Determinants of innovative development on the example of Kazakhstan

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Abstract

Purpose – Although many studies explored the drivers of innovative development and the innovation performance of different countries, very few studies looked at the association of the country's GII score with the qualitative indicators of innovation performance. The purpose of this paper is to contribute such an investigation by looking at the Republic of Kazakhstan (79th in 2019 GII ranking).

Design/methodology/approach – This study looks at eight dynamic variables, among which one dependent (the GII score) and seven independent (R&D spending, innovation grants, the total cost of innovative goods and services, the percentage of innovative organizations, the share of innovative goods and services in gross domestic product (GDP) and the number of R&D staff and R&D institutions) variables associated with innovation performance. Changes in variables were tracked over the period from 2010 to 2018.

Findings – The study found that the Kazakhstan's GII score was reliant on variables, such as the percentage of innovative organizations, the value of innovative goods and services as a share of GDP, R&D spending and the cost of innovative goods and services. At the same time, the number of R&D institutions, innovation grants and number of R&D staff had no substantial impact on the GII score of Kazakhstan.

Originality/value – Using the proposed approach, this study proved that factors, which have no direct association with the country's level of innovative development expressed in GII, could have a significant synergistic impact on this indicator.

Keywords R&D, Sustainable development, Multiple regression analysis, Global Innovation Index, Innovation development, Innovative goods and services

Paper type Research paper

Introduction

In the context of globalization, developed and developing countries face challenges associated with the use of raw materials and global integration. The economic development of the country drives on the simultaneous improvement of production technology and management technology. At the present stage, one of the most important factors and sources of economic development is innovation (Dutta *et al.*, 2018).

Innovation plays a huge role in promoting productivity growth and competitiveness. Employment, export and investment growth, domestic competition, direct foreign investments, new knowledge and technology inundations are among other serious contributions of innovation in a country (Singh, 2020).

It is no longer expedient for economies to rely on labour-intensive industries for economic growth and job creation because such industries have moved to developing countries with

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lower wages and lower production costs. This makes government's place innovative at the centre of their economic growth strategies (Menna *et al.*, 2019).

Analysing the innovative performance of countries is not easy due to the complex structure of national innovation systems. Many global organizations have created indices to rank countries by their levels of innovative development. The well-known examples are the Innovation Union Scoreboard, the European Innovation Scoreboard, the World Economic Forum and the Global Innovation Index (GII) (Cetinguc *et al.*, 2019).

The GII was launched in 2007 by INSEAD. It covers 129 economies around the world and uses 80 indicators (Global Innovation Index Reports, 2019). Despite its methodology does not represent an innovation in itself, its reach to policy makers around the world is profound (Todeva, 2018).

Many studies examine factors influencing the country's level of innovative development. Erciş and Ünalan (2016) examined the innovation development of Turkey and South Korea using GII reports covering the period between 2007 and 2015. They found that the innovation potential of an economy is influenced by factors, such as gross domestic product (GDP) per capita, R&D spending and international trade.

The empirical study by Svagzdiene and Kuklyte (2016) found that R&D spending (percent of GDP), the number of R&D projects, the number of patents issued and the percentage of households with Internet access were the major factors influencing the Summary Innovation Index (the EU analogue of GII) in Germany, Estonia and Lithuania.

The assessment in reading, mathematics and science for 15-year-old students, the patent families filed in at least three offices and the researchers' fulltime equivalence was found as most important variables improving the national innovative capacity in a survey conducted by Hamidi and Berrado (2017).

Jankowska *et al.* (2017) found human capital, knowledge and technology, innovative entities and R&D institutions as the main actors for innovation output of the country in GII score. This study also revealed that the higher innovation input does not necessarily result in higher innovation output in terms of GII.

The investigation of innovation indices in Global Innovation Index Reports (2019) of the Brazil, Russia, India, China and South Africa group revealed that business sophistication, trade and competition, knowledge absorption, investment, education, tertiary education, innovation linkages,general infrastructureand R&D are most influential factors for countries' innovation development.

Institutions, human capital and research, infrastructure, market sophistication and business sophistication were found the most important variables explaining 97% of the variability in GII by Hamidi and Berrado (2018).

Aguilar-Barceló and Higuera-Cota (2019) evaluated the efficiency of 19 Latin American and Caribbean economies in creating innovation-friendly environments based on data from the 2016 GII. The research found thatinfrastructure, human capital and research, tertiary education, R&D, credit and investment and institutions are the most influential factors for innovative development.

The study covering GII scores of 35 OECD countries over a 5-year period (2012–2016) revealed that open, competitive markets and the enabling of hi-tech and information and communication technologies (ICT) exports, together with development and use of ICT, increase in market scale, increased R&D and creative output are the most powerful enablers for raising a developed country's innovation potential (Menna *et al.*, 2019).

Suzuki and Demircioglu (2019) focussed on national level innovation outputs: knowledge and technology outputs (e.g. patent applications, scientific and technical articles, number of new businesses and high-tech exports) and creative outputs (e.g. organizational model

creation, creative goods exports, global entertainment and media output, national feature film production and trademark applications).

In the study of Cetinguc *et al.* (2019), infrastructure, institutions, human capital and research, creative output and knowledge and technology outputs were determined as the factors for innovative development, whereas market sophistication and business sophistication were not taken into consideration in the research.

The regional level investigation for Canada, the USA and Europe presented a list of crucial innovation drivers. Among them are investments in higher education R&D, the quality of local human capital, the colocation of economic actors and activities, the youthfulness of the local population, business enterprise R&D, regional business enterprise R&D expenditure, the availability of skilled human capital, an industrially biased economic structure, the agglomeration of economic activity and exposure to interregional knowledge (Rodríguez-Pose and Wilkie, 2019).

Dotta and Munyo (2019) found a positive correlation between trade openness and the degree of innovation in countries.

Csur and Salvador (2020) indicated that innovativeness performance, R&D and education expenditure, national GDPs and other factors are important for innovation performance and development of countries.

Singh (2020) studied such factors influencing innovation as knowledge and technology, GDP per capita, market sophistication, institutions, human capital and research, market sophistication, infrastructure and business sophistication.

Malik (2020) found that institutional quality, education and trade openness influence innovation favourably whereas foreign direct investments have a negative impact on the level of innovation. In addition, the study detected the U-shaped relationship between financial development and innovation.

It should be emphasized that most studies from above show how important are factors, such as R&D spending, education spending and the amount of qualified human capital available. These factors are crucial for the innovative development of many countries. This confirms the global trend towards establishment of neo-economics (Tsindeliani *et al.*, 2019a, b).

Although many studies explored the drivers of innovative development and the innovation performance of different countries, very few studies looked at the association of the country's GII score with the qualitative indicators of innovation performance. This study sought to contribute such an investigation by looking at the Republic of Kazakhstan (79th in 2019 GII ranking).

According to 2019 GII Report, Kazakhstan ranked 79th. Even though it climbed 18 positions up the ranking compared to 2007 (GII Report, 2007), its position remains low. This may be explained by the fact that Kazakhstan is an economy reliant on oil and gas. To transform and drive national economic development, the country has adopted policies and several strategic documents that aim to boost innovation activities and growth of nanotechnology sector, particularly in the industrial sector (Fomina *et al.*, 2019; Saiymova *et al.*, 2018).

Kazakhstan supports innovative activities in the country by creating techno-parks and sponsoring innovation projects through the QazTech Ventures, JSC (former National Agency for Technological Development) (QazTech,2020). According to the Agency of the Republic of Kazakhstan on Statistics, the country has been experiencing a steady growth in R&D spending, the number of innovation grants, the cost of innovative goods and services, the percentage of innovative organizations, the innovative goods and services as a share of GDP and the number of R&D staff and R&D institutions (Agency of Kazakhstan of Statistics, 2020).

The objectives of the study are as follows:

- to determine indicators of innovation performance that may potentially influence the GII score;
- to investigate the relationship of the above indicators and the GII score of Kazakhstan; and
- to evaluate the loading of each variable on the GII score.

Data and methods

This study seeks to determine factors driving the innovative development of the country such as Kazakhstan. A set of eight variables were selected from the array of variables available in the previous studies and statistical reports, namely:

(1) Global Innovation Index or GII score (data retrieved from 2010/2018 Global Innovation Index Reports).

(2) R&D spending per year (data retrieved from reports by the Agency of the Republic of Kazakhstan on Statistics).

(3) Innovation grants per year (data retrieved from annual reports by QazTech Ventures, JSC).

(4) The total cost of innovative goods and services produced in the country (data retrieved from reports by the Agency of the Republic of Kazakhstan on Statistics).

(5) Percentage of innovative organizations (data retrieved from reports by the Agency of the Republic of Kazakhstan on Statistics).

(6) Value of innovative goods and services as share of GDP (data retrieved from reports by the Agency of the Republic of Kazakhstan on Statistics).

(7) Number of R&D staff by the end of the calendar year (data retrieved from reports by the Agency of the Republic of Kazakhstan on Statistics).

(8) Number of R&D institutions by the end of the calendar year (data retrieved from reports by the Agency of the Republic of Kazakhstan on Statistics).

Changes in variables were tracked over the period from 2010 to 2018. For analysis, costs in Kazakhstani currency, tenge (KZT), were converted to US dollars and were adjusted to dollars between 2010 and 2018 using data from the National Bank of the Republic of Kazakhstan (National Bank of the Republic of Kazakhstan, 2020). Data collected were processed through the descriptive analysis, correlation analysis, multiple linear regression and factor analysis. The relationship between the dependent variable (y) and several independent variables (x) was investigated with the help of a multiple linear regression model:

$$y = \beta_0 \sum_{i=1}^{7} \beta i x i + \epsilon$$

where y is the score of GII; β_0 is a constant; β_i are slope coefficients; x_1 is R&D spending; x_2 is Innovation Grants; x_3 is Innovative Goods and Services; x_4 is Innovative Organizations; x_5 is Innovative Goods and Services as share of GDP; x_6 is R&D Staff; and x_7 is R&D Institutions.

The logic of the study is depicted in Figure 1.

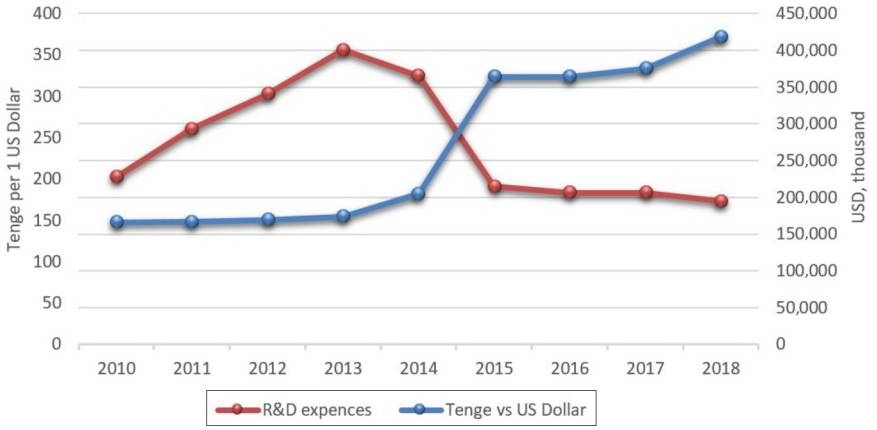

Figure 1.
Logic of the study

The proposed approach makes it possible to determine how strong the examined factors are. This approach has been tested using Kazakhstan as a model country, but it may be applied to other countries. Because each country has its own unique characteristics, a panel of variables should be formed independently for each case, such that to construct a multiple regression model. This implies that the proposed approach is sufficiently flexible.

Results

The comparative study was to determine if there is a relationship between the GII score and the examined variables (R&D spending, innovation grants, etc.). From the comparative analysis of GII score and R&D spending (Figure 2), it can be argued that these variables are stable: no significant fluctuations have been seen over the past four years.

The GII score increased significantly in 2011. The R&D spending grew between 2010 and 2013, but began to gradually decline, such that it was lower in 2018 than in 2010. At the same time, the GII score did not decrease much and remained almost as high as after a rapid increase. This suggests that no clear relationship between these variables exists. Perhaps, the rapid increase in Kazakhstan's GII score between 2010 and 2011 (Tables 1–5) is due to the change of the GII scoring system (from ones to tens).

Changes over time in Kazakhstan's GII score and the number of innovation grants are presented in Figure 3.

The GII score and the count of innovation grants both increased significantly at the beginning of the studied period. A year later, the number of innovation grants decreased, whilst the GII score remained relatively the same. This indicates the possibility that these two variables were not related during the period from 2012 to 2018.

Changes over time in Kazakhstan's GII score and the cost of innovative goods and services are displayed in Figure 4.

As it can be seen in Figure 4, the cost of innovative goods and services fluctuated significantly during the observation period. The fluctuations ended with an increase in the value of the variable to a figure higher when compared to that at the beginning of the study. The GII score did not exhibit a similar behaviour, which suggests that no direct correlation between these two variables exists.

Changes over time in GII score and the percentage of innovative organizations in Kazakhstan are illustrated in Figure 5.

Source	SS	df	MS	Number of obs	=	9
				F(7, 1)	=	575.29
Model	732.496857	7	104.642408	Prob > F	=	0.0321
Residual	.181895201	1	.181895201	R-squared	=	0.9998
				Adj R-squared	=	0.9980
Total	732.678752	8	91.584844	Root MSE	=	.42649

GII	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RD_Expences	.0010127	.0000631	16.05	0.040	.0002109	.0018145
Inn_Grants	-.0002965	.0000483	-6.14	0.103	-.0009102	.0003172
Inn_Goods_Services	-.0001358	8.19e-06	-16.57	0.038	-.0002399	-.0000317
Inn_Entities	16.29405	1.040481	15.66	0.041	3.073486	29.51462
Inn_Goods_Services_GDP	241.4424	14.53757	16.61	0.038	56.72504	426.1598
RD_Staff	-.0067557	.0005706	-11.84	0.054	-.0140057	.0004944
RD_Institutions	.1468775	.023678	6.20	0.102	-.1539795	.4477345
_cons	-270.1739	20.5234	-13.16	0.048	-530.9485	-9.399367

Figure 2.
Comparative dynamics of GII score and R&D expenses of Kazakhstan

Variable	Obs.	Mean	SD	Min	Max
Global Innovation Index, score	9	28.49222	9.569997	3.05	32.75
R&D Expenses, US$1,000	9	271,981.2	79,256.75	194,246	400,368
Innovation Grants, US$1,000	9	9,940.778	14,644.67	12	48,005
Innovative Goods and Services, thousand USD	9	2,253,103	1,009,777	964,431	3,753,980
Innovative Entities, %	9	7.711111	2.078127	4.3	10.6
Innovative Goods and Services in GDP, %	9	1.234444	0.4220519	0.65	1.91
R&D Staff	9	21,901.33	2,939.892	17,021	25,793
R&D Institutions	9	384.1111	27.06217	341	424

Table 1.
Descriptive statistics of variables of the study

Variable	GII	R&D Expenses	Innovation Grants	Innovative Goods and Services	Innovative Entities	Innovative Goods and Services in GDP	R&D Staff	R&D Institutions
GII	1							
R&D Expenses	0.2596	1						
Innovation Grants	0.1985	0.0349	1					
Innovative Goods and Services	0.5272	0.5813	−0.1422	1				
Innovative Entities	0.6231	−0.3257	−0.1835	0.438	1			
Innovative Goods and Services in GDP	0.5525	0.1855	−0.1896	0.9039	0.7105	1		
R&D Staff	0.6629	0.1855	−0.4133	0.4756	0.6972	0.5187	1	
R&D Institutions	−0.5927	−0.5288	0.3184	−0.6517	−0.2647	−0.5382	−0.4343	1

Table 2.
Correlation coefficients of variables of the study

From Figure 5, the percentage of innovative organization demonstrated a steady upward trend, whereas the GII score showed an opposite one. This suggests that innovative organizations could perform better. This also shows the lack of association between GII scores and the percentage of innovative organizations in the country.

Changes over time in GII score and the value of innovative goods and services as percent of GDP are depicted in Figure 6.

The share of innovative goods and services in Kazakhstan's GDP increased almost threefold over the period of eightyears. This proves that Kazakhstan had progressed on the path towards innovative development. The GII score increased drastically at the beginning of the observed period and it value did not change significantly over an eight-year period. Hence, no direct relationship between these variables exists.

Changes over time in GII score and the number of R&D staff are displayed in Figure 7.

As it can be seen from Figure 7 above, the number of R&D staff grew until 2014 and then it dropped. Overall, the value of this variable is increased by 30%. The GII score was inconsistent with the number of R&D staff, which indicate that there was not a clear correlation between these two valuables.

Table 3. Skewness–Kurtosis Test for normality

				Joint					
Variable	Obs	Pr (Skewness)	Pr (Kurtosis)	Adj $\chi^2(2)$	Prob>χ^2	Mean	SD	Min	Max
Residuals	9	0.3901	0.7627	0.90	0.6371	−1.91E−09	0.1507876	−0.272223	0.170724

Table 4. Results of multicollinearity test

Variable	VIF	1/VIF
Innovative Goods and Services	3010.52	0.000332
Innovative Goods and Services in GDP	1655.71	0.000604
R&D Expenses	1100.14	0.000909
Innovative Entities	205.63	0.004863
R&D Staff	123.76	0.00808
Innovation Grants	22.01	0.04544
R&D Institutions	18.06	0.055375
Mean VIF	876.55	

Table 5. Factor matrix after rotation

	Rotated components (blanks are abs(loading) <0.4)		
Variable	Factor 1	Factor 2	Factor 3
Innovative Entities	0.6156		
Innovative Goods and Services in GDP	0.5433		
R&D Expenses		0.7123	
Innovative Goods and Services		0.4127	
R&D Institutions		−0.4562	
Innovation Grants			0.8814
R&D Staff			

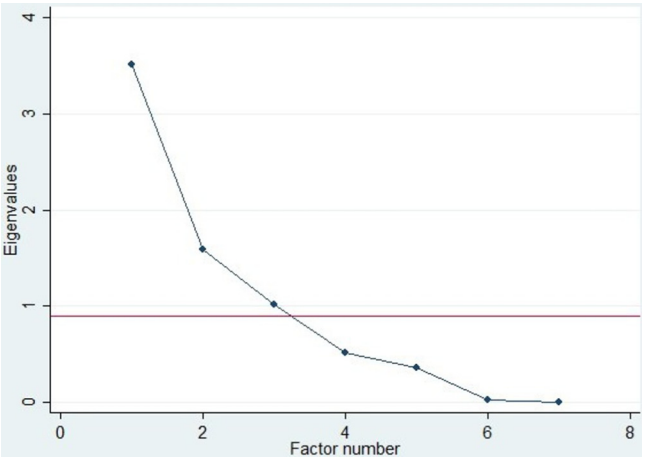

Figure 3.
Comparative dynamics of GII score and innovation grants of Kazakhstan

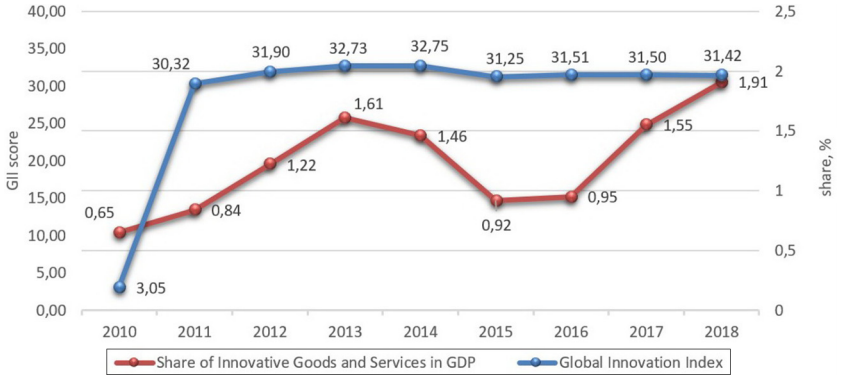

Figure 4.
Comparative dynamics of GII score and innovative goods and services of Kazakhstan

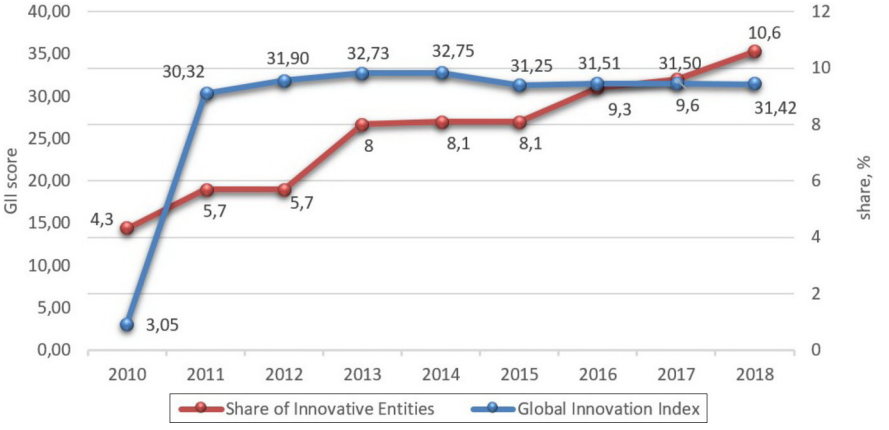

Figure 5.
Comparative dynamics of GII score and innovative entities of Kazakhstan

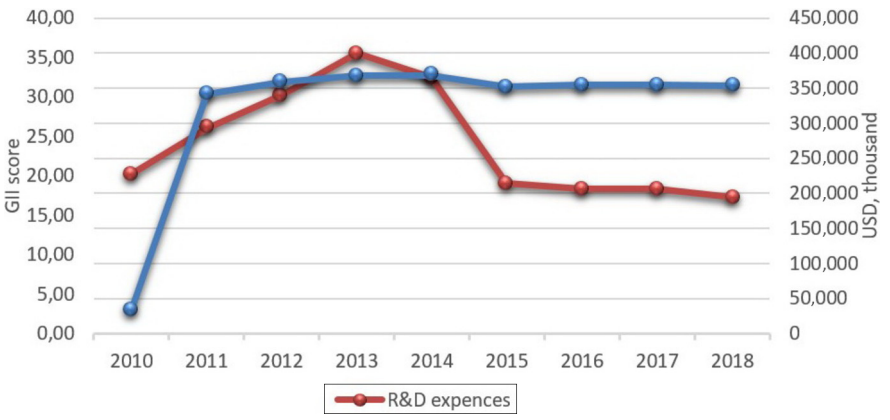

Figure 6.
Comparative dynamics of GII score and innovative goods and services in GDP of Kazakhstan

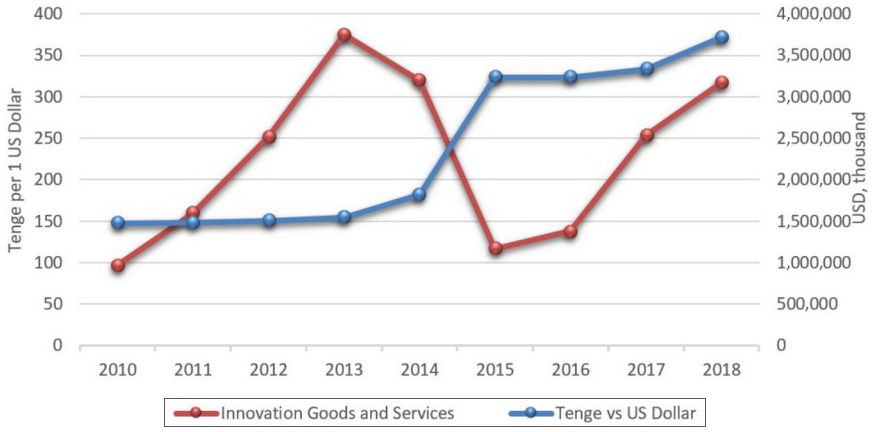

Figure 7.
Comparative dynamics of GII score and R&D staff of Kazakhstan

Changes over time in GII score and the number of R&D institutes in Kazakhstan are illustrated in Figure 8.

From Figure 8, the GII score somewhat correlated with the number of R&D institutes over the past three years. Yet, this correlation was not strong, as evidenced by fluctuations at the beginning of the observed period.

The decrease in R&D spending (Figure 1) and the cost of innovative goods and services (Figure 3) between 2014 and 2015 may be associated with a dollar jump. Changes over time in R&D spending, Innovative Goods and Services and Tenge exchange rate are displayed in Figures 8–10.

Through the analysis of input data, descriptive statistics for dependent (GII) and independent variables (R&D spending, innovation grants, etc.) were obtained (Table 1), which enable a better understanding of the research data.

The obtained numbers contain, among other things, standard deviations. One can argue that variables, such as the GII score, Innovation Grants, Innovative Goods and Services, Innovative Entities and Innovative Goods and Services in GDP, increased manifold. The extent to which the studied parameters are related is displayed in Table 2.

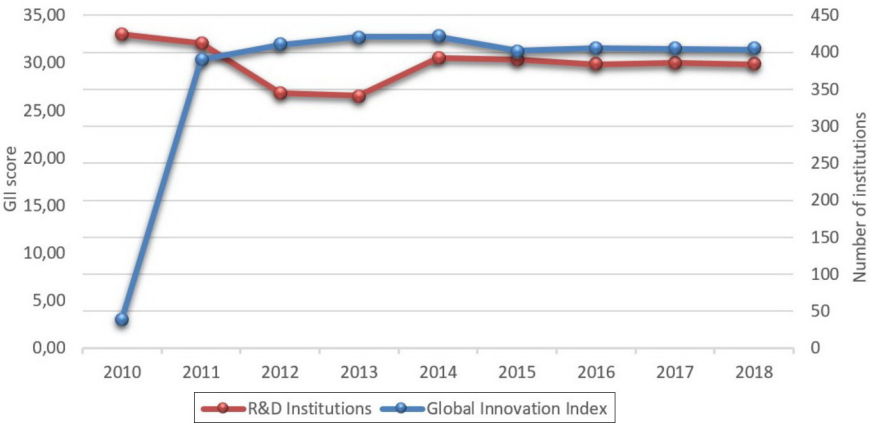

Figure 8.
Comparative dynamics of GII score and R&D institutions of Kazakhstan

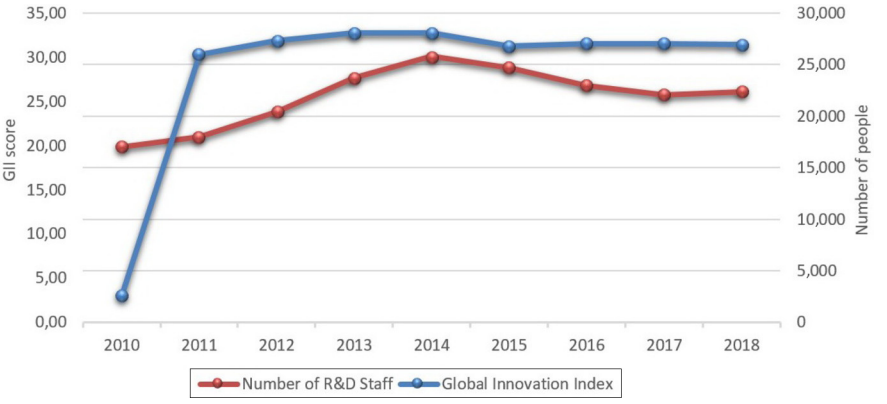

Figure 9.
Comparative dynamics of Tenge exchange rate and R&D expenses (expressed in USD) of Kazakhstan

As it can be seen in Table 3, the GII score is positively associated with all independent variables but the number of R&D institutions (the number of thereof has not changed significantly in recent years whereas the GII score and other variables have).

To prove data adequate, a number of tests were performed, among which data adequacy test, normality test, autocorrelation test, heteroscedasticity test, multicollinearity test and more. The Skewness–Kurtosis test for normality holds that data follows a normal distribution when the p-value is >0.05. The results of the normality test are given in Table 3.

The Durbin–Watson test statistic value is 3.460387, which means that there is no autocorrelation detected. The Breusch–Pagan/Cook–Weisberg test for heteroscedasticity was negative ($\chi^2(7) = 3.78$, Prob > $\chi^2 = 0.8048$, $p < 0.05$). The results of multicollinearity test are depicted in Table 4.

The Bartlett's test of sphericity revealed no interaction between the independent variables ($\chi^2 = 48.689$, degrees of freedom = 15, p-value = 0.000). The Kaiser–Meyer–Olkin test statistic is 0.262, which means that the sampling size was adequate for data analysis. The multiple linear regression model found a R^2 of 0.9998 (Figure 11), which means that the research model explains 99.98% of the variation in GII score, and other 0.02% of the

variation may be accounted for by variables that were not included in the model. The F value is 575.29 and the p-value is 0.0321, which means that the model fits the data well (the significance level was set to 1%).

Additionally, the Kaiser criterion and Cattell's scree test were used to determine the number of factors for extraction. Consequently, three factors were accepted as the most interpretable ones. These factors had eigenvalues >0.9 (Figure 12). The extraction of factors was performed using the method of maximum likelihood.

Table 5 shows the factor matrix after rotation. Small coefficients of <0.40 were suppressed. Matrix shows the loadings of each variable onto each factor. Factor loading is the correlation between the variable and the factor extracted from the data.

From Table 5, the number of innovative organizations (0.6156) and the value of innovative goods and services as shaper of GDP (0.5433) have relatively large positive loadings on Factor 1. R&D spending (0.8033) has large positive loading on Factor 2, whilst the cost of innovative goods and services (0.4127) has moderate positive loading on Factor 2, and the number of R&D institutions (−0.4562) has negative loading on Factor 2. Innovation

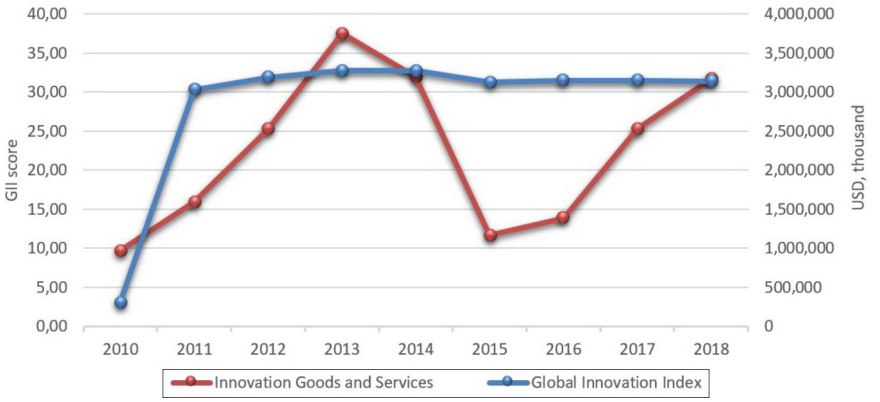

Figure 10. Comparative dynamics of Tenge exchange rate and innovative goods and services (expressed in USD) of Kazakhstan

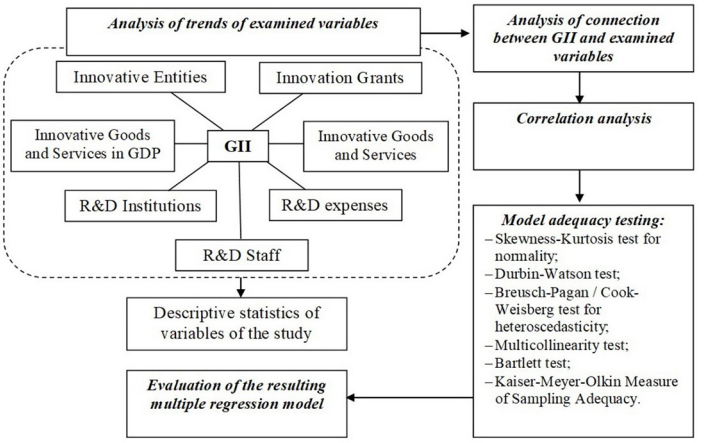

Figure 11. Multiple linear regression

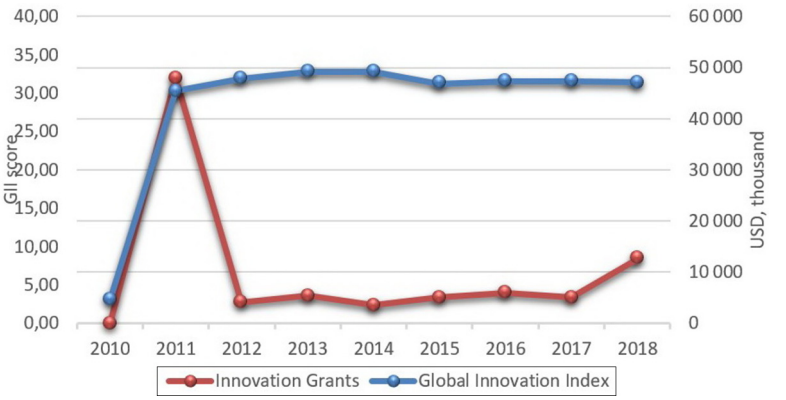

Figure 12.
Scree plot

grants (0.8814) has large positive loading on Factor 3. The number of R&D staff has no significant loading on any of the factors.

Descriptive analytics revealed a rapid increase in GII score at the beginning of the observed period and it remained relatively stable during the subsequent eight years. Fluctuations of varying strength were detected in R&D spending, the number of innovation grants, the volume of innovative goods and services, the percentage of innovative organisations, innovative goods and services (as per cent of) GDP, the number of R&D staff and the number of R&D organizations. At the same time, a comparison of their curves with that of the GII score showed no direct connection between the variables. The multiple regression analysis conducted on the examined variables revealed that the synergetic effect of all factors taken is close to 1. The impact of unaccounted factors is only 0.02%. Model adequacy tests suggest that the proposed regression model is feasible and can help to identify areas of innovative development of the country through modelling its GII score and thus improve its economic competitiveness.

Discussion

Innovation development in Kazakhstan as shown by the GII score is at a relatively low level. Domestic researchers also recognize the problem of low efficiency of innovation in Kazakhstan and dictate the need to take into account the reasons for the low efficiency of innovation in the country. Kazakhstan has a number of features that can contribute to the growth of innovative potential, including a high level of education, the ability to generate, accept and disseminate knowledge, high scientific productivity and constantly improving information and communication infrastructure.

The research showed that among the most influential factor are innovative entities and share of innovative goods and services in GDP (Jankowska *et al.*,2017).

R&D expenses, production of innovative goods and services are also important for the innovative development of a country. This finding is consistent with previous research studies in this field (Csur and Salvador, 2020; Erciş and Ünalan, 2016; Rodríguez-Pose and Wilkie, 2019; Svagzdiene and Kuklyte, 2016).

Aguilar-Barceló and Higuera-Cota (2019), Cetinguc *et al.* (2019), Hamidi and Berrado (2018),Menna *et al.* (2019),Natocheeva *et al.* (2019) and Singh (2020) also indicated the importance of R&D for innovation in the studies.

Innovation grants as a state support of innovations were not mentioned as a significant factor in other research studies. This can be explained by the fact that financial support of separate projects from the state is either not practised by other governments or there's no single authorised agency and/or aggregated statistics on such financial support.

R&D institutions as a determinant of innovative development were also indicated by the study of Jankowska *et al.* (2017).

The study found no remarkable correlation of GII score with the number of R&D staff, whereasSvagzdiene and Kuklyte (2016) found this factor as one of the determinants of innovation development of the country. Other research studies also pointed out the importance of human capital (Cetinguc *et al.*,2019; Hamidi and Berrado, 2018; Jankowska *et al.*,2017; Singh, 2020).

Conclusion

Although many studies explored the drivers of innovative development and the innovation performance of different countries, very few studies looked at the association of the country's GII score with the qualitative indicators of innovation performance. This study sought to contribute such an investigation by looking at the Republic of Kazakhstan (79th in 2019 GII ranking).

This study usedeight dynamic variables, among which 1one dependent (the GII score) and seven independent (R&D spending, innovation grants, the total cost of innovative goods and services, the percentage of innovative organizations, the share of innovative goods and services in GDP and the number of R&D staff and R&D institutions) variables associated with innovation performance. Changes in variables were tracked over the period from 2010 to 2018.

The results of the study show no significant correlation between GII score and other variables, yet this is not true with the number of R&D staff and R&D institutions. The correlation analysis found that GII score had a positive relationship with all independent variables but the number of R&D institutions. The multiple linear regression model was found to explain 99.98% of the variability of the GII score. The factor analysis suggests that the most important factors are the percentage of innovative organizations, the value of innovative goods and services as a share of GDP, R&D spending and the cost of innovative goods and services. The number of R&D institutions, innovation grants and the number of R&D staff were found to have no significant impact on the GII score of the country.

The results of the study suggest that the proposed multiple regression model may be effective in modelling the GII score of the country to identify areas of innovative development and improve economic competitiveness.

The results and methodology of the study may be useful in developing innovation strategies and policies as well as researching the correlation between qualitative indices associated with innovation and other global (regional) indices, such as GII score or otherwise.

This research is limited to the use of quantitative data. Future studies should consider both qualitative and quantitative factors influencing the country's GII score, such as GDP per capita, ITC/innovative good and services export, etc.

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