NETWORK ANALYSIS OF THE SERBIAN INNOVATION ECOSYSTEM

Author Bojan Branovacki
Editors Branka Andjelkovic & Tanja Jakobi
Public Policy Research Centre

INTRODUCTION

This analysis aims to shed light on the collaboration between the public, private, and academic spheres in Serbia, and identify if they create new knowledge to drive innovation. The concept of cross-organizational collaboration emerged in innovation theories during the 1990s with economists' understanding that the complexity of innovation requires interactions within the organization itself, but also a collaboration with other organizations and systems. The hypothesis was that innovation does not take place in isolation but in collaboration and interdependence with other parties (Edquist, 1997). In the Serbian context, the development of the innovation activities was in the past characterized by the lack of links between various spheres of the national innovation system (NIS), and as a result, weak collaboration within it (Kutlača, Semenčenko, 2015). At the same time, NIS in Serbia is pretty young; it emerged only at the beginning of the 21st century, this potentially being one of the reasons for such situation (Miletić, 2019).

Against this background, the study examines the existence of linkages between different types of actors in order to identify which parts of the NIS have been creating the densest networks. This analysis is the first step in depicting the collaboration potential of the Serbian innovation system. It highlights the most important dimension of the collaboration, leaving the nature of networking of actors and the intensity of their collaboration for next research phase. With this broad aim in mind, the analysis shall provide insights into a milieu in which business innovation in Serbia takes place, while also pointing to potential changes regarding the collaboration between different innovation actors in Serbia.

The paper is composed of four parts: the Conceptual Framework, Methodology, Results and Conclusion. The data collection and analysis were carried out from September until December 2021 within the Project Serbia Innovates, supported by USAID in Serbia.

CONCEPTUAL FRAMEWORK

Collaboration in innovation ecosystem

Collaboration in an innovation ecosystem envisages a network of interconnected stakeholders, organized around a central topic or a platform that incorporates both production and use side participants, and focuses on development of new value through innovation. As complexity of innovation requires interactions in the organization itself (among its units), but also a collaboration with other organizations (Bhardwaj, 2019), developing relationships with different actors becomes a cornerstone of innovation. Members of an ecosystem are interlinked by common objectives (value propositions or market goals), and involved in the joint creation of value (Adner, 2006). They need to make the most of each other's resources and capacities (collaboration resources) to achieve those goals (Adner & Kapoor, 2010; Nambisan & Baron, 2013; Panetti, et. al., 2020). From the collaborative perspective of an innovation-driven system, interconnected relationships outline the network through which stakeholders overcome their resource constraints (Cooper & Folta, 2008). Networking provides stakeholders with the knowledge they need for seizing new opportunities through a flow of information in extended networks (Owen-Smith & Powell, 2004).

Networking is often compared to social capital (Woolcock & Narayan, 2000), which is defined as 'social, non-formalized network that is created, maintained, and used by the network's nodes/actors in order to distribute values, preferences, and other attributes and characteristic, but which also emerge as a result of actors sharing some of these attributes (Westlund, 2006). For Putnam (1993), social networks are one of three components of social capital, and they can be both informal and formal (e.g., strategic alliances, joint ventures). A well-functioning economic system will surely have accumulated social capital (Putnam, 1993).

From triple helix to multi-helix model of collaboration

Scholars increasingly conceptualize innovation ecosystems as a multiple sectors environment, i.e., a set of actors who collectively play an important role in influencing innovative performance. This kind of model reflects the increasing complexity of knowledge creation and innovation and emphasizes that multi-actor innovation ecosystems rely on the dynamic and flexible interaction of diverse spheres, rather than a number of synchronized, stable processes. However, it is not easy to design unique criteria for reliable analysis of collaboration due to the complexity of networks between various and heterogeneous stakeholders. A helix model is an analytical framework for explaining knowledge-based socio-economic changes and innovation-driven development. The various helix models define collaboration and consequently bidirectional flows of knowledge over different timescales between the multiple stakeholders.

One of the well-known theoretical frameworks that explain the relationship between the collaboration and innovation process is the triple-helix model (Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003). It emphasizes the importance of cross-sectoral collaboration and deems innovation dependent on networking between the public, private, and academic spheres to create new knowledge to drive innovation. As suggested in Leydesdorff and Fritsch (2006), the triple-helix concept tried to emphasize that the exchange of information in the triangle universities-industry-government leads to the creation of knowledge and its commercialization.

However, contemporary practices stress the need for novel approaches that will modify and exceed the triple-helix model, by outbuilding wider concepts of Quadruple or Quintuple innovation helices aimed to include additional stakeholders in the network (Carayannis & Campbell, 2009; Carayannis & Rakhmatullin, 2014). Such theoretical design often stems from various, ecosystem-specific, innovation networks and allows other actors to be considered as an important part of an innovative system, giving them the role of intermediate actors, or innovation-enablers in cross-sector collaborative schemes (Ponchek, 2016). Whether it is SMEs, large companies, startups, science, civil society, financial sector, or government, they all are specific nodes in knowledge circulation and innovation creation structure. They together foster innovations while these same innovations must arise from ideas that in turn arise in research and development and altogether generate scalable economic and social impacts (Lopes & Farinha, 2018).

Regardless of the number of actors in the helix model(s), they have been associated with two primary claims: first, the ability to describe and explain the growing interactions between different societal subsystems as basic characteristics of contemporary innovation processes, and second, the ability to evaluate and actively promote or revise the nature and interactions within and between the respective spheres.

Empirical evidence and multi-helix models

Most of the empirical studies have referred to the triple-helix framework, focusing on relations between industries and universities (Leydesdorff & Park, 2014) as the most developed form of collaboration in creating innovation. The evidence of networking within national ecosystems stresses out either high level of industry-business interactions or university-industry interactions. In the Netherlands (Leydesdorff, et. al., 2006), Germany (Leydesdorff & Fritsch, 2006), and the most innovative Czech regions (Kadlec & Blazek, 2015) the first model prevails. Other studies pointed to the strong university-industry collaboration. Finland, Austria, Belgium, Denmark, and Sweden were also identified as systems with the intensive and well-balanced university-industry collaboration. On the opposite side are Poland and Bulgaria where university-industry interactions were identified as the weakest (Seppo, et. al., 2014).

Within this framework, university and particularly research institutions continue to be in a strong position as knowledge generators (Schütz, et. al., 2018). However, their conventional role is called into question. Practices showed that knowledge and innovation are no longer produced solely within academic institutions, but also by heterogeneous groups of actors, through so-called mode 2 knowledge production as the result of collaboration between industry and university (Schütz, et. al., 2018). When it comes to government as the third party in triple-helix framework, depending on the structure of the innovation ecosystem, government actors play the role(s) of "enabler", "decision maker", "supporter", "utilizer", "developer", "marketer", and/or "quality controller in processes of innovation creation (Arnkil, et. al., 2010). In that sense, they continue to be one of the key actors in this triple-helix equation.

Identifying empirical studies in the context of the Quadruple/Quintuple helices is more demanding task. Studies by Carayannis and Grigoroudis (2016) emphasized the role of civil society in the innovation ecosystem using the experience of European regions in implementing smart specialization strategies. The authors explained that civil society is a key actor in innovation processes along with university, industry, and government. Civil sector is frequently the end-user of innovation and thus has a strong influence on the generation of knowledge and technologies via its demand and user function. Some other authors (Mineiro, et. al., 2021) expand the collaborative scheme, pointing out to incubators and science parks as enablers in innovation networks. However, this kind of empirical research remains limited in scope.

As noted, majority of studies have explored the triple-helix connections while networking in more extended models has started to draw interest of researchers only recently. In this regard, our research setting is framed to explore collaboration between heterogeneous actors within multiple-helix model.

METHODOLOGY

The theoretical framework to identify actors in the Serbian economy relied on the multiple-helix model. In this paper, collaboration is understood as networking of different actors such as industry, startups, university, government, financial institutions, and civil society, with the aim to jointly drive knowledge and generate innovations within the national innovation system. Our analysis is based on the assumption that all these actors create a collaborative network in the Serbian innovation system. For instance, most of the previous analyses of networks carried out in other countries mainly included traditional companies, not taking into account the actors who are very important generators of innovation - startups. Furthermore, the absence of financial institutions and other supporting actors from the innovations network has been also noticeable. We believe that such innovation system that stimulates collaboration between different types of stakeholders would result in accelerated economic growth of the Serbian economy.

Network Analysis

We use Network Analysis to examine relationships between the identified innovation actors. Network analysis, as "a distinct research perspective within social and behavioral sciences" (Wasserman, 1994), is a set of analyses used to examine relationships between entities in a system or a system as a whole. A network is a set of nodes and edges that connect and "transmit information" between nodes. In addition to the nodes and edges themselves, networks contain information about the nature of the relationship between these components. Network Analysis can help us understand the structure and relationships of the analyzed system, as well as the most influential actors in that network, offering conclusions about individual actors as well as the whole system.

Network Analysis offers a graphical representation of the analyzed system, but also a number of different statistics used to quantify and determine the importance of different nodes or edges in the network. It is usually important and valuable to understand which nodes are of greater importance in the network to be able to better understand the analyzed relationships. Since in most networks, more connected, i.e., more important nodes are algorithmically placed closer to the center of the networks, nodes which are more centered than others are usually more important for the system.

Centrality indices allow us to quantify and examine the centrality of nodes in the network. Freeman (1978) states that central nodes have three basic advantages over peripheral nodes in the network. Concretely, they have more connections, can reach other nodes in network faster (via shorter paths) and control the flow between nodes in the network. There are different indices defined to quantify centrality, but in the context of innovative networks, highest importance is placed on the degree centrality, followed by the betweenness centrality. Degree centrality represents the number of all direct connections a node has in the network, i.e., with how many nodes it is directly connected. The higher degree centrality indicates that organizations are having more direct connections, that they are likely to hold and store information and quickly distribute high levels of information and connect to different parts of the network. We believe that this centrality is of utmost importance when discussing networks of innovative collaboration as high degree centrality indicates the most important organizations in the network. Additionally, betweenness centrality could also be important when analyzing innovative networks. It measures how often a node lies on the shortest path (the shortest path represents a path that takes least number of edges to connect a pair of nodes) between all other pairs of nodes, showing the extent to which, the node facilitates the flow of information through the network. The high betweenness could indicate nodes (organizations) which could impact the flow of the information around the system, as they lie on paths which connect many nodes.

Research design

The multiple-helix model was chosen because it more completely encompasses different actors of the economy compared to the other models. Our data is a snapshot of one point in time based on stratified samples of actors, collected from informants from different sectors. Thus, the multiple-helix model within our analysis includes six main sectors:

1) business sector (traditional industry, i.e., small, medium, and large companies);

2) startups (entrepreneurs, small innovative teams, and newly-founded companies);

3) academia and research sector (universities, institutes, and other research organizations);

4) civil sector (non-governmental organizations which support innovations in the NIS);

5) public sector (government and its organizations and bodies);

6) financial sector (financial organizations, i.e., banks, VC funds, insurance companies, etc.).

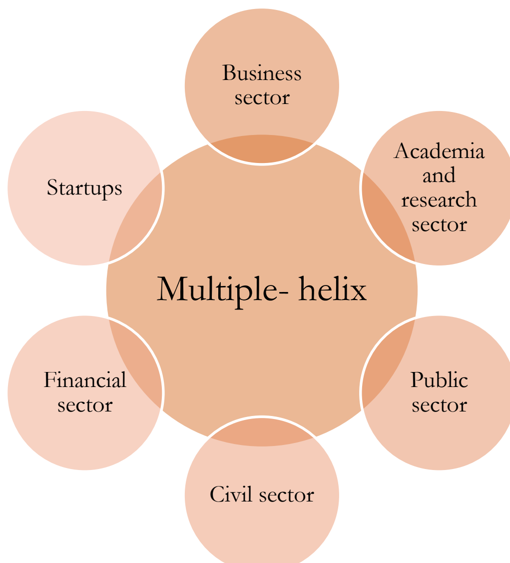

Figure 1. Multiple-helix model

Two helices, startups and financial sectors were added to the model to better reflect the reality of the Serbian innovation system mapped through previous research.

Each participant in the study, representing its organization, is asked whether they had collaboration with other organizations in developing, exchanging, using and monetizing knowledge, technologies and/or innovation in the last 5 years, and that question was asked separately for each of the six-parties in the multiple-helix model. If the answer to the question(s) is positive, i.e., they have established collaboration, participants were asked to cite up to three organizations they are cooperating with in that multi-helix model. Therefore, each organization could state from 0 up to 18 possible partners in a collaboration process regarding innovations. However, since the same organization could be cited by others as a partner, the potential number of connections was higher than 18. The answers we obtained are the base for building the network.

Sample

The nodes in the network consisted of both participants who participated in the survey - 360 representatives of organizations operating in Serbia and of 407 organizations which were named as collaborators by the participants in the survey. In total the sample consisted of 767 nodes. The organization structure of the sample is presented in Table 1.

The analyzed network encompasses all mentioned organizations, regardless of whether they are in the sample (participated in the survey) or are only mentioned as collaborators by the survey respondents and not encompassed by the sample. Thus, the presented network exploits all available information. However, the piece of information is missing about the organizations which were mentioned by survey respondents but were not in our sample. We only know that they are collaborators of our respondents from the sample but we don't have access to the information about their collaborators.

Data analysis

The network analysis is performed in the graph package for R computing language according to the approach and procedure developed by Epskamp et. al. (2012). The matrix used for the network has rows and columns which represent organizations. Each cell had a value of either 1 or 0, 1 signifies the existence of collaboration between organizations while 0 signifies the absence of collaboration. The network is symmetrical, meaning that if the organization A states that it collaborates with organization B, but organization B doesn't state the organization A, their collaboration was considered as if both organizations are stated by each other and indicated as such in the input matrix. This is done because the question which is the basis for the network doesn't examine direction of the influence but only the existence of collaboration. According to that, it is assumed that if the organization A is not cited by organization B (but B is cited as a partner by organization A), that the organization A is not in the top three collaborators of the organization B. The algorithm used for network graphing is force-directed algorithm which iteratively places the nodes with most connections near the center of the graph, while the less connected nodes are positioned further away from the center. The length of the edge is only the byproduct of the force directed graph algorithm and node positioning. Therefore, it has no meaning in itself.

Limitations

Some of the organizations could not state their collaborators because of confidentiality agreements and policies. Thus, it is possible that real connectedness of organizations is somewhat higher (in addition to this reason, non-existent answers in general and invalid / wrong answers are also the reason for the lack of certain connections). There were 80 organizations which stated they collaborate with at least one sector, but did not give an answer (or gave invalid answer) when asked to state concrete collaborators. This was prevalent in highest degree amongst the participants from industry and startup sector (59 out of 80 cases) so it is possible that the real connectedness of organizations from these sectors is somewhat higher.

Another limitation relates to the dimensions examined. This analysis leaves out the nature of networking of actors and the intensity of their collaboration for the next research phase.

RESULTS

Descriptive statistics

In total, there are 1794 edges i.e., collaborations between the 767 nodes. Each node is having in an average 2.34 edges (SD = 4.01) to other nodes which signifies on average low collaboration. **Sectors that seem to be at the forefront of innovative collaboration, at least in terms of the number of collaborative activities, are academic and research sector and public sector**. **The business, financial and startup sectors on the other hand, seem to have the least number of links with other market players in innovations development. Inspection of the network graph (Figure 2) offers some additional conclusions. For example, there are 147 organizations that do not have any innovative collaboration, and most of them are from the business sector** (n = 129, 87.7%), while none are from the academic and research or public sector. It seems that financial sector institutions are mostly on the periphery of the network, which is expected as the financial sector acts primarily as a facilitator and as such it is rarely directly involved in the innovation activity. Center of the network is populated mostly by academic and research sector and public sector organizations, but also with business sector organizations that collaborate with them. Startups, civil sector and business sector seem scattered all over the network, possibly indicating different fields in which they cooperate and innovate.

If we compare the organization structure of the sample and all nodes, the biggest increase, ratio wise, emerges for the public sector which has more than 12 times more representatives when all information is considered.

This analysis clearly shows the cleavage between those actors with the collaboration potential and the ones that are lacking it. Prominent role of the public sector in collaboration can be explained by the fact that the innovation activities in Serbia are mainly driven by the state.

Table 1. sample distribution and average edges per multiple-helix member in the network

	Within sample (participants)	All nodes	Average number of edges (all nodes)
Academic and research sector	44 (12.2%)	126 (16.4%)	5.25
Business sector	250 (69.4%)	439 (57.2%)	1.32
Startup sector	41 (11.4%)	58 (7.6%)	1.90
Civil sector	14 (3.9%)	60 (7.8%)	2.85
Public sector	5 (1.4%)	67 (8.7%)	3.75
Financial sector	6 (1.7%)	17 (2.2%)	1.29
Total	360	767	2.34

Source: Author's calculation

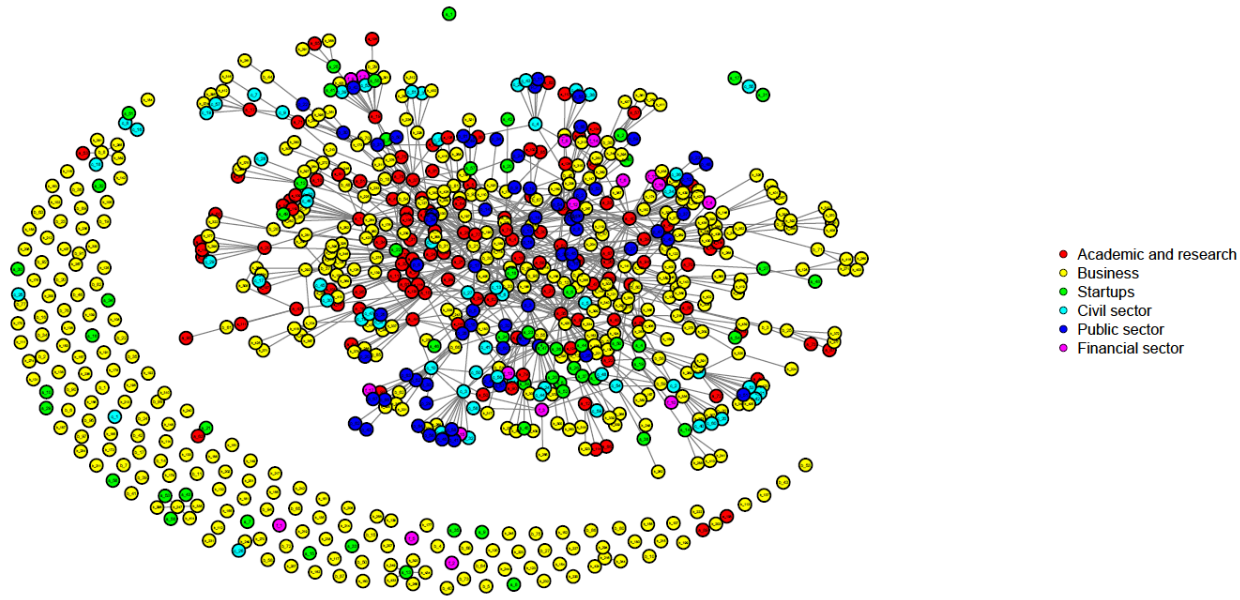

Figure 2. The network of innovative collaboration in the Serbian economy

Intra and inter-sectoral collaboration

Average collaboration of sectors i.e., average number of edges, with its own and other multi-helix sectors is presented in Table 2. The intra-sectoral collaboration is presented in the diagonal. **Highest level of intra-sectoral innovative collaboration is present in the academic and research sector where an average institution is connected to more than two academic and research institutions**. **For all other sectors, average number of intra-sectoral collaborations is lower, lowest being for financial sector which had no intra-sectoral collaboration.** Academic and research and public sectors, on average, have most links with other sectors, primarily with businesses. Prototypical institution from the academic and research sector has almost 2 collaborations with business sector, while public sector organization has on average 1.5. Business sector, i.e., traditional industry has on average most links to academic and research sector (0.56) and public sector (0.23). Average startup has most connections with academic and research sector and business sector. Civil sector organizations on average have similar levels of connections with academic and research, business and public sectors.

The analysis shows that most of the innovative actors still reside in their silos and rarely collaborate even among themselves. Some insights into newly formed innovative companies in Serbia also suggest that often these companies have a very short value chain (Udovički, et. al., 2019) which at least partly explains low level of collaboration among businesses.

Table 2. Average number of edges (collaborations) between sectors

	Academic and research sector	Business sector	Startups sector	Civil sector	Public sector	Financial sector
Academic and research sector	2.05	1.97	0.24	0.31	0.63	0.06
Business sector	0.56	0.33	0.09	0.09	0.23	0.02
Startups sector	0.52	0.69	0.21	0.17	0.29	0.02
Civil sector	0.65	0.67	0.17	0.63	0.63	0.10
Public sector	1.18	1.49	0.25	0.57	0.24	0.01
Financial sector	0.41	0.41	0.06	0.35	0.06	0.00

Source: Author's calculation

Degree and betweenness centrality

In total, there were 30 nodes with degree centrality over 10, i.e., had more than 10 direct connections, which is considered as high. Amongst those nodes, 60% of them belong to academic and research sector, 23.3% are from public sector and 16.7% percent are from civil sector. In case of betweenness centrality, academic and research sector is represented by 20 (66.7%) organization amongst the 30 top rated ones. The remaining 10 organizations are coming from public sector (5), civil sector (4) and business (1). In order to better understand the innovative collaboration in the network and the role of the most connected organizations, ten most connected organizations are named and presented on the network (Figure 3.) and in the Table 3. There is a high degree of similarity between degree and betweenness centralities as the 4 most connected nodes also make up the top 4 nodes with betweenness centrality, and amongst the 10 nodes with highest betweenness centrality there are only 2 of the 10 nodes with highest degree centrality missing. **Amongst the 10 most connected organizations, large faculties occupy 7 out of 10 spots. This indicates that academic and research institutions are central organizations when it comes to innovative collaboration in the Serbian economy. On the other hand, there are also some public sector organizations which appear amongst the most connected, namely Innovation fund and Ministry of Education, Science and Technological Development,** which indicates the importance of state and its facilitator role in the process of innovation.

The results also reflect the concentration of the public innovation institutions in Belgrade and concentration of the major academic and research institutions in Belgrade and partly Novi Sad. It remains to be seen whether recent investments tend to worsen a more regionally balanced innovation system.

Table 3. Key organizations in terms of network centrality

Node – organization	Degree centrality	Degree ranking	Betweenness centrality	Betweenness ranking
Faculty of Economics, University of Belgrade	42	1	22845.4	3
Faculty of Electrical Engineering, University of Belgrade	40	2	26363.6	1
Innovation fund	27	3	22519.0	4
Ministry of Education, Science and Technological Development	25	4	23362.6	2
Faculty of Technology, University of Novi Sad	24	5	12643.4	9
Faculty of Mechanical Engineering, University of Belgrade	24	6	14048.0	6
Faculty of Transport and Traffic Engineering, University of Belgrade	22	7	11181.0	10
Faculty of Medicine, University of Belgrade	20	8	9754.4	13
Faculty of Agriculture, University of Belgrade	20	9	9930.9	12
Chamber of commerce of Serbia	19	10	12905.6	7

Source: Author's calculation

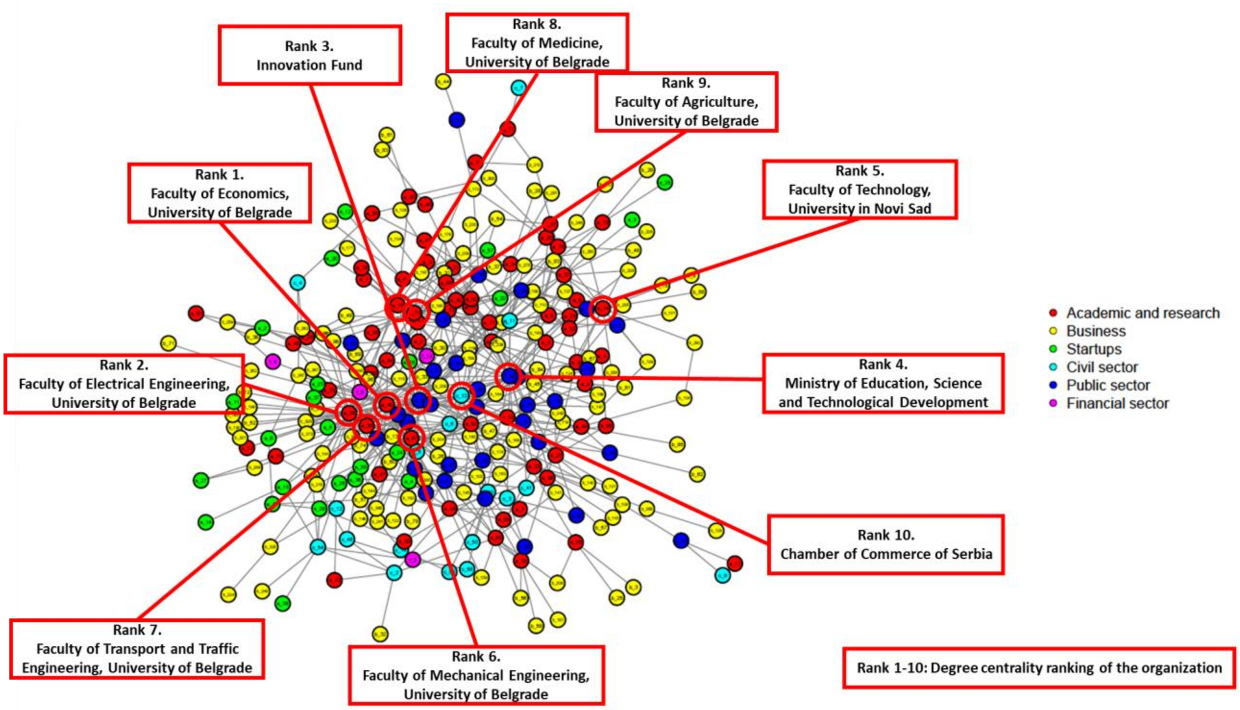

Figure 3. The network of innovative collaboration in the Serbian economy with 10 organizations with most collaborations named. On this network, organizations which have no connections to the central part of the network are removed (organization cluster which resembles crescent moon shape on Figure 2. is removed) in order to make network easier to interpret.

CONCLUSION AND NEXT PHASE

The network analysis of the Serbian economy based on the multi-helix model offers some novel insights when it comes to the landscape of national innovation system in Serbia. **Our results show that the organizations from academic and research sector are dominating nodes in the Serbian NIS. Additionally, the public sector and civil sector are playing an important role as well. If we observe public sector and publicly financed sector in an integral manner, we are coming to conclusion that the state is playing exorbitant role in national innovation system in Serbia.**

On the other hand, financial sector seems to have the least influence on the network when it comes to innovative collaboration. This result is not surprising because organizations from the financial sector are under strong-legislative regulation. Financial organizations are rarely, if at all, directly involved in innovation projects or financing high-risked innovative undertakings.

Maybe surprisingly, startups and business sector, i.e., traditional companies have similar pattern of innovative collaborations as it is the case by financial institutions. **Node with most collaborations had 10 edges in case of the business sector and 7 in case of startups, while average traditional company and startup had between 1 and 2 direct connections.** As noted earlier some of the organizations could not state their collaborators because of confidentiality agreements so it feasible that real connectedness of organizations is somewhat higher. **Regardless, at the lower level of the development of national innovation system, traditional companies and startups are lacking capacities and resources to engaging in innovative activities in broader scale solely driven by incentives coming from the market. It confirms our initial and central finding that the further development of national innovations system requires strong partnership with the state.**

However, further research is needed to deepen our understanding of innovation system in Serbia, especially regarding the quality of innovation linkages within it. For instance, our network shows the existence of the connections but not their fruitfulness or importance. For example, some actors may have created their own "small worlds" where they collaborate with only few parties but in very prolific manner which results in important innovations from business and/or societal perspectives. On the opposite side, some actors with lot of linkages may not have collaborations of such importance. Thus, exploring the nature and patterns of successful collaboration in Serbia between different actors may help us create seductive innovation processes which bring added value not only to particular actors in the innovation system but to the system as a whole.

LITERATURE

Adner, R. (2006). Match Your Innovation Strategy To Your Innovation Ecosystem. *Harvard Business Review*, *84*, 98–107; 148.

Adner, R., & Kapoor, R. (2010). Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in New Technology Generations. *Strategic Management Journal*, *31*, 306–333. https://doi.org/10.1002/smj.821

Bhardwaj, P. (2019). Types of sampling in research. *Journal of the Practice of Cardiovascular Sciences*, *5*, 157. https://doi.org/10.4103/jpcs.jpcs_62_19

Carayannis, E. G., & Rakhmatullin, R. (2014). The Quadruple/Quintuple Innovation Helixes and Smart Specialisation Strategies for Sustainable and Inclusive Growth in Europe and Beyond. *Journal of the Knowledge Economy*, *5*(2), 212–239. https://doi.org/10.1007/s13132-014-0185-8

Carayannis, E., & Campbell, D. J. (2009). "Mode 3" and "Quadruple Helix": Toward a 21st century fractal innovation ecosystem. *Int. J. Technol. Manag.* https://doi.org/10.1504/IJTM.2009.023374

Carayannis, E., & Grigoroudis, E. (2016). *Quadruple Innovation Helix and Smart Specialization: Knowledge Production and National Competitiveness*. https://doi.org/10.17323/1995-459x.2016.1.31.42

Cooper, A., & Folta, T. (2008). Entrepreneurship and High-technology Clusters. In *The Blackwell Handbook of Entrepreneurship* (pp. 348–367). https://doi.org/10.1002/9781405164214.ch17

Edquist, C. (1997). *Systems of Innovation: Technologies, Institutions and Organizations*. Pinter Publisher Ltd, London, UK

Epskamp, S. et. al. (2012). "qgraph: Network Visualizations of Relationships in Psychometric Data." *Journal of Statistical Software*, 48(4), 1–18.

Etzkowitz, H. (2003). Innovation in Innovation: The Triple Helix of University-Industry-Government Relations. *Social Science Information*, *42*(3), 293–337. https://doi.org/10.1177/05390184030423002

Etzkowitz, H., & Leydesdorff, L. (2000). The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University–Industry–Government Relations. *Research Policy*, *29*, 109–123. https://doi.org/10.1016/S0048-7333(99)00055-4

Freeman, L.C., 1978. Centrality in social networks: conceptual clarification. Social Networks 1, 215–239.

June, Arnkil, R., Järvensivu, A., Koski, P., & Piirainen, T. (2014). *Exploring the Quadruple Helix Report of Quadruple Helix Research For the CLIQ Project*.

Kadlec, V., & Blazek, J. (2015). University-Business Collaboration as Perceived by Leading Academics: Comparing and Contrasting the Two Most Innovative Czech Regions. *Erdkunde*, *69*, 327–339.

Kutlača, Đ., & Semenčenko, D. (2015). Nacionalni inovacioni sistem u Srbiji: prošlost, sadašnjost, budućnost. *Beograd: Institut'Mihajlo Pupin', Centar za istraživanje razvoja nauke i tehnologije*.

Leydesdorff, L., & Fritsch, M. (2006). Measuring the Knowledge Base of Regional Innovation Systems in Germany in Terms of a Triple Helix Dynamics. *Research Policy*, *35*, 1538–1553. https://doi.org/10.1016/j.respol.2006.09.027

Leydesdorff, L., & Park, H. W. (2014). Can synergy in Triple Helix relations be quantified? A review of the development of the Triple Helix indicator. *Triple Helix*, *1*(1), 4. https://doi.org/10.1186/s40604-014-0004-z

Leydesdorff, L., Dolfsma, W., & Panne, G. (2006). Measuring the Knowledge Base of an Economy in Terms of Triple-Helix Relations Among "Technology, Organization, and Territory." *Research Policy*, *35*, 181–199. https://doi.org/10.1016/j.respol.2005.09.001

Lopes, J., & Farinha, L. (2018). Measuring the Performance of Innovation and Entrepreneurship Networks. *Journal of the Knowledge Economy*, *9*. https://doi.org/10.1007/s13132-017-0487-8

Miletic, A. (2019). *Development of Innovations Infrastructure - Benchmarking the Leading Organizational Solutions with Serbia.*

Mineiro, A. A. C., Souza, T. A. de, & Castro, C. C. de. (2021). *The quadruple and quintuple helix in innovation environments (incubators and science and technology parks)*. https://doi.org/10.1108/INMR-08-2019-0098

Nambisan, S., & Baron, R. A. (2013). Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self–Regulatory Processes and Their Implications for New Venture Success. *Entrepreneurship Theory and Practice*, *37*(5), 1071–1097. https://doi.org/10.1111/j.1540-6520.2012.00519.x

Owen-Smith, J., & Powell, W. (2004). Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community. *Organization Science - ORGAN SCI*, *15*, 5–21. https://doi.org/10.1287/orsc.1030.0054

Panetti, E., Parmentola, A., Ferretti, M., & Reynolds, E. (2020). Exploring the relational dimension in a smart innovation ecosystem: A comprehensive framework to define the network structure and the network portfolio. *The Journal of Technology Transfer*, *45*. https://doi.org/10.1007/s10961-019-09735-y

Ponchek, T. (2016). To Collaborate or Not to Collaborate? A Study of the Value of Innovation from a Sectoral Perspective. *Journal of the Knowledge Economy*, *7*(1), 43–79. https://doi.org/10.1007/s13132-015-0290-3

Putnam, R. D. (1993). *Making democracy work: Civic traditions in modern Italy*. Princeton University Press.

Schütz, L., Gattinger, A., Meier, M., Müller, A., Boller, T., Mäder, P., & Mathimaran, N. (2018). Improving Crop Yield and Nutrient Use Efficiency via Biofertilization—A Global Meta-analysis. *Frontiers in Plant Science*, *8*. https://www.frontiersin.org/articles/10.3389/fpls.2017.02204

Seppo, M., Rõigas, K., & Varblane, U. (2014). Governmental Support Measures for University–Industry Collaboration—Comparative View in Europe. *Journal of the Knowledge Economy*, *5*(2), 388–408. https://doi.org/10.1007/s13132-014-0193-8

Udovicki, K., Medić, P., & Avlijas, S. (2019). *Competitiveness of Serbia's Economy in the Context of New Global Economy: Opportunities and Threats*. Belgrade: Public Policy Research Centre

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications*. Cambridge, UK: Cambridge University Press.

Westlund, H. (2006). *Social capital in the knowledge economy: Theory and empirics*. Springer Science & Business Media.

Woolcock, M., & Narayan, D. (2000). Social Capital: Implications for Development Theory, Research, and Policy. *World Bank Research Observer*, *15*, 225–249. https://doi.org/10.1093/wbro/15.2.225