Use of cost analysis, estimation and risk management in making project management decisions in construction projects

Miloš Jovanović[1], José Moreno Pérez[2], Bojan Lalić[3], Vladimir Todorović[4]
[1] Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Trg Dositeja Obradovića 6, 21000 Novi Sad, Srbija
[2] Universidad Politécnica de Madrid, Spain
[3] Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija
[4] Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija
e-pošta: ns.milos@gmail.com; jmoreno@etsii.upm.es; blalic@uns.ac.rs; todorovic.ftn@gmail.com

Abstract

This research was conducted in a construction consultancy company located in Madrid. Scenario of Spanish construction company entering Balkan market was created and suggestions were given in that direction. Firstly, cost estimation framework used in Planet Cluster company is improved and presented. Interviews with project managers in Serbia and Spain were conducted and conclusions are obtained. Secondly, definition of key costs in construction projects is done. Costs are identified in three main categories: materials, labour and machinery. After that, market cost analysis of identified key costs in the markets of Serbia and Montenegro and Spain was done. Impact on the total budget of the project is measured, and it is calculated that construction projects in Serbia are around 25 % cheaper than in Spain. This analysis created an improved base for cost estimation, and project management implications in projects executed in the Balkan area. Moreover, list of expected types of risk in the market was created, based on interviews with the experts and on the experience of Planet Cluster company. Finally, the aim of this paper is to improve project management in construction projects by proposing a cost estimation procedure, analysing cost differences between Spain (European Union) and Serbia (non-European Union member), and identifying the construction risk present in the markets.

***Key words**: cost estimation, construction project management, risk control, cost analysis*

1. Introduction

Construction projects consist of many different parts. Managing this broad variety of data and differences requires increase the use and development of project management in construction. Project lifecycle is divided in four main phases: initiation (pre-study), planning, execution and termination (Tonquist, 2004).

Problems that this research paper will try address are the following:

- Causes of poor cost estimation process.
- Cost assessment in new markets (key cost parameters will be defined and their influence on the overall project budget will be discussed).
- Analysis of expected risks in the market.

It is practically impossible to develop a costing model that is universal and perfect in any situation. Construction costs depend on many different factors and risks involved (construction method, employees, experience and many others). Many estimates are unrealistically low and during the approval stage they are furthermore reduced, but inevitably rise during the later implementation stage. Main factors creating cost estimation error are: insufficient time, poor tender documentation and insufficient tender document analysis by team delegated to perform it (Fitzgerald, 2000). Many tools of cost estimation can be found in practice, but there is not a standard method to calculate costs in the construction projects.

Cost estimation of the projects using innovative technology, where we do not have enough expertise can lead us to wrong estimations. (Smith, 1996) states that cost estimating is often done for new products or processes, for which good quality historical data does not exist. In this case predictive modelling would be a useful helping tool. Linear regression is ideal for linear correlations while neural network is most adequate for non-linear. Having non-linear relations in regression model would change results significantly, neural networks should be used in that case (Sonmez, 2009). Case base reasoning model provides better explanation of the calculations made, is easier to update and better uses previous projects data in compare to other two models (linear regression and neural networks).

Price books method, direct calculation of the prices from the special books, gives rough total cost project estimation. This method is used by small contractors not having department or employees dedicated to the cost estimation process. Simplicity of this model is an advantage but in some complex cost estimation process may be misleading. (Akintoye, 2000) determined main factors relevant to the cost estimating practice: complexity of the project, scale and scope of construction, market condition, method of construction, site constraints, client's financial condition, build ability and location of the project.

In this article framework of cost categories involved in construction projects is created. After identification of key cost parameters in construction projects, data collection process was initiated.

The selection of suppliers has been done in three different ways:

- Initial selection was done through the participation in the construction fair in Serbia, where it was observed what kinds of technologies are available on the market.
- Research through internet and construction magazines has been carried out.
- Interviewers are asked for suggestion about reliable suppliers.

Through this process database of key costs has been created. Following the creation of the prices database, comparison between Serbia and Spain has been made. In conclusion, oscillation is measured, weights are given (compared to the influence in the final project cost) and conclusions about construction project management are summarized.

We can choose between controlling and being controlled by the risks in a project. Risk is perceived like a threat of the successful project termination within projected time, costs and quality level. Managers consider risk management techniques too mathematical and difficult to use (Akintoye, 1997). Therefore, using a checklist of possible risk is one of the most widely used techniques. Simplified way of managing risks is to create impact matrix, measuring impact and probability of risk occurrence (PMBOK, 2008). In this paper we focused on identifying risks available in both countries.

Risk in construction projects is divided in 4 groups: Financial, project timeline, design and quality and security (Kanda 1997). Also, risk associated with the lifecycle of construction project s can be divided in two groups: Project planning phase or preconstruction phase and project execution phase of construction phase (Akintoye 1997 & Macomber 1989).

In summary, the research aim of this article was: to explore possibilities of cost reduction and project management improvements in the Balkan area, improving the cost estimation process, by performing cost and risk analysis.

2. Methodology

The research is focused on the differences between two European regions, Spanish and Serbian market, with intention of achieving conclusions useful for managing international construction projects. Primary aim of this research paper was the identification of key cost factors, the improvement of the cost estimation and risk identification process.

Qualitative part is done through interviews with managers working in construction projects. Interviews are conducted both in Serbia and Spain. People interviewed have background of civil engineers and architects, prominent experts to comment this area. All the people interviewed have contacts with residential buildings, which are the most common in practice. They are employed in Spain (two of them) or Serbia (four of them) and their work experience was in average 23 years and annual turnover of the companies they work in is 6.000.000 euro in average. Aim of the interviews was to identify "bottle necks" of the project flow and oscillation of the budgeted costs.

Aim of this qualitative research is to identify problems (risks), possible solutions, key drivers that need to be compared, differences in the project management tools between these two geographical areas areas.

According to the interviews, expertise and historical data of the Planet Cluster company, key cost parameters are identified. In other words, most important cost parameters in construction projects are identified.

Therefore, budget of the whole construction project was divided in different groups and budget grouping was proposed. Following, costs of constructing a building (as one part of the whole budget) are examined further. They present the biggest part in the whole project budget, and these costs are the ones that are hardest to access. Therefore, we choose to measure these costs in Spain and Serbia and make a numerical comparison. In order to make the right comparison, costs carrying more than 70 % of the total construction budgets are identified, quoted in both countries and compared. These costs were divided to the lowest level (labour, materials, machinery) in order to get better comparison. In accordance with cost impact on the final budget project, management decisions are suggested.

Project Management Institute (2008) defines tools and techniques to identify risks. Methodologies used for risk identification in this article were: Interviewing, information gathering technique and documentation review.

3. Cost estimation methodology

Cost estimation methodology in construction projects is not universal and each company has its own way to access costs. In this chapter cost categories of the cost estimation, that should be involved in the calculation are described. Logically, depending on the purpose of the cost estimation, data availability, and project phase, cost estimation precision will change from rough towards detailed.

Important to mention is that there are different steps of the project design (conceptual, basic and executive) and that different cost estimation is needed (rough or more detailed). Along with different phases of the project, error limits change. According to (Hereida, 1996), in the conceptual design of the project (rough estimation) oscillation of the costs is from -20 % till 30 % while in the last phase (executive) situation is different and error goes from -3 % till 5 %. According to the (PMBOK, 2008, p.168) in the project initiation phase, ROM - Rough Order Magnitude estimate is in range of ± 50 %, while later on in the project with more information available, cost estimation error range will decrease to the ±10 %. Therefore, depending on the project phase, and data available, the cost estimation will be more or less precise

In this chapter we proposed cost groups that should be used in the cost estimation process of the residential construction projects. Model used in the Planet Cluster company is improved and presented in this chapter.

Firstly, we will mention calculation methodology of different cost groups. NPV - Net Present Value rule

is common calculation methodology used by investors to evaluate their investment decision. NPV depends on future cash flows of the project. According to (Brealey, Corporate finance, 2007):

$$PV = \Sigma\ CashFlow(t)/(1+DiscountRate(t))^t \quad NPV = I_0 + PV$$

Therefore, NPV method is used to evaluate feasibility of the project investment. Further, we will elaborate different cost categories needed to be involved in this calculation. As previously mentioned, precision of the cost estimation will largely depend on the project phase.

Cost categories involved in the construction project estimation:

1. Land costs – buying, cleaning and preparing the land. Preparation of the land often carries hidden and unexpected costs.
2. Construction costs – all costs incurred while constructing the building (object): labour, materials and machinery. This cost category is examined in detail in the cost analysis section.
3. Facility management costs – involve whole lifecycle of the project. In construction projects this mainly refers to maintenance and warranty costs, which depends on the contract type.
4. Legal and permission costs – permits requested for start of construction phase and approvals needed for the use permit in the end of construction phase.
5. Management costs or fixed costs – in accounting referred as fixed costs: permanent labour, machines, offices and other assets in the company that are involved in the project.
6. Cost of capital – cost of financial sources obtained for the project (debt or shareholder equity).
7. Mark-up and unexpected costs – planned profit from the project, but also a buffer for the unexpected costs.

4. Cost analysis

We will focus on the construction costs group, since they present the biggest expense and they have the maximum change from one project to another. Construction costs in Spain and Serbia will be compared.

Firstly, we should focus on the project planning phase. When we understand type of activities involved in construction projects, division and comparison of the costs done will be clear. So, activity in construction project is presented as follows:

Unique code | Description | Position | Duration | Material | Machinery | Labour | Cost

Figure 1: Graphical presentation of one activity

From the Figure 1 we can see data needed to create an activity in construction projects. Data of interest for us were: material, machinery and labour and cost. We compared cost difference of these 3 groups (material, machinery and labour). Selection criteria for key cost parameters of these 3 groups were to involve most common costs in all the projects reviewed. Key costs chosen present more than 70 % of costs in all projects. In total, 9 residential buildings projects constructed in Barcelona and Madrid with value between 3-15.000.000 euro and size of between 5-18.000 square meters are reviewed.

After key cost definition, their quotation in both countries is done and difference is measured. Short example of this calculation is given in the Table 1:

Table 1: Cost comparison between Serbia and Spain

Unit	Quantity	Cost in Serbia	Cost in Spain	Difference
Materials:				
Sand	m^3	7.5 €	8 €	93.75 %
Concrete MB30	m^3	67 €	63,89 €	104.87 %
Labour:				
Low qualified	1	2 €/h	16,61 €/h	12.04 %
Machines:				
Hand mixer 125 litres	1	189 €	212 €	89.15 %

Difference = cost in Serbia/cost in Spain. If price in Serbia is lower, difference column will be less than 100 %, while if price is higher, difference column will show more than 100 %.

Table 2 demonstrates two phases of construction project. Construction projects may be divided in 14 different physical construction steps starting with rough works, and ending with soft works. Construction phases are: 1) Soil movements, 2) foundations, 3) structure, 4) roof, 5) isolation, 6) enclosure, 7) wall lining, 8) pavements, 9) carpentry aluminium, 10) carpentry wood, 11) plumbing, 12) ventilations, 13) electricity and 14) portable water. For each construction phase proportion of material, labour and machinery and auxiliary resources involved is given. Short example of this division is presented in the Table 2.

Table 2: Labour, machinery, materials and auxiliary resource in different construction phases (source: Planet Cluster company)

Soil movements	**5,94 % of total project cost**
Excavation:	
Labour	15,29 %
Machines	65,61 %
Auxiliary resources	19,1 %
Levelling:	
Labour	31,88 %
Machines	24,64 %
Auxiliary resources	43,48 %

Table 3, connect first two tables and shows impact of price difference between Spain and Serbia in material, labour and machinery on the total project costs. Therefore Table 3 includes multiplication of the cost difference, involvement in phases and impact on the total price of the project. Short example of the table 3.

Table 3: Cost differences impact on the total cost of the construction projects

		Labour	Machinery	Auxiliary resources		Reduction of Costs	Impact on costs	Total cost reduction
		16,11 %	76,15 %	69,36 %	.....			
1. Soil movements	Excavation	15,29 %	65,61 %	19,10 %	.....	65,67 %		
	Levelling	31,88 %	24,64 %	43,48 %	.....	54,06 %	5,94 %	3,25 %
	Transport of soil mass		43,59 %		.....	44,48 %		
					.....			
2. Foundations	Level rising	38,91 %		13,58 %	.....	66,78 %		
	Core walls	27,06 %		2,26 %	.....	81,94 %		
	Foundation	24,83 %	2,55 %	2,38 %	.....	83,14 %	5,23 %	4,25 %
	Pile caps	1,92 %		0,39 %	.....	105,65 %		
	Bases construction	41,38 %		3,44 %	.....	68,40 %		
					.....			
3. Structure	Slab	9,07 %	0,04 %	0,13 %	.....	99,19 %	13,96 %	13,85 %
								.....
								73,35 %

Basically, the rows of the table present Table 2 and columns (captions) take the results from the Table 1. In the final three columns of the table (reduction of costs, impact on costs, total cost reduction) results and impact on the final project cost can be observed.

Columns with results (reduction of costs, impact on costs, total cost reduction) are the one we need for the cost analysis.

- Reduction of costs is calculated as a sum of the multiplications of the elements in row and column. Sum product matrix excel function was used. The purpose of this calculation is estimate reduction in price of one action keeping in mind all the cost involved. In the table example, excavation phase in Serbia is cheaper and costs 65,67 % of the price in Spain.
- Impact on costs, is taken from the Table 2. This column shows how much is the cost of each construction phase involved in the total cost of the project. In other words, this column tells us how much will change in each construction phase change total project budget.
- Total cost reduction, is calculated as a multiplication of one reduction of cost of the construction phase with percentage presenting construction phase´s impact on the total project cost. Both columns are already explained in the text. What kind of information is given by this column? Each construction's phase involvement in the final projects budget. Summing up the rows will give us the impact on the total project price. From the table presented we can see that sum is 73,35 %. That means that construction project budget in Serbia will be 73,35 % of budget in Spain. Therefore, It can be concluded that same project from Spain executed in Serbia will be for one quarter cheaper.

4.1 Result analysis

Cost analysis presented in Tables 1, 2 and 3 creates foundation of this research paper and they show: cost comparison, construction phases division (financial and project resources) and cost difference impact on total project costs.

The key outlines from these tables are (key cost parameters are presented in Table 1):

- In average, labour is five times cheaper in Serbia;
- Difference between low and highly qualified labour in Serbia is close to 250 %;
- Materials in Serbia are cheaper but with lower quality;
- Biggest cost reduction in the project is coming from enclosure, wall lining phase and carpentry construction phases influenced by low labour and wood prices in Serbia;
- Projects in Serbia cost around one quarter less in comparison with Spain.

4.2 Sensitivity analysis and graphical presentation

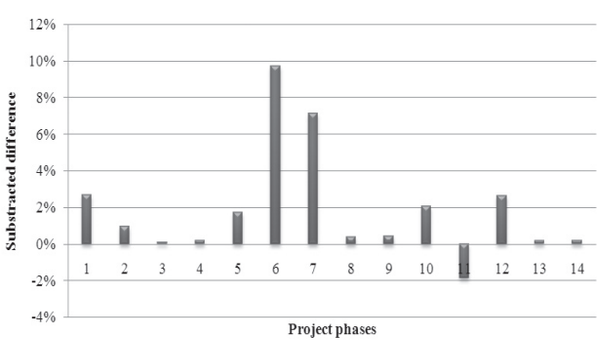

Figure 2: Subtracted impact of Spanish project with Serbian project

Figure 2 is based on the cost difference in construction steps coming from the Table. On the axis, fourteen phases of

construction are marked. Percentage on the vertical bar presents difference between Spanish and Serbian market.

Phases 6 and 7 (enclosure and lining) are creating the greatest cost difference of around 15 %, while the total difference between cost of project in Serbia and Spain is 26,65 %. Also, negative impact can be observed in the phase 11 (plumbing), which means that phase 11 is more expensive in Serbia compared to Spain.

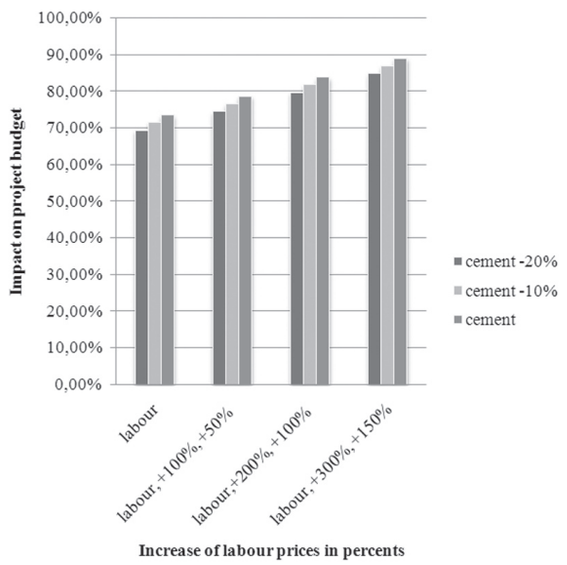

Figure 3: Sensitivity analysis of labour price increases and cements price decrease

Table 4: Sensitivity analysis of labour price increases and cements price decrease

	cement -20 %	cement -10 %	cement
Labour	69,23 %	71,29 %	73,35 %
labour, +100 %, +50 %	74,39 %	76,45 %	78,52 %
labour,+200 %, +100 %	79,56 %	81,62 %	83,68 %
labour, +300 %, +150 %	84,72 %	86,78 %	88,84 %

Sensitivity analysis was done for two units: cement and labour. Those units are chosen to be investigated since they are expected to change in the future.

Labour prices in Serbia are expected to rise significantly. Three groups of labour are identified and prices are increased from 50 to 300 %. At the same time prices of cement in Serbia are decreased. Entering EU will probably imply labour prices increase, and termination of the cement price lobby in Serbia, and therefore price decrease.

Changes in prices are showed in Figure 3, both in table and on graph, for better presentation of the results. From the results obtained using Table 4, it can be seen that impact on the project budget changes from 69,23 % to 88,84 %. Therefore, in the future we can expect that the price difference will decrease between Spain and Serbia but it still expected that constructing in Serbia will be cheaper. Also, it may be observed that just two units have changed the price and that it influences significantly on the cost analysis.

5. Risk identificationst

Risks in construction projects are widely discussed in literature, in this article we focused on prioritizing and comparing risk in Serbia and Spain. Serbia is not a European Union member, labour wages are much lower, regulations are stricter in Spain, geographical location and climate is much different between these two countries.

Therefore, risks with higher probability of appearing in Serbia are:

- Financial risk is highest in the Serbian market
- Currency fluctuation is pretty high in Serbia and it is important to develop a strategy
- Preconstruction preparation and wrong project estimation risk are available in Serbia due to the poor ground installation schemes and little time devoted
- Security risk of the workers is a consequence of lower regulations
- High labour rotation is a consequence of low salaries
- Climate risk is much higher in Serbia and winter period present a potential problem
- Political risk is higher in Serbia due to the political instability in the area
- Supply chain management risk is higher in Serbia due to existence of borders

In Spanish market:

- Time management risk, penalties for project delays are much higher and therefore, more important.
- Contract risk, due to the better law system in Spain, contract agreement has greater impact in Spain
- Quality offered and expected in the market is much higher.
- Greater diversity of construction technologies are available and used in Spain than in Serbia.

6. Conclusion

The global aim of this research paper was to improve project management in construction projects. Specific objectives of the research were focused on cost estimation improvements, cost analysis and its impact on cost differences on the project budget and finally, risk identification and differences in both markets.

Conclusions of the interviews conducted are the following:

- Biggest change in the project price comes from the additional works performed (which are out of the project scope) and not from the poor cost estimation process.
- Biggest threat to the construction projects in Serbia is coming from the financial risk.
- Short time for project planning causes two main problems: wrong project specification leading to the wrong project scope definition and wrong estimation of the current situation on the construction site arising from bad preconstruction preparation and estimation.
- Currency fluctuation is affecting the construction market in Serbia due to the fact that most of the machines and materials are imported and time (price)

difference between planning and execution phase. This fact significantly affects cost estimation process.
- Climate risk is present in both markets but in Serbia is of greater importance and affects flow of operations.
- High labour rotation on the construction sites (due to law salaries, no learning curve exploitation)

According to previous objectives, the following key conclusions are summarized:
- Cost estimation methodology is proposed and seven different cost groups are identified.
- Four conclusions can be obtained from the cost analysis:
  - Construction project budget in Serbia is 27 % cheaper compared to Spain. In average, materials, labour and machinery is cheaper in Serbia but the cost analysis provide us exact impact of those cost differences on the project budget.
  - Serbian market is suitable for prefabrication technology and also specialization trainings are preferable. This conclusion is due to the high cost difference of the labour categories, and low labour prices in general.
  - Tight management control is needed in two construction phases: enclosure and wall lining, due to the quality risks.
  - Possibility of using materials, labour and machinery from Spain for the project executed in Serbia was investigated, and no clear opportunity was identified.
- Risk identification in the Serbian and Spanish markets is created. Risk more expected to happen in Serbia are: financial, currency fluctuation, preconstruction preparation, security, climate, political and supply chain management. Risks of significance in Spain are: time management, contract, quality and construction technology.

In summary, with all the information provided in this paper, construction companies interested in Serbian market will be able to improve project management in areas of: cost estimation and risk control, associated with future projects implemented in Balkan area. The whole costing model puts together different cost components and can be easily updated.

References

[1]. Akintoye, A. (2000). Analysis of factors influencing project costs estimating practice, Construction Management and Economics, vol. 18, issue 1, p. 77-89.

[2]. Akintoye, A.; MacLeod, M. J. (1997). Risk analysis and management in construction, International Journal of Project Management, vol. 15, issue 1, p. 31-38.

[3]. Smith, A. E.; Mason, A. K. (1997). Cost Estimation Predictive Modeling: Regression versus neural network, The Engineering Economist: A Journal Devoted to the problems of Capital Investment, vol. 42, issue 2, p.137-161.

[4]. Tonquist, B. (2004). Project management, Bonniers

[5]. Fitzgerald, E.; Akintoye, A. (2000). A survey of current cost estimating practices in the UK, Construction Management and Economics, vol. 18, issue 2, p. 161-172.

[6]. Kanda, J.; Shah, H. (1997). Engineering role in failure cost evaluation for buildings, Structural Safety, vol 19, issue 1, p. 79-90.

[7]. Project Management Institute. (2008). A guide to the project management body of knowledge, PMI: USA.

[8]. de Hereida, R. (1995). Direccion Integrada de Proyecto - DIP- Project Management.

[9]. Brealey, R. A.; Myers, S. C.; Allen, F.; Mohanty, P. (2007). Principles of corporate finance,8th edition.

[10]. Sonmez, R.; Ontepeli, B. (2009). Predesign cost estimation of urban railway projects with parametric modeling, Journal of Civil Engineering and management, volume 15, issue 4, pp. 405-409.

[11]. Macomber, J. D. (1989). You can manage construction risks, Harvard business review, publication date: Mar 01, 1989. DOI: 10.1225/89210, p. 119-141.

Miloš Jovanović is a PhD student at University of Novi Sad, Faculty of Technical Sciences, Industrial Engineering and Management department. He has five year integrated study MSc degree in Electrical Engineering, from University of Novi Sad. After that he finished international two year master program in Industrial Management and obtained joint degree from 3 Universities: Politecnico de Madrid, Politecnico di Milano and Royal Institute of Technology (KTH) Stockholm. He has done 6 month intership at Planet Cluster construction consultancy company in Madrid, where important input to this research paper was created. His research field is Project Management.

José Moreno Pérez is Professor of Business Administration degree in Industrial Engineering in the Department of Industrial Engineering, Business Administration and Statistics, School of Industrial Engineering at the Polytechnic University of Madrid. He has a PhD in Industrial Engineering from the Polytechnic University of Madrid. He has long working experience as an auditor and his research field is Management Control.

Bojan Lalić, M. Sc., graduated at Faculty of Technical Sciences at University of Novi Sad, Serbia in the field of industrial engineering and management. Since 2002 he is working as research and teaching assistant within courses Operation Management, Production Systems, Strategic Project Management and Electronic Business. He is author and co-author of numerous papers in international Journals. Bojan is lecturer at MBA program and specialistic study programmes. M. Sc. Lalic is Institut Program Manager at Cisco Entrepreneur Institute.

Vladimir Todorović is M. Sc. student at University of Novi Sad, Faculty of Technical Sciences, Industrial Engineering and Management department. He has five year integrated study MSc degree in Electrical Engineering, at the Department of Power, Electronics and Telecommunications Engineering at University of Novi Sad. He was a project management member of the first student Tempus project implemented in Serbia: "Implementation of Students' Parliament in Serbia and Montenegro". His research field is Innovation and Project Management.