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AFFORDABILITY OF EMERGING TECHNOLOGIES – CASE OF BROADBAND ADOPTION IN WESTERN BALKAN COUNTRIES

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Abstract:*Broadband technology fosters economic growth and development and increases the global competitiveness of the country. The affordability of technology is very important for broader use of specific technology. The main problem is not the covering of initial cost of technology installation, but the cost associated with using of given technology. The purpose of the present paper is to analyse the current level and dynamics of broadband adoption in Western Balkan countries using simple Data Envelopment Analysis based composite indexes constructed on data about broadband coverage and service prices. The current level of broadband adoption foreach country is measured in relation to other sample countries. The values of the calculated composite indexes indicate the strong and weak sides of the corresponding aspects of broadband technology implementation and give directions for setting further priorities for political intervention in the domain of information society building.*

Key words: *broadband internet,composite indexes,affordability,economic growth*

1. INTRODUCTION

Today, the existing variations in economic performances between countries and the competitiveness of their economies in larger measure depend on adoption, use and speed of broadband internet technology.Broadband access contributes to improving the overall social welfare, as well. This technology reduces the cost of searching, collecting and processing the necessary information, which makes it easier to compare prices which encourages and enhances competition and improves the quality of products.

The purpose of the paper is to analyse the current level and dynamics of mobile broadband adoption in Western Balkan countries using simple Data Envelopment Analysis based composite indexes constructed on data about mobile broadband coverage and service prices. The current level of mobile broadband adoption for each country is measured in relation to other sample countries. The values of the calculated composite indexes indicate the strong and weak sides of the corresponding aspects of mobile broadband technology implementation and give directions for setting further priorities for political intervention in the domain of information society building.

This paper is structured as follows. After introduction and discussion on the economy context of the achieving broadband level measurement, the index calculation methodology is explained and the adoptionand affordability indexes are calculated for Western Balkan countries. Third Section discusses the main results and explains the calculated values of indexes regarding priorities in country's policies aimed at decreasing the digital divide and increasing the global economic competitiveness. Fourth Section contains main conclusions and recommendations for further research.

2. LITERATURE REVIEW

According to Qiang and Rossotto (2009), it is noticed that in high-income economies during the period 1980-2002 an increasing in total broadband subscribers per 100 people would lead to increase in GDP per capita for 1.21 percentage point (all others factors being equal), while in developing countries increasing of GDP per capita would be 1.38 percentage point. Koutroumpis (2009) emphasized that in OECD countries during the period 2002-2007 average percentage of country's growth attributed to broadband infrastructure is 10.54%. Also, this research shows that average impact of broadband infrastructure on GDP in these countries was equal to 0.24%. Countries with higher broadband

penetration had higher impact of broadband infrastructure to economic growth. Czernich et al. (2011) also observed relation between broadband penetration rate and GDP growth in OECD countries in period 1996-2007. Researchers concluded that after introduction of broadband, country's GDP per capita was 2.7–3.9% higher on average than before its introduction. According to this research "an increase in the broadband penetration rate by 10 percentage points raised annual growth in per capita GDP by 0.9–1.5 percentage points."

Gruber et al. (2014) argue that at the level of the EU the broader economic benefits of broadband investment are higher than their cost. The total economic benefits from investment in broadband infrastructure are 32% higher than the cost (for the EU in total). Kolko (2012) found positive link between higher penetration of broadband technologies and local economic growth. But, there is no evidence that broadband availability reduce unemployment rate (Czernich, 2014). The impact of development of local broadband infrastructure on economic activity as measured by local employment rates is positive, but economically rather limited (Fabritz, 2013). Similarly, Whitacre et al. (2014) concluded that there was positive link between level of broadband adoption in US rural areas and income growth between 2001 and 2010 and negative relationship between the level of broadband adoption and unemployment growth.

There are also researches that encompass other broadband characteristics than simple broadband penetration and their impacts on economic growth like speeds of data transmission, type of broadband connection, quality of broadband service and service providers. Kongaut and Bohlin (2014) analysed the relationship between broadband speed and economic growth. They used the sample of high and low income OECD countries and data for broadband speed and GDP from period 2008-2012. The main conclusion from this research study is that broadband speed contributes positively to economic outputs such as GDP and that the effects of broadband speed are also greater in countries with lower income. Despite the presence of several limitations in this analysis, authors concluded that an increase in broadband speed of 10% leading to an increase in GDP per capita of 0.8%. Jung (2014) performed an analysis of the impact of broadband on regional productivity in Brazil and also concluded that faster download speed and critical mass to account for network externalities enhance of the economic impact of broadband.

3. DATA AND METHODOLOGY

The calculation of the BAD and BAF indexes implies the determination of its individual indicators weights. The simplest way is to give equal importance to all indicators and determine the same weight. However, this method of determining the weight would be suitable only in the case when the opportunity costs of moving from one to another technology (for example, from a cable modem to the mobile broadband) would be the same in all countries, which is, of course, far from reality (Badasyan et al. 2011).

The overview of the recommended indicators used in analysis for indexes calculation is given in Table 1.

Table 1. Statistical indicators

Sub-index	Indicator used
Broadband Adoption (BAD)	BD1 – xDSL penetration rate per population
	BD2 – Cable modem penetration rate per population
	BD3 – Dedicated data cards/wireless modems per 100 population
Broadband Affordability (BAF)	BF1 – HHI based on mobile telephony market share by revenues
	BF2 – Fixed-broadband prices as a percentage of GNI p.c.
	BF3 – Mobile-broadband prices as a % of GNI p.c.

We havedecided on the Data Envelopment Analysis (DEA) methodology. In short, based on the data related to each country individually, the DEA methodology, constructs the "efficiency frontier" using mathematical linear programming, which determines the best state of the practice and, in relation to that state, measures the relative position of each of the countries in terms of the value of the set of the observed indicators.

In order to apply the DEA methodology and determine the weight, the values of all the individual indicators must be normalized. This is very important because different indicators aren't expressed in the same direction. The raw values are normalized into an interval between 0 and 1 – higher indicator's value represents better performance of given country in the broadband area analysed. The normalization of the values of the individual indicators was carried out according to OECD (2008).

The normalized values for the 6 broadband indicators are calculated for 35 countries, but because of lack of space we presented here only values for Western Balkan countries + Turkey + Iceland as EU candidate countries: Croatia (HR), FYR Macedonia (MC), Montenegro (ME), Serbia (SR), Turkey (TU), Albania (AL), Bosnia and Herzegovina (BH) and Iceland (IC). The raw data we used for the analysis was taken from the statistics base Eurostat and national statistics offices of the countries analysed (all values are for 2013 year).Calculated normalized numerical values are given in Table 2.

Table 2. Normalized values of the indicators

Country	BD1	BD2	BD3	BF1	BF2	BF3
HR	0.489	0.113	0.093	0.250	0.664	0.756
MC	0.158	0.310	0.000	0.194	0.174	0.628
ME	0.264	0.035	0.154	0.417	0.207	0.307
SR	0.210	0.274	0.044	0.417	0.000	0.606
TU	0.200	0.040	0.024	0.222	0.766	0.744
AL	0.000	0.072	0.016	0.139	0.273	0.000
BH	0.131	0.198	0.029	0.472	0.541	0.023
IC	0.544	0.000	0.201	0.750	0.883	0.972

Source: Calculated by author

We then determined the main indexes using the DEA methodology according to Zhou et al. (2006), Cherchye et al. (2006), Zhou et al. (2007), Cherchye et al. (2008), OECD (2008), Hatefi and Torabi (2010). Indexesare calculated as the weight sum of the corresponding individual indicators, where the weights are endogenously determined by mathematical linear programming so as to obtain the maximum possible value of the indexes for each individual country. In this way, certain combinations of the weight for the individual indicators within the main indexes for a country is the best possible combination – there is no other combination of the weights that would enable a country to achieve a greater index value. In other words, we consider the most favourable situation for each country.

The resulting indexes are ranged between zero (the worst possible performance) and 1 (the best possible performance – benchmark). The optimal calculated set of weights provides the best position for the given country related to all other analysed countries. Any other weighting profile would worsen the relative position of the given country.

The calculated numerical values of the broadband indexes for Western Balkan countries are given in Table 3.

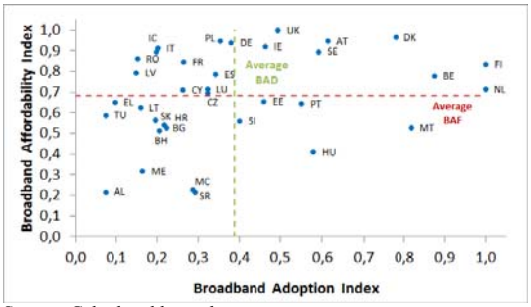
Table 3. Calculated values of the broadband indexes

Country	BAD	BAF
HR	0.216	0.541
MC	0.287	0.226
ME	0.164	0.316
SR	0.292	0.216
TU	0.074	0.588
AL	0.074	0.216
BH	0.206	0.512
IC	0.197	0.892

Source: Calculated by author

4. CALCULATED VALUES – DISCUSSION

The ranking of countries according to the calculated indexes values is presentedon Figure 1.



Source: Calculated by author

Figure 1. The ranking of countries according to broadband indexes

The leading country in the Western Balkans in terms of implementation of mobile broadband internet access is Croatia, followed by Montenegro, Macedonia and Serbia. Serbia is in a better position than Croatia when it comes to the adoption and implementation of broadband Internet access (infrastructure development), but is worse in terms of paying ability or affordability of these services for residents and businesses. Montenegro is in a better position than Serbia when it comes to the service price (affordability), different modalities of use of mobile broadband Internet access services and available internet speed for users, but its position was worsened by the degree of adoption of this technology by users. Albania and Bosnia and Herzegovina occupy the last place according to the value of calculated indexes owing primarily to the unevenly prevalent technology of broadband access among the population, worse infrastructure and the degree of adoption of the given technology by the users in the country.

In the field of broadband affordability Serbian government needs to pay more attention to institutional, regulatory and legal framework which is very inadequate – active state regulations create burden on businesses, individuals and households that discourage broadband adoption and make related services less affordable.For example, according to indicator BF2 (fixed-broadband prices as a percentage of GNI per capita)Serbia takes the last position in total sample analysed.At the same time, predominantly market share regarding fixed broadband technologies remains cover by the telecom company in the state ownership.

5. CONCLUSION

Based on recent researches presented in the literature and using the proposed methodology which takes into account broadband adoption and affordability, this contribution provide a more comprehensive picture of global competitiveness of Western Balkan countries. The values of the calculated indexes indicate the strong and weak sides of the corresponding aspects of broadband technology implementation and, thus, help when setting further priorities for political intervention not only in the domain of information society building, but also in the improvement of the competitive advantage of the country.Such policies require additional investment in new ICT, permanent education of population, research and development processes in enterprises, scientific institutions and universities and better legal and institutional framework related to intellectual property rights.

Although the methodology presented in this paper is only basic, the analysis showed that the BADand BAF indexes can serve as a good tool that will allow the classification of goals and priorities when designing the development policies of the Western Balkans countries and the evaluation of accomplished achievements (by comparing to other countries in the region and the European Union).

As one of interesting and very important relation in further research it should be analysed if there exists positive correlation between BAD and BAF indexes showing broadband adoption and affordability and

the indexes that indicate the degree of the digital divide in Western Balkan countries. It can be analysed by using DIDIX and TDI indexes as it is proposed by Hüsing and Selhofer (2004), Vehovar (2006) and Howard et al. (2010). There is an example in literature of the analysis showed that between the level of digital divide and the affordability to broadband technology there is a negative correlation (Badasyan et al. 2011). It would be expected because the increasing competition in the domain of providing broadband services leads to a reduction of their prices and greater availability for end users. However, increased competition is more expressed in urban than in rural areas and, therefore, on one hand, there is an increase in the affordability of these services, but it could be expected a lower value of the sub-index regarding the level of digital divide.

REFERENCES

[1] Badasyan, N., Shideler, D. & Silva, S. (2011). Broadband Achievement Index: Moving beyond Availability. *Telecommunications Policy,* 35 (11), pp. 933–950.

[2] Cherchye, L., Moesen W., Rogge, N., &Puyenbroeck, T. V. (2007). An introduction to 'Benefit of doubt'composite indicators.*Social Indicators Research,* 82 (1), pp. 111-145.

[3] Cherchye, L., Moesen W., Rogge, N., Puyenbroeck, T. V., Saisana, M., Saltelli, A., Liska R. &Tarantola, S. (2008). Creating Composite Indicators with DEA and Robustness Analysis: The Case of Technology Achievement Index. *The Journal of Operational Research Society,* 59 (2), pp. 239-251.

[4] Clark, M. (2003). E-development?Development and the New Economy.(WIDER Policy Brief № 7).UNU WIDER.http://www.wider.unu.edu/publications/policy-briefs/en_GB/pb7/_files/78807311701704847/default/ pb7.pdf

[5] Czernich, N., Falck, O., Kretschmer, T. &Woessmann L. (2011). Broadband infrastructure and economic growth.*The Economic Journal,* 121 (552), pp. 505–532.

[6] Fabritz, N. (2013). The Impact of Broadband on Economic Activity in Rural Areas: Evidence from German Municipalities.*Ifo Working Paper No. 166*. http://www.cesifo-group.de/portal/page/portal /DocBase_Content/WP/WP-Ifo_Working_Papers/wp-ifo-2013/IfoWorkingPaper-166.pdf

[7] Golany, B. & Roll, Y. (1989). An Application Procedure for DEA.*Omega,* 17 (3), pp. 237-250.

[8] Gruber, H., Hätönen, J. &Koutroumpis, P. (2014). Broadband access in the EU: An assessment of future economic benefits. *Telecommunications Policy,* 38 (11), pp. 1046–1058.

[9] Hatefi, S. M. &Torabi, S. A. (2010). A common weight MCDA–DEA approach to construct composite indicators.*Ecological Economics,* 70 (1), pp. 114–120.

[10] Howard, P.N., Anderson, K., Busch, L. &Nafus, D. (2009). Sizing Up Information Societies: Toward a Better Metric for the Cultures of ICT Adoption. *The Information Society,* 25 (3), pp. 208-219.

[11] Hüsing, T. andSelhofer, H. (2004). DIDIX: A Digital Divide Index for Measuring Inequality in IT Diffusion. *IT&Society,* 1 (7), pp. 21–38.

[12] Jung, J. (2014). Regional inequalities in the impact of broadband on productivity: Evidence from Brazil. (MPRA Paper No. 56177), University Library of Munich, Germany. http://mpra.ub.uni-muenchen.de/56177/1/MPRA_paper_56177.pdf

[13] Kolko, J. (2012). Broadband and local growth.*Journal of Urban Economics,* 71 (1), pp. 100–113.

[14] Kongaut, C. &Bohlin, E. (2014). Impact of broadband speed on economic outputs: An empirical study of OECD countries. 25th European Regional Conference of the International Telecommunications Society (ITS), Brussels, Belgium, 22-25 June 2014. http://econstor.eu/bitstream/10419/101415/1/795234465.pdf

[15] Koutroumpis, P. (2009). The economic impact of broadband on growth: A simultaneous approach. *Telecommunications Policy,* 33 (9), pp. 471-485.

[16] OECD (2008). Handbook on Constructing Composite Indicators – METHODOLOGY AND USER GUIDE.http://www.oecd.org/std/42495745.pdf

[17] Qiang, C. Z. &Rossotto, C. M. (2009).Economic Impacts of Broadband. In Information and Communications for Development 2009: Extending Reach and Increasing Impact (pp. 35–50). Washington, DC: World Bank.

[18] Vehovar, V., Sicherl, P., Hüsing, T. &Dolnicar, V. (2006).Methodological Challenges of Digital Divide Measurements.*Information Society,* 22 (5), pp. 279-290.

[19] Zhou, P., Ang B.W. &Poh, K.L. (2006).Comparing aggregating methods for constructing the composite environmental index: An objective measure.*Ecological Economics,* 59 (3), pp. 305-311.

[20] Zhou, P., Ang B.W. &Poh, K.L. (2007).A mathematical programming approach to constructing composite indicators.*Ecological Economics,* 62 (2), pp. 291-297.

[21] Whitacre, B., Gallardo, R. &Strover, S. (2014). Broadband's contribution to economic growth in rural areas: Moving towards a causal relationship. *Telecommunications Policy,* 38 (11), pp. 1011–1023.