

## EFFECTS OF INNOVATION LINKAGES IN THE CONTEXT OF NATIONAL INNOVATION SYSTEM DEVELOPMENT<sup>1</sup>

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Key words: national Innovation System, Innovations, Innovation Linkages Index, Global Innovation Index, Triple Spiral Model, Clusters

**Introduction.** Studies aimed at creating an innovative economy in Armenia and other countries of the former Soviet Union gained momentum during the transition to a market economy. Despite the different policies and tools used, the results are still not enough. One of the reasons is the existing problems in the field of operation of the national innovation system.

The guarantee of effective operation of the national innovation system is the existence of links between the various components of the system. The analysis of the latter is aimed at the study, within the framework of which the level of innovation linkages in the world, in Armenia, as well as in other EEU member states and neighboring countries of the Republic of Armenia has been studied. The level of innovation connections in general was studied, as well as according to the different directions of those connections. During the research, detailed reference was made to the "university-industry" cooperation in terms of research and development in different countries, the depth of development of innovation clusters, the depth of funding for research and development in foreign countries. Providing a high level of these three components allows the development of a national innovation system, which should contribute to the smooth transition to an innovative economy in the country. On the other hand, the analysis refers to indicators such as the number of transactions made for joint ventures or strategic alliances (Per Billion PPP\$ GDP), as well as patent families (Per Billion PPP\$ GDP). In fact, if it is possible to ensure the high level of work of these 5 components, a more developed and flexible system of innovative connections is provided. As a result of the research, some conclusions have been made, which aim to further strengthen the national innovation system of Armenia in terms of ensuring a higher level of innovation linkages.

**Methodology.** 6 indicators were included in the research. Based on the data of the World Intellectual Property Organization, the Innovation Linkages Index and 5

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sub-indices describing the latter (University-industry R&D collaboration, State of cluster development and depth, GERD financed by abroad, % GDP, Joint venture/strategic alliance deals (Per Billion PPP\$ GDP) and Patent families (Per Billion PPP\$ GDP) were observed. All indicators are presented as of 2021 and comparisons of indicators change compared to 2020 levels have been made. The study included the top three countries among 140 countries by the level of innovation linkages, cluster development level and depth sub-index. To the monitoring of the above-mentioned indicators in Armenia was given special importance. On the other hand, the indicators were observed in other EEU member states and in Armenia's neighboring countries: Azerbaijan, Georgia, Turkey, Iran. During the comprehensive research conducted in the mentioned countries, numerous diagrams were widely used to show the existing differences visually and practically.

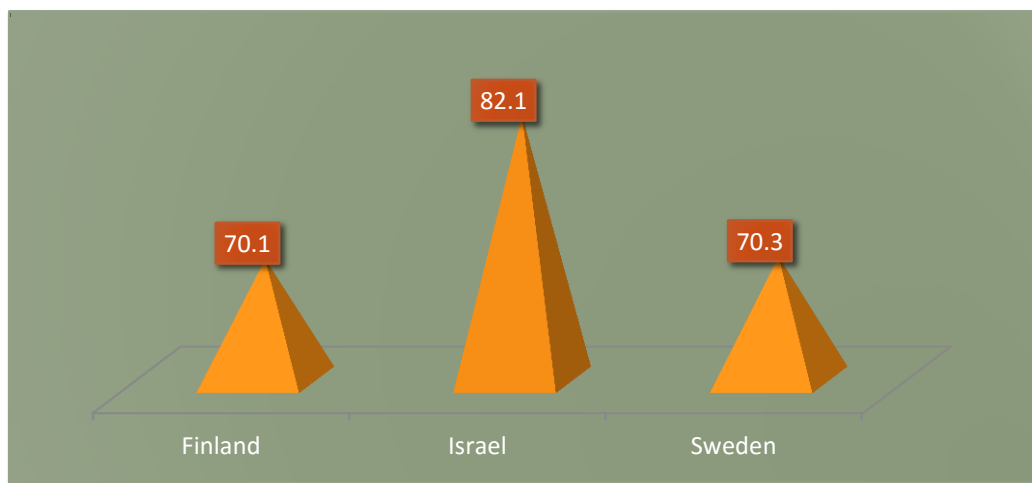
**Literature review.** Since 1980, a number of scientists-economists have been studying the issues of formation and development of the national innovation system. The founders of these directions are C. Freeman, B. Lundvall, R. Nelson, and S. Metcalfe [Bondarenko, 2018, 4]. There are many definitions of a national innovation system. This diversity - once again represents the complexity of the system and its dynamic nature. According to one definition, a national innovation system is a network of public-private sector organizations whose interaction promotes, introduces, modernizes, and disseminates new technologies [Freeman, 1995, 5-7]. In this definition one can pay attention to the term "interaction".

There are numerous studies, rich economic and modern literature on the national innovation system, its separate components and their interaction. In particular, C. Freeman in his study "Technology policy and economic performance. Lessons from Japan» [Freeman, 1987, 38-66] notes that the study of the structure and work processes of already formed and operating national innovation systems in developed countries shows that there are serious differences between countries, which correspond to their cultural, technological, socio-economic characteristics. In his work "Towards the fifth-generation innovation process" R. Rothwell [Rothwell, 1994, 7-31] introduces model of national innovation system development from the linear process to the triple spiral. As stated in N. Smorodinska's "Triple Spiral as a New Matrix of Economic Systems" article [Smorodinskaya, 2011, 66-78] the triple spiral model is a network interaction of three participants (science, state, business) in a hybrid social structure.

As stated in Y. V. Danilina's article "Problems of Balancing the Integration of Institutions of National Innovation Systems of the Russian Federation" [Danilina, 2018, 63-67] the problems of incomplete functioning of national innovation systems are due to in-

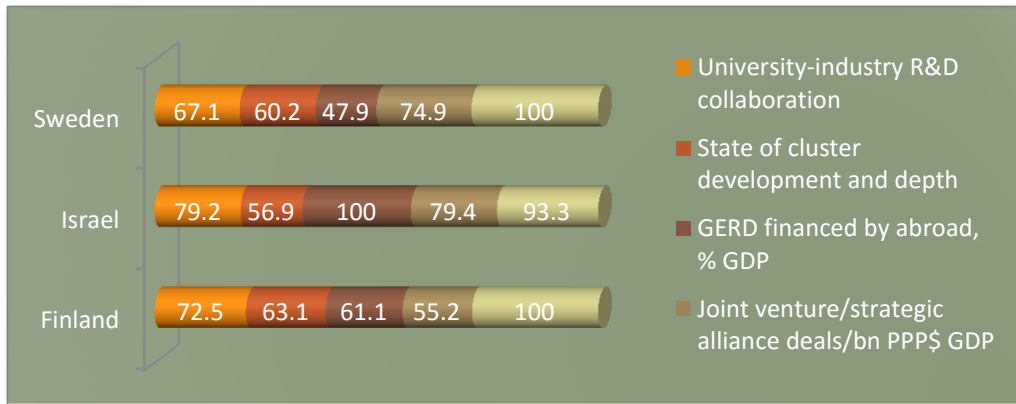
sufficient interactions or connections between participants in innovation processes. Moreover, weak innovation linkages prevent forming a complete chain from the idea to its realization in the market. The lack of an information communication environment is emphasized, in which it would be possible to carry out effective coordination and not only vertical, but also horizontal connections establishment.

**Analysis.** For the full and effective operation of the country's innovation system, it is necessary to ensure a viable level of innovation linkages. In this regard, it is important to understand the level of development of innovation linkages in different countries of the world.



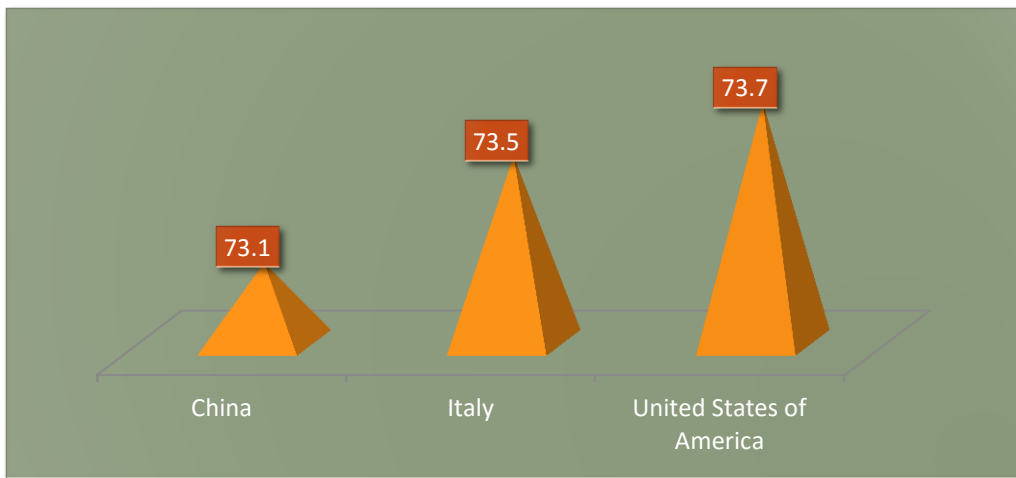
**Figure 1.** Innovation Linkages Index in Israel, Finland and Sweden in 2021  
[Source` Indicator Rankings & Analysis | Global Innovation Index]

According to statistics, in 2021, the first three places in terms of innovation linkages were occupied by Israel, Sweden and Finland, respectively. Israel scored 82.1 points in the Innovation Linkages Index, while Finland and Sweden scored 70.1 and 70.3 respectively. The innovation linkages of Israel and Finland have improved by 0.5 and 1.6 points, respectively, compared to 2020. In Sweden, the index decreased by 5.9 points. Why have these countries taken the lead? To answer this question, for each of the top three countries, it is necessary to consider the levels of the innovation sub-indexes as of 2021. Note that, for example, Israel has provided the highest level of foreign-funded domestic expenditure on research and development / GDP ratio. The latter was registered in 2021 at the maximum level of 100 points. Israel provided a high score for patent families, providing a score of 93.3. Sweden and Finland are the leaders in the index of patent families, which has been set at 100 in both countries. Examining the available statistics, we notice that the countries occupying the first three places have registered very low levels in terms of the state of development of the clusters and depth.



**Figure 2.** Innovation Linkages Index sub-indexes in Israel, Finland and Sweden in 2021  
 [Source` Indicator Rankings & Analysis / Global Innovation Index]

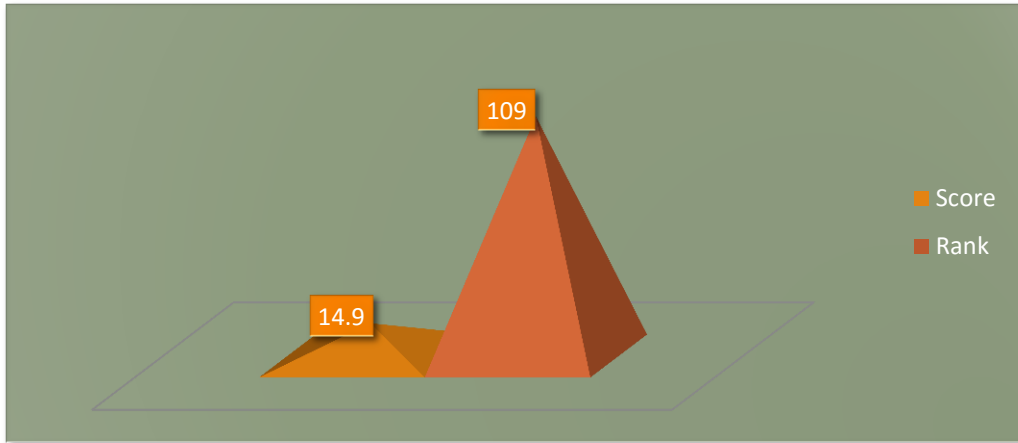
In particular, in 2021, Israel ranked only 32nd out of 140 countries in terms of depth of cluster development, with a score of 56.9. Finland and Sweden ranked 19th with 63.1 points and 25th with 60.2 points, respectively. Let's study the countries that have the best results of cluster development, depth and occupy the first, second and third place.



**Figure 3.** State of cluster development and depth sub-index in USA, Italy, China (2021)  
 [Source` Indicator Rankings & Analysis / Global Innovation Index]

The first place by the sub-index of the state of cluster development and depth belongs to the USA, where in 2021 the index result of 73.7 points was registered. It should be noted that the United States ranked 6th in terms of innovation linkages. Italy is in the second place at the level of 73.5 points. Italy ranks 27th in terms of innovation linkages. The third place belongs to China. In 2021, the latter ranked only 32nd in terms of the index of innovation linkages, and the third in terms of the depth and development of the

clusters with a score of 73.1. China has made significant progress in state of cluster development and depth. The index has increased by 13.5 points in 2021 as compared to 2020. The United States and Italy, on the contrary, had a setback.. The index has decreased by 1.1 and 1.4 points compared to 2020, respectively. Armenia still has a lot to do in terms of innovation linkages.



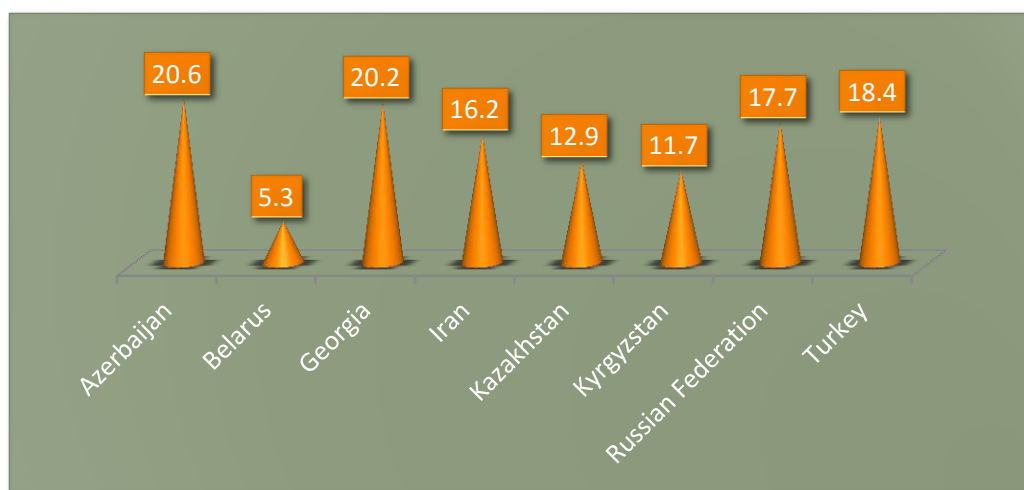
**Figure 4.** The score and the rank of the Innovation Linkages Index in Armenia in 2021  
 [Source` Indicator Rankings & Analysis | Global Innovation Index]

Armenia ranked 109th among 140 countries in 2021 by the index of innovation linkages, and the score of index of innovation linkages was 14.9. Compared to 2020, the score of the index of innovation linkages in Armenia has decreased by 1.3 points. As a result, Armenia has moved from the 101st position to the 109th position in terms of this indicator. Let's study the behavior of the components of innovation linkages index in Armenia.



**Figure 5.** The score, the rank of sub-indices of Innovation Linkages Index in Armenia  
 [Source: Indicator Rankings & Analysis | Global Innovation Index]

As of 2021, Armenia was the 62nd by the index of patent families, which is a rather good result in comparison with the other components of the innovation linkages index. The worst situation is in terms of the number of joint ventures/strategic alliances (Per Billion PPP\$ GDP). In terms of this indicator, Armenia is ranked 100th. It is also a difficult situation in terms of University-industry R&D collaboration sub-index. As of 2021, Armenia ranked 96th in terms of this index with a score of 35.7. In order to build a sustainable innovation system, it is very important to understand the reasons for the low level of innovation linkages from all sides. With regard to the latter, let us consider the geographical position of the Republic of Armenia, which can also be the reason for the low level of innovation linkages in a certain way.

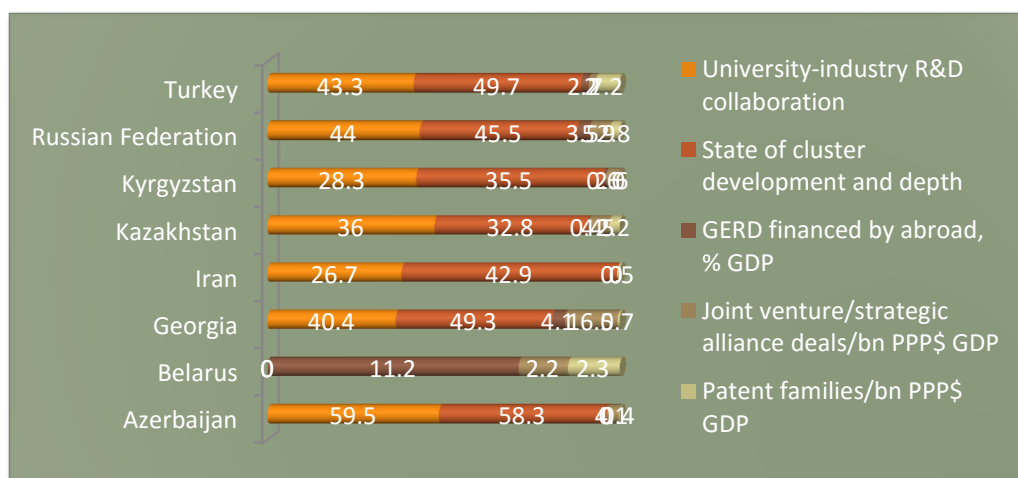


**Figure 6.** Innovation linkages index in the neighboring countries of Armenia and in the EEU member states in 2021

[Source: Indicator Rankings & Analysis | Global Innovation Index]

Azerbaijan, Georgia and Turkey have registered good results in terms of the index of innovation linkages from our neighboring and EEU countries. As of 2021, Azerbaijan ranks 66th in terms of innovation linkages with a score of 20.6, which is an increase of 0.5 points compared to 2020. The second place in the region belongs to Georgia, which is ranked 68th out of 140 countries, with a result of 20.2 points, which has increased by about 4 points compared to 2020. Turkey is in the third place which ranked 79th with 18.4 points. The latter has increased by 1 point compared to 2020. The situation in Belarus is difficult, as in 2021 the index of innovation linkages recorded 5.3 points, occupying the 128th place. In terms of innovation linkages sub-indexes both in the EEU member states and the neighbouring countries of Armenia have registered the following

results. Let's pay attention to the fact that Azerbaijan, which has registered quite serious results in terms of innovation linkages index, is ranked 23rd in terms of research and development in the university-industry cooperation sub-index with a score of 59.5. In addition, it ranks 27th among 140 countries in terms of cluster development and depth. The situation in Azerbaijan is difficult in terms of expenditures on foreign-funded research and development. In terms of this index the country is in the 100th place. In the case of Belarus, there is a low level of all subindicators of the innovation linkages index



**Figure 7.** Level of Sub-Indices of the Innovation Linkages Index in Armenia's Neighboring Countries and EEU Member States in 2021

[Source: Indicator Rankings & Analysis | Global Innovation Index]

**Scientific novelty.** In the research, the basis for the effective operation of the National Innovation System is the level of development of innovation linkages. After comparing the countries with the best results in the Innovation Linkages Index by 2021, a transition is made to those countries with the highest level of cluster development. After reviewing the analyzes of a number of researchers in this article, a study of the Innovation Linkages Index, including its sub-indices, was conducted specifically for Armenia. During the analysis, the study of the reasons for the innovative connections and the changes in its components in the context of the peculiarities of the geographical location of Armenia was especially used. For this purpose, the dynamics of innovation linkages and its components in the RA neighboring and EEU member states were studied.

**Conclusions.** As a result of the analysis, it became clear that one of the most important components of the establishment and operation of the national innovation system is the provision of strong links between the elements of the system. One of the Global Innovation Index sub-indices, the Innovation Linkages Index, was used to describe the

current state of these links. It turned out that as of 2021, the first three places in terms of innovation linkages were occupied by Israel, Finland and Sweden among 140 countries. However, even in leading countries, the provision of innovation linkages is not going smoothly. During the analysis it became clear that in these countries there are problems with the level of cluster development. Within the framework of the work, the countries that are not in the first places in terms of innovation linkages, but they occupy significant positions at the level of cluster development were observed. Those countries are the USA, Italy and China.

Within the framework of the conducted research, special reference is made to the level of innovation linkages in Armenia. We state that Armenia is quite behind with this index, there is a lot of work to be done. Even tax incentives for the development of national innovation systems can also provide the enabling environment necessary for linking the relevant components of national innovation systems. In the case of Armenia, not only the current state of innovation relations was recorded, but also the level of development of its components was studied in detail. It was proved that as of 2021, there is a low level of the formation of joint ventures and strategic alliances. In terms of this index, in 2021 Armenia took the 100th place among 140 countries. Overcoming the existing obstacles in terms of innovation linkages in the establishment of the RA national innovation system should be a priority. Understanding the region, the geopolitical situation in which Armenia found itself, the current state of the latter's level of innovation linkages, the further course of its development is also connected with the level of development of innovation linkages with Armenia's neighbors and EEU partners. Based on this circumstance, the current situation of innovation linkages and its components as of 2021 with regard to the neighbours of the Republic of Armenia and EEU member states has been considered.

During the research, it was found out that Azerbaijan has a leading position, ranking 66th among 140 countries in terms of innovation linkages. The situation in Belarus is difficult. The latter took the 128th place. Examining the components of innovation linkages, we came to the conclusion that there are problems in Azerbaijan that have a direct impact on the further development of the country's national innovation system. As a result of the analysis, it became clear that the level of the Innovation Linkages Index in Armenia and existing problems in it almost repeat the existing problems in terms of the components of the innovation linkages and its components of the other EEU members and neighbouring countries.



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### Effects of Innovation Linkages in the context of National Innovation System development

*Key words: National Innovation System, innovations, Innovation Relations Index, Global Innovation Index, triple helix model, clusters*

The national innovation or innovation system is of central importance for the development of the innovative economy of the country. As a result of the smooth operation of all components of the system, the entry of innovations into the country is carried out more smoothly and efficiently. However, the work of individual components of the national innovation system is not enough to ensure the stability of the system. Numerous research economists have drawn attention to the connections between the individual components of the national innovation system. The effectiveness of the national innovation system depends on the level of their development. In this regard, this study examines the interconnection and mobility of innovative connections and its components in the global and regional context. The article analyzes innovative connections in the context of the dynamics of the global innovation index changes in the indicator and comparisons are made at the level of different countries and their groups (clusters). Special attention is paid to Armenia, its neighbors and other EAEU member states. In the abovementioned countries, comparisons of the innovation relations index and the results recorded by its components are carried out. The risks of each of the components of innovation links that create problems for the stable operation of the innovation system are analyzed.