and for higher values of the ln*I* it indicates complete diversification.

However the issue with SEI is that it is not possible to calculate the value of the index for any country with sectoral shares that have exports equal to zero. When we talk about small values for exports in the case of some sectors we notice that the SEI does not change significantly, implying that very small sectoral shares only have a negligible effect on the level of specialization.

5. An empirical application

In the previous sectors several methodological options have been presented with the approach of measuring the degree of trade competition between two countries. For a better understanding of the theoretical measurements we propose an empirical example. We analyse the trade competition among eight economies that are predicted to be the ruling world economies in 2050—China (CH), India (IN), United States of America (US), Indonesia (ID), Brazil (BR), Russia (RU), Mexico (MX), Japan (JP) in 2016 (Hawksworth et al., 2017). As destination markets we chose the four most powerful European economies Germany (DE), France (FR), the United Kingdom (GB), Italy (IT) alongside to the eight previous economies (i.e., M = 14).

Trade data (in value and volume) is drawn from Eurostat using the Harmonized Commodity Description and Coding System (HS nomenclature). The largest level of sectoral disaggregation is HS6. Additionally, for incorporating inter-sectoral similarity, exports data (in value) classified in terms of HS2 and HS4 are also considered.

We will be applying the methodological option that has proven to be the most relevant to this study in section 2.1 and producing examples for each of the 6 competition perspectives presented in the subsections of chapter 3. All off the data produced will illustrate the applicability of the indexes proposed for all the possibilities of competition.

Trade competition between two countries for one destination market

Firstly we focus on the perspective where we measure the competition between two countries *a* and *b* in market *m*. The trade competition assumes the exports of these countries in a given destination market. The economies chosen for this example are USA, India and China regarding with the destination market Germany. In the table below we have the values for E-HS6 that is the result of the modified Krugman index applied on the data from Eurostat for the highest level of disaggregation-HS6; S2 is the value for intersectoral similarity; A is the obtained value for intrasectoral similarity and C2 is the total similarity including all factors.

Table 1: USA, India, China exports to Germany

DE	CH-US	CH-IN	IN-US
E - HS6	0.252	**0.270**	0.185
S2	0.286	**0.311**	0.227
A	0.105	0.163	0.077
C2	0.176	**0.231**	0.146

Source: Designed by the authors based on own calculations.
Data sources: European Commission (EUROSTAT) (2016)

The values obtained for the three country pairs produce some interesting conclusions. Analysing the E-HS6 level we may observe that the Chinese and Indian economies result to be most similar, followed at a quite small difference by the Chinese and American similarity. After including the intersectoral similarity and intrasectoral similarity factors the difference becomes clearer with TCI_{CHINDE}=0.231. An interesting factor is that China and India are most similar at intersectoral level.

Trade competition between two countries in all the markets

Through this method we can measure the competition between countries *a* and *b* in all the markets. Applying this index we will compare countries a and b and also all the markets they export to. Considering the fact that this is an example we will take the same three countries as used in the previous example: China, India, United States and the four European markets: Germany, Italy, France and United Kingdom.

Table 2: USA, India, China exports to Germany, France, Italy and UK

IN-US

TCI	DE	FR	IT	UK
E6	0.055977	0.039239	0.021756	**0.07899**
S2	0.068646	0.045672	0.026407	**0.090153**
A	0.023153	0.013683	0.005933	**0.02755**

IN-CH

TCI	DE	FR	IT	UK
E6	0.039797	0.058382	0.054362	**0.113655**
S2	0.045848	0.06814	0.064053	**0.1297**
A	0.02403	0.034363	0.032331	**0.067148**
C	0.034023	0.050125	0.047529	**0.094819**

US-CH

TCI	DE	FR	IT	UK
E6	0.039278	0.043191	0.034521	**0.093739**
S2	0.044615	0.049653	0.055416	**0.107513**
A	0.016376	0.014894	0.009141	**0.038184**
C	0.027439	0.02843	0.036381	**0.065847**
C	0.044028	0.026505	0.014539	**0.051573**

Source: Designed by the authors based on own calculations.
Data sources: European Commission (EUROSTAT) (2016)

Above we have three tables with each country pair: India-United States, China-India and China- United States. It is very interesting to notice that through comparing either of India, China or United States in pars of two, in the same 4 countries as destination markets for their exports it is clear that the highest (marked with bold) competition between India-United States, China-India, China- United States lies in the British market. Comparing the results in the United Kingdom market, between all three country pairs, the highest similarity is between China and India, therefore the highest competition.

Competition faced by a country in a specific destination market

In this situation we measure the degree of competition that a country *a* faces in market *m* from all the other countries exporting to *m*. As explained before in the above example we measure the degree of competition that China faces in the German market from all the remaining countries (India, United States, Indonesia, Brazil, Russia, Mexico and Japan).

Table 3: Competition faced by China in German market

TCI	CH-IN	CH-US	CH-ID	CH-BR	CH-RU	CH-MX	CH-JP
E6	0.021679	**0.139509**	0.007928	0.005016	0.0075606	0.010252	2.5E-05
S2	0.024975	**0.158466**	0.009265	0.006387	0.0092729	0.012715	2.92E-05
A	0.01309	**0.058164**	0.004141	0.002218	0.0017379	0.004226	9.6E-06
C2	0.018534	**0.127855**	0.006424	0.004288	0.0049059	0.008196	1.8E-05

Source: Designed by the authors based on own calculations.
Data sources: European Commission (EUROSTAT) (2016)

Table 3 presents the competition faced by China in the German market, by all the other exporting countries to Germany. The country that China is the most similar with is United States clearly determined with higher values in all situations. The Chinese and American export pattern to the German market is very similar including intersectoral similarity and intrasectoral similarity.

6. Conclusion

In conclusion there is a wide range of indexes that can be used to measure competition but not all result in being as efficient when measuring trade competition. One property that was fundamental when choosing the index to be further used in the measurement of all types of competition was the adaptability to be modified. None of the initially presented indexes provide inter-industry linkages therefore creating the need for a modified version of the most applicable index that is relevant to this study. The Krugman index was modified in order to measure all the types of competition, covering the competition between two countries in a certain market up to global competition and has provided relevant results. The limitation for this type of application is the great amount of data that needs to be extracted for all categories of products for all the countries which proved to be time consuming.

Further development of the topic would be widening the spectrum of competition. In order to obtain a complete study the geographical spectrum should be further researched.

To conclude, with the combined research done until this point a broad perspective on trade competition can be reached. Structural similarity is a very important component in trying to measure competition from any perspective (taking into account the competition between two markets in a certain market m, or any of the above presented types of competition) and through an empirical example it can reveal a relevant assessment. Nevertheless trade competition is formed by structural similarity and geographical similarity.

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