

QUANTITATIVE MEASUREMENT OF CROSS-BORDER INTERACTIONS (EXAMPLE OF AFRICA)

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ABSTRACT

Cross-border cooperation is one of the advantages of the EU that presented conditions for economic growth of all Member States when the organization was formed. The aim of the work was to look for quantitative indicators and data processing methods that would characterize cross-border interactions, while looking for and marking out high-integration regions. The authors' previous studies (Paiders, Paiders, 2010) were aimed at conducting measurements of cross-border interactions in the cluster of European states. In this work, the authors use the already-familiar methodology and indicators in order to analyze the cross-border interactions of African states. The layout of highly integrated borders allowed marking out four groups of African states with the greatest economic integration with neighboring states.

KEY WORDS: *spatial autocorrelation, Africa's regions, neighbour effect.*

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Introduction

Cross-border cooperation is one of the advantages of the EU that presented conditions for economic growth of all Member States when the organization was formed. The aim of the work was to look for quantitative indicators and data processing methods that would characterize cross-border interactions, while looking for and marking out high-integration regions. As evidenced by the authors' previous studies (Paiders, Paiders, 2010: 31), cross-border interaction must be viewed in a much wider context, not only in geographical, economic, or political categories. Cross-border influence (migration, exchange of information, etc.) affects cultures, social and demographic areas, which is reflected in indicators connected with these areas.

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Application of European experience in the economic and social transformation of the continent of Africa became particularly significant in the beginning of 2010, when social processes in North Africa (the Arab Spring), and several other Middle Eastern countries marked a shift from authoritarianism to searching for democratic models in state administration. Revolution in Egypt, Tunisia, Libya has a negative impact on almost all economic sectors in these countries. Also, the possibility of successful future economic development if the demographical situation stays the same is not likely to happen (Noury, 2011).

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The authors were personally encouraged to conduct a study in this area by European Commissioner for Development Andris Piebalgs, as the results of the work may be used to apply quantitative indicators and methods of quantitative analysis to define areas with a high tendency of integration and mark those state borders that have become real barriers interfering with regional cooperation and development.

1. Data and methods

Information on the amount of trade is obtained from Trademap (Trade Map, 2009) data on external trade of countries, based on official sources (COMTRADE, Eurostat, etc). Hence for this research annual changes in gross domestic product (GDP) per capita, based on purchasing-power-parity (PPP) valuation, were selected as an indicator, using International Monetary Fund World Economic and Financial Surveys obtained from the World Economic Outlook Database. Gross domestic product (GDP) per capita: annual changes based on purchasing-power-parity (PPP) valuation. Data of Human Development Index are based on United Nation statistic sources (Human Development, 2009).

As a parameter for determining the weight of the weighted average for neighbour territories, authors have used the proportion of length of the land border of neighbour territories against the total length of the land border. The weighted average for neighbour territories was obtained according to the formula

$$\overline{X}_n = \frac{\sum_1^n R_n \times X_n}{\sum_1^n R_n}$$

where n – the number of territories that border territory i ;

\overline{X}_n – the weighted average parameter of neighbour territories;

R_n – the total length of border with the respective territory;

X_n – the value of the respective parameter in the neighbour country.

Further in the regression analysis it was assumed that an indicator of a territory is a function of the weighted average of the respective indicator in all neighbour countries.

In this case, the border will serve as a variable that describes spatial interaction, assuming that the longer a border between corresponding territories, the stronger the spatial interaction between them. However, not all borders can serve as measures of spatial interaction. If there are indicators that describe spatial interaction between two countries, the value of the indicator (compared against the length of border) would serve to describe the amount of interaction.

Following the standard used by Frolova (2005), the zero hypothesis was tested for regression models, checking whether zero was included in the credibility interval of the regression coefficient (t-statistic) but significance of determination coefficient (R Square in tables) was tested using F empirical.

As a measure to characterize interaction, external trade turnover was chosen; borders were classified according to the size of this indicator per border kilometre.

Since often significant inequalities are seen in neighbour countries' mutual trade agreements, the authors have used an improved formula to calculate the economic permeability of borders.

$$C = \frac{(X_{eksp} + Y_{imp}) + (Y_{eksp} + X_{imp})}{2R}$$

where C – economic permeability of border;

- R – the length of border (km);
- X_{exp} – exports of country X to country Y;
- Y_{imp} – imports of country Y from country X;
- Y_{exp} – exports of country Y to country X;
- X_{imp} – imports of country X from country Y.

It is possible to calculate the economic permeability of borders in a simpler manner by using the following formula:

$$C = \frac{T}{R},$$

- where C – economic permeability of border;
- R – length of border (km);
- T – mutual amount of external trade between countries (imports + exports).

Whereas in the previous study the authors focused on cross-border interactions as a scalar field, the present study has obtained the first results by looking at international trade in the form of a vector field.

International trade can be expressed spatially as a vector whose numeric value is proportional to the trade balance amount, while the vector’s direction is determined by the trade surplus (the vector’s plus sign) or trade deficit (minus sign).

At the time when data for the study was being collected, South Sudan had not yet declared its independence – therefore, the work and figures use the former borders of Sudan.

2. Results and discussion on the influence of autocorrelation and cross-border measurement

The obtained results (tables 1, 2) force to conclude that there are parameters and geographical territories, for which the neighbour influence is extremely high. Results show that, for many economic and other indicators, including the average changes of the same indicator in surrounding territories explains most of dispersion in regression analysis. For instance, for all world countries the GDP per capita (2007) closely correlates to the average GDP per capita of neighbour countries ($R^2 = 0.67$).

Table 1. Neighbour effect (spatial autocorrelation) in World countries

Indicators	Number of countries	R Square	F-empirical	t-statistic
GDP per capita 2007	143	0,67	290,47	17,04
GDP per capita 2008	143	0,61	223,43	14,95
Increase in GDP per capita 2007 / 2006	143	0,66	269,57	16,42
Increase in GDP per capita 2008 / 2007	143	0,19	33,88	5,82
Average lifespan 2009	142	0,78	482,39	21,96
Average lifespan (men) 2009	142	0,75	409,67	20,24
Average lifespan (women) 2009	142	0,80	549,76	23,45
Birth rate 2009	143	0,77	479,77	21,90
Child mortality	142	0,61	222,56	14,92
Average number of children per woman 2009	142	0,71	341,78	18,49
Change in population 2007/2006	143	0,67	291,23	17,07
Human Development Index (HDI) 2007	140	0,80	564,65	23,76

Source: author’s calculations.

When looking at various indicators characterizing the development of states in Africa (Table 2), it can be noted that the autocorrelation of values of neighboring African states is generally significantly weaker than on the global scale (Table 1). However, for all examined indicators, the correlation between the weighted average of a state and its neighboring states is still statistically significant. The reason why the interlinking of a state and its neighboring states is lower on a continental scale is connected with the fact that, when shifting from the global scale to a smaller (continental) scale, the variation in values of the examined parameter is reduced.

Table 2. Neighbour effect (spatial autocorrelation) in African countries

Indicators	Number of countries	R Square	F-empirical	t -statistic
GDP per capita 2007	46	0,37	26,08	5,11
GDP per capita 2008	46	0,28	17,48	4,18
Increase in GDP per capita 2007 / 2006	46	0,40	28,94	5,38
Increase in GDP per capita 2008 / 2007	46	0,12	6,03	2,46
Average lifespan 2009	46	0,48	41,32	6,43
Average lifespan (men) 2009	46	0,45	36,72	6,06
Average lifespan (women) 2009	46	0,53	48,66	6,98
Birth rate 2009	46	0,52	47,77	6,91
Child mortality	46	0,21	11,76	3,43
Average number of children per woman 2009	46	0,45	35,66	5,97
Change in population 2007/2006	46	0,34	22,44	4,74
Human Development Index (HDI) 2007	46	0,26	15,40	3,92

Source: author's calculations.

Figure 1 shows the African state borders that practically act as barriers. As evidenced by the obtained results, the African continent is splintered, due to both geographical and political reasons. Moreover, splintering is characteristic to parts of Africa with different climatic and geographic specialization, which could complement each other. In Sub-Saharan Africa informal trade can be explained by the fact that land borders are not similar to the local ethnic group borders (Walther, 2009) Barriers in African land borders have a negative impact on the future economic development of African countries (Sipetean, Ivan Oana, 2010). Borders that practically function as barriers are the main obstacle that prevents Africa from using the opportunities that cross-border cooperation gives to, for example, Europe. In the other hand income inequality is a barrier in successful future economic development in African countries (Fanta, Upadhyay, 2009). Also, informal sector cross-border trade plays a much larger role in Africa than in Europe (Peberdy, 2000).

Areas with a high level of cross-border cooperation are shown in Figure 2. It displays the African borders with the greatest border throughput – where the border's economic throughput exceeds USD 600,000 per year per one kilometer of the border. Such level of throughput is comparable with the least-integrated borders of European states in the Balkans and Eastern Europe. Intra-regional trade in Africa as a part of the total trade has traditionally been low in comparison to other forms of integration (Bilas, Franc, 2010).

When comparing the level of integration in Europe and Africa, it must be concluded that the differences are statistically significant. In essence, borders that would be defined as barriers within the context of Europe must be viewed as highly integrated in Africa.

Figure 3 displays Africa's cross-border cooperation in the form of a generalized vector space, revealing the main directions and centers of international trade.

Figures 1–3 served as the basis for developing the regionalization scheme of Africa's cross-border interactions (Figure 4).

The work has resulted in the development of a regionalization scheme (Figure 4), marking out Africa's regions with a high level of cross-border interactions. The layout of highly integrated borders allowed marking out four groups of African states with the greatest economic integration with neighboring states.

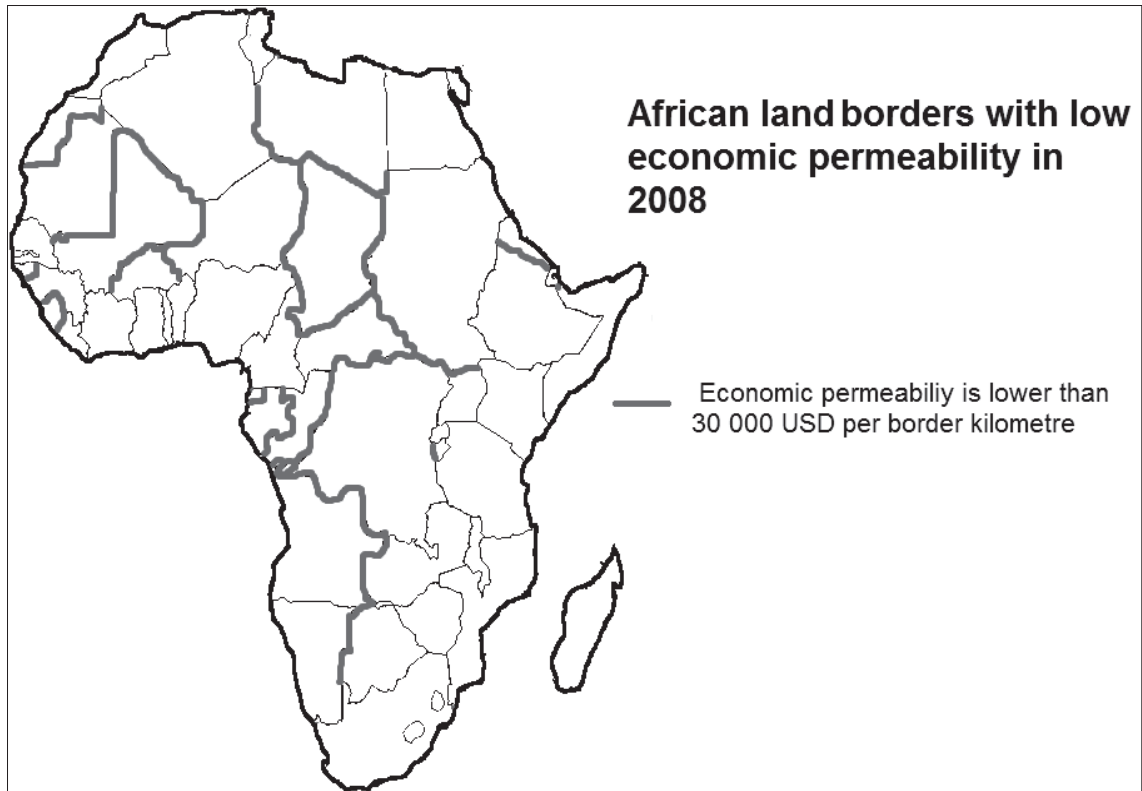


Figure 1. African land borders with low economic permeability in 2008
Source: Trade Map, 2009; author's calculations

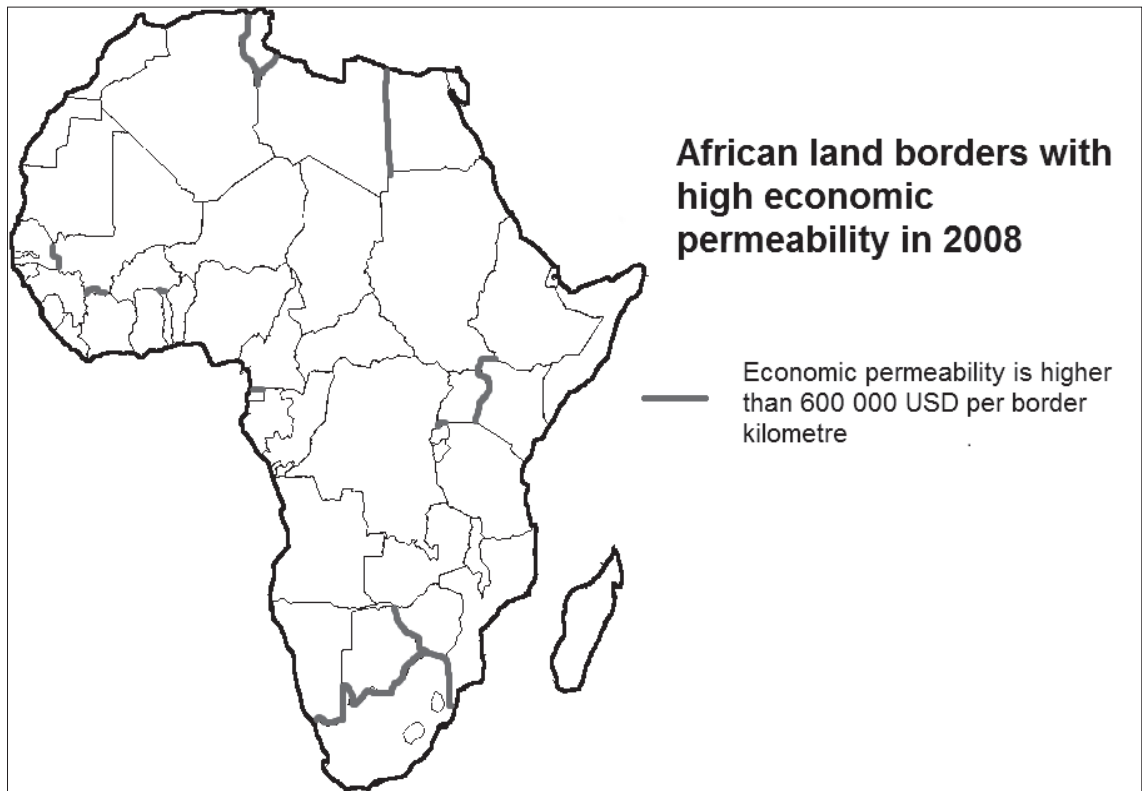


Figure 2. African land borders with high economic permeability in 2008
Source: Trade Map, 2009; author's calculations

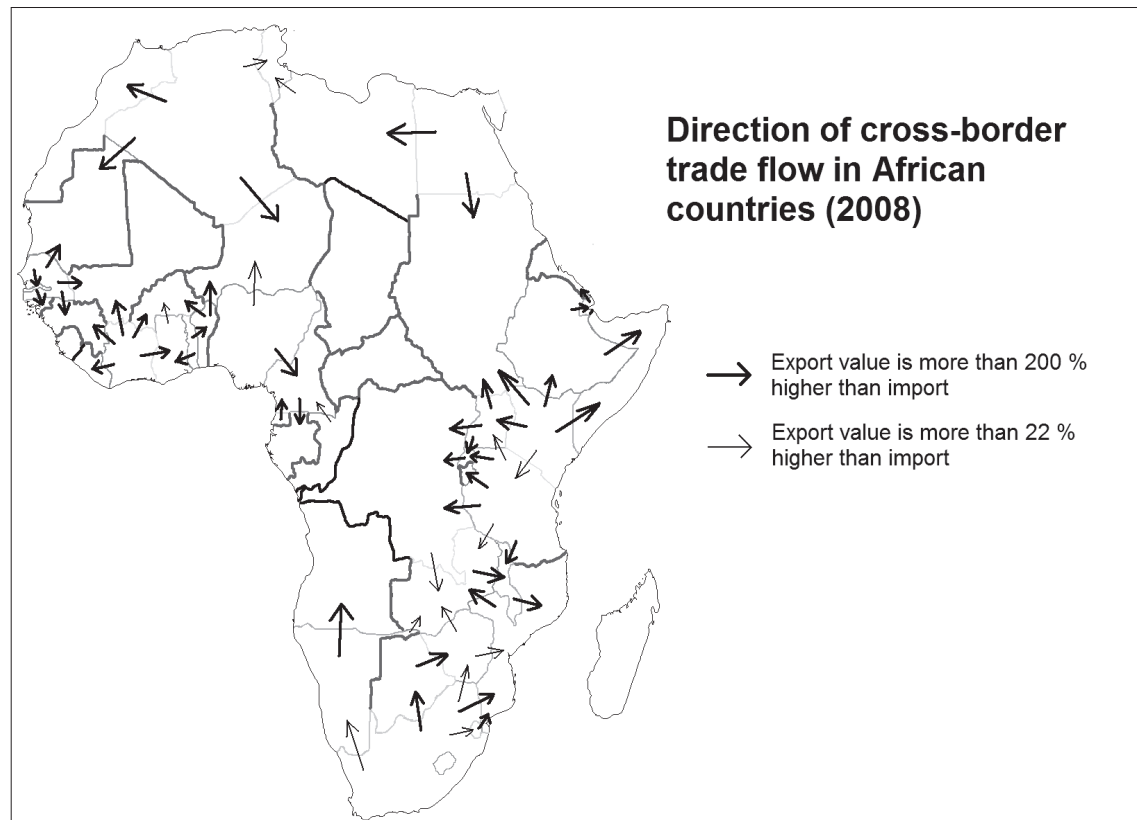


Figure 3. Direction of cross-border trade flow in African countries (2008)

Source: Trade Map, 2009; author's calculations

A – Arab states of North Africa. This group includes Algeria, Morocco, Tunisia, Libya, and Egypt. These states, in spite of the relatively great lengths of the borders between them, are characterized by large border throughput, compared to the average level of Africa. This is largely due to being populated by one nation (Arabs) and having a unifying religion (Sunni Islam). Considering that instability negatively affects tourism and international trade, it can be expected that the revolutions in Tunisia and Egypt in spring 2011, as well as the Libyan civil war, will have affected the integration of this region's states negatively in the short term. However, upon removal of the political obstacles, the Arab states of North Africa could become one of the most promising examples of high integration in the future.

B – Coastal states of the Gulf of Guinea. This group includes both coastal states of the Gulf of Guinea and the border-states thereof, with which there is rather significant economic integration. The central and economically most powerful states of this group, Ivory Coast and Ghana, also have significant economic throughput on the land borders. The borders of this area on which the economic integration exceeds USD 600,000 per year per kilometer are the ones connecting coastal states with landlocked states. The great economic throughput is largely explained by the need of landlocked countries (Mali, Burkina Faso) to access the sea. It must also be noted that the high economic throughput per kilometer is largely due to the small length of these borders.

C – East Africa Community (EAC). This group includes Kenya, Tanzania, Uganda, Rwanda, and Burundi. The economic integration of all of these states, except for Burundi, is rather high on the overall African background. The most integrated borders in this group are those with Kenya, which is the most developed country of the region. One of the specific tasks of the EAC is to facilitate the mutual economic integration of these states.

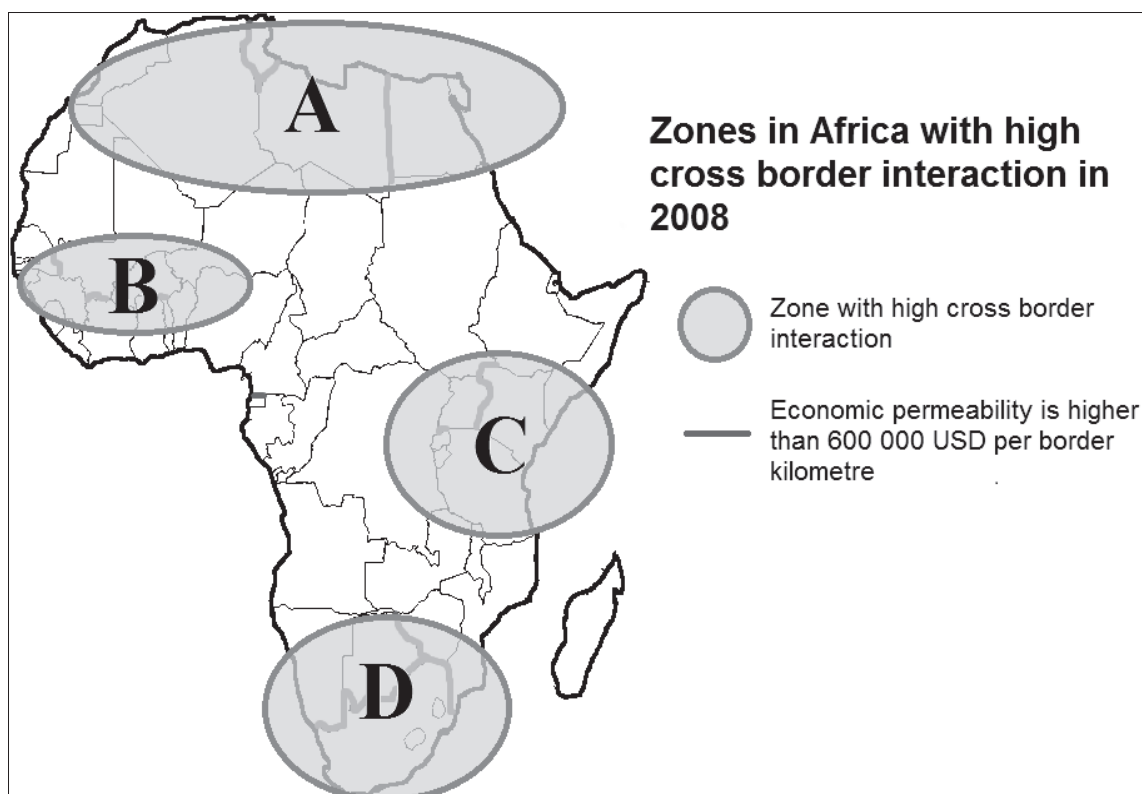


Figure 4. Zones in Africa with high cross-border interactions in 2008
Source: Trade Map, 2009; author's calculations

D – Republic of South Africa and its neighboring states (mostly Southern African Development Community countries). This group includes South Africa, as well as Namibia, Botswana, Zambia, Mozambique, and Swaziland. The high integration of the borders of these states is connected with the relationship of South Africa as an economically powerful center with its less-developed neighboring states. The economic relations of South Africa with its neighboring states are characterized by a significant trade surplus. South Africa acts as an economic engine dragging up the neighboring states. Southern African Development Community has higher regional integration between member countries compared to East African Community (Sissoko, Sohrabji, 2010). Unlike the Arab region of North Africa, in which there is no marked economic leadership or dominance, this region is mono-centric.

Conclusions

African regions with the greatest economic integration with neighboring states are Arab states of North Africa, Coastal states of the Gulf of Guinea, East African Community, Republic of South Africa and its neighboring states.

African borders with the greatest border throughput are comparable with the least-integrated borders of European states in the Balkans and Eastern Europe.

Republic of South Africa and its neighbor countries could become one of the most promising examples of high integration in the future.

References

- Bilas, V., Franc, S. (2010). Globalization, Regionalization and Information – Communication Convergence of Africa. *Interdisciplinary Description of Complex Systems*, No. 8(2), p. 104–118.
- Frolova, L. (2005). Korporatīvā sektora attīstība Latvijā un to ietekmējošie faktori. (The Development of the Corporate Sector in Latvia and Factors Influencing it.) 690. [sēj.]. Latvijas Universitātes Raksti. Vadības zinātne. Rīga: Latvijas Universitātes akadēmiskais apgāds, lpp. 52.–67. (In Latvian)
- Human development reports statistics*. (2009). <http://hdr.undp.org/ne/statistics/data>
- Noury, V. (2011). N African revolution: counting the cost. *African Business*, Issue 374. p. 46–50.
- Paiders, J., Paiders, J. (2010). Measuring Influence of Neighbour Effect on Sustainable Development of Countries. *Human Resources – the Main Factor of Regional Development. Journal of Social Sciences*, No. 3. Klaipēda: Klaipēda University, p. 29–35.
- Peberdy, S. (2000). Border Crossings: Small Entrepreneurs and Cross-border Trade between South Africa and Mozambique. *Journal of Economic & Social Geography*, Vol. 91, Issue 4, p. 361–378.
- Sipetean, C., Ivan Oana, N. (2010). Beyond the Borders of Globalizations EU-AFRICA, Economy and Conflict. *Annales Universitatis Apulensis – Series Oeconomica*, Vol. 12, Issue 2, p. 589–593.
- Sissoko, Y., Sohrabji, N. (2010). Current account sustainability in African economic communities: Are there regional differences? *China-USA Business Review*, Vol. 9, Issue 10, p. 13–29.
- Trade Map: Trade statistics for international business development*. (2009). <http://www.trademap.org/Index.aspx>
- Walther, O. (2009). A Mobile Idea of Space. Traders, Patrons and the Cross-Border Economy in Sahelian Africa. *Journal of Borderlands Studies*, Vol. 21, Issue 1, p. 34–46.

KIEKYBINIS PASIENIO SAŅEIKOS MATAVIMAS (AFRIKOS PAVYZDYS)

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Santrauka

Pasienio bendradarbiavimas buvo vienas iš ES teikiamų privalumų, lėmusių visų organizacijos narių ekonominę plėtrą. Šio darbo tikslas – nustatyti kiekybinius rodiklius ir duomenų apdorojimo metodus, kurie leistų apibūdinti pasienio sąveiką, kartu ieškant ir išskiriant labai integruotus regionus. Ankstesni autorių (Paiders, Paiders, 2011) darbai skirti matuoti pasienio sąveiką Europos valstybių klasteryje. Šiame darbe ta pati metodologija ir rodikliai naudojami Afrikos valstybių pasienio sąveikai įvertinti. Ankstesni autorių tyrimai sutelkti ties pasienio sąveika kaip skaliariniu lauku, o šiame darbe tarptautinė prekyba vertinama vektorijų forma. Tarptautinė prekyba gali būti išreikšta vektoriumi, kurio skaitinė reikšmė proporcinga prekybos balansui, tuo tarpu vektoriaus kryptį nulemia prekybos paviršius (teigiama vektoriaus reikšmė) arba prekybos deficitas (neigiama vektoriaus reikšmė).

Lyginant Europos ir Afrikos integracijos lygį, padaryta išvada, kad skirtumai yra statistiškai svarbūs. Iš esmės sienos, kurias galima apibūdinti kaip skiriančias ribas Europos kontekste, Afrikoje būtų laikomos labai integruotomis. Ištyrus labiausiai integruotas sienas, išskirtos keturios Afrikos valstybių grupės, kurios labiausiai ekonomiškai integruotos su kaimyninėmis valstybėmis.

Tyrimo išvados:

1. Labiausiai integruoti Afrikos regionai yra arabų valstybės šiaurėje, pakrantės valstybės Gvinėjos įlankoje, rytų Afrikos bendruomenė, Pietų Afrikos Respublika ir jos kaimyninės valstybės.
2. Labiausiai integruoti Afrikos regionai Europos kontekste būtų lygintini su mažiausiai integruotais Balkanų ir Rytų Europos regionais.

3. PAR ir jos kaimyninės valstybės ateityje turėtų tapti didesnės ekonominės integracijos Afrikoje pavyzdžiu.

Tyrimo rezultatai gali būti panaudoti taikant kiekybinius rodiklius ir kiekybinius tyrimo metodus, apibrėžiant regionus, kur didžiausias integravimosi potencialas, ir pažymint tas valstybių sienas, kurios tapo skiriamąja riba, stabdančia regioninį bendradarbiavimą ir vystymąsi.

PAGRINDINIAI ŽODŽIAI: *erdvinė autokoreliacija, Afrikos regionai, kaimynystės efektas.*

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