Analysis of the Diffusion of E-services in Public Sector Using the Decision Tree Method

Ljiljana Kašćelan
Faculty of Economics Podgorica, University of Montenegro
Vujica Lazović
Faculty of Economics Podgorica, University of Montenegro
Tamara Đuričković
Agency for Control and Quality Assurance of Higher Education, Montenegro
Biljana Rondović
Faculty of Economics Podgorica, University of Montenegro

Abstract

The results of the this study showed that there is a difference in individual and interactive impact of technological, organizational and environmental factors on the diffusion of e-services in the public sector, as well as a difference regarding the factors that independently impact the diffusion of e-services oriented to citizens and those oriented to business. The results of the study also showed that external factors have a predominant impact on the diffusion of e-services oriented to citizens, while, in the case of e-services oriented to business, in addition to external factors, technical factors also have a high impact. For the purposes of this paper, based on the Technology-Organization-Environment framework (TOE), the conceptual model suitable for e-services in the public sector is developed, while the Decision Tree (DT) Method is used for testing the effects of the proposed variables. This study offers valuable inputs both for the government, for creators of national strategies oriented towards the promotion and support of the availability and usage of electronic services in the public sector, which is very important especially for developing countries.

Keywords: ICT diffusion, public e-services, decision tree, TOE framework
JEL classification: C53, C83, O32, O33

Introduction

As a consequence of the development of technology that characterized the end of the 20th and the beginning of the 21st century, the need arose to facilitate and simplify the relations between the state and the citizens as well as between the state and the businesses, which led to a greater degree of introduction of e-services in public administrations both in developed and developing countries.

However, despite the large number of studies, initiatives and programs, the introduction of e-services is not always followed by a high degree of application which could be seen from the available UN reports (Department of Economic and Social Affairs, United Nations, 2016). This problem is especially evident in developing countries, like Montenegro, (Weerakkody et al., 2011), what motivated the authors to deal with the issues of e-services diffusion in public administration in the context of the Innovation Diffusion Theory.

Since the Technology-Organization-Environment Framework – TOE (Depietro et al., 1990) is often used to examine factors that influence the adoption and diffusion of new technologies, it was logical to expand the use of this framework to IT innovations (Oliveira et al., 2010; Palacios-Marqués et al., 2015). However, due to the lack of empirical research on the impact of TOE factors on the degree of e-service diffusion in public administration, the authors considered that this framework could be relevant and significant for this type of study.

More precisely, using a customized TOE framework, the authors analyzed the individual and interactive impact of technological, organizational and environmental factors on diffusion of e-services in public sector, and the existence of differences regarding the impact of identified factors depending on whether it is about the services oriented to citizens or the services oriented to business. In this research, the DT method is proposed because it efficiently solves all the mentioned deficiencies of regression analysis. In addition to pointing to the importance of individual factors, this method enables an automatic detection of the interactive influence of factors in the form of simple to understand if-then rules.

The rest of the paper is organized as follows: the second part offers an overview of the literature on the topic, in which the authors found their motive for the present study; the third part features the research methodology; the fourth section presents the results with discussion. The paper ends with concluding remarks, study limitations and guidelines for future research.

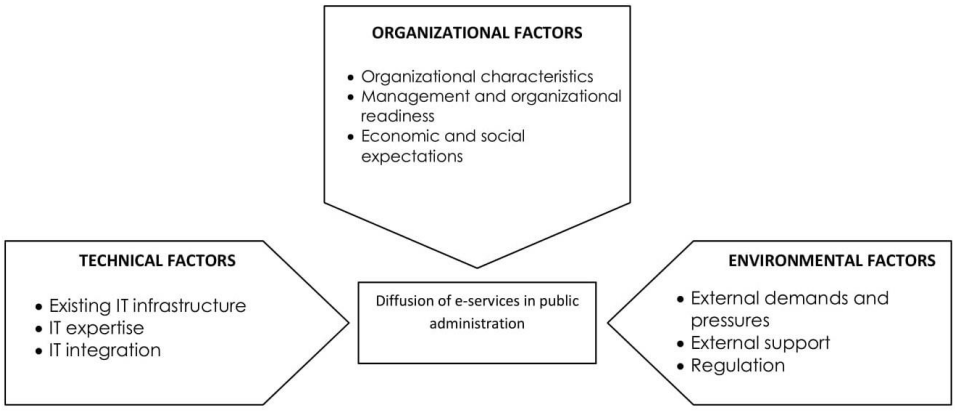
Methodology

Based on the research objective, the authors defined two research questions:

- What are the determinants that influence the diffusion of e-services in public administration and what is their individual and interactive impact?
- Are there any differences in the impact of the identified e-government diffusion factors, depending on whether e-services are offered to citizens or to businesses?

Taking into account the TOE framework which considers the adoption of ICT innovation by enterprises in technological, organizational and environmental contexts (Tornatzky et al., 1990), the need to consider the specificities of the IT innovation being studied (Cao et al., 2012), as well as related literature (Table 1), the authors defined the conceptual model shown in Figure 1.

Figure 1 The Proposed Research Framework



Source: Authors' Illustration

The choice of factors within these three proposed contexts was made after analysing the existing valid research models that explain the adoption and diffusion of IT innovation (Table 1).

Table 1
Selection of Variables Based on Literature

Variables	Supporting studies
IT infrastructure	Choi et al. (2016); Chan, et al. (2012); Krishnan et al. (2012); Baker (2012); Lin et al., (2008); Pan et al. (2008); Zhu et al. (2006)
IT expertise	Hunnius et al. (2015); Lin et al. (2008); Pan et al. (2008)
IT integration	Gangwar et al. (2015), Chan et al. (2013); Chourabi et al. (2011); Wang et al. (2009)
Organizational Characteristics	Lucia-Palacios et al. (2015), Aboelmaged (2014), Pan et al., (2008); Ifinedo (2011); Teo et al. (2009); Zhu et al. (2006)
Management and organizational readiness	Lucia-Palacios et al. (2015); Pansiri et al. (2010); Azad et al. (2010); Lin et al. (2008); Niehaves (2007); Zhu et al., (2006)
Economic and social expectations	Martins et al. (2016); Ghobakhloo et al. (2011); Gant (2008)
External demands and pressures	Henderson et al. (2012); Cordery et al. (2011); Pan et al. (2008)
External support	West (2004); Von Haldenwang (2004)
Regulation	Pan et al. (2008); Zhu et al. (2006)

Source: Authors' work

A questionnaire-based survey was used to find answers to the research questions raised. The survey was forwarded to the state authorities and institutions of Montenegro in order to be filled out by IT managers and managers employed in the marketing sector. The survey lasted three months, and out of 300 questionnaires sent (to 90 state bodies and institutions), 136 were returned completely filled out (from 62 companies), giving a response rate of 45.3% for the questionnaires (with a response rate of around 68.8 % for companies).

For the assessment of the current degree of the use of e-government as well as the impact of the defined factors on the diffusion of e-government, a 7-point Likert scale was used (Ifinedo, 2011).

The assessment of the current degree of e-government diffusion in the surveyed state bodies and institutions was taken to be the dependent variable. Table 2 shows the dependent variable, the nine independent variables, the control variable and their distribution.

Table 2
The Variables for Analysis Generated Based on the Results of the Survey

Name	Type	Statistics	Range
Diffusion*	numeric	avg = 3.081 +/- 0.489	[2.000 ; 4.000]
IT.infrastruct	numeric	avg = 6.237 +/- 0.693	[5.000 ; 7.000]
IT.integration	numeric	avg = 6.033 +/- 0.387	[5.500 ; 7.000]
IT.expertise	numeric	avg = 4.467 +/- 0.644	[3.000 ; 6.000]
Org.character	numeric	avg = 3.476 +/- 0.290	[2.600 ; 4.000]
Org.readiness	numeric	avg = 2.511 +/- 0.534	[1.500 ; 4.000]
Expectations	numeric	avg = 4.012 +/- 0.195	[3.583 ; 4.500]
Ext.req	numeric	avg = 2.911 +/- 0.456	[2.000 ; 4.333]
Ext.support	numeric	avg = 5.900 +/- 0.468	[5.000 ; 6.500]
Regulation	numeric	avg = 5.844 +/- 0.487	[5.000 ; 7.000]
E.services**	binominal	mode = G2B (74), least = G2C (61)	G2B (74), G2C (61)

Note: *Diffusion is dependent variable; ** E.services is control variable
Source: Authors' work

For the analysis of the collected data and generating a model by which the answers to the research questions could be obtained a data mining DT method was used.

This method systematically analyzes data to derive important relationships between the dependent variable and the independent variables and display them in a tree structure. The three is composed of nodes, branches and leaves. Each node in the tree is associated with one of the input variables and each branch of the tree is associated with a subset of values of the corresponding target variable. If the target variable is discrete, then the tree is considered to be a classification tree and each leaf represents one value of the target variable (one class).

In this analysis, the independent variables are the nine factors influencing the diffusion of e-services as defined in section 3.1, while the target variable is the degree of e-government diffusion.

In order to find the answers on research question, the classification CART tree method was selected because through this method, classification rules are obtained for the individual values of the target variable, i.e. degrees of e-government diffusion. The rules describe the required interactive impact in a simple way. This method also generates the significance of variables and, therefore, the impact of individual factors can be determined (Rondović et al., 2017).

Results

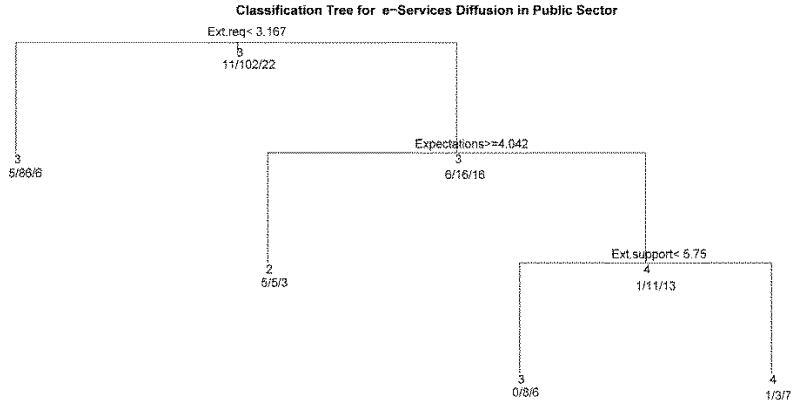
In order to answer the first research question, a classification decision tree was generated using the CART method (Figure 2).

By analyzing the decision tree in Figure 2, it can be seen that Ext.req is the root variable, which means that this variable has the highest classification power. From the root variable, the data set branches into the left sub-tree (for the values of the root variable < 3.167) and the right sub-tree (for the values of the root variable >=3.167). The right sub-tree includes 38 data items out of which 6 have a degree of diffusion "2", 16 have a degree "3" and 16 have a degree "4". In the right sub-tree, the splitting is continued by attribute which now has the highest classification power. It continues on until a leaf is reached.

The ratio of the amount of correctly classified data and the total amount of data represents the accuracy of the classification. By collecting the correctly classified

data by leaves (86+5+8+7) we obtain the number, which is 78.52% in relation to the total number of data of 135. Therefore, the overall accuracy of the classification in this model is 78.52%.

Figure 2
The Decision Tree Model for the Diffusion of E-Services in Public Administration



Source: Authors' illustration

Table 3 shows the significant "if-then" rules derived from the model in Figure 2. The derived rules confirm the existence of the interactive effect of the factors on the degree of e-services diffusion, with satisfactory accuracy.

Table 3
Significant Rules for the Diffusion of E-services in Public Administration

Leaf	Rule IF	THEN	Acc(%)	Cov(%)
1	Low Ext.req	3	88.6	71.8
4	High Ext.req and Low Expectations and High Ext.support	4	63.6	8.1

Source: Authors' work

When generating the model, the individual factors' importance in relation to the degree of e-services diffusion is also calculated (Table 4).

Table 4
TOE Factors Importance for the Diffusion of E-services in Public Administration

TOE Factor	Importance
Ext.req	72
Expectations	14
Ext.support	8
IT.integration	2
Org.readiness	2
IT.expertise	1
IT.infrastruct	1

Note: Rounded values are shown
Source: Authors' work

In order to answer the second research question, the decision tree models in Figures 3 and 4 were generated. The overall accuracy of the classification for these models is 68.85% and 87.84%, respectively.

Table 5
TOE Factors Importance for G2C and G2B

TOE Factor/ Importance	G2C	G2B
Ext.req	82	77
IT.integration	9	16
Expectations		2
Ext.support		2
IT.infrastruct		2
Org.readiness	9	2

Note: Rounded values are shown
Source: Authors' work

Table 6 and Table 7 summarize the significant rules derived from the generated models.

Table 6
Significant Rules for the Degree of E-service Diffusion (G2C)

Leaf	Rule IF	THEN	Acc(%)	Cov(%)
1	Low Ext.req	3	79.0	70.4
2	High Ext.req	4	61.5	21.3

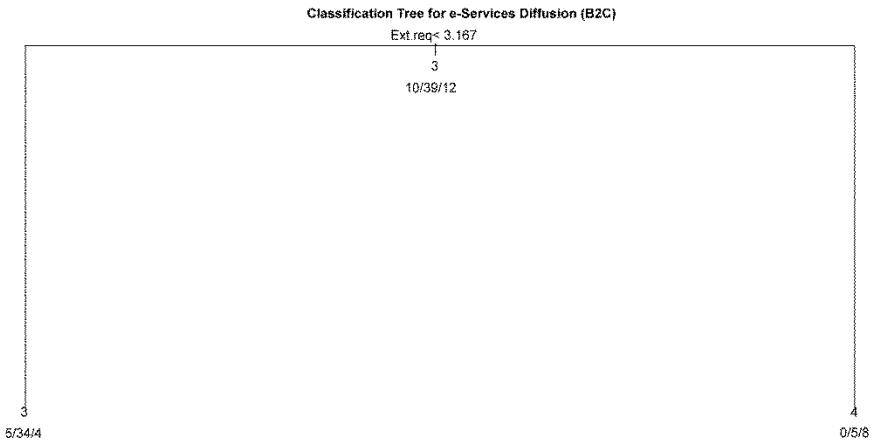
Source: Authors' work

Table 7
Significant Rules for the Degree of E-service Diffusion (G2B)

Leaf	Rule IF	THEN	Acc(%)	Cov(%)
1	Low Ext.req	3	96.3	73
3	High Ext.req and High IT.integration	4	69.2	17.6

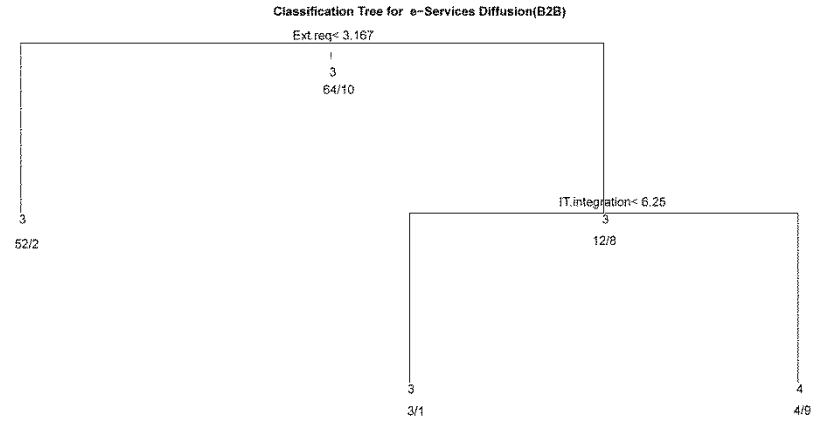
Source: Authors' work

Figure 3
The Decision Tree Model for the Classification of the Degree of Diffusion of E-services (G2C)



Source: Authors' illustration

Figure 4
The Decision Tree Model for the Classification of the Degree of Diffusion of E-services (G2B)



Source: Authors' illustration

Discussion

If we observe the whole sample, that is, all state bodies and institutions included in the study, it can be seen that the greatest single impact on the degree of use of e-services is exerted by external requirements and pressures.

This finding is justified by the fact that e-government implies interoperability, civic-centricity, an integration of all government services, information resources and processes, and that it is logical that the diffusion of e-government in each state body and institution is determined by the requirements and pressures of other bodies and institutions.

In addition, it should not be forgotten that, thanks to various initiatives and strategies, governments around the world were under pressure to implement e-services and that internationally, a need is still recognized for new initiatives, strategies and action plans to ensure a successful diffusion of these services (Ngafeeson et al., 2015).

The weakest single impact on e-government diffusion is exerted by two technological factors – IT infrastructure and IT expertise. The result can be explained in several ways. It is possible that these factors were more significant when the decision was made to adopt this type of IT innovation, and that the diffusion problem should be addressed by influencing the third technical dimension – IT integration, which is not foreign to diffusion of innovation (Chan et al., 2013).

When considering the interactive impact at the whole sample level (Table 2), it is noted that if there are high external requirements and pressures, assisted by a higher degree of external support, a higher degree of e-government diffusion can be achieved even with low expected benefits.

According to the empirically obtained results, there are differences as regards the factors that individually and in interaction affect the diffusion of e-services in the public administration, depending on whether services are offered to individuals or to businesses.

E-government diffusion both for those offering e-services to individuals and those offering them to companies largely depends on external requirements and pressures, with the impact of this factor somewhat higher in the G2C category. The analysis also showed that the impact of technical factors is somewhat stronger with government bodies offering services to enterprises (in particular, IT integration).

Conclusion

Using the decision tree method and the TOE framework in this study, technical, organizational and environmental factors which influence e-government diffusion were identified. Furthermore, a step forward was made in relation to previous studies dealing with the diffusion of IT innovation, since, in addition to their individual influence, their interactive influence was also investigated. In addition, a difference was found regarding the importance of the mentioned factors, depending on whether a company offers e-services to individuals or other companies.

External requirements and pressures are recognized as a key factor for e-government diffusion, and, therefore, should be seen as the most important drivers of greater e-service offer. Organizational factors, in particular, economic and social expectations have a slightly lower, but significant potential for e-government diffusion.

Thanks to the recognized interactive effect of the factors, this analysis has shown that the problem of non-recognition of economic and social benefits can be solved by influencing some of other factors. In this concrete example, these are high external requirements and pressures and a higher degree of external support.

From a methodological point of view, the study has shown that the DT method is a good alternative to standard regression methods for detecting factors that influence the diffusion of e-services in the public sector.

This study can motivate other scholars to start new surveys based on the DT method and use the TOE framework to study other types of IT innovation.

This study can provide guidelines to creators of e-government strategies and action plans, as well as to those in the managing positions of state bodies and institutions, as it can secure a positive outcome in the phases following the adoption of these systems.

Just like every other study, the present one has certain limitations, which can be understood as challenges to overcome in some future research.

Firstly, this research was done for one developing country only. Secondly, this research focuses on the post-adoption period. Thirdly, the results are based on data that reflect the perception of IT managers and managers in marketing sectors. In

future studies, when e-government enters some more mature stages, surveys could be designed in such a way as to gather data that also reflect the opinions of employees in other sectors. Finally, in this, as in other studies where the TOE framework is used, the names of variables and items are never a fixed category, they depend on the nature of IT innovation and can be modified and improved in future studies.

References

1. Aboelmaged, M. G. (2014), "Predicting e-readiness at firm-level: An analysis of technological, organizational and environmental (TOE) effects on e-maintenance readiness in manufacturing firms", International Journal of Information Management, Vol. 34, No. 5, pp. 639-651.
2. Azad, B., Faraj, S., Goh, J. M., Feghali, T. (2010), "What shapes Global Diffusion of e-Government: Comparing the Influence of National Governance institutions", Journal of Global Information Management, Vol. 18, No. 2, pp. 85–104.
3. Baker, J. (2012), "The technology–organization–environment framework", in Dwivedi, Y., Wade, M., Schneberger, S. (Eds.), Information systems theory, Springer, New York, NY, USA, pp. 231-245.
4. Cao, Q., Baker, J., Wetherbe, J. C., Gu, V. C. (2012), "Organizational Adoption of Innovation: Identifying Factors that Influence RFID Adoption in the Healthcare Industry", in proceedings of the European Conference on Information Systems (ECIS), Vol. 94, AIS Electronic Library (AISeL), Association for Information Systems.
5. Chan, F. T. S., Chong, A. Y. L. (2013), "Determinants of mobile supply chain management system diffusion: a structural equation analysis of manufacturing firms", International Journal of Production Research, Vol. 51, No. 4, pp. 1196-1213.
6. Chan, F. T., Chong, A. Y. L., Zhou, L. (2012), "An empirical investigation of factors affecting e-collaboration diffusion in SMEs", International Journal of Production Economics, Vol. 138, No. 2, pp. 329-344.
7. Choi, H., Park, M. J., Rho, J. J., Zo, H. (2016), "Rethinking the assessment of e-government implementation in developing countries from the perspective of the design–reality gap: Applications in the Indonesian e-procurement system", Telecommunications Policy, Vol. 40, No. 7, pp. 644-660.
8. Chourabi, H., Mellouli, S. (2011), "E-government: integrated services framework", in proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, 12-15 June 2011, College Park, Maryland, USA, ACM, pp. 36-44.
9. Cordery, C. J., Fowler, C. J., Mustafa, K. (2011), "A solution looking for a problem: factors associated with the non-adoption of XBRL", Pacific Accounting Review, Vol. 23, No. 1, pp. 69-88.
10. Depietro, R., Wiarda, E., Fleischer, M. (1990), "The context for change: Organization, technology and environment", The processes of technological innovation, Vol. 199, No. 0, pp. 151-175.
11. Gangwar, H., Date, H., Ramaswamy, R. (2015), "Understanding determinants of cloud computing adoption using an integrated TAM-TOE model", Journal of Enterprise Information Management, Vol. 28, No. 1, pp. 107-130.
12. Gant, J. P. (2008), "Electronic government for developing countries", International Telecommunication Union (ITU), Geneva.
13. Ghobakhloo, M., Arias-Aranda, D., Benitez-Amado, J. (2011), "Adoption of e-commerce applications in SMEs", Industrial Management & Data Systems, Vol. 111, No. 8, pp. 1238-1269.
14. Henderson, D., Sheetz, S. D., Trinkle, B. S. (2012), "The determinants of inter-organizational and internal in-house adoption of XBRL: A structural equation model", International Journal of Accounting Information Systems, Vol. 13, No. 2, pp. 109-140.

15. Hunnius, S., Paulowitsch, B., Schuppan, T. (2015), "Does E-Government education meet competency requirements? An analysis of the German university system from international perspective", in proceedings of the 48th Hawaii International Conference on System Sciences (HICSS), Kauai, HI, USA, IEEE, pp. 2116-2123
16. Ifinedo, P. (2011), "Internet/e-business technologies acceptance in Canada's SMEs: an exploratory investigation", Internet Research, Vol. 21, No. 3, pp. 255-281.
17. Krishnan, S., Teo, T. S. (2012), "Moderating effects of governance on information infrastructure and e-government development", Journal of the Association for Information Science and Technology, Vol. 63, No. 10, pp. 1929-1946.
18. Lin, H. F., Lin, S. M. (2008), "Determinants of e-business diffusion: A test of the technology diffusion perspective", Technovation, Vol. 28, No. 3, pp. 135-145.
19. Lucia-Palacios, L., Bordonaba-Juste, V., Polo-Redondo, Y., Grünhagen, M. (2014), "E-business implementation and performance: analysis of mediating factors", Internet Research, Vol. 24, No. 2, pp. 223-245.
20. Martins, R., Oliveira, T., Thomas, M. A. (2016), "An empirical analysis to assess the determinants of SaaS diffusion in firms", Computers in Human Behavior, Vol. 62, pp. 19-33.
21. Ngafeeson, M. N., Merhi, M. I. (2015), "E-government diffusion: evidence from the last decade", in I. Management Association (Ed.), Public Affairs and Administration: Concepts, Methodologies, Tools, and Applications, IGI Global, Hershey, PA pp. 1274-1291.
22. Niehaves, B. (2007), "Innovation Processes in the Public Sector–New Vistas for an Interdisciplinary Perspective on E-Government Research?", in Wimmer, M. A., Scholl, J., Grönlund, Å. (Eds.) International Conference on Electronic Government (EGOV), Lecture Notes in Computer Science, Vol. 4656, Springer, Berlin, Heidelberg, pp. 23-34.
23. Oliveira, T., Martins, M. F. (2010), "Understanding e-business adoption across industries in European countries", Industrial Management & Data Systems, Vol. 110, No. 9, pp. 1337-1354.
24. Palacios-Marqués, D., Soto-Acosta, P., Merigó, J. M. (2015), "Analyzing the effects of technological, organizational and competition factors on Web knowledge exchange in SMEs", Telematics and Informatics, Vol. 32, No. 1, pp. 23-32.
25. Pan, M. J., Jang, W. Y. (2008), "Determinants of the adoption of enterprise resource planning within the technology-organization-environment framework: Taiwan's communications industry", Journal of Computer information systems, Vol. 48, No. 3, pp. 94-102.
26. Pansiri, J., Temtime, Z. T. (2010), "Linking firm and managers' characteristics to perceived critical success factors for innovative entrepreneurial support", Journal of Small Business and Enterprise Development, Vol. 17, No. 1, pp. 45-59.
27. Rondović, B., Kašćelan, L., Lazović, V., Đuričković, T. (2017), "Discovering the determinants and predicting the degree of e-business diffusion using the decision tree method: evidence from Montenegro", Information Technology for Development, pp. 1-30.
28. Teo, T. S., Lin, S., Lai, K. H. (2009), "Adopters and non-adopters of e-procurement in Singapore: An empirical study", Omega, Vol. 37, No. 5, pp. 972-987.
29. Tornatzky, L. G., Fleischer, M., Chakrabarti, A. K. (1990), Processes of technological innovation, Lexington Books.
30. Department of Economic and Social Affairs, United Nations (2016), "United Nations E-Government Survey 2016 - E-Government in support of sustainable development", available at: http://workspace.unpan.org/sites/Internet/Documents/UNPAN97453.pdf (21 May 2018)
31. Von Haldenwang, C. (2004), "Electronic government (e-government) and development", The European Journal of Development Research, Vol. 16, No. 2, pp. 417-432.
32. Wang, Y., Shi, X. (2009), "E-business assimilation in SMEs of China", International Journal of Electronic Business, Vol. 7, No. 5, pp. 512-535.

33. Weerakkody, V., El-Haddadeh, R., & Al-Shafi, S. (2011), "Exploring the complexities of e-government implementation and diffusion in a developing country: Some lessons from the State of Qatar", Journal of Enterprise Information Management, Vol. 24, No. 2, pp. 172–196.
34. West, D. M. (2004), "E-government and the transformation of service delivery and citizen attitudes", Public administration review, Vol. 64, No. 1, pp. 15-27.
35. Zhu, K., Dong, S., Xu, S. X., Kraemer, K. L. (2006), "Innovation diffusion in global contexts: determinants of post-adoption digital transformation of European companies", European journal of information systems, Vol. 15, No. 6, pp. 601-616.

About the authors

Ljiljana Kašćelan, Ph.D, is a Full Professor at Faculty of Ecomomics- University of Montenegro. She is a graduate of the Faculty of Natural Sciences and Mathematics-University of Montenegro. She received her Master's from Faculty of Electrical Engineering – University of Montenegro and her Ph.D from Faculty of Economics-University of Montenegro. Dr. Ljiljana Kašćelan has over twenty years of teaching experience. She has experience in developing and implementing business intelligence systems in organizations. She is active in research in the areas of data warehousing, OLAP and data mining. The author can be contacted at **ljiljak@ac.me.**

Vujica Lazović, Ph.D, is Associate Professor at the Faculty of Economics, University of Montenegro. His research interests cover the Digital Economy, Business Informatics and Information systems and he has been involved in many projects and research activities in these areas. He was a dean of the Faculty of Economics, University of Montenegro for the period 2000-2006. He was a Deputy Prime Minister for economic policy and financial systems at Government of Montenegro for the period 2006-2016 as well as a Minister of information society and telecommunications for the period 2009-2016. Currently he is appointed as Ambassador of Montenegro to the Slovenia. Author can be contacted at **vujical@t-com.me.**

Tamara Đuričković has worked as a teaching assistant at the Faculty of Economics, University of Montenegro where she got her PhD Degree. Her main research activity is in the area of digital economy, e-government, e-business and information systems and she has been involved in many projects and research activities in these areas. She worked at the Government of Montenegro from 2007-2010 where she was working in the area of development of information society and e-government in Montenegro. Currently, she works at the Agency for Control and Quality Assurance of Higher Education. Author can be contacted at **tamara.djurickovic@gmail.com.**

Biljana Rondović is Associate Professor at the Faculty of Economics, University of Montenegro Montenegro where she teaches Information System and Electronic Business. She has finished postgraduate studies "Financial management" at Faculty of Economics in Podgorica 2000 and postgraduate studies "Information Systems and Technologies"at Faculty of Organizational Science in Belgrade in 2001. In 2005 she has received PhD degree at Faculty of Economics in Podgorica. She is member of Montenegrin Association of Economists and Montenegrin Association of Informatics. She is the author of many papers in the field of Electronic Business. Author can be contacted at **biljaro@ac.me.**