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COMPARATIVE ANALYSIS IN CASE OF INNOVATION AND INTELLECTUAL PROPERTY: HOW TO OVERCOME THE GAP IN THE INNOVATION ACTIVITY

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KAPOSVÁR

2024

Content

INTRODUCTION

Innovation, derived from the Latin word "innovare" meaning "into the new," is a crucial aspect of the business sector, driving technological advancements and playing a significant role in the global economy (Kuczmarksi 2003; Costello & Prohaska 2013; Baskaran & Mehta 2016; Stenberg 2017). Schumpeter identified five types of innovation, including new product development, novel production techniques, exploring new distribution opportunities, and achieving market dominance (Schumpeter 1980). It has evolved through different theoretical approaches and led to the concept of innovation systems (Porter & Stern 2001; Remøe 2005; Hekkert et al. 2007; Gee & McMeekin 2011). Technological progress is closely intertwined with economic growth, with studies demonstrating its contribution to national economies (Pitti 2008; Pece et al. 2015; Pan et al. 2022). The relationship between economic growth and innovation has been explored by various scholars, each emphasizing different aspects (Solow 1956; Griliches 1957; Schmookler 1962, 2013; Nelson & Winter 1982; Kline 1986; Freeman & Perez 1988; Sagar 2006; Lee et al. 2010; Balogh 2012). Intellectual property, including patents, copyrights, and trademarks, plays a crucial role in innovation, but evaluating its impact can be challenging due to the lack of clear ownership boundaries. The historical and economic perspectives of intellectual property, particularly patents, are explored. The impact of intellectual property on economic growth is debated, as strong IP rights can encourage technology development but may impede domestic R&D in developing nations. Patents provide exclusive rights to inventors in exchange for disclosure and play a significant role in technology planning and competitor analysis. However, debates exist regarding the use of patent data for measuring innovation, and other forms of intellectual property are also considered in innovation analysis.

OBJECTIVES AND RESEARCH QUESTIONS

The overall objective is **to determine the role of intellectual property** indicators **that contributes to innovation activity in Kazakhstan through** the prism of **the EIS methodology** and **understand the process of the invention in Kazakhstan** to increase the number of patents and their commercialization. It explores pathless issues in innovation and intellectual property commercialization in Kazakhstan. The declared objective enables the investigation of the functioning of multi-level national innovation systems in regard to intellectual property protection and promotion, in addition to comprehending the process of invention. Thus, it leads to the overarching **research questions**:

RQ1: How do the innovation activity indicators in the European Innovation Scoreboard interact with intellectual property indicators, and what's their contribution distribution within the innovation ecosystem?

RQ2: Do countries with strong national innovation systems, reflected in high innovation outcomes, prioritize intellectual property protection more than those with lower innovation outcomes?

RQ3: What variables are important for the potential growth of intellectual property through inventiveness and patenting in Kazakhstan?

RESEARCH GAPS

Despite significant strides in innovation and intellectual property (IP) research, several gaps remain, particularly in the context of Kazakhstan's economic and innovation landscape. Addressing these gaps is crucial for fostering a robust national innovation system that can effectively leverage IP to drive economic growth. This section outlines the key research gaps identified in the dissertation.

- One of the primary gaps in the existing literature is the lack of empirical research on innovation activities within Kazakhstan. Most studies on innovation systems tend to focus on developed countries, with limited attention given to developing economies like Kazakhstan. Consequently, there is a need for comprehensive empirical studies that examine the specific challenges and opportunities associated with innovation in Kazakhstan. Such research would provide valuable insights into how national policies and economic conditions influence innovation outcomes.
- The commercialization of patents remains an underexplored area in Kazakhstan. While there has been a steady increase in the number of patents granted, the rate of commercialization is relatively low. Many patents remain unused, often due to inefficiencies in the innovation ecosystem and a lack of supportive infrastructure for commercialization. This gap highlights the necessity for research focused on identifying the barriers to patent commercialization and developing strategies to overcome these challenges. Understanding the factors that hinder the practical application of patents could significantly enhance the effectiveness of Kazakhstan's innovation policies.
- Another gap is the insufficient exploration of regional innovation dynamics within Kazakhstan. Innovation activities and their outcomes can vary significantly across different regions due to diverse economic, cultural, and infrastructural factors. Existing studies have largely treated Kazakhstan as a homogenous entity, overlooking regional disparities. There is a critical need for research that disaggregates data by regions to understand the unique innovation challenges and potentials in various parts of the country. Such studies would enable more tailored and effective regional innovation policies.

- The inventive processes leading to patent creation are not well-documented in Kazakhstan. Most studies focus on secondary data from statistical reports, without delving into the detailed processes that inventors undergo. This lack of primary data on the inventive process creates a significant gap in understanding how inventions are conceived, developed, and eventually patented. More research is needed to explore these processes, including the motivations, challenges, and experiences of inventors. Such insights could inform policies aimed at supporting inventors throughout the innovation lifecycle.
- The level of intellectual property rights protection in Kazakhstan is another area that requires further investigation. Compared to developed countries, the mechanisms for protecting IP rights in Kazakhstan are weaker, which can deter innovation and investment. There is a need for studies that assess the effectiveness of current IP protection laws and enforcement mechanisms. Research should also explore the impact of IP rights protection on innovation activities and economic growth, providing evidence-based recommendations for strengthening the IP framework.
- Awareness and utilization of intellectual property tools among inventors and businesses in Kazakhstan are limited. Many inventors are not fully aware of the benefits and processes associated with IP protection and commercialization. This lack of awareness can lead to underutilization of available IP tools, hindering the potential for innovation. Research is needed to assess the level of awareness and understanding of IP among stakeholders and to develop educational and support programs that enhance the utilization of IP tools.

This dissertation investigates the challenges of patent commercialization and innovation, both of that remain idle in Kazakhstan.

EXPERIMENT LOCATION PROFILE

Kazakhstan is the ninth-largest state in the world with a population of 19 million people in 2020 (Figure 1).

Figure 1. Map of Kazakhstan

Multiple natural resources are advantageous to Kazakhstan: uranium, bauxite, lead, zinc, nickel, cobalt, coal, natural gas, iron ore, manganese, chromium ore and so on. Kazakhstan is one of the world's leading wheat producers. An important portion of the agricultural industry is made up of the dairy and livestock industries. Kazakhstan's agro-food production is practically self-sufficient. 64 percent of the working population is employed by it, and it contributes 56.1% to GDP.

According to the Committee on Statistics of the Ministry of National Economy, the main numbers of innovation presented in the Table 2.

Table 2. Indicators of innovation statistics of Kazakhstan from 2018 to 2020

Indicators	Years		
	2018	2019	2020
Gross domestic product, KZT billion	61819,5	69532,6	70714,1

Volume of innovative products (goods, services), KZT million	1064 067,4	1113566,5	1715500
Share of innovative products (goods, services) in relation to GDP, %	1,72	1,60	2,43
Innovation costs, KZT million	861915	545046,2	783271
Share of spending on innovation in relation to GDP, %	1,39	0,78	1,11
Number of enterprises, units	30501	28411	28087
Number of enterprises with innovations, units	3230	3206	3236
The level of activity in the field of innovation, in %	10,6	11,3	11,5

Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan

Currently, the Kazakhstan Patent Office has received 973 innovation applications, including 811 from domestic applicants and 162 from foreign applicants. These numbers are 0.9% lower than the same indication in 2018 (Figure 3). The proportion of domestic and international applicants was around 83% and 17%, respectively. In addition, 544 national applicants and 186 international applicants received patent protection paperwork for the invention in 2019. In 2019, the number of applications submitted under the Patent Cooperation Agreement (PCT) protocol increased by 38.9% over 2018, while the number of applications filed under the Eurasian Patent Convention (EAPC) procedure increased by 14.6%.

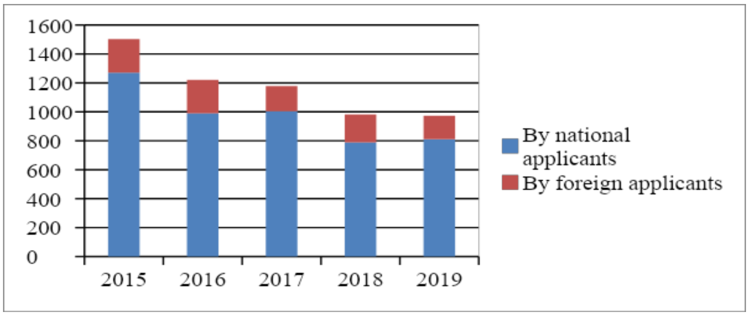


Figure 3. Dynamics of filing applications for inventions from 2015 to 2019.

MATERIALS AND METHODS

This thesis uses the longitudinal design in datasets with two repeated measures to perform an empirical analysis. Notably, we use **a dataset based on the European Innovation Scoreboard (EIS)** database for the research. **The dataset used on data from** the Kazakhstan intellectual property, namely, **the patent survey with inventors**.

The Dataset Based on the European Innovation Scoreboard

This part of empirical research consists of **quantitative data**. The first stage is crucial for data selection and collection. The data used to investigate innovation comes from two primary sources: the European Innovation Scoreboard (Report in 2008 and 2018) and the Statistics database's National Committee of Statistics.

The selection of indicators assumes the argumentation of choice. The fundamental problem comes down to choosing the weight with which the components contribute to the composite practice. The dilemma of choice consists of no single opinion between experts in choosing variables (Grupp & Schubert 2010).

This study examines **the EIS in 2008** and **2018** with difference in one decade. The first level of the data gathering includes identifying the main variables and individuals for the following analysis. It needs to determine what indicators participate in EIS publications for ten years. For instance, from 2008 to 2018, the number of indicators decreased from 29 to 27. Every indicator has its capacity (load), proved by the EIS near two decades from 2001 to recent years. Past scientific studies have demonstrated what indicators are important for innovation interpretation (Hollanders & van Cruysen 2008, Schibany &

Streicher 2008). **The main indicator components in calculating are numerator and denominator** (Table 4).

Table 4. Indicator Components.

Indicator	Numerator	Denominator	Data source
Q1	Number of doctorate graduates	Population between and including 25 and 34 years	World Bank data and Committee on Statistics of Kazakhstan
Q2	Number of persons in age group with some form of post-secondary education	Population between and including 25 and 34 years	World Bank data and Committee on Statistics of Kazakhstan
Q3	Population of lifelong learning statistics refers to all persons in private households aged between 25 and 64 years	Total population of the same age group	Analytical report on the implementation of the principles of the Bologna process in Kazakhstan (2018) and webpage: theglobaleconomy.com
Q4	All R&D expenditures in the government sector	Gross Domestic Product	Committee on Statistics of Kazakhstan
Q5	All R&D expenditures in the business sector	Gross Domestic Product	Committee on Statistics of Kazakhstan
Q6	Sum of total innovation expenditure for enterprises, excluding intramural and extramural R&D expenditures	Total turnover for all enterprises	Committee on Statistics of Kazakhstan
Q7	Number of Small and medium-sized enterprises (SMEs) with in-house innovation activities	Total number of Small and medium-sized enterprises (SMEs)	Committee on Statistics of Kazakhstan
Q8	Number of Small and medium-sized enterprises (SMEs) with innovation co-operation activities	Total number of Small and medium-sized enterprises (SMEs)	Committee on Statistics of Kazakhstan
Q9	Number of public-private co-authored research	Total population	Committee on Statistics of Kazakhstan
Q10	Number of patent applications	Gross Domestic Product in Purchasing Power Standard	National Patent Office in Kazakhstan and Committee on Statistics of Kazakhstan
Q11	Number of trademark applications applied	Gross Domestic Product in Purchasing Power Standard	National Patent Office in Kazakhstan and Committee on Statistics of Kazakhstan
Q12	Number of industrial design applied	Gross Domestic Product in Purchasing Power Standard	National Patent Office in Kazakhstan and Committee on Statistics of Kazakhstan

Q13	Number of Small and medium-sized enterprises (SMEs) who introduced at least one product innovation or process innovation either new to the enterprise or new to their market	Total number of Small and medium-sized enterprises (SMEs)	Committee on Statistics of Kazakhstan
Q14	Number of Small and medium-sized enterprises (SMEs) who introduced at least one new organizational innovation or marketing innovation	Total number of Small and medium-sized enterprises (SMEs)	Committee on Statistics of Kazakhstan
Q15	Number of employees in high-growth enterprises in 50% 'most innovative' industries	Total employment for enterprises with 10 or more employees	Committee on Statistics of Kazakhstan
Q16	Number of employed persons in knowledge-intensive activities in business industries	Total employment	Committee on Statistics of Kazakhstan
Q17	Value of medium and high tech exports	Value of total product exports	Committee on Statistics of Kazakhstan
Q18	Exports of knowledge-intensive services	Total value of services exports	Committee on Statistics of Kazakhstan
Q19	Sum of total turnover of new or significantly improved products, either new-to-the-firm or new-to-the-market, for all enterprises	Total turnover for all enterprises	Committee on Statistics of Kazakhstan

Source: created by the author

The list of countries rises at the EIS 2018 in comparison with 2008. In this investigation, the basis of the countries list is 2008. We **add Kazakhstan** because it lies at the point of our research interests during the whole research. **The individual variables are present as developed countries, countries with transition economies, and developing countries of the European Union and Central Asia**. Namely, we observe about 29 countries dividing these members into four groups: Innovation Leaders, Strong Innovators, Moderate Innovators, and Modest Innovators. Probably, during the decade the position of some countries had changed. (Annex A). This study reflects the innovation activity of 29 European and Central Asia countries: Austria (1), Belgium (2), Bulgaria (3), Cyprus (4), Czech Republic (5), Germany (6), Denmark (7), Estonia (8), Spain (9), Finland (10), France (11), Croatia (12), Hungary (13), Ireland (14), Italy (15), Lithuania (16), Latvia (17), Malta (18), Netherlands (19), Norway (20), Poland (21), Portugal (22), Romania (23), Sweden (24), Slovenia (25), Slovakia (26), The United Kingdom (27), Turkey (28), and Kazakhstan (29). However, we don`t know what group Kazakhstan belongs to. Finally, **this dataset includes 29 countries called individuals and 19 indicators called variables**.

The Dataset Based on the Patent Survey in Kazakhstan

This study uses selective data to produce **qualitative results** focusing on innovation and **how patents realize innovation performance in Kazakhstan practice**. A patent survey is a supportive part of our study about the place of intellectual property in the national innovation system. This data set will help to consider the main features of contemporary invention in Kazakhstan. Empirical data collection choices include in-depth interviews, participant observations, and Patent Office reports in Kazakhstan.

The study period applies only to granted patents in 2008. Firstly, this is the start of an innovative activity study in Kazakhstan at this research. Secondly, commercialization usually takes more than six years in the case of medical and chemical patents. We choose this year by giving time for the realization of granted patents in the industries.

In 2008 the total amount of granted patents was 171 at the Republic of Kazakhstan. The 22,8% of granted patents are the foreign granted patents. We skip them because we interest in how national patents develop in Kazakhstan. **Organizations are filed the 96 granted patents, like research institutes, universities, and 36 inventions are filed independently by one inventor or a group of authors**. Total numbers of authors and co-authors of 132 inventions were near 570. Although, **near 104 domestic inventors participates in this survey**.

The questionnaire's frame is the previous surveys in the field of the patent (Griliches 1998; Gambardella et al. 2008; Joho et al. 2010) and the author's experience in intellectual property. The questionnaire builds in English, but the personal interview has conducted in Kazakh or Russian languages. The translation and pre-test of the survey help us avoiding the misunderstanding and takes near two weeks. The questionnaire's design starts at the end of 2018 and collecting the answers - at the beginning of 2019. **The patent survey includes 43 questions about a patent, an inventive process, and a commercialization process**. The questionnaire had Likert-type scales, semantic differential, yes/no questions, multiple-choice questions, rank order questions, dichotomous questions. We choose granted patents from Kazakhstan residents without separation in fields of inventions because the small number of granted patents in 2008.

Some of the answers of inventors were greatly expanded and we categorized them by ranks: total number of patents by one inventor, time spent on invention, and the value of the patent. **The research includes the dependent variables** (Table 5) **and the groups** (Table 6).

Table 5. Dependent (Measurement Variable) Variables Used in the R

Dependent variables			
Variable name	Description of variables	Types of variables	Type of answer
authors	Number of authors in one granted patent	categorical variables	"1", "2", "3", "4", "5", "6", "7", "8", "9"
pat_rank	Total number of patents by one inventor	categorical variables	"1-3", "4-10", "11-20", "21-50", "< 50"
srs_R&D	Source for R&D "1" - Internal funds "2" - Funds from any other organization "3" - Funds from the financial	categorical variables	"1", "2", "3", "4", "5"

	intermediaries of any kind “4” - Government research programs “5” – Other		
time_rank	Time spent for invention	categorical variables	“3 months – 1 year”, “1-2 years”, “2-4 years”, “4-6 year”
val_pat_rank	The value of patent	categorical variables	“L $ 30 000”, “$ 30 000 - $ 100 000”, “$ 100 000 - $ 1 000 00”, “$ 1 000 000 - $ 3 000 000”

Source: created by author

Table 6. Groups Used in the R Commander

Grouping variables			
Name in R	Description of variables	Types of variables	Type of answer
city_inv	City of invention	categorical variables	“Almaty”, “Astana”, “others”
com_use	Commercial use of granted patent	categorical variables	“yes”, “no”, “I don`t know”
educ	Education of respondents	categorical variables	“PhD”, “Bachelors”, “others”
pat_fam	Existence of patent family	categorical variables	“yes”, “no”, “I don`t know”
work	Work place during invention process	categorical variables	“Hospital”, “University or research institution”, “Private and public research organization”, “Private companies and others”
year	The age of author	categorical variables	>45, >59, <60

Source: created by author

This research used the R program to analyze the data. The following methods were manipulated for calculating innovation activity by the EIS and the result of the patent survey in Kazakhstan:

Innovation activity:

- Harmonization data
- Principal component analysis
- Cluster

Patent survey:

- Shapiro-Wilk test
- Kruskal-Wallis test
- Dunn's test

RESULTS

Harmonization data

Before data manipulation, we follow the EIS recommendation to normalize the data. The research findings confirm the feasibility of normalizing Kazakhstan's data based on the EIS methodology (Archibugi et al., 2009; Bielińska-Dusza & Hamerska, 2021). This **normalization process** specifically **applies to Kazakhstan variables**, as data from other European countries were already normalized and reported in the EIS 2008 and 2018 (Annex A).

Table 7. Normalization of Kazakhstan data according to EIS 2008, 2018

Indicator	2008	2018
Q1*	0,07	0,3
Q2*	22,7	53,98
Q3*	1	1,1
Q4**	0,22	0,25
Q5**	0,11	0,5
Q6**	0,002	0,37
Q7***	3,1	36,6
Q8***	3,3	36,8
Q9***	1,6	5,9
Q10***	11,3	7,1
Q11***	22,6	29,2
Q12***	1,1	1,1
Q13***	2,4	6,6
Q14***	0,8	10,5
Q15****	0,2	2,3
Q16****	8,7	10,3
Q17****	20,2	17,3
Q18****	5,94	3,5
Q19****	17	32,7

Notes: *human capital indicators; **investment indicators; ***innovation activity indicators; ****innovation effect indicators.

Source*:* created by author

The received indicators reflected an underestimated average value compared with highly developed innovative countries. However, as a country with a transition economy, **Kazakhstan's indicators showed a stable rise in the potential development of innovative activity in the country**. The four groups of innovation indicators showed remarkable growth empirically from 2008 to 2018 during data normalization (Table 7).

The first group of indicators focused on human capital (Q1-Q3), where Kazakhstan's indicators showed a weak rate of growth compared to other countries in 2008 and 2018. Improving the level of highly-educated individuals in the country is crucial for fostering long-term growth in science and technology. **The second group of indicators (Q4-Q6)** pertained to investment in research and development (R&D). Kazakhstan's R&D expenditures in the public sector experienced slight growth, while expenditures in the private sector tripled. However, the growth rate was affected by fluctuations in the national currency due to exchange rate differences with foreign currencies. Countries with higher levels of R&D spending from the government and SME sectors generally exhibit increased innovativeness, innovation capacity, and economic growth. **The third category of indicators (Q7-Q14)** represented innovation activity, which showed a significant increase in Kazakhstan's variables from 2008 to 2018. However, these indicators mostly remained average for moderate countries and did not surpass medium values. Kazakhstan companies needed to strengthen their human resources and equipment potential. The rate of public-private co-authored research publications was relatively low, indicating room for improvement in collaboration. **Intellectual property indicators remained relatively stable, with a notable change in the calculation of the EIS methodology between 2008 and 2018. The last group of indicators (Q15-Q19)** focused on the innovation effect. The number of employees in the innovation sphere in Kazakhstan demonstrated comparable growth to strong innovator countries such as Austria, Finland, and Belgium. However, there were significant differences in the value of high-tech exports compared to these countries.

Principal component analysis

Table 8 showed variances and cumulative variances associated with the principal components with eigenvalues greater than 1 for the 2008 and 2018 samples. **The first two components should provide an adequate representation of the indicators** (the overall value for each researched year is less than 60%)

Table 8. Variance explained by each principal component, 2008 and 2018

Component	Variance explained, 2008			Variance explained, 2018		
	Variance (Eigenvalue)	%	Cumulative %	Variance (Eigenvalue)	%	Cumulative %
1	8.59	45.25	45.25	7.46	39.28	39.28
2	2.43	12.79	58.04	2.58	13.58	52.86
3	1.96	10.34	68.38	2.07	10.9	63.76
4	1.32	6.93	75.31	1.67	8.83	72.59
5	1.01	5.29	80.6	1.39	7.36	79.95
6	0.93	4.89	85.49	1.21	6.39	86.34
7	0.69	3.64	89.13	0.59	3.09	89.43
8	0.46	2.41	91.54	0.51	2.66	92.09
9	0.37	1.93	93.47	0.39	2.07	94.16
10	0.35	1.86	95.33	0.27	1.41	95.57
11	0.25	1.34	96.67	0.21	1.11	96.68
12	0.17	0.88	97.55	0.19	1.02	97.7
13	0.13	0.69	98.24	0.11	0.58	98.28
14	0.1	0.55	98.79	0.1	0.52	98.8
15	0.09	0.46	99.25	0.09	0.48	99.28
16	0.05	0.28	99.53	0.06	0.33	99.61
17	0.04	0.21	99.74	0.04	0.23	99.84
18	0.03	0.14	99.88	0.02	0.12	99.96
19	0.02	0.12	100	0.01	0.04	100

Source: created by author

The principal component analysis is crucial for assessing the quality and contribution of each variable to innovation. The quality function provides an interpretation of the estimated values' quality, while the contribution function describes the correlation of variables with the principal components, indicating the most critical factors explaining the data set's variability (Annex B).

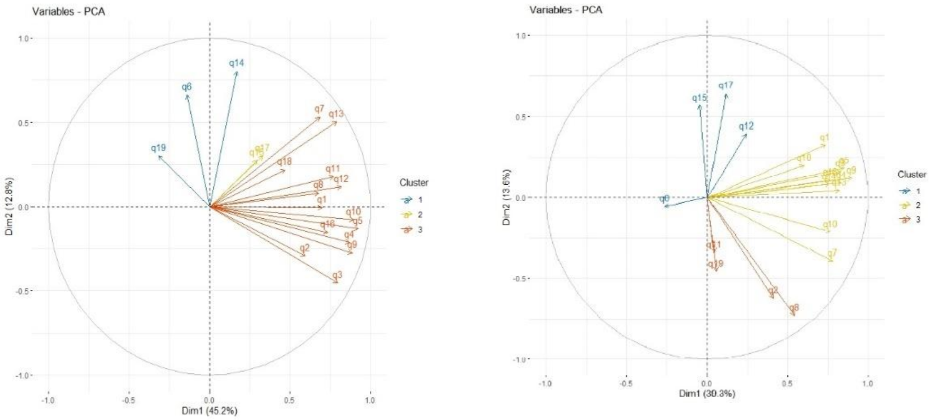


Figure 9. Cluster plot of loadings for first two components, innovation indicators data, 2008, 2018.

In this research, **the variables related to human resources, R&D, and innovation activity constituted the first principal component in both 2008 and 2018**, demonstrating their importance in explaining variability (Figure 9). **The indicator of the number of innovative SMEs consistently contributed to multiple components**, emphasizing their significance for future innovation development.

The separation of dimensions highlighted how intellectual property variables, such as patents, industrial designs, and trademarks, correlated with the principal components. Patents made the largest contribution to PC1 in 2008, while in 2018, **patents had the most considerable contribution to the PC1 and PC2 dimensions** among the intellectual property indicators.

The comparison between 2008 and 2018 revealed differences in variable groups through cluster analysis. Correlated variables demonstrated interrelatedness, indicating that when one indicator increased, the correlated indicators also improved. The study provided insights into the differences between the European and Kazakhstan systems of supporting innovation and analyzed the distribution of countries into clusters based on innovation and the contribution of intellectual property variables.

Overall, the principal component analysis allowed for a deeper understanding of innovation tools and their implications for individual countries, particularly in the context of intellectual property, and offered insights into innovation development through the EIS framework.

Cluster

The result of this study noted that the IP indicators were located on the planes of the first and second clusters. Patents were the most far-reaching points of the centre than other IP indicators. **The trend of the patent indicator showed that strong IP protection was more typical for countries with strong innovative skills** (Tarantola & Gatelli 2007; Leogrande et al. 2020), namely **for the first cluster**. From the general IP group, it was patents that made a significant contribution to innovation. It was also **important to note that the second group of countries had also developed IP protection, which was sufficient for this stage of innovation development**. In this case, IP was presented as a tool for reinforcement innovation. Moreover, geographical distance had long been one of the characteristics of proximity that has been stressed and used in a multitude of studies across a variety of disciplines. Distance had been the most important component of geographical proximity (Boschma 2005; Ponds et al. 2007), and geographical proximity could impact innovation rates (Saxenian 1990; Audretsch & Feldman 1996; Ellison & Glaeser 1999; Lundvall 2009).

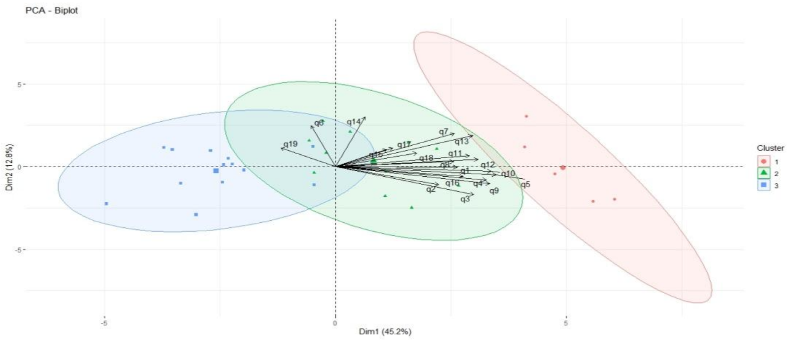


Figure 10. Score plot of PC2 versus PC1 for 2008 samples.

According to Figure 10, the biplot indicates the establishment of three clusters. In 2008 the individual cluster analysis branched three groups out of countries: **the first cluster** - Germany, Austria, Denmark, Finland, Sweden; **the second cluster** – Estonia, Cyprus, Portugal, Italy, Spain, France, Ireland, Norway, the United Kingdom, Netherlands, Belgium, and **the third cluster** – Romania, Slovakia, Czech Republic, Turkey, Croatia, Malta, Poland, Hungary, Slovenia, Bulgaria, Lithuania, Latvia, Kazakhstan (Figure 12).

The cluster distribution shows the importance of the geographical location of the country (Rhoden et al. 2022). Countries' spatial distribution considers their standard features in many ways, including the individual's location on the map. For instance, **the Q14 indicator is typical only for the first and second clusters**. The growth of cooperation between these clusters is higher than between the first and third. The second group acts as an intermediary between the first and third groups. It interacts only with the first or only the third group separately.

The biplot shows that Kazakhstan and other countries of the third cluster also have indicators of innovation activity but poor quality (Figure 9). They need to concentrate on improving these indicators in future years. Furthermore, considering the distance from the centre of the biplot to the cluster centroid, the countries close to the cluster centroid advanced cluster are more likely to move to a higher level. For example, **the second group countries - the Netherlands, Belgium, Ireland, Great Britain, France, and Norway-are close to the centroid of the first cluster, and the proximity to the centroid assumes that the following countries will be more comfortable with making the transition from the second group to the first.**

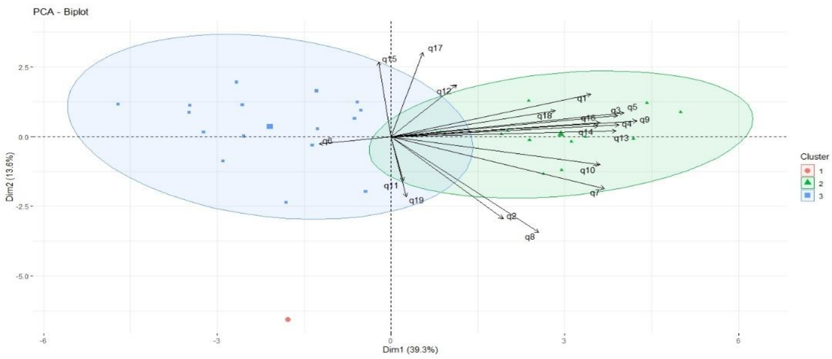
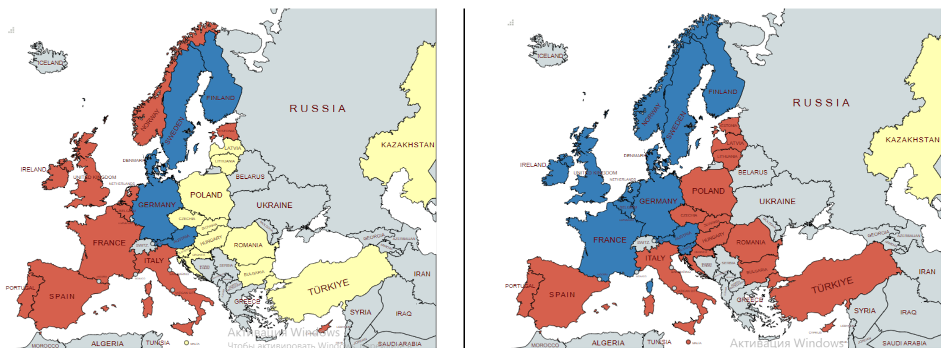


Figure 11. Score plot of PC2 versus PC1 for 2018 samples.

In 2018 the biplot reveals three clusters with indicator distributions at the four planes (Figure 11). The second and third clusters include the majority a number of countries, while the first one emphasizes just a single country. **The second cluster** comprises Denmark, Sweden, Germany, Slovenia, Ireland, France, the United Kingdom, Norway, Belgium, Finland, Austria, and the Netherlands, and **the third group** unites the following countries: Turkey, Latvia, Croatia, Hungary, Slovakia, Romania, Poland, Portugal, Bulgaria, Lithuania, Cyprus, Estonia, Spain, Malta, the Czech Republic, and Italy. Only **the first cluster** has a single country – Kazakhstan (Figure 12).



2008 2018

Figure 12. Cluster distribution in 2008 and 2018

Both 2008 and 2018 show that enhanced IP protection is typical for countries with strong innovation skills (Figure 10, 11). Precisely **these countries devote importance to developing and improving IP where IP indicators enter the**

leading group of variables important for innovation. The most significant indicator among IP variables is a patent, followed by industrial designs, and only then trademarks. However, the remaining indicators on the same plane as a patent are significant for innovation activity because one indicator's growth extends the possibilities of other indicators standing nearby on the same plane.

In a comparison of the distance between clusters, there is a probability of shifting from one level to a more advanced cluster. For example, in 2008, **countries marked as close to the centroids of the advanced group of countries showed a transition to a more advanced level than other countries in innovation.** In 2018, these countries reach the level of countries with strong skills in innovation: the Netherlands, Belgium, Ireland, the United Kingdom, France, and Norway. Thus, by reinforcing one of the groups of variables as human resources, R&D and the innovation activity indicators, these countries achieved a transition from one cluster to another.

Shapiro-Wilk test

Patent data influence ingenuity to a greater extent than other variables by stimulating innovation activity in Kazakhstan. The relevance of patent data is demonstrated in the analysis above by its contribution to innovative activity in Europe and Kazakhstan. The previous empirical studies had established the value of patents and who were the inventors of West society. This study revealed the characteristics and potential of Kazakhstan's inventiveness and its impact on the market.

The **normalization data process by Shapiro-Wilk test showed that the data**: author, pat_rank, srs_R.D, time-rank, val_pat_rank **are significantly deviate from a normal distribution** (Table 13).

Table 13. The normalization data process of dependent variables by Shapiro-Wilk test

Data	W	P-value

author	0.93854	0.0027
pat_rank	0.95214	0.0125
srs_R&D	0.70669	3.467e-10
time_rank	0.91989	0.0003
val_pat_rank	0.91588	0.0122

Source: created by author

The data is none normally distributed, we need to use nonparametric test - Kruskal-Wallis test.

Kruskal-Wallis test

Table 14. The Result of Kruskal-Wallis Test

The differences	*Chi-squared (X2)*	*Df*	*P-value*
srs_R.D by city_inv	5,3474	2	0,069
srs_R.D by work	7,2558	3	0,06418
srs_R.D by com_use	4,5646	2	0,102
srs_R.D by year	7,5333	2	0,02313
val_pat_rank by city_inv	5,2935	2	0,07088
val_pat_rank by work	8,1159	3	0,04368
authors by pat_fam	5,7157	2	0,05739
pat_rank by work	5,8954	3	0,1168

Source: created by author

The source of R&D the Kruskal-Wallis test for independent samples (Table 14) indicated a significant difference between geolocation ($p<0.7$) where inventors live, the activities ($p<0.06$) and age ($p<0.02$) of the inventors and potential of commercial use of granted patent ($p<0.1$). Moreover, Kruskal Wallis tests further revealed a significant patent value difference in reported time spent in the process of inventiveness by location ($p<0.07$) and a considerable difference between the place of work ($p<0.04$). Significant differences were also evident in terms of the number of authors ($p<0.06$) with the existence of patent family and the number of patents invented by one author ($p<0.1$) with the work of inventor. The analysis highlighted the importance of factors such as the city of invention, the inventor's place of work, organizational capabilities, and the inventor's age. **Significant correlations were found between patent-related variables, including the city of**

invention, commercial use potential, patent family, work year, and dependent variables such as authors, patent value, sources for R&D and the total number of patents.

Dunn test

The important part of next step after nonparametric test is the post hoc test - Dunn test. It will clarify the difference inside the needed groups and show the difference among groups.

When we interface **R&D resources with cities**, we observe that the main focus is on the national cities of Astana and Almaty. As a result, **survey respondents emphasized the necessity of regional R&D development for potential growth in inventiveness** (Guo et al., 2022) (Table 15).

Table 15. The post hoc test variables result «srs_R.D by city_inv»

dunn.test(kwt$srs_R.D, kwt$city_inv, alpha=0.1, method= “bonferroni”)		
Kruskal_Wallis chi-squared = 5.3474, df = 2, p-value = 0.07		
Col Mean-Row Mean	Almaty	Astana
Astana	-2.300514	
	0.0321*	
others	-0.712635	1.565961
	0.7141	0.1760
Alpha = 0.1		
Reject H0 if p <= alpha/2		

Source: created by author

Simultaneously, significant results mostly **on value of patents** were discovered in Almaty and other cities during the analyze process. This presents a picture of authors recognizing the value of their patents to society and the future of licensing in these cities (Table 16).

Table 16. The post hoc test of variables result «val_pat_rank by city_inv»

dunn.test(kwtval_pat_rank, kwtcity_inv, alpha=0.1, method= “bonferroni”)		
Kruskal_Wallis chi-squared = 5.2935, df = 2, p-value = 0.07		
Col Mean-Row Mean	Almaty	Astana
Astana	-0.758491	

	0.6722	
others	-2.283019	-0.873235
	0.0336	0.5738
Alpha = 0.1		
Reject H0 if p <= alpha/2		

Source: created by author

When we looked at **R&D resources in relation to commercialization**, we observed that the indicators are between an awareness of the significance of commercialization and concerns about profitability and intellectual property licensing. **It showed the necessity to establish and train patent management, as well as to bring to the public and commercial sectors methods of incentive and support for patent implementation** (Etzkowitz, 2002) (Table 17).

Table 17. The post hoc test of variables result «srs_R.D by com_use»

dunn.test(kwt$srs_R.D, kwt$com_use, alpha=0.1, method= "bonferroni")		
Kruskal_Wallis chi-squared = 4.5636, df = 2, p-value = 0.1		
Col Mean-Row Mean	IDN	No
No	1.225919	
	0.3303	
Yes	1.862232	1.555181
	0.0939	0.1799
Alpha = 0.1		
Reject H0 if p <= alpha/2		

Source: created by author

Post-hoc tests showed that the impact of patents, particularly in terms of R&D funding sources, was mainly concentrated in major cities like Astana and Almaty, with private and public institutions and companies playing key roles. However, the flow of funding from private companies was limited. The estimated value of patents was higher in cities such as Almaty compared to Astana.

CONCLUSIONS AND RECOMMENDATIONS

The thesis explores the innovation process through the use of intellectual property tools, focusing specifically on Kazakhstan. By comparing innovation performance and intellectual property practices between EU, non-EU countries, and Kazakhstan over a decade, the study provides a nuanced understanding of the innovation landscape. This comparative analysis highlights disparities and commonalities among diverse economies, shedding light on factors that drive or inhibit innovation.

Kazakhstan serves as a compelling case study, allowing for the examination of unique challenges and opportunities within its innovation ecosystem. The research identifies areas where Kazakhstan may lag or excel, offering potential strategies for bridging the innovation gap and fostering sustainable growth. The thesis emphasizes the importance of targeted policy interventions to bolster innovation ecosystems worldwide.

The research adopts the European Innovation Scoreboard (EIS) methodology to analyze innovation indicators in Kazakhstan. This approach, tailored to Kazakhstan's specific economic landscape, provides a more accurate and meaningful comparative analysis with EIS member countries. The normalization process of Kazakhstan's data ensures reliability and offers insights into the country's strengths, challenges, and opportunities.

Overall, the thesis contributes to the broader discourse on innovation and intellectual property by providing valuable perspectives on how different countries navigate the complexities of technological advancement and knowledge creation. The study underscores the significance of intellectual property in driving innovation and the necessity of robust IP frameworks and effective enforcement mechanisms.

NEW SCIENTIFIC RESULTS

1. This chapter highlights the thesis's scientific results. Although the uniqueness of this doctoral dissertation lies in the integration of concepts that have either not been investigated before or have previously been considered in uniform trends in previous research. It obtained the following four main and new The research conducted in this thesis underscores the critical importance of innovation and intellectual property in the Digital Era. By delving into the intricacies of innovation performance within the rapidly evolving technological landscape, the study sheds light on the drivers and barriers to innovation in Kazakhstan and beyond.
2. A primary objective of this study is to bridge the innovation gap between countries by examining the innovation process through the lens of intellectual property tools. Through a comparative analysis spanning a decade, the thesis elucidates differences in innovation performance and intellectual property practices among EU, non-EU, and Kazakhstan. This approach provides valuable insights into the factors influencing innovation outcomes and the strategies needed to enhance innovation capacity.
3. The research employs the European Innovation Scoreboard (EIS) methodology to analyze innovation indicators across different economic levels. By normalizing Kazakhstan's data and enabling comparative analysis with EIS member countries, the study offers a robust framework for understanding innovation dynamics. This methodological approach facilitates nuanced insights into the complex interplay between intellectual property, innovation, and economic development.

4. Principal component analysis reveals the significant role of intellectual property indicators in driving innovation. The study identifies correlations between intellectual property and various innovation variables, highlighting the pivotal role of patents in innovation processes. These findings underscore the importance of fostering a conducive environment for intellectual property protection and innovation promotion.
5. Cluster analysis elucidates differences in innovation variables over time and predicts innovation gaps based on principal component analysis. By examining the interactions between national innovation systems and the contribution of intellectual property indicators, the study provides predictive insights into future innovation trends. This analytical approach offers valuable guidance for policymakers and stakeholders seeking to prioritize interventions and investments in innovation.
6. The empirical study of the Patent Survey uncovers statistically significant differences in various patent-related metrics in Kazakhstan, shedding light on the state of the patent system and its impact on innovation activity. These empirical findings underscore the need for targeted interventions to address challenges in patenting and commercialization processes, thereby enhancing innovation activity in Kazakhstan.
7. The conclusion highlights blind spots in the patent system and commercialization processes in Kazakhstan, suggesting areas for improvement to foster innovation ecosystems conducive to economic growth and development. By addressing these challenges and implementing targeted policy interventions, Kazakhstan can unlock its innovation potential and position itself as a global player in the Digital Era.

ANNEX A

Harmonized data according to the EIS in 2008 and 2018

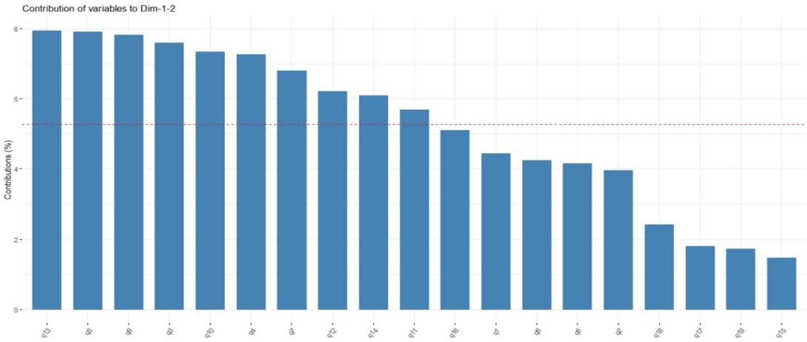
	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	q11	q12	q13	q14	q15	q16	q17	q18	q19
AT	1,72	17,6	12,8	0,75	1,81	n/a	41,1	18	58	183,1	237,1	284,6	47,8	54,9	6,66	14,15	53,2	31,3	7,08
BE	0,94	32,1	7,2	0,57	1,3	0,73	40,8	16,7	49,4	129,1	121,4	116,2	45,4	45,3	6,31	15,54	48,7	43,9	7,39
BG	0,36	22,4	1,3	0,33	0,15	0,79	15,1	3,8	0,5	1,4	32,8	19,2	17,8	15,7	5,13	8,35	21,2	18,2	3,59
CY	0,22	33,1	8,4	0,31	0,1	2,12	37,5	26,2	9,1	17	282,8	31,2	37,9	50,9	0,9	15,8	45,9	35,4	7,04
CZ	0,86	13,7	5,7	0,55	0,98	0,88	28	11,7	12,6	7,3	47,1	67,7	32	36,2	10,85	10,92	61,3	35,5	4,72
DE	1,56	24,3	7,8	0,76	1,77	1,07	46,3	9	45,9	275	187,7	222,6	52,8	68,1	10,72	15,37	65,5	53,8	10,11
DK	0,93	32,2	29,2	0,88	1,65	0,51	40,8	14,9	108,7	174,6	212,1	280,4	35,7	45,4	6,03	10,92	41,2	67,2	4,05
EE	0,57	33,3	7	0,58	0,54	3,36	37,1	18,1	14,5	5,6	81,4	17,9	45,8	48,4	3,9	11,01	36,2	38,5	9,27
ES	0,67	29	10,4	0,55	0,66	0,49	24,6	5	10,6	29,3	163,8	104,5	29,5	29,5	4,47	14,22	52,3	n/a	8,48
FI	2,17	36,4	23,4	0,94	2,51	n/a	40,9	27,5	83,1	267,6	137,3	116,8	44,7	n/a	7,03	16,49	51,5	26,7	4,83
FR	1,13	26,8	7,4	0,74	1,31	0,33	28,3	11,5	27,9	119,2	94,4	107,5	29,9	41,3	6,35	15,76	58,9	n/a	5,56
HR	0,47	16,2	2,9	0,55	0,38	0,92	24,4	9,6	11,9	5	4,5	2,9	28,3	38,1	4,7	9,71	39,5	14,8	8,45
HU	0,42	18	3,6	0,46	0,49	0,72	13,2	6,5	16,9	7,8	26	18,3	16,8	26,4	8,82	11,35	69,3	25,6	2,7
IE	1,11	32,2	7,6	0,44	0,88	0,96	38,8	11,7	14	64,1	172,5	132,7	43,8	40,9	5,26	16,05	51,8	70,5	5,43
IT	0,89	13,6	6,2	0,52	0,55	1,1	28,1	4,3	17,2	76,1	120	184,2	33	37,5	7,59	15,57	51,1	n/a	4,52
LT	0,61	28,9	5,3	0,58	0,23	0,64	17,7	10,3	0	1,3	20,4	2,6	19,7	28,5	2,44	8,19	33,1	13,8	6,39
LV	0,24	22,6	7,1	0,42	0,21	n/a	n/a	5,6	0,4	5,7	23,7	21	14,4	n/a	1,88	10,57	23,8	37,6	1,25
MT	0,03	12,5	6	0,21	0,39	1,1	n/a	5,7	0	21,6	127,1	46,7	14,4	31,8	6,16	15,22	74,5	23	3,85
NL	0,87	30,8	16,6	0,67	1,03	0,29	27,3	12,5	83,7	173,3	195,8	135,3	32,9	31,8	3,15	17,97	48,3	39,9	4,87
NO	0,94	34,4	18	0,77	0,81	0,17	25,9	9,8	38,5	95,5	51,2	67,1	29,8	34,7	4,21	16,05	11,4	54,8	3,17
PL	0,86	18,7	5,1	0,38	0,18	1,03	17,2	9,3	1,3	3	33,2	45,5	20,4	29,1	5,5	10,33	48,9	27,9	5,55
PT	2,75	13,7	4,4	0,46	0,61	0,95	34,1	6,7	4	7,4	118,5	55,8	38,7	53,4	3,45	9,65	38,7	27,5	6,12
RO	0,48	12	1,3	0,31	0,22	1,08	17,9	2,9	3,1	0,7	13,5	3	19,4	35,4	5,66	5,26	37,5	46,6	13,69
SE	2,25	31,3	32	0,99	2,64	0,66	41,8	16,6	116,1	184,8	201,9	161,9	40,7	n/a	6,2	18,45	54,8	49,7	5,1
SI	0,96	22,2	14,8	0,6	0,94	1,12	n/a	15,1	28,2	32,2	68,7	50,5	31,7	n/a	9,09	10,89	54,2	20,7	7,5
SK	0,89	14,4	3,9	0,27	0,18	1,51	17,9	7,2	4,5	5,8	20,6	18	21,4	21,5	9,89	9,86	57,2	20,8	8,95
TR	0,12	9,7	1,5	0,37	0,21	0,16	28,2	5,3	0,3	1	1,9	4,5	29,5	50,3	3,6	5,53	38	12,9	11,17
UK	1,61	31,9	26,6	0,64	1,08	n/a	n/a	10,7	54,7	91,4	153,1	87,1	25,1	30,3	5,4	18,64	58,2	8,9	4,81
KZ	0,07	22,7	1	0,22	0,11	0,002	3,1	3,3	1,6	11,3	22,6	1,1	2,4	0,8	0,19	8,7	20,2	5,94	17

	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	q11	q12	q13	q14	q15	q16	q17	q18	q19
AT	1,9	40,3	15,8	0,87	2,2	0,47	35	20,5	82,3	4,7	13,09	6,98	40,7	46,1	1,9	15	58	43,1	11,98
BE	1,9	45,7	8,5	0,74	1,73	0,56	39,8	28,6	80	3,16	8,11	2,72	48,3	45,1	2,7	15,6	48,2	68,9	7,6
BG	1,5	33,4	2,3	0,21	0,57	0,74	11,2	3,1	3	0,64	9,1	5,56	14	14,8	6,6	10,2	33,8	39	4,8
CY	0,6	57	6,9	0,27	0,17	0,21	30,5	11,7	21,1	0,82	43,15	3,67	32,8	31,1	0,1	17	54,4	70	4,49
CZ	1,7	33,8	9,8	0,64	1,03	0,94	28	10	21	0,93	5,09	4,07	30,8	25,7	6,5	12,9	65,7	43,8	14,57
DE	2,8	31,3	8,4	0,94	2	1,26	37,9	10,1	62,4	6,11	9,51	6,72	41,6	49,1	4,6	14,8	68,2	14,6	13,34
DK	3,2	46,2	26,8	0,97	1,89	0,29	28,2	13,2	162,8	6,05	12,79	7,94	34,7	40	4,5	15,1	48	71,7	6,96
EE	1,1	43,1	17,2	0,61	0,66	0,85	15,8	10,8	10,6	1,01	16,55	5,84	17,4	15	3,2	13,5	41,2	48,6	10,48
ES	2,6	42,6	9,9	0,55	0,64	0,36	14,5	6,7	21,1	1,45	8,99	2,97	18,6	25,5	4,8	12,5	47,2	33,1	15,94
FI	2,9	40,3	27,4	0,91	1,81	0,32	38,3	16,8	85,4	7,43	12,3	4,11	44,1	37,3	2,8	16,2	44,7	70,3	9,27
FR	1,7	44,3	18,7	0,78	1,43	0,5	31,5	13,2	42,8	3,98	6,04	2,96	35,5	41,6	4,1	14,5	58,5	67,6	15,02
HR	1,2	32,7	2,3	0,46	0,38	1,2	21,1	6,8	17,3	0,61	4	0,9	25,4	30,8	3,5	11,6	39,9	19,1	4,91
HU	1	30,2	6,2	0,29	0,89	0,75	11,7	6,2	29,6	1,34	4,15	1,15	15,1	15,2	8,7	11,6	68,5	49	12,47
IE	2,6	53,5	8,9	0,35	0,83	0,47	41,3	13,9	45,4	1,8	5,08	1,09	45,7	52,5	7,1	20,6	56	94,2	18,07
IT	1,5	26,9	7,9	0,5	0,75	0,57	30,5	6,7	22,2	2,16	8,46	6,23	32,7	34,6	3,1	13,7	52,4	50,9	10,06
LT	0,9	55,6	5,9	0,55	0,3	2,01	30,4	15,2	3,9	0,81	7,39	1,71	33,7	24	2,1	9,7	36,9	22	8,57
LV	0,7	41,6	7,5	0,33	0,11	0,58	10,2	2,8	1	0,82	7,77	1,2	11,9	19	5,2	12,1	34,7	52,4	5,31
MT	0,7	33,5	10,1	0,23	0,39	0,36	23,9	4,2	0	1,31	40,88	13,05	26,7	30,8	6,1	18,4	61,6	33,9	4,12
NL	2,4	46,6	19,1	0,87	1,16	0,16	35	17,5	99,3	5,82	9,78	4,34	42,9	32,5	4,8	17,1	49,7	77,7	10,81
NO	2	48,3	19,9	0,95	1,08	0,63	35,2	19	82,2	2,66	3,79	0,52	41,1	43,3	4	15,4	14,3	78,3	6,16
PL	0,6	43,6	4	0,32	0,63	1,24	8,3	3,5	5,4	0,69	5,33	5,71	13,3	11,4	5,8	10,3	49	40,2	6,45
PT	1,9	34	9,8	0,64	0,61	0,64	25,6	7,8	13,2	0,95	8,1	4,04	42,1	37,8	5	10,6	38,5	41,1	6,27
RO	0,8	25,6	1,1	0,21	0,27	0,23	4,5	1,8	3,7	0,22	2,64	1,31	4,9	8,8	2,6	7,7	55,8	46,2	6,51
SE	2,7	47,4	30,4	0,98	2,26	1,12	35,1	13,5	130,6	9,08	11,44	4,67	40,4	35,1	5,5	18,5	54,5	73,2	6,89
SI	3,5	44,5	12	0,49	1,51	0,81	26,1	13,2	56,1	1,65	11,09	2,97	32,6	33,2	3,2	13,7	57	36	12,44
SK	2,2	35,1	3,4	0,39	0,4	0,58	13,9	8,4	10,3	0,51	4,49	1,46	16,7	22,4	7,7	10,6	66,5	33,2	19,12
TR	0,4	30,5	5,8	0,44	0,44	2,7	22,5	6,3	2	0,73	1,34	0,11	31,5	40,5	n/a	6,7	43,4	31,9	10,51
UK	3,1	47,3	14,3	0,52	1,13	0,67	19	20,6	65,1	3,06	6,95	3,07	32,6	45,4	6,4	18,5	57,1	71,7	20,81
KZ	0,3	53,98	1,1	0,25	0,5	0,37	36,6	36,8	5,9	7,1	29,2	1,1	6,6	10,5	2,3	10,3	17,3	3,5	32,7

Source: created by author

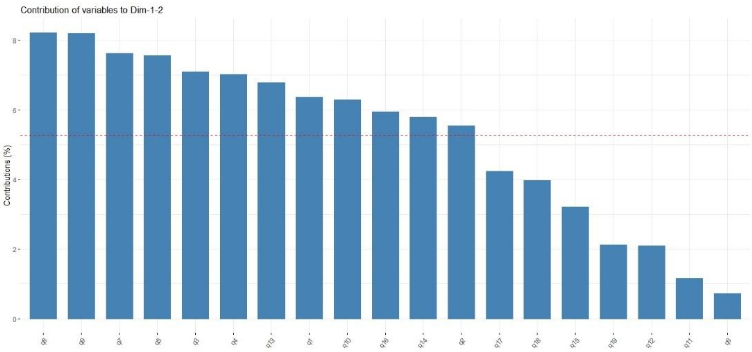
Annex B

The correlation of contributed variables with PC1-PC2 in 2008



Source: created by author

The correlation of contributed variables with PC1-PC2 in 2018



Source: created by author

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