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TRADE DYNAMICS, REVEALED COMPARATIVE ADVANTAGE, AND INTERNATIONAL COMPETITIVENESS: EVIDENCE FROM MACEDONIA

ABSTRACT: *This paper examines the sectoral specialisation and competitiveness of Macedonia in relation to that of the EU28, using four indices of revealed comparative advantage for the years 2000–2015. Additionally, we estimate the stability of the distribution and of the value of trade specialisation indices over time, as well as the duration and probability of the long-term survival of continuing export competitiveness. The findings suggest that the structure of Macedonia's comparative advantage has changed somewhat over the past few years, and there is also evidence of a weakening in the level of comparative advantage as revealed by the Balassa (B) index. The comparisons made between the implied (theoretically derived) probability distributions and their empirical counterparts*

demonstrate that the Markov transition probabilities accurately characterise the data-generating process that highlights the distributions of the B index, and thus allow for obtaining a precise prediction about the probability distribution vectors, including the limiting distribution. Finally, the results of estimating the survival function show that the survival times of revealed comparative advantage are not persistent over the period observed. The continuous decline in the chance of certain product groups surviving indicates that Macedonia is becoming increasingly vulnerable to competition from other markets.

KEY WORDS: *revealed comparative advantage, Markov chain model, mobility index, survival analysis*

JEL CLASSIFICATION: F10; F14; C41; C43; P27; O57

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1. INTRODUCTION

Trade integration is a vital component of Macedonia's economic development and, given the importance of the country's foreign trade (around two-thirds of the total), the European Union (EU) has been pivotal in supporting the process. The EU has encouraged this deepening through an active trade policy, including the Stabilization and Association Agreement (SAA) that provides for the creation of a free trade area between the European Union and Macedonia, which has filed its candidature for EU membership. Relative competitiveness will play an important role in determining changes in trade flows and patterns between Macedonia and EU member states. Unless candidate countries have products and companies that can withstand market competition they will be unable to exploit the benefits of integration (Palankai 2010). Evidence shows that transition economies, including all the 'new' EU member states [eight first-wave accession countries that joined the European Union on 1 May 2004 (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia), two second-wave accession countries that joined on 1 January 2007 (Romania and Bulgaria), and the third-wave accession country that joined on 1 July 2013 (Croatia)] and the Western Balkan candidates have met the first Copenhagen economic sub-criterion of being functioning market economies. However, there are large differences between them concerning the second economic sub-criterion, i.e., the capacity to cope with the competitive pressures of the EU single market. Macedonia has less trouble transforming itself into a functioning market economy than in making its economy competitive in the enlarged EU market (MoFRM 2009). The small size of the country's economy means that external demand and export-led growth will be of critical importance. Therefore, addressing external competitiveness has become more critical than ever before, while improving competitiveness is exceptionally important in terms of EU accession, improved convergence, and sustainable growth.

This paper examines Macedonia's relative competitiveness and compares the structure of the country's trade specialisation vis-à-vis the EU, focusing on three aspects of particular interest. The first is the question of whether Macedonia is increasing the number of products with trade potential, as opposed to maintaining a static number of products that can be competitively exported. To investigate this, several alternative specifications of revealed comparative advantage (RCA) will be included in the analysis. Since this paper's focus is assessing Macedonia's competitiveness within the European context we have

opted for computing RCAs with the EU as comparator, but taking into account total, instead of bilateral, trade flows. RCAs are nicely interpretable measures of changes in the structure of trade specialisation, i.e., how stable or not the trade specialisation of a given country is. Hence, the second aspect of this paper, which has received limited attention in previous studies, is the exploration of the stability of indices over time, so that we can assess possible structural changes at the industry level. Stability is analysed in terms of both the distribution of indices and the value of indices for particular product groups from one period to the next. The first investigation is actually the one that tries to answer whether the distribution is the same or drastically different. The stability of the value of the Balassa (B) index for the particular product groups is examined in two steps. First, the Markov chain model is a common way to evaluate intra-distribution dynamics and the structural stability of trade specialisation indices over time. We have therefore opted to employ a transition probability matrix to assess the persistence and mobility of the revealed comparative advantage. Second, the index of mobility is used to summarize the degree of mobility in patterns of specialisation: this formally estimates the degree of mobility throughout the entire distribution of RCA indices and facilitates direct comparison between one period and another. An interesting and additional way to estimate the extent to which export competitiveness has developed is by observing at the duration of revealed comparative advantage. The paper therefore examines the duration and probability of long-term survival of the continuing export competitiveness by applying a non-parametric Kaplan-Meier product limit estimator of the survival function to estimate the duration of revealed comparative advantage. Hence, this work aims to contribute new knowledge to recent literature and policy discussions on measures for attaining export expansion and steady convergence of the Macedonian economy. The analysis conducted here allows us to discover strengths and weaknesses which are more important to the future than to the present or past.

The rest of the paper is organized as follows. Section 2 deals with the main theoretical arguments behind the concept of comparative advantage, systematically compares all major attempts to measure comparative advantage using the RCA indices, and examines real cases that have employed the concept of revealed comparative advantage. Section 3 outlines our approach to measuring revealed comparative advantage. The results for Macedonia and the stability and duration of RCA indices are discussed in section 4. Section 5 concludes and makes recommendations.

2. SELECTED LITERATURE REVIEW

2.1. On the theoretical basis and empirical measures

How to predict international trade flows is one of the most important issues in economic theory. Traditional trade theory (Ricardo, Heckscher-Ohlin) describes trade specialisation patterns by focusing on the distinctive characteristics of each country, which give rise to relative cost differences, termed ‘comparative advantage’. Ricardo’s model finds that international differences in labour productivity are the only reason for cross-country differences in comparative production costs. On the other hand, the Heckscher-Ohlin theory explains trade specialisation patterns as based on differences in factor endowment and intensity. Although the ‘new trade theory’ of the 1980s ascribed equal importance to comparative advantage and economies of scale as explanations of why countries trade, “as far as trade flows prediction between similar and different (in factor endowments or technology) countries is concerned, comparative advantage is still the main theoretical explanation” (De Benedictis and Tamberi 2001, p.3). Countries will essentially specialise in and become net exporters of goods in which they have a comparative advantage.

The theoretical ground for detecting the good or industry in which a country has a comparative advantage has been provided by observing the sign of the difference between autarkic and free trade relative prices (Deardorff 1980). However, a problem arises when we move from the theory to the measurement of comparative advantage, since relative autarkic prices are not observable variables. To overcome this obstacle it has become an empirical convention to measure comparative advantage using available post-trade data and to analyse the specialisation patterns of countries by Revealed Comparative Advantage (RCA) measures. Although several efforts have been made to connect RCA to the theory of comparative advantage, the typical approach is to compare national sectoral shares with their international equivalents and to identify the underlying pattern of comparative advantage by examining the actual output and/or trade flows. The implication of this approach is that there can be as many RCA indices as there are combinations and transformations of the variables (production, trade sectoral data) used to infer comparative advantage (Vollrath 1991).

De Benedictis and Tamberi (2004) raise the independence issue regarding measurement from theory by referring to the literature on overlapping generations (Galor 1992; Mountford 1998) and oligopoly theory (Cordella

1998). The findings suggest that even if autarkic relative prices were observable they might not predict true comparative advantage. Moreover, it is “demonstrated by Deardorff (1980) that there is a negative correlation between net exports and relative autarkic prices under relatively general conditions” (Sanidas and Shin 2010, p.10), which leads to the conclusion that, while comparative advantage cannot be precisely measurable, indices based on post-trade observations may reveal much more about the patterns of comparative advantage (Ballance, Forstner, and Murray 1987).

Conventionally, there are three interpretations of RCA indices (Ballance et al. 1987). The most common is that they can provide a demarcation between countries that enjoy a comparative advantage in a particular sector and countries that do not (dichotomous measure). Second, they produce possible cross-sector (within a country) and cross-country (with respect to a given sector) rankings (ordinal measure). Third, they can quantify the sector-specific degree of comparative advantage enjoyed by a given country vis-à-vis any other country or set of countries (cardinal measure).

The different measures proposed to infer the comparative advantage from actual data can be classified according to the applied variables. Balassa (1965) came up with a major innovation concerning the measurement of comparative advantage. He proposed using a relative-export-share measure of revealed comparative advantage. The simplicity of calculation and its convenience when handling data in empirical research are perhaps the most cited reasons for making the Balassa index one of the most widely used trade performance indices. Originally, Balassa limited his analysis to manufactures, since many primary products are subject to quotas and subsidies, etc. Nevertheless, the index has subsequently been applied to other industries, e.g., agriculture (Bojnec 2001) and services (Hisanaga 2008; Seyoum 2007). It is worth mentioning that it is difficult, if not impossible, to theoretically derive the distribution of the Balassa index. The index has therefore been criticized for its incomparability across time and space, which arises from its asymmetry (a variable upper bound, which may theoretically tend to ∞ , a fixed lower bound at 0, and a demarcation value of 1), a variable mean value across both time and space, and dependence of the index's distribution on the number of reference countries along with the level of aggregation, which may also affect its mean and the upper bound. Thus, in theory the Balassa index can only indicate whether a comparative advantage exists or not, as its magnitude has neither the ordinal property nor the cardinal property (Hillman 1980; Yeats 1985).

The inconsistency and declared incomparability of the Balassa index have induced several researchers to propose different methods to improve the original index and remedy some of its shortcomings. Following Ballance et al. (1987), they can be classified in three index classes: a trade-cum-production class with indices containing both trade and production variables (Bowen 1983; Lafay 1992); exports-only indices that include only export variables and mostly focus on re-normalising the original Balassa index around a stable mean with a symmetric distribution, while at the same time preserving its simplicity and practical easiness (Vollrath 1991; Dalum, Laursen, and Villumsen 1998; Proudman and Redding 1998; Hoen and Oosterhaven 2006); and indices using a hypothetical situation, for instance, the comparative-advantage-neutral point (Yu, Cai, and Leung 2009).

While these indices attempt to overcome the defects of the Balassa index, none of them is perfect. As every single index has pros and cons, they should be used according to their individual properties.

2.2. Specialisation Patterns and RCA Indices: Synopses of Studies

After our comparison of all the major efforts to measure comparative advantage, we apply the prior discussion to exploring real cases, as some notable studies have employed the concept of revealed comparative advantage.

Yue (2001) uses revealed comparative advantage indices to demonstrate that China has changed its export strategy to coincide with the law of comparative advantage and points to the distinct differences in export patterns between the coastal and interior regions. Bender and Li (2002) investigate the structural performance and shift of exports and the revealed comparative advantage of Asian and Latin American regions over a selected time period. The authors perform a two-sided analysis both to examine the existence of related changes in export patterns between different regions and, using RCA indices, to verify if those changes are related to shifts in comparative advantage between regions.

Kaitila (2001) examines trade between Central and Eastern European (CEE) countries and the EU for the period 1993–1998. Among other methods, the author calculates the revealed comparative advantage of CEE countries in the EU internal market and estimates the results in a two-dimensional space, showing relative labour skills and capital intensity. The results point to diverse development of comparative advantage among various CEE countries.

Fertő and Hubbard (2003) investigate the competitiveness of Hungarian agriculture in relation to that of the EU by employing four indices of revealed comparative advantage for the period 1992 to 1998. The consistency test of the indices as cardinal measures is based on the correlation coefficient between paired indices in each of the seven years, and suggests that they are useful in identifying the demarcation between comparative advantage and comparative disadvantage. Despite the fact that they are not consistent as cardinal measures of comparative advantage, RCA indices provide a useful guide to underlying comparative advantage and offer a further insight into competitiveness and the implications for trade.

Recently, we have witnessed a renewed interest in empirical work on comparative advantage. Sanidas and Shin (2011) use two main RCA indices (Balassa's and the most recent 'normalised' indices) and different quantitative techniques to draw systematic conclusions about the comparative advantage of three East Asian countries. They find that in the three countries there still exists a strict hierarchy in terms of comparative advantage, even though there is also a catching-up process between them with a convergence towards a more competitive structure of RCA in exports.

Amighini, Leone, and Rabellotti (2011) examine the evolution of specialisation patterns for the Italian provinces by investigating the dynamics of the sectoral distribution in the Balassa RCA index. The findings point to just a few provinces having stable international specialisation patterns, while the majority show decreased specialisation. There is also a higher average degree of persistence for what they define as 'district provinces', but no systematic differences exist between provinces with or without industrial districts. Erlat and Erlat (2012) use the Balassa RCA index to examine the comparative advantage of Turkish exports so that they can identify those sectors that have exhibited an increase in comparative advantage.

Startienė and Remeikienė (2014) use the standard measure of revealed comparative advantage and the alternative Revealed Symmetric Comparative Advantage (RSCA) index in order to evaluate the competitiveness of Lithuanian industrial products in global markets for the period 2007–2011. Bojnec and Fertő (2015) explore the competitiveness of EU country agri-food exports in global markets using the revealed comparative advantage (*B*) index over the period 2000–2011. Panel unit root tests, a mobility index, and the Kaplan-Meier survival rates of the *B* index are employed. The authors conclude that most agri-

food products in EU27 countries exhibit a comparative disadvantage in the global market. Most of the old EU15 Member States enjoyed a greater number of agri-food products having an extended duration of revealed comparative advantage than most of the new EU12 Member States.

Finally, Sawyer, Tochkov, and Wenting (2017) use data from input-output tables to assess the comparative advantage of Chinese provinces in the three main economic sectors over the period 1992–2007. The authors not only construct RCA indices for overall trade but also bilateral indices for interprovincial trade. The results show that West and Central China have a comparative advantage in agriculture/mining, the coastal provinces in manufacturing, and the metropolitan provinces in services. However, interprovincial trade exhibits a more complex pattern. Regression analysis recognises labour endowments as the key determinant of comparative advantage in total trade, while physical capital is the driving force behind domestic trade.

3. METHODOLOGY FOR MEASURING REVEALED COMPARATIVE ADVANTAGE

Revealed comparative advantage (RCA) is a commonly used approach for identifying a country's weak and strong sectors. As previously stated, there can be as many RCA indices as there are transformations and combinations of the variables used to infer the existence of comparative advantage from actual data (Vollrath 1991). That measurement issues are independent of the underlying theory provides a certain degree of freedom in the selection of a specific RCA index to be used in applied research, but it also entails a higher awareness of the implications of the selection. Although Liesner (1958) was the first to empirically research RCA, the most advanced and frequently used measure of RCA, as already emphasised, was that popularised by Balassa (1965). Given the reference area, the Balassa RCA index essentially estimates the normalised export shares, such that normalisation concerns the exports of the same commodity (or industry) in the reference area. Thus, if X represents exports, i is a country, j is a commodity (or industry), t is a set of commodities (or industries), and n is reference area (set of countries), then the country i 's Balassa index of RCA (B), for a commodity (or industry) j , is:

$$B = \left(X_{ij} / X_{it} \right) / \left(X_{nj} / X_{nt} \right) = \left(X_{ij} / X_{nj} \right) / \left(X_{it} / X_{nt} \right) \quad (1)$$

If $B > 1$, the country i is said to ‘reveal’ a comparative advantage in commodity (or industry) j , since the particular commodity/industry is more important for country i ’s exports than for exports of the reference area. On the contrary, if $B \leq 1$ the country is considered to have a comparative disadvantage in the commodity (or industry).

While the above formula provides some insight into a country’s international competitiveness, the Balassa index is biased as it fails to capture the demand side by considering imports, especially when the country-size effect is significant (Greenaway and Milner 1993). Therefore, it implies possible over- or underestimation of any underlying comparative advantage or disadvantage. Vollrath (1991) has attempted to advance the application of revealed comparative advantage through the development of three alternative measures. The first specification, commonly known as the relative trade advantage (RTA), accounts for the import side of trade flows as well as exports. It is expressed as the difference between relative export advantage (RXA), which equals the original Balassa index (B), and relative import advantage, (RMA):

$$RTA = RXA - RMA \quad (2)$$

where

$$RXA = B = (X_{ij} / X_{it}) / (X_{nj} / X_{nt}) = (X_{ij} / X_{nj}) / (X_{it} / X_{nt}) \quad (3)$$

while

$$RMA = (M_{ij} / M_{it}) / (M_{nj} / M_{nt}) \quad (4)$$

where M stands for imports. Hence,

$$RTA = [(X_{ij} / X_{it}) / (X_{nj} / X_{nt})] - [(M_{ij} / M_{it}) / (M_{nj} / M_{nt})] \quad (5)$$

It should be noted that Vollrath’s RXA differs from the Balassa index, B , in that (a) it prevents possible double counting (the country’s or commodity/industry’s); and (b) it is predominantly global in nature, viz. it accounts for all traded goods and all countries, instead of subsets. Given that we are interested in the competitiveness of Macedonia within the European

context, the indices computed in this paper have a combined structure, in that the set of commodities (or industries), t , refers to all trade, but the reference area, n , is restricted to the EU as the comparator. Double counting is not avoided but is not problematic for two reasons: (a) the reasonably low level of commodity aggregation used, and (b) the fact that Macedonia has not yet become an EU member state.

Vollrath's second RCA measure ($\ln RXA$) stands for a logarithm of the relative export advantage:

$$\ln RXA = \ln B \quad (6)$$

The third, more comprehensive indicator, developed by Vollrath, is the revealed competitiveness, RC , defined as:

$$RC = \ln RXA - \ln RMA \quad (7)$$

Symmetry about the origin (in a Cartesian coordinate system) is a clear advantage of the indices presented in logarithmic forms. If Vollrath's three measures (RTA , $\ln RXA$, RC) exceed 0, then country i is said to have a comparative/competitive advantage in commodity (or industry) j .

When it comes to employing these and similar RCA indices based on observed trade patterns, government intervention (e.g., import restrictions, export subsidies) may cause problems when interpreting the underlying comparative advantage. Fertő and Hubbard (2003) use nominal assistance coefficients (NACs) for Hungary and the EU as a measure of government support to agriculture estimated by OECD (1999). Greenaway and Milner (1993) recommend the advantage of a price-based measure of RCA termed 'implicit revealed comparative advantage' (IRCA) to take away the distortions triggered by post-policy intervention. Although problems from the trade-distorting effect of government intervention may not be completely mitigated, the four RCA indices, when interpreted with caution, are still considered to be a valuable instrument for identifying the comparative and competitive advantage of a country. In fact, Vollrath (1989) states: "the most competitive agricultural exporters are often the least protected... Protection in the form of government intervention may enhance competitiveness in the short run... The EC-10, the United States, Brazil, Australia, and Canada were used to compare revealed agricultural competitiveness and agricultural producer subsidy equivalents....

The EC-10 has the highest level of government intervention, and it alone among the major agricultural exporters operates with a revealed competitive disadvantage in agriculture.” This may indicate that product groups that already have a comparative advantage have the potential for increased competitiveness should the markets become further liberalised.

4. DATA AND EMPIRICAL FINDINGS

4.1. Revealed Comparative Advantage Indices

Given the detailed explanation above regarding the contributions of Balassa and Vollrath and the usefulness of RCA indicators in providing proper information with regard to comparative advantage, we employ the four indices to gain insight into the international competitiveness of the Macedonian economy and to assess the possible implications for trade when the country is scheduled to become an EU member state. To calculate the indices we have used annual two-digit Standard International Trade Classification (SITC) Rev.3 data (63 product groups). In order to estimate the patterns and evolution of RCA indices it is necessary to select an appropriate level of aggregation. The definition of what constitutes an industry is probably the most contentious issue in the applied research. Over time, it has become generally accepted that the appropriate criterion essentially relates to production rather than consumption. Whilst statistical product classifications are inevitably imperfect in this respect, they are nevertheless largely guided by the correct criterion, i.e., grouping together goods with similar input requirements (Brühlhart 2008). This still leaves open the issue of the most suitable level of statistical aggregation. The three-digit level is often taken as being approximately equivalent to economists’ definition of an industry. Nevertheless, this may still result in a high degree of aggregation bias. One of the problems is that the product groups used by statisticians are often based on statistical expediency rather than economic relevance. Even when an attempt is made to use economically meaningful categories, the problem of the proper criteria for grouping products together may appear. In other cases the product groups implemented make sense, but over-aggregation may be present. However, a higher level of disaggregation is not suitable in all cases, as it would result in separating products that essentially belong to the same industry and thus run the risk of losing the economic meaning of the groups employed. Hence, we have opted for a two-digit level of aggregation to calculate RCA measures, as it appears the most appropriate for answering the research issues; i.e., (1) the characterisation and establishment of the trends and patterns of specialisation, and (2) discovering whether Macedonia has managed to

gradually shift towards higher value-added categories and has not merely diversified the production base in already established sectors, which would certainly require the higher level of disaggregation. Since the coefficients are mostly dependent upon the percentage share of the particular product group in total exports or imports, we have opted to exclude products pertaining to the 9th sector (commodities and transactions not classified elsewhere in the SITC) in order to obtain more accurate estimates. The analysis covers a sixteen-year period (2000-2015; 2016 data was missing for EU28) and includes data for exports and imports of Macedonia and EU28 obtained from the country's National Bank and the UN Comtrade (a total of $63 \times 16 \times 2 \times 2 = 4,032$ records).

The statistical findings (mean and coefficient of variation) for the four indices exhibit similar patterns, and according to their common characteristics, they point to a revealed comparative advantage for 10 product groups: vegetables and fruit; beverages; tobacco and tobacco manufactures; hides, skins, and furs, raw; oil-seeds and oleaginous fruits; crude fertilizers other than those of division 56, and crude minerals (excluding coal, petroleum, and precious stones); metalliferous ores and metal scrap; iron and steel; articles of apparel and clothing accessories; and footwear (Table 1). The results suggest that there is a relationship between RCA values and the share of product groups in total exports. In other words, the product groups that reveal comparative advantage are generally found among the leading export sectors of Macedonia and account for 58.11% of total exports on average during the period taken into consideration (2000–2015).

In order to look at differences across sectors, evaluate the quality of trade, and link specialisation developments to the most prominent sources of comparative advantage, we further consider a classification of products according to factor intensity, compiled by Hinloopen and Van Marrewijk. This is based on UNCTAD/WTO classification using SITC Rev.2 codes and distinguishes between the five main groups of sectors at the 3-digit level (Hinloopen and Van Marrewijk 2008). The SITC was developed by the United Nations with the intention of classifying traded products not only on the basis of their physical and material properties but also, for ease of economic analysis, according to processing stage and economic function. It is therefore the preferred classification for the analysis of comparative advantage by factor intensity.

Table 1. Revealed comparative advantage of Macedonia vs. EU28 by product group and index, 2000–2015

Commodity code + Commodity		Mean				Coefficient of Variation			
		B	RTA	ln RXA	RC	B	RTA	ln RXA	RC
Revealed comparative advantage if:		> 1	> 0	> 0	> 0				
05	Vegetables and fruit (primary products)	6.37	5.51	1.83	1.98	18.84	22.07	10.81	11.66
11	Beverages (primary products)	1.92	0.34	0.59	0.16	32.26	255.73	64.22	344.16
12	Tobacco, tobacco manuf. (primary products)	17.53	14.76	2.83	1.84	26.29	30.66	9.69	17.75
21	Hides, skins, furskins, raw (primary products)	2.14	0.84	0.56	0.39	69.14	171.50	113.05	148.05
22	Oil seed, oleaginous fruit (primary products)	1.64	1.17	0.40	1.18	49.94	69.13	114.06	43.39
27	Crude fertilizer, mineral (primary products)	4.27	3.28	1.43	1.47	20.26	26.52	13.75	19.15
28	Metalliferous ore, scrap (primary products)	4.09	3.02	1.30	1.53	40.77	41.82	41.45	48.96
67	Iron and steel (human-capital intensive products)	8.45	5.01	2.12	0.92	17.41	28.74	8.04	26.88
84	Clothing and accessories (unskilled labour-intensive products)	13.43	13.17	2.57	3.97	23.42	23.80	9.53	8.90
85	Footwear (unskilled labour-intensive products)	4.72	4.14	1.53	2.08	21.90	24.48	15.01	10.93

Commodity code + Commodity		Mean				Coefficient of Variation			
		B	RTA	ln RXA	RC	B	RTA	ln RXA	RC
Revealed comparative advantage if:		> 1	> 0	> 0	> 0				
59	Chemical materials nes	3.08	1.39	-0.45	-0.96	134.30	282.22	-448.30	-199.88
74	General industl. mach., and machine parts...	0.35	-0.76	-1.87	-1.97	137.47	-67.01	-67.90	-65.37
77	Elec mach., appar. ..., and electrical parts...	0.59	0.03	-0.65	-0.05	63.74	926.68	-73.53	-546.73
79	Othr. transport equipment	0.07	-0.02	-2.70	0.05	35.33	-418.90	-11.79	2,266.41
82	Furniture, bedding, etc.	1.07	0.20	-0.14	0.02	72.38	439.82	-456.19	3,713.45

Source: Authors' calculations based on SITC data at the two-digit level

Nevertheless, switching from SITC Rev.2 to our Rev.3 (3-digit) codes led to the creation of many new industry categories. To maintain a consistent set of SITC industries over the sample period, we aggregate industries from the three-digit to the two-digit level. By following this approach we satisfy the need to exclude the 9th section from the analysis, as the four-article difference between the two revisions at the 2-digit level refers only to this section. The results show that it is predominantly primary products and a few manufactures (human-capital intensive and unskilled labour-intensive products) that have a comparative advantage, corresponding to the level of economic development, the availability of natural resources, and the price of production factors (labour). An export structure based on these product groups is not a long-term solution. The prices of primary products can be relatively unstable and also exhibit a long-term downward trend. Mineral resources can be exhausted and agricultural

production is greatly affected by climatic factors. Thus, the comparative advantage can easily disappear: the ore stocks are limited, while exploitation costs determine price competitiveness; finally, the exports of textile and apparel industry are highly dominated by imports for further processing, accounting for about 93% of the apparel production (Agency for Foreign Investment and Export Promotion of Macedonia 2014). Thus, the Republic of Macedonia, even with certain restructuring of the overall composition of trade over the last years, is moving very slowly away from products requiring unskilled labour, low technology, and significant resources (including primary products). In other words, the majority of exports are still generated by products of low complexity (Kostoska and Mitrevski 2016). This will certainly limit further growth, taking into account competition from Asia and other low-wage regions (Orszaghova, Savelin, and Schudel 2013).

4.2. Stability and Duration of RCA Indices over Time

The higher coefficients of variation (defined as the ratio of the standard deviation to the mean) indicate a greater dispersion in the variable and thus a relative instability of RCA indices during the analysed period (Table 1). However, these findings require a more detailed analysis, and thus we need to apply additional stability measures to indices. In essence, two types of stability can be distinguished (Hinloopen and Van Marrewijk 2001): (1) stability of the distribution of indices from one period to the next, and (2) stability of the value of indices for particular product groups from one period to the next. A simple indicator of stability is the relative importance of product groups that reveal a comparative advantage (RCA) in the period t , but a comparative disadvantage (RCD) in the time period $t+1$. At the same time, we analyse the product groups with RCD in the time period t and RCA in $t+1$ (Hoekman and Djankov 1997). The product groups in which Macedonia had RCA in 2000 but RCD in 2015 exhibit certain variations but are still within the range of relatively low values of total exports in 2000, i.e., between 17.42% (according to B and $\ln RXA$) and 18.66% (according to RTA and RC), or 3.13% (according to B and $\ln RXA$) and 4.45% (according to RTA and RC) in 2015 (Table 2). The product groups showing a reverse movement (RCD in 2000, but RCA in 2015) exhibit similar dynamics when it comes to the percentage shares of product groups in 2000 (Table 2). However, when observing the percentage shares in 2015 the situation is rather different, i.e., the product groups with RCD in 2000 and RCA in 2015 range between 33.56% (according to RTA and RC) and 45.12% (according to B and $\ln RXA$) of total exports in 2015 (Table 2).

Table 2. Stability of revealed comparative advantage

Index	Percentage share of product groups where:			
	RCA ₂₀₀₀ and RCD ₂₀₁₅		RCD ₂₀₀₀ and RCA ₂₀₁₅	
	2000	2015	2000	2015
<i>B</i>	17.42%	3.13%	5.50%	45.12%
<i>RTA</i>	18.66%	4.45%	1.51%	33.56%
<i>lnRXA</i>	17.42%	3.13%	5.50%	45.12%
<i>RC</i>	18.66%	4.45%	1.51%	33.56%

Source: Authors' calculations based on SITC data at the two-digit level

This would seem to support the argument that the structure of Macedonia's revealed comparative advantage has changed somewhat over the last few years. In essence, the results are attributable to the diversification of exports and structural changes in the economy, mainly on account of foreign investment. With foreign investors increasing production, the structure of exports has shifted somewhat towards higher-value-added products, i.e., the export of spare parts for the car industry (in the seventh category – machinery and transport equipment¹) has boosted the growth of total exports. The export of chemical materials and products has also increased² due to the exploitation of a new export-oriented facility in the free economic zones.

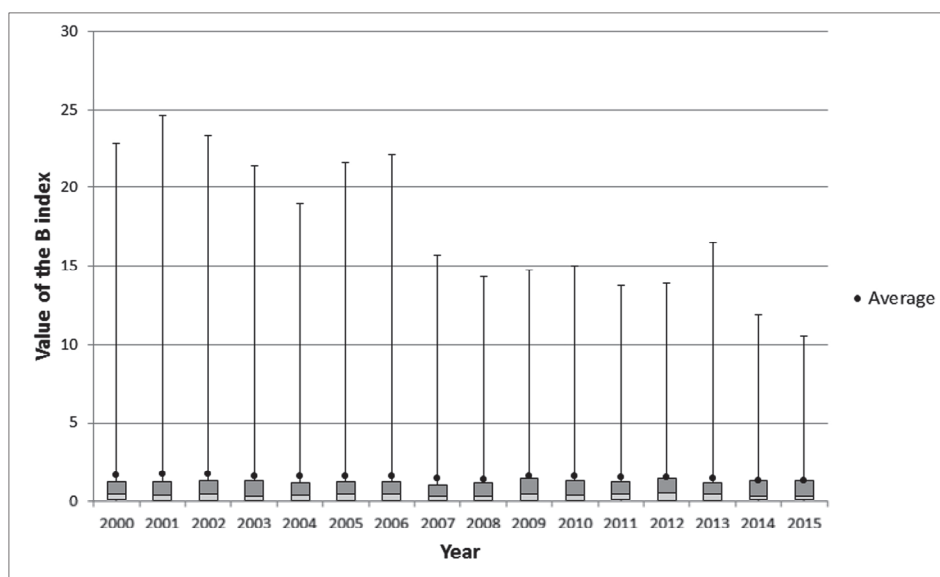
Further analysis of the changes in the distribution of the Balassa (*B*) index (Hinloopen and Van Marrewijk 2001) indicates that Macedonia's revealed comparative advantage has weakened somewhat; that is, the distribution has tended to shift to the left (positive values of the skewness indicate that data are skewed right), producing a higher proportion of lower value indices (Figure 1). The summary statistics (Table 3) clearly show that the mean value of the *B* index has fallen by 21% (from 1.63 to 1.29) and the maximum value has more than halved over the period. Moreover, the median, perhaps a better indication of the central tendency (most resistant to outliers) than the arithmetic mean, indicates that, at most, half of the values of the *B* index were less than or equal to 0.51 in 2000, and this figure has dropped to 0.37 in 2015. Finally, 76.2% of the *B* values in 2001 were less than 2; by 2015 this share has risen to 85.7%. This

¹ Machinery and transport equipment exports accounted for 24.7% and 6.3% of the total in 2015 and 2000, respectively.

² The share of this product group in total exports has increased from 0.2% in 2000 to 19.1% in 2015.

apparent weakening of comparative advantage corresponds to the fall in the share of Macedonia's traditional export sectors (e.g., iron and steel, clothing)³.

Figure 1. Box and Whisker plot showing the 5-number summary statistics of the distribution of the *B* index over the observed period



Source: Authors' calculations based on SITC data at the two-digit level

³ The share of iron and steel in total exports decreased from 21.9% in 2000 to 12.8% in 2015; clothing exports accounted for 24.0% and 11.8% of the total in 2000 and 2015, respectively.

Table 3. Distribution of the *B* index

	2000	2001	2002	2003	2004	2005	2006	2007
Minimum	0.00496	0.01124	0.00033	0.01512	0.00006	0.00063	0.00003	0.00152
Q1	0.12304	0.14139	0.09957	0.09635	0.13206	0.08319	0.07846	0.09821
Median	0.50658	0.46829	0.50074	0.40634	0.42641	0.50677	0.48039	0.34744
Q3	1.23457	1.29557	1.34978	1.33401	1.16883	1.29654	1.26189	1.09617
Maximum	22.83954	24.63004	23.35386	21.42963	18.99729	21.58838	22.16831	15.70795
Average	1.63473	1.79329	1.76863	1.64622	1.61343	1.65559	1.59557	1.46219
< 1	68.3%	63.5%	68.3%	68.3%	68.3%	68.3%	68.3%	69.8%
< 2	81.0%	76.2%	76.2%	79.4%	81.0%	79.4%	84.1%	82.5%
< 4	88.9%	82.5%	84.1%	88.9%	88.9%	88.9%	90.5%	88.9%
< 8	95.2%	90.5%	95.2%	93.7%	93.7%	93.7%	95.2%	93.7%
< 16	98.4%	93.7%	95.2%	95.2%	95.2%	95.2%	98.4%	98.4%

	2008	2009	2010	2011	2012	2013	2014	2015
Minimum	0.00687	0.00420	0.01003	0.00232	0.00518	0.00143	0.00069	0.00519
Q1	0.08897	0.11310	0.11864	0.13775	0.11227	0.11567	0.12985	0.14786
Median	0.41410	0.49875	0.43530	0.52118	0.56890	0.47769	0.39081	0.37291
Q3	1.20988	1.47757	1.32340	1.24339	1.46667	1.20763	1.33597	1.28947
Maximum	14.34788	14.73933	15.00304	13.75886	13.92486	16.55197	11.88787	10.53563
Average	1.43538	1.62588	1.62659	1.51112	1.54288	1.47460	1.31701	1.28991
< 1	61.9%	60.3%	63.5%	66.7%	68.3%	73.0%	68.3%	69.8%
< 2	82.5%	79.4%	81.0%	85.7%	82.5%	85.7%	85.7%	85.7%
< 4	85.7%	88.9%	87.3%	85.7%	88.9%	90.5%	90.5%	90.5%
< 8	90.5%	96.8%	95.2%	95.2%	96.8%	93.7%	95.2%	95.2%
< 16	95.2%	100.0%	100.0%	100.0%	100.0%	98.4%	100.0%	100.0%

Source: Authors' calculations based on SITC data at the two-digit level

However, this first type, the stability of the distribution of indices does not imply that the observations of indices are persistent over time. Indeed, there might be some seasonal fluctuations in the exports of a particular product group, and to the extent that they do not happen simultaneously in the country under investigation and the group of reference countries, these fluctuations lead to variations in RCA indices which are hard to interpret. Moreover, information about the value of RCA indices for a certain product group in a particular period is also indicative of indices values in that industry for the next period. This second type of stability, that of the value of the Balassa (*B*) index for particular product groups, is examined in two ways. Following Bojnec and Fertő (2008), Hinloopen and Van Marrewijk (2001), and Proudman and Redding (2000), we employ a Markov transition probability matrix to estimate the persistence and mobility of revealed comparative advantage over time.

To the best of our knowledge, there is no consensus among scholars regarding the classification of RCA indices into appropriate categories. Most studies

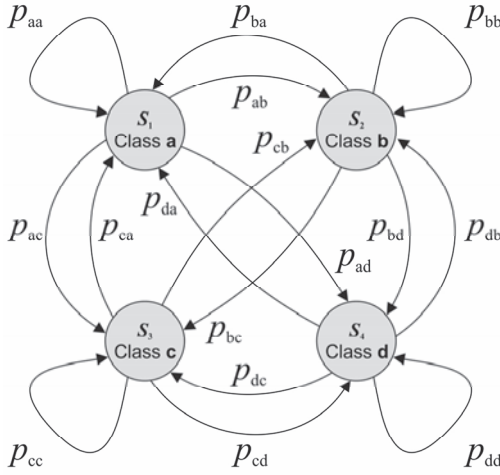
classify data into various percentiles, like quartiles or quintiles. Following Hinloopen and Van Marrewijk (2001), we distinguish four classes:

- Class *a*: $0 < B \leq 1$ (Product groups without a comparative advantage)
- Class *b*: $1 < B \leq 2$ (Product groups with weak comparative advantage)
- Class *c*: $2 < B \leq 4$ (Product groups with medium comparative advantage)
- Class *d*: $4 < B$ (Product groups with strong comparative advantage)

The dynamic behaviour over time of a system consisting of $N = 63$ product groups, each one of which can, theoretically, switch among $K = 4$ possible classes that take their values from the set $L = \{Class\ a, Class\ b, Class\ c, Class\ d\}$, can be presented by describing all different possible states the system itself can take (i.e., by specifying the state-space), and by indicating how it can move/transit among these states (i.e., the evolution represented by transitions from one state to another). Assuming that each of the $N = 63$ product groups of the system belongs to one and only one class at any given moment, the total number of possible states would equal the number of permutations with repetition of $K = 4$ possible classes over the $N = 63$ product groups. The resulting state-space would be very large, since it would comprise $K^N = 4^{63}$ possible states. Every single state would be represented by an N -tuple $(C_1\ C_2\ C_3\ \dots\ C_N)$ made up of $N = 63$ product groups C_k , $k = 1, \dots, N$, where $C_k \in L$. Such an enormous state-space, along with the corresponding transitions between each pair of states, would be practically impossible to represent and take advantage of. In order to simplify the problem, we treat the system consisting of $N = 63$ product groups as a single unit. Consequently, the state-space reduces to only $K^1 = 4^1 = 4$ states. Rather than representing an N -tuple, each state now represents a single-valued element S_i , $i = 1, \dots, 4$. In fact, the set of all possible states $S = \{S_1, S_2, S_3, S_4\}$ becomes equivalent, and corresponds, to the set of all possible classes L . Figure 2 shows the resulting Markov chain, where states/classes are represented by circles, while one-step transitions between each pair of states are given by directed arcs, labelled with the values of transition probabilities. In this case, the

Markov chain, as a type of Markov process⁴, has both a discrete (i.e., finite, countable) state-space and a discrete index set (i.e., its state changes at discrete time instances) (Stewart 2009).

Figure 2. Generic Markov chain depicting the four possible states/classes, along with the corresponding one-step transition probabilities p_{ij} , $i, j \in L$, of moving from state/class “ i ” (at time t) to state/class “ j ” (at time $t+1$)



Source: Authors' own representation

Given that at each time instance t the system (as a whole) cannot be solely found in any particular state/class, it would make sense to discover the relative frequency $f(S_i)$, $i=1,...,4$ of product groups in each particular class, for all classes in the set L .

$$f(S_i) = \frac{\text{Number of groups of commodities belonging to class } S_i}{\text{Total number of commodities, } N} \quad (8)$$

⁴ The Markov process is a stochastic process that satisfies the Markov property, i.e., the property of ‘memorylessness’, which means that one can make predictions for the future of the process based solely on its present state, independent of the process’s past history.

The relative frequencies (8) play the role of the probability of being in each particular state/class. At every single time instance t the state of the system (taken as a single unit) can be described by a stochastic row vector $\pi^{(t)} = [\pi_a^{(t)} \quad \pi_b^{(t)} \quad \pi_c^{(t)} \quad \pi_d^{(t)}]$, which is a probability distribution for all $N = 63$ product groups that belong to the classes a, b, c , or d , respectively, and each element of the vector, $\pi_k^{(t)}$, $k \in L$, is given as follows: $\pi_k^{(t)} = f(S_i)$; $k \in L$; $i = 1, \dots, 4$. Accordingly, the sum of probabilities $\pi_k^{(t)}$, $k \in L$ is always 1, i.e., $\sum_{k \in L} \pi_k^{(t)} = 1$.

The elements p_{ij} of the Markov, or stochastic, matrix P (9) are actually one-step transition probabilities, independent of time n , i.e., $p_{ij} = \text{Prob}\{X_{n+1} = j | X_n = i\}$ for all $n = 0, 1, 2, 3, \dots$. They give the conditional probability of making a transition from state $x_n = i$ to state $x_{n+1} = j$ when the time parameter increases from n to $n+1$. For the estimates made here, the element p_{ij} indicates the probability that, for the next period, the B index of a particular product group falls in class j , given that, for this period, the same sector's B index belongs to class i .

$$P = \begin{bmatrix} p_{aa} & p_{ab} & p_{ac} & p_{ad} \\ p_{ba} & p_{bb} & p_{bc} & p_{bd} \\ p_{ca} & p_{cb} & p_{cc} & p_{cd} \\ p_{da} & p_{db} & p_{dc} & p_{dd} \end{bmatrix} \quad (9)$$

Hence, the resulting discrete-time Markov chain is time-homogeneous. These conditional probabilities satisfy the following two properties (10):

$$\begin{aligned} \forall i, j: 0 \leq p_{ij} \leq 1 \\ \forall i, i = 1, \dots, 4: \sum_j p_{ij} = 1 \end{aligned} \quad (10)$$

Let $\pi_i^{(0)}$ be the probability that the Markov chain begins in the state i (i.e., a particular class) at time instance $t = 0$, and let $\pi^{(0)}$ be the row vector whose i -th element is $\pi_i^{(0)}$. Then, under the assumption that P is a transition probability matrix of a time-homogeneous discrete-time Markov chain, the j -th element of the vector that results from making the product $\pi^{(0)} \cdot P$ gives the probability of being in a state j (i.e., a particular class) after the first time step (11):

$$\pi^{(1)} = \pi^{(0)} \cdot P \text{ i.e. } \pi_j^{(1)} = \sum_{i \in L} \pi_i^{(0)} p_{ij} \quad (11)$$

The elements of the row vector $\pi^{(1)}$ provide the probability of being in various states of the Markov chain (i.e., the probability distribution) after the first time step. The computation of $\pi^{(n)}$, i.e., the probability distribution after n time steps, is provided by the following expression (12):

$$\pi^{(n)} = \pi^{(n-1)} \cdot P = \pi^{(n-2)} \cdot P^2 = \dots = \pi^0 \cdot P^n \text{ i.e.}$$

$$\pi_j^{(n)} = \sum_{i \in L} \pi_i^{(n-1)} p_{ij} = \sum_{i \in L} \pi_i^{(n-2)} p_{ij}^2 = \dots = \sum_{i \in L} \pi_i^0 p_{ij}^n \quad (12)$$

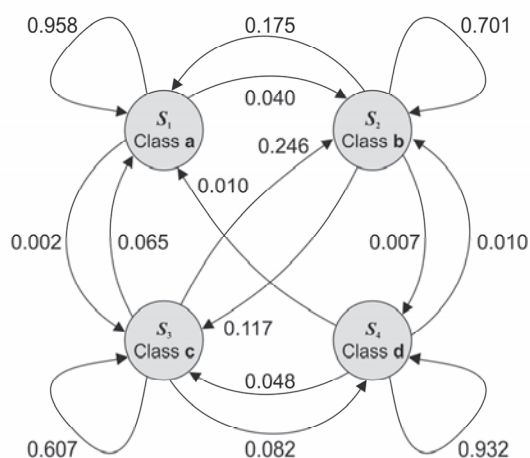
The transition probability matrix for Macedonia, P_{MK} , is given as follows (13):

$$P_{MK} = \begin{bmatrix} 0.958 & 0.040 & 0.002 & 0.000 \\ 0.175 & 0.701 & 0.117 & 0.007 \\ 0.065 & 0.246 & 0.607 & 0.082 \\ 0.010 & 0.010 & 0.048 & 0.932 \end{bmatrix} \quad (13)$$

The Markov matrix P_{MK} resembles the Markov chain as provided in Figure 3. In essence, the matrix P_{MK} shows the results for one-step empirical transition probabilities over the whole period considered (2000–2015), provided that these probabilities are the same in all sectors. The diagonal elements of the matrix

indicate that from one period to the next (e.g., 2000 and 2001; 2001 and 2002;; 2014 and 2015) the observations of the B index are more persistent for both low (class a) and high (class d) cases than for the evidently more transient intermediate classes (class b and class c). This implies that for a given industry with no comparative advantage this year (class a for annual observations) the probability of maintaining the same status over the next year is 0.958, while the probability of moving to weak comparative advantage (class b) or medium comparative advantage (class c) is 0.040 and 0.002, respectively.

Figure 3. Discrete-time Markov chain for Macedonia



Source: Authors' own representation

Additionally, there is no possibility of a product group that shows a comparative disadvantage obtaining a strong comparative advantage (class d). The probability of losing the comparative advantage (i.e., moving to class a) is considerably higher for those product groups with a weak comparative advantage (0.175) than those with medium (0.065) or strong comparative advantage (0.010). There is also a higher probability of a given industry with medium comparative advantage (class c) obtaining a weak comparative advantage (moving to class b) than the other way round (moving from class b to class c) (0.246 and 0.117 respectively). Finally, the chance of product groups with strong comparative advantage (class d) showing either weak (0.010) or medium comparative advantage (0.048) is very low.

At a glance, the initial, $\pi_e^{(0)}$ ($t = 2000$), and final, $\pi_e^{(15)}$ ($t = 2015$), empirical probability distribution vectors point to a certain weakening of the revealed comparative advantage for Macedonia (Table 4). More specifically, the share of product groups showing a comparative disadvantage increased from 68.3% in 2000 to 69.8% in 2015. Likewise, the initial and final distributions clearly indicate that the number of product groups exhibiting a weak comparative advantage has increased (12.7% and 15.9% in 2000 and 2015, respectively), while those with medium and strong comparative advantage have somewhat decreased. These results once again support the notion that there is a certain ‘slippage’ in Macedonia’s comparative advantage.

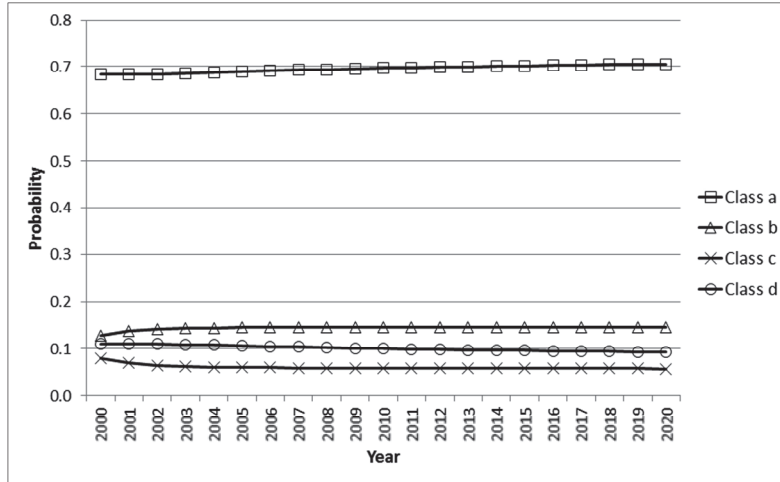
In order to assess whether the Markov transition matrix captures the underlying data-generating process and allows for making more accurate predictions, we have computed the implied (theoretically derived) probability distributions and compared them with their empirical counterparts. Expression (12) defines the procedure we have used to obtain the implied (theoretically computed) probability distribution vectors (Table 4). The results are then compared with those of the empirical distribution (Table 4). They appear to be very similar, showing that the transition probabilities accurately characterise the data-generating process that highlights the distributions of the B index and thus enable a precise prediction of the probability distribution vectors (Figure 4), including the limiting distribution.

Table 4. Selected probability distribution vectors for Macedonia

		Vector components			
		π_a	π_b	π_c	π_d
Empirical probability distribution vector, $\pi_e^{(0)}$ (2000)	$\pi_e^{(0)} =$	0.683	0.127	0.079	0.111
Empirical probability distribution vector, $\pi_e^{(15)}$ (2015)	$\pi_e^{(15)} =$	0.698	0.159	0.048	0.095
Implied (theoretically computed) probability distribution vector, $\pi_t^{(15)}$ (2015)	$\pi_t^{(15)} =$	0.702	0.144	0.058	0.096
Forecasted (theoretically computed) probability distribution vector, $\pi_t^{(20)}$ (2020)	$\pi_t^{(20)} =$	0.706	0.144	0.057	0.093

Source: Authors’ calculations based on SITC data at the two-digit level

Figure 4. Dynamics of the probability distribution vectors π over time (2000–2020)



Source: Authors' calculations based on SITC data at the two-digit level

As previously stated, there is no transition from *state a* to *state d*, as the corresponding transition probability is $p_{ad} = 0$ (Figure 3). Therefore, *state d* cannot be reached directly from *state a* (i.e., in one time step). Instead, it can be done indirectly (i.e., in more than one time step), which means that the resulting Markov chain is irreducible.⁵ Since the resulting Markov chain is finite, aperiodic,⁶ and irreducible, it is ergodic. Moreover, the corresponding transition probability matrix P_{MK} is regular, because some power of it has all positive entries.⁷ Thanks to this feature, a limiting probability distribution $\bar{\pi}$ such that $\bar{\pi} = \bar{\pi} \cdot P_{MK}$ does exist. The solution can be obtained by solving the system of linear equations (14).

⁵ Irreducibility means that it is possible to get to any state in the Markov chain from any other state, not necessarily in one step, i.e., the state-space of the Markov chain is a single communicating class.

⁶ Aperiodicity means that all states in the Markov chain have a period of 1, i.e., any return to any of the states occurs in multiples of one time step.

⁷ In this particular case, it is sufficient to find out the matrix P_{MK}^2 . All its entries are strictly positive.

$$\begin{aligned}
 0.958 \cdot \bar{\pi}_a + 0.175 \cdot \bar{\pi}_b + 0.065 \cdot \bar{\pi}_c + 0.010 \cdot \bar{\pi}_d &= \bar{\pi}_a \\
 0.040 \cdot \bar{\pi}_a + 0.701 \cdot \bar{\pi}_b + 0.246 \cdot \bar{\pi}_c + 0.010 \cdot \bar{\pi}_d &= \bar{\pi}_b \\
 0.002 \cdot \bar{\pi}_a + 0.117 \cdot \bar{\pi}_b + 0.607 \cdot \bar{\pi}_c + 0.048 \cdot \bar{\pi}_d &= \bar{\pi}_c \\
 0.007 \cdot \bar{\pi}_b + 0.082 \cdot \bar{\pi}_c + 0.932 \cdot \bar{\pi}_d &= \bar{\pi}_d \\
 \bar{\pi}_a + \bar{\pi}_b + \bar{\pi}_c + \bar{\pi}_d &= 1
 \end{aligned} \tag{14}$$

The solution is given as follows (15):

$$\begin{aligned}
 \bar{\pi} &= [\bar{\pi}_a \quad \bar{\pi}_b \quad \bar{\pi}_c \quad \bar{\pi}_d] = \\
 &= \left[\frac{155011}{217181} \quad \frac{473308}{3257715} \quad \frac{62034}{1085905} \quad \frac{54628}{651543} \right] \approx \\
 &\approx [0.713741 \quad 0.145288 \quad 0.057127 \quad 0.083844]
 \end{aligned} \tag{15}$$

The stationary row vector $\bar{\pi}$ is unique. It remains unchanged in the Markov chain as time progresses, i.e., $\bar{\pi}$ is invariant by the Markov matrix P_{MK} . Its existence shows that, regardless of the initial probability distribution $\pi^{(0)}$ at time instance $t=0$, the system is going to enter an equilibrium state (i.e., steady state, stationary state), described by $\bar{\pi}$, in a large number of time steps, i.e., when $t \rightarrow \infty$. The stationary distribution gives information about the stability of the stochastic process described by the Markov chain and, in certain cases, explains the limiting behaviour of the Markov chain.

The degree of mobility in patterns of specialisation can also be assessed by an index of mobility that formally appraises the degree of mobility throughout the entire distribution of RCA indices and facilitates direct comparisons between one period and another. The mobility index M_1 evaluates the trace (tr) of the Markov transition probability matrix (Shorrocks 1978). Therefore, the index directly captures the relative magnitude of diagonal and off-diagonal terms, and can be shown to equal the inverse of the harmonic mean of the expected duration of remaining in a given class (Bojnec and Fertő 2016):

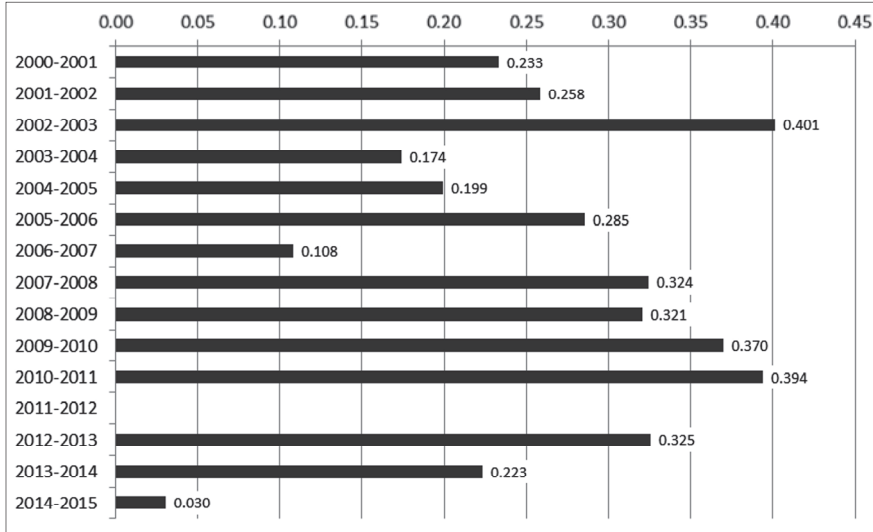
$$M_1 = \frac{K - \text{tr}(P^*)}{K - 1} \quad (16)$$

where K is the number of classes and P^* is the Markov transition probability matrix. Since we are interested in assessing the degree of mobility in the B index using a one-year lag, the Markov transition probability matrices are calculated for every two adjacent years of the observed period (2000 and 2001, 2001 and 2002...2014 and 2015); i.e., a total of 14 Markov matrices P^* is constructed (the one for the period 2011–2012 is missing due to a lack of shifts from class c in 2011 to any other class in 2012). A higher value of M_1 indicates greater mobility (the upper limit in our case is $4/3$), while the value of zero (the lower limit) points to perfect immobility. The empirical findings in Figure 5 indicate a higher mobility in the evolution of patterns of the B index in 2009–2010, 2010–2011, and 2012–2013 than in the years before 2009–2010. These results confirm once again the unstable export specialisation of Macedonia over the past few years, and the diversification of exports mainly on account of foreign investors. A higher mobility index is also observed in 2002–2003. However, this is mostly the result of export growth in all major (traditional) product categories in 2003 (e.g., iron and steel, clothing, etc.), lifted by the previous two years' exceptionally low base, when a consecutive decline in exports was recorded.

Following the latest empirical literature (Bojnec and Fertő 2008, 2015), we will now examine the duration of revealed comparative advantage. The duration of $B > 1$ is estimated by the Kaplan-Meier product limit estimator. In essence, the Kaplan-Meier survival analysis (Kaplan and Meier 1958), also known as the 'product-limit method' or 'product-limit estimator', is a nonparametric statistics used to estimate the probability of survival past given time points; i.e., it calculates a survival distribution from lifetime empirical data, taking censoring into account. In other words, it is a statistical technique used to describe and quantify 'time-to-event' data. For the analysis conducted here the 'event' is actually a time instance of dissolving the revealed comparative advantage of a certain product group; i.e., $B > 1$ shifts to $B \leq 1$. In survival analysis the existence of an event is usually defined by the term 'failure' (even though, in some other applications, the event can be interpreted as a 'success'). This situation of moving from 'success' ($B > 1$) to 'failure' ($B \leq 1$) is not desirable, as it resembles death. The term 'survival time' specifies the 'time to event' length; i.e., the length of time for an event to occur, given a starting time point.

The longer the $B > 1$, period a given product group has, the longer its survival time, and therefore the higher the survival rate.

Figure 5. Mobility of the B index for Macedonia (2000–2015)



Source: Authors' calculations based on SITC data at the two-digit level

In view of the time series (2000–2015) for the successive outcomes of each product group such that 0 means $B > 1$ and 1 stands for $B \leq 1$, we have applied the Kaplan-Meier method to estimate the cumulative survival function for the product groups as a single unit. As a first step we identify the uninterrupted sequences of time instances/years with $B > 1$ (Figure 6). Figure 6 clearly states a situation of two possible cases at the end of the identified time sequences:

- The case when an event has occurred (i.e., $B > 1$ shifts to $B \leq 1$): the event is marked 1 at the end of the time sequences of successive 0s. Hence, the minimum length of the time sequence is 2 (at least two adjacent time instances have to be considered), while the maximum length is 16.
- The case of an event not happening, i.e., no moves from $B > 1$ to $B \leq 1$: this case contains censoring at the final year of the observed period. Theoretically, the minimum length of such a time sequence is 1, while the maximum is 16.

Figure 6. Tabular representation of selected product groups, along with the corresponding uninterrupted periods of ‘liveness’ (0: $B > 1$; 1: $B \leq 1$) over the years 2000–2015

Commodity code	2000	2001	2002	2003	...	2008	2009	2010	2011	2012	2013	2014	2015
00	1	1	1	1	...	0	0	0	1	1	1	1	1
01	0	0	0	0	...	0	0	0	0	0	0	0	0
...					...								
24	0	1	1	1	...	1	1	1	1	1	1	1	1
...					...								
42	1	1	0	1	...	1	0	0	0	0	1	0	0
...					...								
58	0	0	0	1	...	0	0	0	0	0	0	0	0
59	1	1	1	1	...	1	1	0	0	0	0	0	0
...					...								

Source: Authors’ calculations based on SITC data at the two-digit level

In order to conduct the Kaplan-Meier method properly we have excluded those product groups where no event happens (26 in total)⁸. Consequently, our Kaplan-Meier survival analysis contains a total of 37 product groups. It is noteworthy that the analysis covers multiple occurrences (at least two) of uninterrupted time sequences (including those of case (a) solely, or (a) and (b) simultaneously) within a given product group⁹ (e.g., the product group ‘42’ includes 3 multiple occurrences, 2 of case (a) and 1 of case (b)).

Taking this analysis further, we have summarized the information about all detected individual time sequences of ‘liveness’ (Table 5). Our sample contains 48 independent observations (t_i, c_i) , whereupon $i = 1, \dots, 48$; t_i is the survival time, and c_i is the censoring indicator variable C (taking a value of 1 or 0 if an event or right censoring occurred, respectively) of observation i . Note that the event has happened (the time sequence ends with 1) in 29 cases (60.4%), while 19 cases (39.6%) are found to be right-censored (the time sequence ends with 0). Here the right censoring means that a given group of products has a revealed comparative advantage at the end of the period (2015), and it does not necessarily mean that an event has occurred after the period observed. The

⁸ These are the product groups that constantly have $B \leq 1$ over the years 2000–2015: 02, 08, 23, 25, 41, 51, 52, 53, 54, 55, 57, 61, 62, 63, 64, 71, 72, 73, 75, 76, 78, 79, 83, 87, 88, and 89.

⁹ Multiple occurrences have been registered in the following product groups: 33 (3), 34 (4), 35 (3), 42 (3), and 58 (2).

Kaplan-Meier procedure makes the assumption that censoring does not change the probability of survival.

Table 5. Summary information on the structure of individual time sequences of ‘liveness’ detected during the analysed period (2000–2015)

Observation No.	Commodity code	Time sequence length [periods]	Status / Censoring indicator
1	00	4	1
2	01	16	0
...
14	24	2	1
...
31	42	2	1
32	42	5	1
33	42	2	0
...
35	58	4	1
36	58	8	0
37	59	6	0
...
48	85	16	0

Source: Authors’ calculations based on SITC data at the two-digit level

The frequencies of particular time lengths with $B > 1$ are given in Table 6. The resulting survival function $S(t)$ for Macedonia is shown in Figure 7. The survival function is unique to a certain country, product group, and observation period, and thus it has all the qualities of a ‘fingerprint’. In view of the fact that the analysis is based on counts of time segments with discrete lengths and the indexing set is presented by discrete time points, the curve of the survival function is usually presented in a step format; i.e., it is a series of declining horizontal steps which, with a large enough sample size, approaches the true survival function. The results of estimating the survival function show that the survival times of revealed comparative advantage are not persistent over the period observed (Figure 7). For example, at $t = 0$ there are no shifts from $B > 1$ to $B \leq 1$, so $S(0) = 1$ (the survival chance equals 100%).

The probability of survival drops to 0.791 after $t = 2$ time periods (e.g., years), and falls again to 0.745 after $t = 3$ periods, and below 0.5 (0.465) after $t = 5$ time periods. The latter means that, in general, the chances of a given product group surviving at least 5 time periods continuously (i.e., not moving from

$B > 1$ to $B \leq 1$) are less than 50%. For even greater time lengths the probability of having $B > 1$ continues to decrease, but not so severely, such that for $t = 16$ it equals exactly 0.318 (Table 7). In effect, a 31.8% chance of certain product groups surviving 16 periods or more continuously, although not negligible, indicates that Macedonia is becoming increasingly vulnerable to competition from other markets where only the most viable will survive.

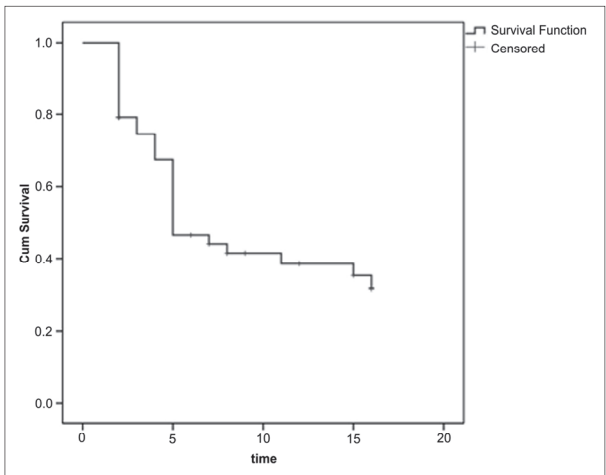
Table 6. Frequencies of time sequences with specific length, ranging from 1 (minimum) to 16 (maximum), for 37 product groups during the analysed period (2000–2015)

Time length [years]	1	2	3	4	5	6	7	8
Frequency	0	14	2	3	9	1	2	2

Time length [years]	9	10	11	12	13	14	15	16
Frequency	1	0	1	1	0	0	2	10

Source: Authors' calculations based on SITC data at the two-digit level

Figure 7. Plot of the survival function $S(t)$ for Macedonia, encompassing 37 product groups as a single unit (2000–2015)



Source: Authors' calculations based on SITC data at the two-digit level with the IBM® SPSS® Statistics v20, following the procedure described by Laerd Statistics (2013)

The complete calculation of the survival rates is based on the following assumptions: for each time t_j , $j = 0, \dots, 16$, the risk set R_j is actually the set of all product groups that have survived from time 0 to the time just before t_j . Thus, the risk set R_j consists of product groups that may have either moved to $B \leq 1$ at time t_j or those that have been censored (i.e., possibly switched to $B \leq 1$ after time t_j). We further define n_j as the number of all product groups still having $B > 1$ at time t_j , while d_j denotes the number of those groups that move to $B \leq 1$ at time t_j . Hence, the survival rates $S(t_j)$ can be calculated iteratively as follows (Zaiontz 2013):

$$S(t_0) = 1, \text{ for } j = 0$$

$$S(t_{j+1}) = S(t_j) \cdot \left(1 - \frac{d_j}{n_j}\right), \text{ for } 1 \leq j \leq 15 \quad (17)$$

Table 7. Kaplan-Meier survival analysis for Macedonia (2000–2015), including 37 groups of products

t	d	n	$1 - \frac{d}{n}$	$S(t)$	S. E.	Lower bound	Upper bound
0		48		1			
2	10	48	0.791667	0.791666667	0.058618	0.647396	0.882038
3	2	34	0.941176	0.745098039	0.063751	0.594367	0.846698
4	3	32	0.906250	0.675245098	0.069368	0.519064	0.790449
5	9	29	0.689655	0.465686275	0.075192	0.314651	0.603433
6	0	20	1.000000	0.465686275	0.075192	0.314651	0.603433
7	1	19	0.947368	0.441176471	0.075123	0.292181	0.580279
8	1	17	0.941176	0.415224913	0.075053	0.268410	0.555790
9	0	15	1.000000	0.415224913	0.075053	0.268410	0.555790
11	1	14	0.928571	0.385565991	0.075324	0.240681	0.528497
12	0	13	1.000000	0.385565991	0.075324	0.240681	0.528497
15	1	12	0.916667	0.353435492	0.075590	0.210915	0.499048
16	1	10	0.900000	0.318091943	0.075845	0.178622	0.466883

Source: Authors' calculations based on SITC data at the two-digit level

Assuming a 95% confidence interval, the survival analysis shows that the mean survival time is 8.726, with a standard error of 0.916, whilst the median survival time is 5.000, with a standard error of 0.964.

5. CONCLUSIONS

Macedonia has filed its candidacy to become an EU member state. Preparing the country for accession will require addressing its specific competitiveness weaknesses, providing a sense of the challenges it currently faces, and evaluating the extent to which the country will likely contribute to overall European competitiveness. This paper provides a comprehensive analysis of Macedonia's competitiveness with the EU28 as a comparator, using four indices of revealed comparative advantage (RCA) for the period 2000–2015. All four indices point to a revealed comparative advantage for 10 out of 63 two-digit SITC product groups. In order to look at differences across sectors, estimate the quality of trade, and link specialisation patterns to the most prominent sources of comparative advantage, we have also considered a classification of products according to factor intensity. The findings suggest that primary products and a few manufactures (human-capital intensive and unskilled labour-intensive products) have a comparative advantage, corresponding to the level of economic development, the availability of natural resources, and the price of production factors (labour). In other words, change in the composition of exports remains slow, with limited progress towards higher-value-added products over the last few years.

The higher coefficients of variation indicate a greater dispersion in the variable, and thus a relative instability of RCA indices over the period observed. This has been further investigated by applying additional stability measures; i.e., the stability of the distribution of indices and the stability of the value of indices from one period to the next. The findings confirm the argument that the structure of comparative advantage has changed somewhat over the past few years. With foreign investors increasing production in recent years, the structure of exports has shifted somewhat in favour of higher-value-added products (e.g., machinery and transport equipment). Moreover, the analysis of changes in the distribution of the Balassa (B) index indicates that Macedonia's RCA has weakened somewhat, i.e., the distribution has tended to shift to the left, producing a higher proportion of lower value indices, corresponding to a relative fall in the share of Macedonia's traditional export sectors (e.g., iron and steel; clothing). The second type of stability, that of the value of the Balassa (B) index for particular product groups, is evaluated in two ways. First, The Markov transition probability matrix for Macedonia presents the results for one-step empirical transition probabilities over the whole period considered (2000–2015), provided that these probabilities are the same in all sectors. The diagonal

elements of the matrix show that the observations of the B index are more persistent for both low (class a) and high (class d) cases than for the evidently more transient intermediate classes (class b and class c). At a glance, the initial and final empirical probability distribution vectors indicate a certain weakening of Macedonia's revealed comparative advantage. These findings once again support the view that there is a certain 'slippage' in Macedonia's comparative advantage. With the aim of assessing whether the Markov transition matrix captures the underlying data-generating process and allows for making more accurate forecasts, we have also calculated the implied (theoretically derived) probability distributions and compared them with their empirical counterparts. They appear to be very similar, showing that the transition probabilities are suitable for obtaining an accurate prediction regarding the probability distribution vectors, including the limiting distribution. In the second step we estimated the degree of mobility in patterns of RCA by an index of mobility M_1 , which evaluates the trace of the Markov transition probability matrix. The findings reveal some instability in Macedonia's export specialisation over the past few years, with a certain mobility in the evolution of the patterns of comparative advantage. Finally, we applied the Kaplan-Meier method to estimate the cumulative survival function for the subset of product groups taken as a single unit. The results show that the survival times of revealed comparative advantage are not persistent over the period observed. In other words, a 0.791 probability of surviving after two time periods (e.g., years) falls to below 0.5 (0.465) after five time periods. For even greater time lengths the probability of having a comparative advantage continues to drop, but not so severely, such that for sixteen time periods it equals exactly 0.318. In essence, a 31.8% chance of certain product groups surviving sixteen periods or more continuously, although not negligible, indicates that Macedonia is becoming increasingly vulnerable to competition from other markets where only the most viable will survive.

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