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Exploring the Management Perspective in the Formation of Digital Hub

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Abstract

The rapid growth of the term digitalization was seen throughout the COVID-19 pandemic all over the world. Digitization and ICT have become a part of people's lives. Currently, the concept of digital or technological hubs is relevant. The purpose of forming those hubs was to interact with the stakeholders and provide them with the resources (technological services, competent ICT specialists, financial investments, qualitative training, accelerating start-ups, incubators) to come to the best solution as in the global questions arriving in the world by improving the network and ecosystem, also in business questions occurring in the society. The appropriate infrastructure is needed to form such hubs, including competent personnel, technologies, finances, markets, and other resources. The purpose of this article is to identify the level of ICT, management, business, economics, and students' familiarity and interest in the digital hub concept and examine the influence of the number of universities on the number of students, number of graduated students, and employed population of 15-28 years old by economic activities. The methods of systematic literature review of foreign literature, quantitative survey, and correlation analysis were used in the paper. The students from different universities in Kazakhstan took part in the survey. The survey's findings revealed that the vast majority of aspiring specialists are enthusiastic and confident about their plans to work in the ICT industry.

Keywords: Digitization, Digital Hub, Digital Technologies, ICT, Digital Skills, Digital Capacity

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1. INTRODUCTION

The increasing interest in digitalization has heightened the need for competent IT, management, business, and economic specialists to predict forming digital hubs in regions, as hubs represent spaces for testing and implementing innovations, boosting the region's economy. The development of digitalization as a global trend worldwide is affected by factors such as the development of national strategies and government programs, ICT, and digital technologies. These factors include the development of digital cities, the risks associated with cyber-security during the spread of COVID-19, and the development of innovation management. The sudden shift to online mode, the state of emergency, and other measures to prevent the spread of the virus have significantly boosted the adoption and use of modern technology in countries worldwide. As the COVID-19 situation demonstrated, countries placed a significant emphasis on developing their ICT infrastructure, which allowed for the quick conversion of physical worlds into digital ones. The digitalization process occurs in almost all countries, and each country has its priorities and directions for digital enhancement, depending on the country's potential. The implementation of digital National digitalization programs determines digital development in countries, currently more than 15 countries are implementing them. The leading countries in digitalizing national economies are China, Singapore, New Zealand, South Korea, Denmark, and others. China is integrating digital industries with traditional industries in its Internet Plus program, Canada is creating an ICT hub in Toronto, Singapore is building a Smart Economy driven by ICT, and South Korea is focusing on developing human capital, entrepreneurship, and dissemination of ICT achievements. In contrast, Denmark focuses on the digitalization of the public sector.

According to the Digital Kazakhstan program, the main goal is to accelerate the pace of economic development and improve the quality of life of the population through the use of digital technologies, as well as in the long term to create conditions for the transition of Kazakhstan's economy to a digital economy. One of the vectors for achieving this goal is "Creating the digital industry of the future", which means ensuring long-term sustainability, launching the country's digital transformation by increasing the level of human capital development, and progressive development of the digital ecosystem. Since one of the crucial human capital resources is young people, paying attention to their skills and knowledge in digitalization and developing digital hubs.

Recently, there has been growing interest in technology or digital hubs, which provide necessary services to organizations, medium and small enterprises, and businesses in testing business ideas and using digital technologies. In managing the formation of digital hubs, the first consideration is the available infrastructure and the human resource factor in the form of competent ICT professionals.

The problem of a shortage of IT professionals to form digital hubs has been highlighted at the national level. However, considering business, economics, and management professions is also essential. In their capacity, IT specialists cannot superintend the whole process of hub activities, from creation to sustainability. Since the purpose of forming digital hubs involves working towards creating and producing innovations, these specialisms are critical.

A digital hub has several functions, including technical, financing, training and testing, where the job of IT specialists is to implement technical operations. The management specialists' aim is the process of planning, organising, motivating, coordinating and controlling the activities of the digital hub. The task of the economic specialists is to fulfil the plans, strategies, cost accounting, income of the digital hubs, attracting specialists to the hub, therefore creating new workplaces. As a result, they raise living standards by providing services to local organisations, developing business ideas and start-ups that will benefit the local population with taxes, and develop the

region's infrastructure. The role of business professionals is proposing creative ideas, brainstorming, supporting start-ups and finding investors.

Of particular interest are students from higher educational institutions at the bachelor's level, as not many continue studying master's and doctoral programs, graduating from university and entering the workforce, must have digital skills in the rise of digitization. Many recent studies have focused on analyzing ICT skills of students and separately ICT skills of teachers in various fields, but there are no studies in identifying digital skills for the formation of digital hubs. However, this study aims exploring self-evaluation of digital skills of students' of higher education institutions at bachelor's level as future professionals in forming the digital hub and real experience of academic staff facing challenges with students who lack the digital skills in educational process.

2. LITERATURE REVIEW

In the academic community, most scientists have noted in their research papers that the promotion of business development and innovation contributes to poverty alleviation and is accompanied by economic growth in the long run (Fagerberg, 2009; Hall et al., 2012; Abisuga-Oyekunle, 2020). Most prominently, the productivity of digital development is critical in rural areas. However, one major drawback of remote areas is that the population usually underestimates the significance of digital skills, the digitalization of the economy, and the development of digital hubs. This is usually because rural areas primarily focus on the possibility of having access to finances. However, the development of the financial sector is doomed without the digitalization of the area (Dyba et al., 2020). As a result of the formation of hubs, citizens are seen through the lens of market players as entrepreneurs and citizens improving their development.

Educational institutions stand out as prominent participants in developing a digital hub. In particular, higher educational institutions function as a bridge between private and public integration. Consequently, this increases the importance of the curriculum provided to students, such as access to various information systems, availability of necessary software, and development of digital skills, for example, in online computation (Kelly & Firestone, 2016). According to the study, students who have learned ICT skills clearly express thoughts and are better problem-solvers and self-directed than others (Somerville et al., 2008). The role of ICT while working with information, finding the needed one, evaluating and understanding it is essential for students' academic and personal needs (Perez & Torelló, 2012; Simona et al., 2017). ICT efficiency in the learning process, especially when working with information, using it for solving problems and making decisions, is also mentioned in the works of Horton (Horton, 2008). According to other research, digital literacy is more than just about owning technical skills; it also considers situative practices with communicative and functional competencies (Knutsson et al., 2012). The social and ethical challenges arising while participating in digital networks, management, and searching for information in the virtual area are highlighted in the work of Henriksen (Henriksen, 2011).

Moreover, incorporating digital skills by teaching staff increases the possibility for students to develop and practice their skills. The opportunity to practice digital skills improves the possibility for students to become part of the digital ecosystem and contribute to the development of private industry (Mahmood, 2009; Guzmán-Simón, 2017; Ghafar, 2020; Wang, 2021). According to the study, among the teachers of various fields, science teachers' attitudes to ICT showed the highest contribution (Har et al., 2022). The situation with COVID-19 showed significant changes in learning processes worldwide for teachers and students, highlighting the need to improve their digital skills (Yu, 2022). The results of another study ascertain that the capacity to adjust

information technologies in blended, online, and offline contexts is concerned with digital literacy, which is essential in the learning process (Kara, 2021).

It must be mentioned that initially, educational institutions are regarded as a third space for innovation development and, consequently, the development of digital hubs. Moreover, at the stage of secondary education, such skills as using online applications and digital tools (such as mobile phones or tablets) are already highly valued. The application and usage of local technologies indicate students' readiness for the development of a digital hub (McDougall et al., 2018). Digital skills, such as the ability to use digital tools (such as mobile phones or personal computers), digital artifacts, and social media, play a mediating role in information seeking among bachelor's degree students (Atoy et al., 2020). In their study, Radovanović et al. (2020) emphasized the importance of using digital skills in surfing digital artifacts. They divided the skill of using the Internet of Things into three groups: surfing social media and applying analytical skills using traditional formal skills in the Internet search engine (Radovanović et al., 2020). Digital literacy is using digital tools and artifacts to reduce barriers to obtaining knowledge and thus reduce the differences between students, including students with special needs. Therefore, digital literacy in various directions is becoming a critical skill (Hillier, 2017; Tohara et al., 2021).

The necessity of digital skills was vividly vital during the burst of COVID-19. Such stagnation of the economy in urban areas leads to massive destruction of the economic ecosystem, such as job loss, private business bankruptcy, etc. (Banai, 2020). The two sectors of the economy that have shifted massive functioning to online mode, especially in crises, are education and healthcare. The lockdown conditions pushed specialists in these fields to gain new knowledge in digital literacy (De et al., 2020; Lee & Trimi, 2021; Turnbull et al., 2021).

The human resource factor in forming digital hubs is crucial, as the human resources implement and make the most critical decisions and operations in the hub's activities. There is a need for more competent ICT professionals in Kazakhstan. According to this study, it was revealed that the level of proficiency in ICT skills also depends on age, so it was found that educated and adult people have a higher level of proficiency in ICT skills than the younger generation, who use the Internet and ICT more often than expected (Van Deursen, 2010). Another researcher also confirmed these results (Eshet-Alkalai, 2004). The digital skills of staff in enterprises and organizations in the industry, the public sector, and services are becoming overwhelmed by the growing demands. The provided literature review showed that existing literature on the development of hubs is not more focused on studying existing hubs and factors affecting their development. Few studies discuss developing digital skills in educational and social environments. However, it is still important to explore the view of bachelor's degree students about their digital skills, as they are the primary labor force and the engine for digital hub development.

Digitalization penetrates all spheres of society, and using digital technologies in various activities is increasingly frequent. Digital hubs help to determine the level of digitalization of organizations and improve the existing level. Digital hubs are based on the region's innovation infrastructure and human resources. Human resources in digital hubs play a significant role. Therefore, a survey was conducted among undergraduate students about their awareness of hubs and interest in future activities with digital technologies as a perspective of digital hub management. Significantly, future professionals' digital skills and competence will influence their work in digital activities.

To examine the role of universities in the labor market of economic activities following hypothesis were examined:

H1: Number of universities impact the number of students.

H2: Number of universities impact the number of graduated students.

H3: Number of universities impact the employed population 15-28 years old by economic activities.

The study aims to identify the level of familiarity with the concept of "digital hub" among students of leading universities at undergraduate level, the level of familiarity with the programme "Digital Kazakhstan", self-assessment of digital skills, identifying factors hindering the formation of digital hubs in Kazakhstan, identifying students' interest in working with digital technologies in the future and teachers' experience of working with students of various fields on implementing digital skills and digital instruments in the educational process.

Research questions are following: to what extent do undergraduate students have an understanding of the concept of digital hubs? How many of them see themselves in digital and ICT-related activities? How do teachers define students' digital skills?

3. METHODOLOGY

The methods of investigation are conducting survey among students at higher education institutions at bachelor's level and interviewing among academic personnel. The research design of the study is based on the provided literature review and uses qualitative research methods in order to establish the level of digital skills among the students at higher education institutions at undergraduate level and to identify teaching personnels' experience towards students' using digital skills at the educational process. A conducted literature review manifested that students lack the understanding of digital skills and enhancing practical application during learning process.

Data sampling was carried out as follows: 1) university lecturers are the main guiding and interest link in teaching undergraduate students the knowledge of profile and subject-specific specialties, as well as in today's realities the identifying link of students' digital skills through the use of digital attributes in teaching; 2) undergraduate students of IT, management, innovation management, economics, business specialties were selected for the survey, as the staff of these specialties directly affect the management of digital hubs. A total of 200 questionnaires were sent to undergraduate students, but 170 of them were answered.

Table 1 includes research questions of the interview.

TABLE 1. List of the interview questions

No.	Interview question blocks	Question
1	What is the level of digital skills of first year students?	How would you describe digital skills of your students? Do they need basic skills training?
2		How often do students need to use digital skills? Do they have to use them at particular subjects or topics?
3	How does digital skill impact on the students' educational process?	How does the level of digital skills impact on the progress of students? Does basic knowledge of ICT usage play a crucial role?
4		What is the usual reason of students appeal if they fail exams?
Note: compiled by authors		

Specifically, students of bachelor degrees at higher institutions are of great importance, as a minority of undergraduates continue studies at master's and doctoral levels, entering the labour market. Progression of digital skills in using various online platforms and devices such as mobile phones, tablets or personal computers contribute to the quality of education. Moreover, according to several studies the significance of applying digital skills in daily occurrence exhibited rectification of students' digital literacy levels. The designation of survey questions and inquiry

for the provision of interview was based on the conducted literature review. Hence, the questionnaire consisted of three following blocks. The survey consisted of 30 questions.

The first part of the survey comprised next descriptive statistics: university title, type of specialty, and curriculum. Students' self-evaluation of digital skills at the undergraduate level was the second part of the questionnaire. Confidence in applying digital skills plays crucial role among students in gaining new knowledge. The awareness of students about the digitalization and the concept of digital hubs is analyzed in the third group of the questionnaire. There were distributed 200 surveys among students of higher education institutions at bachelor's level, but only 170 returned.

Secondly, five interviews among university academic staff were carried out, who run lectures and seminars for students of various specialties. The interviews were conducted on an individual basis. According to ethical issues, the interviewees were informed that the research would include the interview results.

The interview comprised two groups of questions, which included two questions each. During the interview process the questions were modified where necessary. Thus, the structure of the analysis was based on the three main questions. The first group of questions was focused on the analysis of students' digital skills knowledge after completing secondary education, as basic skills were taught at schools. In addition, questions were focused on the features of the educational process. The second group of questions was concentrated on the analysis of the impact of digital skills on the performance of the students. The goal was to identify the reasons students indicate appealing in cases of exam failure. The interviews were mainly directed at the real opinion of the academic staff as they deal with students and know current issues students face during education.

Correlation analysis is applied in the research, the formula of which is presented below (1):

$$r_{xy} = \frac{\Sigma(x_i - x_{medium})(y_i - y_{medium})}{\sqrt{\Sigma(x_i - x_{medium})^2 * \Sigma(y_i - y_{medium})^2}} \quad (1)$$

where r_{xy} −is Pearson correlation coefficient,
x_i −is the i-th element of the selection x,
y_i −is the i-th element of the selection y,
x_{medium}, y_{medium} −are the i-ths elements of the selection x and y.

For the current research following variables were chosen: y – number of universities; x_1 − number of students; x_2- number of students graduated; x_3- employed population 15-28 years old by economic activity.

The data was collected from the official statistical yearbooks of the Bureau of National Statistics of Republic of Kazakhstan from 2010 to 2021 and were seen in Table 2 below.

Table 2. Description of study sample

Indicator	Variable	Unit of measurement	Period of time
Y	Number of Universities	Units	2010-2021
X1	Number of students	Units	2010-2021
X2	Number of students graduated	Units	2010-2021
Note: compiled by authors			

The aim of correlation analysis is to test number of universities affecting number of students, number of graduated students and employed population 15-28 years old by economic activity from 2010 to 2021.

4. FINDINGS AND DISCUSSION

The analysis of the survey showed that there were 170 participants of five universities in three fields of specialties. The data on descriptive information is presented in Figure 1.

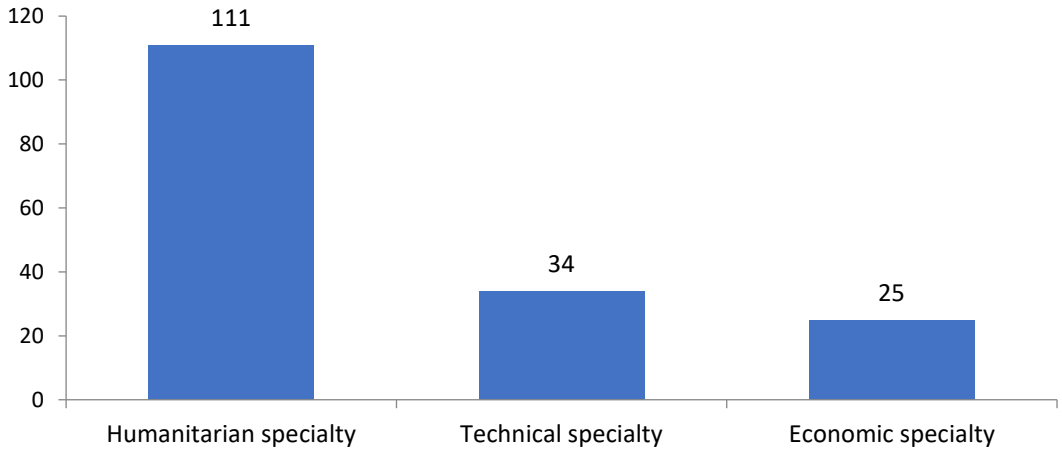

FIGURE 1. Distribution of survey participants according to specialties, in %

Note: compiled by authors

Humanitarian (65%), economic (15%) and technical specialties comprise about 20% respectively. According to the survey, 81% of respondents stated that they study subjects on digitalization, information and communication technology, IT. Interestingly, 9.4% of participators were not sure if their educational curriculum had subjects on digitalisation, information and communication technology, and IT.

Figure 2 shows data on respondents' self-evaluation the level of digital skills.

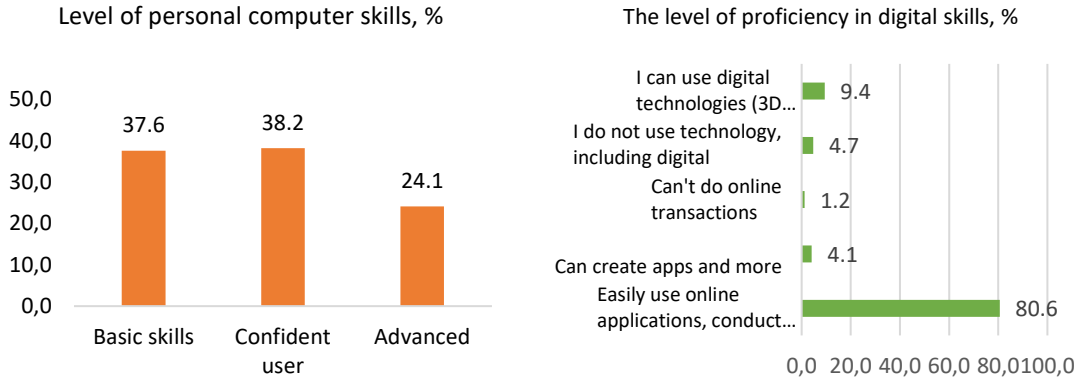

FIGURE 2. Self-evaluation of digital skills by respondents, in %

Note: compiled by authors

Of all respondents, only 24.1%, evaluate themselves as having advanced skills in using a personal computer. In comparison with advanced users, students with basic and confident skills

of computer usage proved to be quite different comprising around 38% each, supporting the results for digital skills proficiency. A great number of attendees, 80.6% feel confident using online applications or conducting various online operations. This shows that, as a whole, students are confident users of personal computers or other gadgets and furthermore feel confident using digital artifacts. Slightly less than 10% of students used more advanced digital technologies or software such as Internet of things (39.4%), artificial intelligence (24.1%), robotics (17.1%), blockchain (11.2%), 3D printing (9.4%), big data (15.3%). 30% of the respondents answered they did not use any of those technologies, and 5.3% mentioned they used all of the listed digital technologies. The advantages and disadvantages of digitalization are presented in Figure 3.

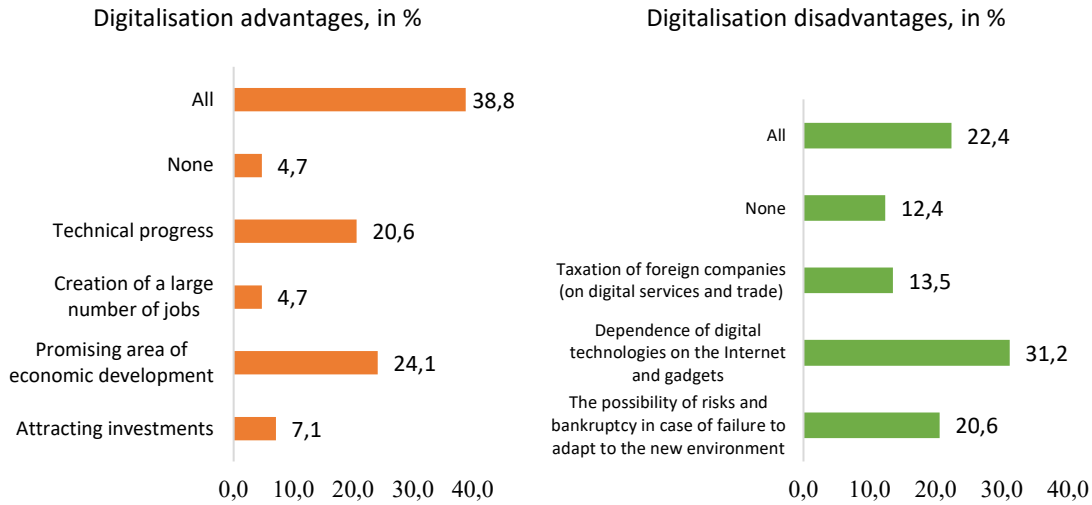

FIGURE 3. Digitalization advantages and disadvantages, in %

Note: compiled by authors

Among the advantages of digitalization, most students mark the development of the economy and technological innovation as the main contribution and comprise showing 24.1% and 20.6%, respectively. Few students concentrated to the decrease in unemployment. According to the results, 38.8% of students consider all fields as advantages in the economy's digitalization process. Nevertheless, it can further be regarded as necessity to gain more knowledge in digitalization impact and development of digital hubs.

Dependence of the technological innovations to access to the Internet (31.2%) was underlined as the main disadvantage. This additionally highlights the challenges of implementing of broadband internet, especially in remote areas. Next, the possibility of private business development failure made up 20.6%. Taxation of foreign companies is not regarded by the majority as a disadvantage, only 13.5%. This could be explained by the fact that students at the level of bachelor's degree might need more knowledge about global economic development and the impact of international agreements, etc.

71% of students are familiar with the Digital Kazakhstan program. 47.1% of students intend to work with digital technologies, in comparison with 32.9% who are not sure, but are interested. Respondents consider financial 42.4% and human resources 37.1% to be the main hindering factors in the formation of digital hubs in Kazakhstan.

The second part of the analysis includes the interviews conducted among the academic staff from five universities. The interview had two groups of questions. The interview analysis was built according to the main interview questions.

The first group of interview questions results ("What is the level of digital skills of first year students?"). The results of the interview indicated that first year students have poor basic digital skills. Interestingly, students can easily pass their assignments through mobile applications as they feel confident when using device. On the contrary, using computers was more challenging for them as among issues that students' experiences are starting a computer, creation of MS word document or Excel, usage of online platforms. Some students have trouble in learning the interface of an online platform at the beginning. Undergraduate students still need basic training of computer usage or usage in online platforms. Moreover, there are some subjects, which are conducted all the way on computers. Additionally, majority of the exams first year students pass on computers in test format, mid-terms exams are usually passed online as well. The results are different for academic staff from the rest universities. Mostly, because the rest of the academic staff conduct humanitarian subjects which are not highly dependent of digital tools. Students have the possibility to pass their assignments in a written form or orally.

The second group of interview questions results ("How does digital skill impact on the students' educational process?"). The first question was about the reasons why students appeal when they fail their exams. All of the respondents stated that most students, when they appeal to receive more points or have the opportunity to pass the examination for the second time, have two reasons. The first reason is related to health conditions, which explains that they could not cover all questions. The second reason is that during lectures or seminars, the information included in the exam needed to be presented on the slide, or the teacher gave no recommendations on the literature to study the material.

According to the academic staff, students sometimes need additional time to prepare for classes. The lack of familiarity with online platforms led to breaking the deadline of handing the materials. Even though students have good skills in using ICT, they have not developed the habit of working online. Unlike secondary education at universities, students are not reminded about their assignments or deadlines. The online platforms include all information needed. The tricky moment for students working online indicates the reason why they miss the deadline for assignments to pass. Another reason, especially among undergraduate students, is a necessity for digital skills in using a personal computer, particularly MS WORD, Excel, and PowerPoint.

Nevertheless, the reasons mentioned above for exams and assignments failure are present at all levels including the students of higher education at a bachelor's level. This puts conditions for academic staff to soften the requirements for developing the educational curriculum. That is, students need more knowledge related to the usage of various software or digital tools.

The results of correlation analysis of variables are presented below (Table 3).

TABLE 3. Descriptive Statistics

Ind.	Mean	Median	Observed		Stnd. Dev.	Excess kurtosis	Skewn.	P value
			min	max				
Y	129.833	126.000	122.000	149.000	8.971	0.484	1.386	0.001
X1	546481.333	571691.000	459369.000	629507.000	56412.666	-1.409	-0.118	0.403
X2	152974.917	153627.000	127084.000	177678.000	15897.648	-1.094	-0.061	0.888
X3	2156.355	2182.720	1985.773	2341.100	121.368	-1.690	-0.044	0.139
Note: compiled by authors								

Table 3 shows the descriptive statistics of the study data. The mean value representing the sum of observations is presented. The lowest value shows Y is 129.833 and the highest value shows X1 is 546481.333. In terms of standard deviation values, X1 also shows a high value of 56412.666. The high value of standard deviation shows the sufficient spread of the sample. An indicator of the strength of relationship between the variables is Cramer's V. This indicator varies between 0 and 1. A value of 0 indicates no relationship between the variables. The values of current studies range from 0.001 to 0.888 where Y-0.001, X3-0.139 indicates weak relationship with the variables, values X1-0.403 shows medium relationship and value X2-0.888 shows strong relationship. The indicators of normal distribution are skewness and excess kurtosis. Excess kurtosis shows the peaks of distribution, the degree of skewness shows the normal distribution of variables. Parameters of skewness varying from -1 to +1 are rated as excellent, values between -2 and +2 are considered acceptable, in this study the value of Y-1.386 indicate excellent parameters. The parameters X1, X2, X3 have negative zero skewness which means they are acceptable if the skewness is between 0.4 and -0.4 which is the criterion for large samples. A negative value indicates a flat distribution. When the kurtosis and skewness are close to zero, the model is considered a normal distribution (George & Mallery, 2019; Hair et al., 2022). According to the V-Kramer value, a value of 1 indicates perfect relationship and 0 indicates no relationship. The null hypothesis whose value is greater than zero $p > 0.05$ means that it is a normal distribution and is accepted, while if the value is less than $p < 0.05$ it indicates non-normality of the distribution and is rejected (Martínez-Camblor et al., 2014). In this study, the indicators indicate normal distribution except for the Y value, 0.001.

The following Table 4 indicates correlation matrix.

TABLE 4. Correlation matrix

Item	Y	X1	X2	X3
Y	1.000			
X1	0.599	1.000		
X2	0.479	0.187	1.000	
X3	0.432	-0.316	0.695	1.000
Note: compiled by authors				

According to the results obtained during the analysis of the correlation matrix, we can see a strong relationship between the number of universities and the number of specialists employed in economic activities, which is 0.695. The number of universities also has a slightly higher than average relationship and shows a value of 0.599 with the variable X1-number of university students, but the effect of the number of universities on the number of graduated students shows a weak correlation, 0.187.

The hypotheses were tested:

H1: Number of universities impact the number of students – supported.

H2: Number of universities impact the number of graduated students – supported.

H3: Number of universities impact the employed population 15-28 years old by economic activities – supported.

5. DISCUSSIONS

The research results showed that teachers sometimes are pushed to soften requirements when working on the educational curriculum as students come unprepared to work on online platforms or search for correct sources of information. Moreover, students are required to use their digital skills constantly for every class. However, some teachers do not consider the level of digital

literacy among students as it is a mutual requirement. Nevertheless, existing studies mostly discuss that it is mainly the responsibility of academic staff that students are not improving their skills, and low level of digital skills among teachers is the main reason for students' poor digital skills and knowledge (Hillier, 2017; McDougall et al., 2018).

Most existing studies discuss that digital skills have become a compulsory characteristic of a student (Radovanović et al., 2020; Tohara et al., 2021). Notwithstanding, basic knowledge of digital tools usage, such as personal computers is taught at the stage of secondary education. Therefore, the responsibility put on higher educational institutions must be related to the digital knowledge background of students. Secondly, the results of the questionnaires supported that specialty plays a significant role in the distribution of the current educational curriculum is usually based on the specialty. However, the survey results showed that there were students from three specialties. Among students of humanitarian specialty, 80% stated that they studied subjects related to digital literacy; among students of technical specialty, they comprise 77%; among students of economic specialty, 94% stated that they had subjects related to digital literacy and skills development.

According to the survey results, most subjects studied by students were in the humanities. This shows that the current educational curriculum of universities is dominated by humanitarian subjects, which contradicts the current realities of digitalization. Previous studies showed that the job market is primarily driven by emerging technologies (Connell et al., 2014). Thus, digital technology and ICT are drivers of economic and social development (Kim et al., 2011, p. 22), affecting education, medicine, business, culture, and more. There is a shortage of professionals with digital skills, but the market is oversaturated with specialists with soft skills (Wenjing & Jin, 2021). However, technology is the engine for creating innovation. Digital technologies are increasingly being embedded in organisations, which requires the importance of developing and mastering hard skills and digital skills. This means that digitisation and technical subjects need to be introduced in all education programmes, as competent professionals with digital skills in all areas are still lacking.

It can be assumed that a lack of digital skills and access to digital tools results in the failure of students. Although scientists discuss that digital hub development is based on the labor force potential, this issue has yet to be studied. This shows that putting the responsibility on one side is wrong. Digital hubs are a combination of various organizations and specialists who are willing to create a space beneficial for the private sector and the community as well (Hall et al., 2012; Abisuga-Oyekunle, 2020; Rundel et al., 2020)

The development of digital hubs goes through the development of digital skills. The role of competent specialists is fundamental while forming digital hubs. However, compared with the previous generations, computers and technologies have become part of almost every job. Although students enlarge their digital knowledge and improve their digital literacy through an educational curriculum of higher educational institutions, secondary education acts as a booster. It would be practical for stakeholders of digital hubs to organize meetings in the region and discuss the educational curriculum with the specialties and skills needed at the job according to the fields of study. Based on that, the educational curriculum must be developed on the digital literacy background of students to accelerate the development of digital hubs.

In conclusion, it is significant to equally develop both humanities and technical specialties in higher education institutions. The number of universities influences the number of students, graduated students, and employed population. It is also important to include technical subjects in all specialisations, as digitalization affects all areas of life and requires skilled professionals in the labour market. Previous studies did not consider educational programs (Miörner et al., 2019). Current study shows that Basic digital skills impact students' performance, and there is a lag in understanding further digital skills.

6. CONCLUSIONS

The current research focused on studying digital skills among bachelor's degree students. Development and practice of digital skill is crucial for the potential of digital hubs development. Usually, practice and improvement of digital skills is achieved through the educational curriculum at higher educational universities. Therefore, universities stand out as the entire space for digital hub development.

The study results showed that economic specialities are more focused on developing digital literacy, using digital tools that develop students' digital skills. The next is the interaction between students and the academic staff during the educational process. The results showed that in those universities where the work of students is done through online platforms and exclude paper routine, digital skills are used constantly. Moreover, it is easier to detect that students need more experience and knowledge in digital tools. They are more experienced in searching for correct sources of information for studying educational material. Although students have skills in using digital gadgets such as mobile phones and state themselves as confident users of personal computers, this only sometimes contributes to their ability to work on online platforms. Moreover, the results reveal that this is one of the primary reasons for the failure of students to pass their assignments on time.

Universities can adopt foreign experience and introduce the subject of study skills, which prepares first-year students to study in higher educational institutions. A low level of digital literacy and lack of experience or practice using online platforms impacts the quality of the educational curriculum.

To sum up, higher education institutions need to improve the educational curriculum for first-year students and include courses on the preparation of students to study in a particular university. Overall, the role of universities remains prestige in labour market. Teachers and students must pass training on online platforms or software students learn to use during education. This way, the education process will be interactive, and students will have the opportunity to develop their skills.

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Assessment of the Global Experience of Strategies for Gender Asymmetry Reduction

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Abstract

Gender asymmetry often denotes significant gender inequality, encompassing disparities in societal norms, cultural convictions, and historical legacies. This asymmetry results in an unequal distribution of opportunities, resources, and power between individuals of different genders, with one gender often enjoying certain privileges over the other. This article analyzes the effectiveness of implemented and tested strategies in reducing gender asymmetry, with a special focus on four countries such as the United States, Great Britain, Germany and Kazakhstan. Special attention is paid to comparing approaches and results in different countries, which makes it possible to identify the most successful practices and general trends. Despite the implementation of various government policies and standards aimed at achieving equal pay for employees of all genders, women still tend to receive lower salaries compared to their male counterparts, even when they hold similar positions and perform similar job responsibilities. Through meticulous investigation and the application of statistical methodologies, it is attempted to gauge whether these strategies have contributed to a reduction in gender asymmetry, comparing the statistics from 2019 to 2023 for the outcomes' evaluation. In conclusion, the article offers recommendations for the development and implementation of effective strategies that can be used by governments and organizations to further promote gender equality.

***Keywords**:* Economics, Empowering Equality, Gender Equality, Asymmetry Reduction, Gender Pay Gap, Employees, Payment Inequality, Kazakhstan, Equality Strategies

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1. INTRODUCTION

In recent decades, it can be stated that questions of gender equality have become one of the most discussible social topics in many developing and developed countries around the world (Carli, 2020). It is possible to consider challenges of gender inequality as a particular issue that has existed throughout human history, directly influencing not only individuals and societies but the global economy accordingly (Breda et al., 2020). An interesting aspect in a long fight against any form of gender inequality is that not depending on all the efforts, there is still a sufficient disparity, leading to gender asymmetry. This asymmetry is represented in many forms, such as wage gaps, domestic violence, unequal access to education, and an underrepresentation of women in leadership roles in business (Breda et al., 2020). Analyzing a variety of relevant studies by researchers about gender asymmetry and its effective reduction, it becomes clear that achieving gender equality is not just a matter of social justice (Carli, 2020; Breda et al., 2020; England et al., 2020; Foley & Cooper, 2021). Success in this field can effectively impact the growth of the popularity of sustainable development, the stable promotion of social cohesion, and the obtaining better potential of better human capital.

Generally, it should be highlighted that gender asymmetry usually refers to a significant gender inequality involving disparities in social norms, cultural beliefs, and historical legacies (King et al., 2020). It means that such asymmetry provides an unequal distribution of opportunities, resources, and power between individuals of different genders when a representative of one gender gets some privileges compared to another. The obvious illustration of gender asymmetry is the gender pay gap. Not depending on the fact that most modern governments implement policies and standards towards equal pay to employees of both genders, women are continuing to get smaller salaries in comparison with their male colleagues, who can take similar positions and scope of jobs (King et al., 2020; Chung et al., 2021). This situation happens not only in countries with weak economies but also in strong ones, where authorities make a lot of efforts to achieve gender equality in different social aspects, including workspace. It is possible to emphasize that such wage disparity not only limits economic independence for women but also negatively impacts the cycle of financial dependence (Wynn, 2020). Education is another challenge, leading to a fact of gender asymmetry. For example, in several countries, women still have problems getting a qualified education on an equal basis with men (Chang & Milkman, 2020). It leads to such dimensions that they have fewer opportunities and freedoms for personal self-development. Therefore, women get smaller roles in society, where they do not have a vote or a chance to speak for themselves due to issues with self-sufficiency. The same situation is observed in taking leading positions by women and stable rates of violence against women, especially cases of domestic violence where female citizens have almost no legal protection. In the post-Soviet states, there is still a massive gap in law regarding domestic violence and ways of combating it effectively (Silander et al., 2022; Leung et al., 2020; Eden & Wagstaff, 2021; Iversen et al., 2020).

However, considering all the existing problems in empowering quality, specific progress takes place in some countries, such as Europe, Australia, the United States of America (US), the United Kingdom (UK), and others. Its governments have launched a variety of strategies and methods to eliminate gender asymmetry properly to provide women more opportunities for both personal and professional growth, as well as let them feel safer in a modern society, which rely on masculine world stereotypes rather than equal opportunities between genders. This article analyzes the effectiveness of implemented and tested strategies in reducing gender asymmetry, focusing on four countries: the United States, Great Britain, Germany, and Kazakhstan. Through careful investigation and statistical approaches, it would be possible to visualize whether these strategies have helped to reduce gender asymmetry and compare statistics of its results for the period from 2019 to 2023.

2. LITERATURE REVIEW

Considering that the topic of gender equality has been common since the end of the previous century, there are many comprehensive studies and theoretical assumptions regarding its roots and causes, as well as strategies to eliminate its negative influence on the development of modern society. Empowering equality is not just a moral imperative (Odera & Mulusa, 2020). This is a necessity for encouraging inclusive and sustainable societies. Undoubtedly, to be equal not depending on the gender is one of fundamental human rights, which is specified in various international documents, such as the Universal Declaration of Human Rights and the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW). These agreements underline the importance of reducing discrimination and promoting the equal participation of women in all spheres of life (Sen, 2019).

Researchers have stated that gender equality is a key to stable economic growth at both local and global scales. Both previous and recent studies have shown that closing the gender pay gap and reducing gender asymmetry can boost GDP and drive innovations (Tang, 2021). Furthermore, gender-balanced decision-making processes lead to better governance and policy outcomes. Stimulation of diversities in perspectives impacts problem-solving and leads to the fact that the needs and concerns of all citizens are considered (Niaz & Iqbal, 2019). Addressing issues of gender asymmetry is essential for achieving the United Nations Sustainable Development Goals (SDGs), particularly Goal 5: Gender Equality, which intersects with other development challenges such as poverty, health disparities, and environmental sustainability (United Nations, 2023).

The following study would like to focus on strategies for gender asymmetry reduction in four regions, such as the USA, the UK, Germany, and Kazakhstan. Therefore, it is possible to highlight some core elements of the previous studies to specify the importance of a new one. The USA can be considered one of the countries that made sufficient progress in empowering equality. The report of Shriver et al. (2023) has found that the recent COVID-19 pandemic has negatively influenced women, providing an inevitable inequality at work and home, so the study has provided some recommendations to improve the situation through providing better childcare, increasing paid family leave, launching updated equal pay legal norms, boosting educational programs for female employees, and challenging patriarchal approaches in a governmental system. The article by Eagly and Sczesny (2019) emphasized that paid family leave would be a great solution to eliminate gender disparity and help women with low incomes. Canetto (2020) has stated that women now have better opportunities than at the beginning of the century. However, there are still many challenges with their societal role due to corruption and bureaucracy issues.

Europe and the UK are characterized by significant progress in eliminating gender asymmetry, as well as the USA. The article by Wuya (2021) has indicated the causes and consequences of the gender pay gaps, leading to an underestimation of women's abilities and opportunities in comparison with men. Barker and Jirasz (2020) have examined the impact of the pandemic on gender asymmetry in Europe, as women were expected to work and do home duties while men were treated better, avoiding more responsibilities. Cox-Han and Heldman (2023) have underlined that Europe still needs to focus on the root causes of inequality and address gender stereotypes that exist in the workplace.

The situation with Kazakhstan is different from that in the USA, UK, and Europe, as this is an entirely patriarchal and Muslim country with historically solid gender stereotypes and beliefs. Khamzina et al. (2020) have prepared a comprehensive analysis of gender inequality in the labor market of Kazakhstan, where they mentioned cultural specifics influencing the asymmetry.

Buribayev and Khamzina (2019) have presented findings in a qualitative investigation of the influence of the pandemic on gender asymmetry in Kazakhstan. Ryskaliyev et al. (2019) have discussed Kazakhstan's progress towards achieving the UN sustainable development goals, including reducing gender inequality. Palymbetov et al. (2020) have focused on the current image of gender inequality in the country through the lens of tendencies. Maltseva (2021) has provided an analysis of barriers and limitations of Kazakhstan's women in its political participation, explaining that gender stereotypes and inequality explain a lack of women in politics. One of the good examples, which was illustrated, is that the authorities of Kazakhstan allow women to participate in elections for some positions but do not allow them to win and take leading roles in the government.

Based on the analysis of the previous studies, the current article would like to make a comparison of the effectiveness of the strategies for reducing gender asymmetry, which are proposed and implemented in such regions as the US, the UK, Germany, and Kazakhstan. It would help to see what policies and methods are qualified, leading to a visible result, while others need to be more workable and should be improved. It is interesting to reveal how different countries face the same challenges and what its government maintains to solve a social problem, connecting with the increasing or stable gender asymmetry. At the end of this study, it would be possible to compare the outcomes and achievements of these countries and revise the strategies for eliminating gender inequality.

3. METHODOLOGY

Analyzing gender asymmetry from the side of theoretical approaches and frameworks, it is necessary to mention several assumptions applicable to societal inequality issues. Considering that gender asymmetry means that in a particular place or region, unequal distribution of opportunities and roles is happening, in most cases, this is about favoring men over women due to different norms and beliefs (King et al., 2019). Therefore, it is possible to specify such theories as patriarchy, feminism, intersectionality, structural functionalism, conflict theory, gender binary, and institutional sexism as core ones to explain gender asymmetry and a tendency to empower equality around the globe.

First, from the aspect of the patriarchy theory, such phenomenon can be explained that since the ancient times men take the primary power and dominate in roles of political leadership, moral authority, social privilege, and control of property (Evans, 2021). Focusing on the problem of gender asymmetry, this concept should be specified as it is fundamental in understanding why the power is in the male hands during the centuries and how it influences on the establishment of gender relationships in the society previously and now (Khelghat-Doost & Sibly, 2020). Generally, Friedrich Engels (1884) has significantly contributed to the roots of the patriarchy theory, arguing that patriarchal systems have emerged due to the growth of private properties and nuclear patterns. In 1949, French existentialist philosopher Simone de Beauvoir (1949) emphasized that women had been oppressed historically and got only secondary roles in society. Comparing Beauvoir's assumptions and conclusions from one of her famous books "The Second Sex" (1949), where she did a good analysis of how patriarchy and gender positions were developed, leading to emerging feminist movements, there are countries where women are not considered as equal as men, limiting in their rights, at the modern times.

Based on the patriarchy theory, the following hypothesis was generated for the study:

H1: Strategies for reducing gender asymmetry, focusing on addressing the root causes of patriarchy, lead to a reduction of gender asymmetry.

Second, feminism theory focuses on investigating and promoting perspectives to challenge and change gender asymmetry in the most proper way to reduce inequalities in the world. These

theories include not only classical feminism but also liberal feminism (focus on equal rights of men and women), radical feminism (focus on challenging and eliminating the power of patriarchy), and post-modern feminism (focus on the fluidity of genders) (Aggestam & Rosamond, 2019). The first feminist movements started at the end of the 19th and the beginning of the 20th centuries, claiming that women should have equal rights with men on a legal basis and criticizing patriarchy theories (Cox-Han & Heldman, 2023). In the United States , the first wave of feminism was in 1800, led by feminists Elizabeth Cady Stanton and Susan Anthony. Over time, the requests of these movements have updated and improved, turning from the fight for the right to vote to problems of sexual harassment, reproduction, and equal pay (Khalifa & Scarparo, 2021). Now , feminism includes women's rights and LGBTQ+, women with disabilities, and the "Black Lives Matter" movement.

Based on the feminism theory, the following hypothesis was generated for the study:

H2: Increasing the number of women in leading positions leads to a reduction of gender asymmetry.

Third, based on the intersectionality theory, which was developed by Kimberlé Crenshaw in 1989, who has pointed out challenges of black women in the US legal system, judging by gender features is only a part of a problem, so gender asymmetry is more complicated topic than it seems to be (Ringblom & Johansson, 2020). Through means of intersectionality theoretical framework, it becomes clear that such factors as social class, race, gender, disability, and others allow the creation of a specific impression, which other people would possess, concerning their perception of individuals (Canetto, 2020). In this regard, gender inequality can happen not only because of the gender reason, depending on the case.

Based on the intersectionality theory, the following hypothesis was generated for the study:

H3: Challenging racism, heterosexism, and classism in the workspace leads to a reduction of gender asymmetry.

Fourth, one more theory structural-functionalism considers that society consists of different aspects influence stability within it. In the context of gender asymmetry, structural-functionalism suggests that gender roles and asymmetry exist because they serve a functional purpose in society (Wuya, 2021). For example, traditional gender roles might be seen as ensuring the stability of the family unit, which means that men should work and women should raise children. The theory was created by a French sociologist, Emile Durkheim, in 1917, who believed that each gender should follow its historical roles to provide an order in the world, where everyone knows their duties and responsibilities (Bourguignon & Coron, 2021).

Based on a structural functionalism theory, the following hypothesis was generated for the study:

H4: Launching laws to protect women from discrimination and violence leads to a reduction of gender asymmetry.

Fifth, according to the conflict theory, society can be described as constant competition and inequality, especially in the qualified distribution of resources and power (Chung & Lippe, 2020). Gender conflict exists between genders to maintain a societal position, considering different groups. Therefore, based on the conflict theory, the gender pay gap can be explained by the fact that male employees have more privileges in business than female ones, as well as a lack of women in politics and high rates of violence against women (Elomaki & Johanna, 2020). The patriarchy theory is one of the directions of the conflict theory, which brightly examines the domination of men over women in the modern world. Among conflict theorists and scholars, who have considered that gender asymmetry is not an inevitable phenomenon but primarily a result of social and economic interactions (Chung & Lippe, 2020; Cislaghi & Heise, 2020).

Based on the conflict theory, the following hypothesis was generated for the study.

H5: Building a solidarity among marginalized groups leads to a reduction of gender

asymmetry.

Sixth, the gender binary theory divides genders into two opposite forms as men and women, excluding and marginalizing individuals whose gender identities do not conform to these categories (Eagly & Sczesny, 2019). It is especially common in the recent years when other forms of gender have appeared due to the increased popularity of gender change and LGBT+. Now this theory is criticized by both patriarchal and feminist scholars (Fisher & Ryan, 2021).

Based on the gender binary theory, the following hypothesis was generated for the study:

H6: Educating the society about gender diversity and inclusion leads to a reduction of gender asymmetry.

The final theory, which is applicable to the following study, is an institutional sexism, which refers to a systemic discrimination against individuals based on their gender, especially in such institutions as government, education, healthcare, and the workplace (Tildesley et al., 2022). It is highly obvious when women are discriminated at politics, not getting an opportunity to take leading positions or get more responsibilities in comparison with men. Patricia Collins was Black feminist researcher, who has stated that sexism takes a huge role in a modern society, not allowing women to take better social roles. Catherine MacKinnon has supported her ideas, considering that sexism is a kind of a norm for many people, but this is a legal discrimination, which is not controlled and punished (Tildesley et al., 2022; Barker & Jirasz, 2020).

Based on an institutional sexism theory, the following hypothesis was generated for the study:

H7: Implementing gender-sensitive strategies at the workplace leads to a reduction of gender asymmetry.

Now it is possible to summarize a theoretical analysis of gender asymmetry. See Table 1 below.

TABLE 1 – Theoretical frameworks towards gender asymmetry

Theory	Definition	Concept towards gender asymmetry	Scholars-contributors
Patriarchy theory	Men take the primary power and dominate in roles of political leadership, moral authority, social privilege, and control of property.	It is fundamental in understanding why the power is in the male hands during the centuries and how it influences on the establishment of gender relationships.	Kate Millett, Germaine Greer, Shulamith Firestone, Karl Marx, Friedrich Engels.
Feminism theory	Promotion of female perspectives to challenge and change gender asymmetry in the most proper way to reduce inequalities.	Requests of these movements have updated and improved, turning from the fight for the right to vote to problems of a sexual harassment, reproduction, and equal pay.	Simone de Beauvoir, Adrienne Rich, Gloria Steinem, Angela Davis, Patricia Hill Collins.
Intersectionality theory	Such factors as social class, race, gender, disability, and other allow to create a certain impression, which would be possessed by other people, concerning their perception of individuals.	Gender inequality can happen not only because of the gender reason, depending on the case.	Kimberle Crenshaw, Audre Lorde, Sara Ahmed.
Structural functionalism theory	Society is consisted of different aspects, influencing on a stability within it.	Gender roles and asymmetry exist because they serve a functional purpose in society.	Emile Durkheim, Talcott Parsons, Robert Merton, Kingsley Davis, and Wilbert Moore.
Conflict theory	Society can be described as a constant	There is a conflict	Juliet Mitchell, Ann

	competition and inequality, especially in the field of a qualified distribution of resources and power.	between genders to maintain a position in the society, considering different groups.	Oakley, Zillah Eisenstein, Heidi Hartmann, Christine Delphy.
Gender binary theory	Genders are divided into two opposite forms as men and women, excluding and marginalizing individuals whose gender identities do not conform to these categories.	There are no other genders except men and women.	-
Institutional sexism theory	A systemic discrimination against individuals based on their gender, especially in such institutions as government, education, healthcare, and the workplace.	Women are discriminated at politics, not getting an opportunity to take leading positions or get more responsibilities in comparison with men.	Patricia Collins, Catherine MacKinnon, Michael Kimmel, Cynthia Enloe.
Note: compiled by authors			

Based on Table 1 above, addressing gender asymmetry and empowering equality requires a multifaceted approach that draws from these theoretical concepts and frameworks.

For the following investigation it was decided to select the data of the USA, the UK, Germany, and Kazakhstan for the period from 2019 to 2023 to test the effectiveness of its gender equality strategies through gender pay gap, the percentage of women in leadership positions, the percentage of violence against women, and the percentage of women, who get a degree at university.

The data for this article was collected from such sources as the World Bank, International Labour Organization, United Nations Development Programme, Global Gender Gap Report for the period from 2019 to 2023.

The data was analyzed using descriptive statistical and regression analysis through t-tests. Descriptive statistics were used to calculate and interpret the mean, median, mode, standard deviation, and variance of the indicators of gender equality. In addition, differences were tested for in gender equality across the selected four countries. Regression analysis was used to identify interconnections between gender equality and realize what countries use better strategies for reducing gender asymmetry.

4. FINDINGS AND DISCUSSION

4.1 Descriptive Results

The results of a descriptive statistics in Table 2 below shows sufficient changes between four countries, highlighting whether its strategies to reduce gender asymmetry are effective for the recent five years for the period from 2019 to 2023. It should be stated that the results of each country were carefully analyzed by the following aspects:

Gender pay gap.

Percentage of women, taking leadership positions.

Percentage of violence against women.

Percentage of women, who have completed university and have at least one academic degree.

The preliminary data has demonstrated that Kazakhstan has the lowest indicators in comparison with other three states. See Table 2 below.

TABLE 2 – Descriptive statistics of the selected countries, where mean = m, median = M, standard deviation = s

Region	**USA**			**UK**			**Germany**			**KZ**		
Indicator	**m**	**M**	**s**	**m**	**M**	**s**	**m**	**M**	**s**	**m**	**M**	**s**
Gender pay gap	82,3	82,3	0,2	15,2	15,1	0,3	18,3	18,2	0,2	25,2	25,2	0,4
Leadership	30,2	30,2	1,2	35,9	35,9	1,1	29,3	29,3	1,3	20,3	20,3	1,4
Violence	24,2	24,2	0,7	20,3	20,3	0,7	31,6	31,6	0,9	37,4	37,4	1
Education	42,5	42,5	0,8	47,7	47,7	0,7	45,7	45,7	0,9	39,7	39,7	1
Note: compiled by authors												

Based on the results of Table 2 above, it is possible to deliver some conclusions. First, according to indicators of gender pay gap, mean and median are lowest in the UK and highest in Kazakhstan. The standard deviation is lowest in the USA and highest in Kazakhstan. It means that the gender pay gaps are more variable in Kazakhstan than in the other three countries. The analysis shows that women earn less than men in the USA and Kazakhstan.

Second, according to indicators of the percentage of women in leading positions, mean and median percentage of women in leadership positions are highest in the UK and lowest in Kazakhstan. The standard deviation is lowest in the UK and highest in Kazakhstan. It concludes that the percentage of women in leadership positions is more variable in Kazakhstan than in the other three countries as in the gender pay gaps results. The analysis shows that in Kazakhstan men are usually taking leading positions rather than women.

Third, according to indicators of the violence against women, mean and median percentage of women experiencing violence is highest in Kazakhstan and lowest in the UK. The standard deviation is lowest in the UK and highest in Kazakhstan. It also proves that the percentage of women experiencing violence is more variable in Kazakhstan than in the other three countries. The analysis shows that in the USA and the UK there is higher percentage of violence against women, and they feel unprotected by the local law system.

Fourth, according to indicators of the percentage of educated women, Kazakhstan again has the smallest results, proving that there are less than 50% of women are fully educated in the country.

4.2 T-tests

T-tests relate to qualified instruments to see statistical differences of gender pay gap, the percentage of women, taking leadership positions, the percentage of violence against women, and the percentage of women, who have completed university and have at least one academic degree across the USA, UK, Germany, and Kazakhstan.

For the study it was used the following t-test:

t = (x1 - x2) / sqrt(s1^2/n1 + s2^2/n2),

where:

x1 and x2 are the mean in two comparing countries,

s1 and s2 are the standard deviations two comparing countries,

n1 and n2 are the sample sizes in two comparing.

Using this t-test, it became possible to compare indicators between the USA and the UK, the USA and Germany, the USA and Kazakhstan. For each comparison t-statistic and p-value were calculated. The p-value is a probability of obtaining a t-statistic as extreme or more extreme than the one observed, assuming that the null hypothesis is true. It means that there is no difference in the gender pay gaps between the two countries.

If the p-value is less than a significance level of 0.05, we reject the null hypothesis and

conclude that there is a statistically significant difference in the gender pay gaps between the two countries. See Table 3 below.

TABLE 3 – Results of t-tests for the selected countries

Indicators	**Gender pay gap**		**Leadership**		**Violence**		**Education**	
Country comparison	t-statistics	p-value	t-statistics	p-value	t-statistics	p-value	t-statistics	p-value
USA vs UK	0,56	0,57	1,78	0,07	2,34	0,02	1,28	0,2
Germany vs USA	1,23	0,22	2,23	0,03	3,57	0	1,86	0,06
Kazakhstan vs USA	2,45	0,01	3,89	0	4,76	0	2,94	0
Note: compiled by authors								

Table 3 shows three statistically significant differences in the gender pay gap, percentage of women in leadership positions, percentage of violence against women, and percentage of educated women between the USA and the UK, the USA and Germany, and the USA and Kazakhstan.

The results of the t-tests suggest that there is a significant gender asymmetry in all four countries. However, the USA has a higher degree of gender asymmetry than the UK, Germany, and Kazakhstan. Considering the outcomes of Table 3, it is possible to specify several findings. First, gender pay gap is higher in the USA, which means that women in the USA earn less than men on average, even when controlling for factors such as education, experience, and occupation. Second, the percentage of women in leadership positions is lower in the USA, which means that women are underrepresented in leadership roles in the USA. Third, the percentage of violence against women is higher in the USA, so women in this country are more likely to experience violence than women in the UK, Germany, and Kazakhstan. Fourth, the percentage of educated women is lower in the USA, which suggests that there is a gender gap in education in the USA, but that it is smaller than the gender gap in education in Kazakhstan.

These findings are consistent with the previous research on gender asymmetry, which were mentioned above. For example, a study, which was prepared by the World Economic Forum (2023), has found that in 2022 the USA ranked 28th out of 156 countries in terms of gender equality. The UK ranked 19th, Germany ranked 11th, and Kazakhstan ranked 75th. It means that all these countries have some challenges in empowering equality in the most effective way, which means that the government still have a lot of work to complete towards a reduction of gender asymmetry.

Based on the getting findings from t-tests, it is possible to maintain some results.

First, H1 is justified.

H1: Strategies for reducing gender asymmetry, focusing on addressing the root causes of patriarchy, lead to a reduction of gender asymmetry (justified).

Germany as one of the European countries and the UK show the best results, proving that its governments have addressed the reasons of patriarchy to promote more equality in all aspects of a social life.

Second, H2 is justified.

H2: Increasing the number of women in leading positions leads to a reduction of gender asymmetry (justified).

The USA and Kazakhstan have received the lowest indicators in the percentage of women in leading positions, proving that there is still a disproportion of men and women at the workplace, while the UK and Germany have higher ones. It means that increasing a role of women through allowing them to be leaders would positively influence on an elimination of gender asymmetry.

Third, H3 is justified.

H3: Challenging racism, heterosexism, and classism in the workspace leads to a reduction of gender asymmetry (justified).

The result for this hypothesis reflects on the previous one, where the USA and Kazakhstan got less results in comparison with the UK and Germany.

Fourth, H4 is justified.

H4: Launching laws to protect women from discrimination and violence leads to a reduction of gender asymmetry (justified).

Considering t-tests in Table 3 above, those countries, which have focused on a prevention of any kind of discrimination and violence, have better statistical data on gender equality. Not depending on a variety of measures, the USA has negative results as well as Kazakhstan. The only difference is that the USA is the superpower while Kazakhstan is only emerging country.

Fifth, H5 is justified.

H5: Building a solidarity among marginalized groups leads to a reduction of gender asymmetry (justified).

In this case, marginalized groups are women, who are suffering from gender asymmetry at workplace. The justifications for this hypothesis are correlated with the results for the previous ones.

Sixth, H6 is justified.

H6: Educating the society about gender diversity and inclusion leads to a reduction of gender asymmetry (justified).

Through the analysis of the previous studies and statistical reports, as well as the results of t-tests, it becomes clear that Europe and the UK have better progress in comparison with Kazakhstan. The government of the USA also make actions, but due to a variety of other forms of discrimination and migration issues, there are some challenges, leading to lower indicators.

Finally, H7 is justified.

H7: Implementing gender-sensitive strategies at the workplace leads to a reduction of gender asymmetry (justified).

Through t-tests it is obvious that gender-sensitive strategies in business play a significant role and could change attitudes of individuals towards genders, specifying that both women and men have the same potential and rights for realizing own career goals and dreams. The case of Germany has shown that it is effective. Even Kazakhstan got a progress in delivering equality perceptions in the society.

5. CONCLUSIONS

To sum up, empowering equality and reducing gender asymmetry are central to creating more sustainable world. The current study has decided to compare four different indicators in four countries to understand whether the implied strategies for reducing gender asymmetry are effective or need to be improved. The getting results were unpredictable because the USA got almost the same statistical indicators as Kazakhstan. It is explained by the fact that the USA is a developed country with a strong leadership in a global market, promoting democracy and equality more than others, while Kazakhstan is only on its way to turning from a patriarchal approach to more liberal.

The investigation has claimed that not depending on a status of the country, the authorities should pay more attention on good strategies, which would help to reduce a strong gap between a social perception of men and women, as well as enhancing better understanding of how its roles should be distributed. Considering that the world is always changing, it is required to rechange a stereotypic mind not only in the society, but within governmental bodies for stimulating and

encouraging a process of a transformation from old paradigms to new ones, which are more common in the globalized world.

AUTHOR CONTRIBUTION

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Artificial Intelligence Models for Predicting Budget Expenditures

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Abstract

This study develops and tests a machine learning (ML)-based cost forecasting model against traditional earned value management (EVM) techniques. Utilizing Python for ML implementation, the research applies algorithms to a dataset of completed projects globally, evaluating their performance with metrics like mean absolute percentage error (MAPE) and percentage error (PE). The results confirmed that ML give more accurate results than the traditional methods. Thus, the initial rate showing that XGBoost is more accurate than the traditional method using Index-2 is 88%. In 23 of 25 randomly selected projects, this algorithm was more accurate. At the middle stage, the same frequency is 92.6%; later stage, the selected criterion further confirms that the ML algorithm is more accurate than the traditional method, accounting for 75% of 21 projects out of 28. By introducing ML into project management forecasting, managers could spend less time on the technical tasks in their projects. Despite its effectiveness, the study's scope is limited by a small sample size of 110 projects and the testing of only three algorithms. Future research is suggested to expand the dataset and explore additional algorithms, including neural networks and tree-based methods, to enhance forecasting precision.

Keywords: Economics, Business, Project Management, Cost Forecasting, Earned Value Method, Artificial Intelligence, Machine Learning, Machine Learning Models, Python

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1. INTRODUCTION

Despite the growing body of knowledge and best practices in the Project Management (PM) field both globally (Alvarez-Dionisi, 2015; Derici, 2019) and in Kazakhstan (Narbaev, 2015), rising expenditures and project failures continue to be a common issue. Globally, more than 67% of projects suffer from such cost overruns, and about 12% of investments in infrastructure projects are wasted due to inappropriate use of PM techniques.

There are a lot of underestimated or even overlooked cost items in projects, but they can lead to various financial and business problems later. For instance, in the course of project realization there are various types of costs; some of them are direct (they can be easily related to product manufacture or service offer on the project), others are indirect costs, not directly related to product manufacture or service offer, but indirectly related to project execution (Anicic, 2019). Project managers, in cooperation with financial experts, do the estimation of these costs and benefits for better management of projects. Because a proper model of cost forecasting may help to avoid project risks. Moreover, considering that many projects do not develop according to plans, new ways of cost estimates are necessary, with the aim of finding alternative solutions.

For instance, in Kazakhstan, over 60% of infrastructure projects are delivered with cost overruns (Tsekhovoy, 2010). Moreover, managers may receive considerable information during projects, leading to slowdowns in decision-making (Barber, 2021). Therefore, new models are being invented and implemented that will make it possible to predict the project budget with a low percentage of errors and minimal losses, and even better, work much faster and more efficiently, which will help project managers reduce the time for calculations. In such conditions, artificial intelligence (AI) technology can simplify and speed up work (Dacre, 2020). AI can be defined as the machines that are created to simulate human intelligence to do and learn as a brain of human do (Mentzas, 1994).

Artificial intelligence is a reality in our days getting more and more relevancy. Therefore, it should be explored both scientifically and business wise (Bento et al., 2022). Implementing AI in the project management field will help in a wide range of missions and tasks, such as increasing automation, productivity, help in making intelligent decisions, solving complex problems, managing repetitive missions and tasks, enhancing lifestyle, and assisting in complex analysis (Jiang et al., 2017; Ribeiro et al., 2021). The varieties of AI applications and tools enable better project performance as well as enhance the efficiency of the project management implementation (Elkhatib et al., 2022).

AI has great potential that cannot be ignored because its application contributes to more accurate budget forecasting and overall increased project efficiency, thereby ensuring organizational growth (Kyläheiko et al., 2017). Therefore, to solve the problems in PM, more advanced and complex AI approaches are increasingly being applied, such as ML techniques (Haenlein & Kaplan, 2019), which are used by every second application or website worldwide.

To date, despite the unconditional relevance of this area, a limited number of studies have been conducted that used ML approaches in PM. Therefore, this paper aims to develop a new project completion budget forecasting model using ML algorithms to address the above research gap.

The structure of the study consists of the following stages: at the initial stage, an analysis of previous literature was carried out; a database of 110 real projects from all over the world has been created; and 2 algorithms were analyzed to predict the cost of a project upon completion ML. As a result, a model was developed in the Python programming language and conclusions and recommendations for further research were drawn up.

2. LITERATURE REVIEW

This section considers the theory of cost forecasting models, the concept of AI and its application for Predicting Budget Expenditures. Project costs management is a process necessary for project realization within certain budget which includes cost management planning, cost estimation, budget setting and cost control (PMI, 2007). The forecasting models vary for different data set. Moreover, Fildes and Lusk (1984) stated that no forecaster could be the 'best' method from the various forecasting competitions. All forecasting methods have distinct advantages and disadvantages. Therefore, selecting the proper forecasting method is critical to all decision-makers.

Ma et al. (2023) conducted an exploratory review and found that frequently used forecasting models are traditional forecasting, hybrid methods, and AI tool – machine learning algorithm. While traditional methods like time series analysis, hedonic price model and regression analysis may allow for standard deviations and take time, AI tools are more trustworthy due to more accurate and faster calculations. In addition, AI is observed as an effective forecasting method by PM managers. That's why this study is focused on using AI for making more valid and reliable forecasting of chosen projects.

AI was defined as a set of machines that can perform multi-tasks in intelligent ways by adapting to several situations (Mahmood et al., 2023). Ju et al. (2020) stated that AI positively impacts company performance. But the literature analysis found that the application of AI is not so widespread in companies and especially not in all of project management areas (Bento et al., 2022). Ong and Uddin (2020) note that with the new era of data, the application of AI will be significantly expanded.

The literature review founds the different directions of studies related to using AI in PM like benefits of AI in project management (García et al., 2017), project duration forecasting (Wauters and Vanhoucke, 2016), the development of strategic roadmaps and their implementation supported by project management (Kerr and Phaal, 2017), the potential of using AI to improve processes and optimize strategies in various fields (Elmousalami, 2020), applying ML to predict project duration (Pellerin & Perrier, 2019) and costs (Kim, 2015).

After reviewing the general concepts of AI in PM, articles (Chou et al., 2010) move on to a more specialized topic that explores AI methods and models for accurately estimating project costs and optimizing costs. For example, Fridgeirsson et al.(2021) explored the role of AI in improving cost management according to PMI's Project Management Body of Knowledge. The panel determined that AI will significantly impact not only cost, also schedule, and risk management in the future through the use of historical data for estimating and planning. Still, it will likely not have the same impact in areas that require human leadership skills and interpersonal interactions.

A study by Alhares et al. (2019) examines the application of coupled intelligent models to improve project completion forecasting in the construction industry. The researchers used a two-step approach, combining global harmony and brute force algorithms with an extreme learning machine to make more reliable predictions. The results show that the proposed models provide improved cost forecasting accuracy, which helps project managers make informed decisions and improve control.

The article by Chou et al. (2015) discusses applications of AI, including multiple regression analysis, artificial neural networks, case-based reasoning, and a new hybrid approach. In the first case, the authors use a hybrid approach to estimate the development costs of liquid crystal display manufacturing equipment, highlighting cost control and decision-making improvements. The second paper uses case-based reasoning with genetic algorithm integration to predict bid amounts for bridge construction projects. In two studies, the authors use accurate data and apply a cross-

validation method to evaluate the performance and accuracy of the models. The results confirm that AI-based hybrid models, especially those using artificial neural networks and genetic algorithms, demonstrate high efficiency and accuracy in predicting bid amounts, which can help contractors make informed bidding decisions in the bridge construction industry.

In turn, Kazakh authors who used AI approaches, particularly ML methods in PM, conducted a limited number of studies. For example, Narbaev and De Marco (2017) improved statistically based EAC ($) cost forecasting by integrating risk patterns. Algiev (2012) proposed a PM-based framework for public projects to predict their success using qualitative research but limited themselves to practical recommendations.

The general trend of these studies emphasizes that AI is becoming an integral part of modern business and PM. Process optimization, cost forecasting, risk management, and efficiency improvements are becoming more accessible and accurate using modern AI methods and models.

3. METHODOLOGY

3.1 Data collection

This study used the data of 110 projects from various fields, which were collected and published by the Operations Research & Schedule team. Only data such as Actual Cost (AC), Planned Cost (PV), Earned Value (EV), and projects with tracking period information were included in the collected database because the absence of tracking periods indicates that work was not performed.

3.2 Data processing

MS Excel software analysis

Initially, the database was generated and divided into intermediate stages on the MS Excel platform. Afterwards, all calculations were performed using the traditional EVM method. Managers use cost estimates to complete (CEAC) to re-estimate the total cost of completing a project, which helps stakeholders more accurately assess the impact of changes in input data. This study used all three post-completion assessment approaches (PMI, 2017, Sixth Edition):

1) The first formula:

$$CEAC\ (\$) = AC + (BAC - EV) \qquad (1)$$

The above Equation indicates that the current deviation in the future will differ from the original estimate, i.e. It is the summation of the actual cost with the remaining cost of the work that needs to be completed.

2) The second formula has two different wordings, but the meaning will differ:

$$3) \quad CEAC\ (\$) = AC + \frac{(BAC - EV)}{(CPI)} \qquad (2)$$

$$4) \quad CEAC\ (\$) = \frac{BAC}{CPI}$$

Equation (3) is applied when the initial estimate is completed without deviation, which means the project progresses well at all levels. It can be assumed that CPI and SPI are maintained at appropriate levels. In such cases, managers should maintain ratios equal to one or greater than one.

3) The third Formula:

$$CEAC\ (\$) = AC + \frac{(BAC - EV)}{(CPI \times SPI)} \qquad (3)$$

Formula (3) is used to calculate the actual budget for the current day, with the remaining amount being adjusted based on performance, i.e. this formula is implemented when the current liquidity ratio corresponds to the initially predicted one.

Programming software and ML algorithms used

The programming language used to make predictions using ML models was Python.

Two ML algorithms, such as XGBoost and Random Forest, were chosen as the basis for subsequent analysis. One of the most famous and widely used models is the eXtreme Gradient Boosting (XGBoost) algorithm (Reddy, Teja, and Subhani, 2019).

It is necessary to divide the data into two subsamples to train the model: training and testing. It is also required to determine the input and source variables and implement the correct formula in the code. The total database of 110 projects was divided into three stages to see which stage would give us the best results, and which of the tools would be more suitable for early, middle and final predictions:

− Early stage: 1-29%;
− Middle stage: 30-69%;
− Late stage: 70-100%;

This approach which divides the projects according to stages and ranges was used earlier by Narbaev and De Marco (2014) in their article. This split approach is considered convenient for cost control, as the budget at the beginning of the project may be very different from what will be at the end.

Normalized EVM data (AC, BAC, EV, CPI, and SPI, depending on the formula used) were used from a database of already separated stages extracted from an MS Excel file and denoted as "x". The variable "y" was equal to the EAC value calculated using the traditional index formula. Next, for each file, the data was divided into a training set - 75% and a test set - 25% of the total data. The variables were implemented and trained through all three algorithms, separately, which were run through their libraries and hyperparameters. Then, as each algorithm predicted an outcome, it was compared to the EAC data calculated by the traditional method, and the percentage error (PE) and mean absolute percentage error (MAPE) were determined.

The percentage error (PE) is equal to the deviation between the cost estimate to complete (CEAC) and the actual cost to end (CAC) divided by the CAC multiplied by 100%. The percentage error indicates how significant the difference is between the cost of completion and the actual cost of projects. This indicator shows the accuracy of projects. Formula (4):

$$PE,\ \% = \frac{(CEAC - CAC)}{CAC} \times 100 \qquad (4)$$

Mean absolute percentage error (MAPE) shows a measure of relative error. It can be calculated using the previously calculated PE, specifically by summing all the resulting PE data for each project and obtaining the average for the data set. This indicator is expressed as a percentage and shows the accuracy and how much the model can be wrong in percentage terms. For example, if the metric showed that MAPE = 10%, the model error was 10% of the actual value.

Formula (5):

$$MAPE,\ \% = \frac{1}{n}\sum_{i=1}^{n} |PE_i| \qquad (5)$$

PE – error percentage for each project;
n – number of projects.

The higher the score, the greater the variability in the range, indicating higher risk; the lower the indicator, the more the values are clustered around the average and indicate low volatility.

First, overall trade data is presented, followed by a discussion of the most significant changes in 2022. As most of the changes were related to Kazakhstan's export structure, a comparison of these changes with Russian imports and the list of sanctions is provided.

4. FINDINGS AND DISCUSSION

This section examines the obtained values using the traditional EVM index method, which was separately calculated in an MS Excel spreadsheet using 3 EAC ($) equations and two ML algorithms. As noted earlier, the database was divided into three phases for more accurate forecasting since there was a different amount of work done at the beginning and end of the project, which also affected the budget spent during this time. Below is what the database looks like for an early stage, and the other files follow the same sequence. The early-stage dataset is given in Figure 1.

Project	Tracking _period	AC	BAC	EV	CPI	SPI	BAC.1	EV.1	AC.1	CAC	const_
1	1.1	13526.64	180485.27	13526.64	1,000	1,000	1,000	0.075	0.075	1,000	1.039
2	2.7	23426.56	180759.44	22454.88	0.959	0.52	1,000	0.124	0.13	1.057	1.039
3	3.4	49234.67	484398.413	48729.174	0.99	0.971	1,000	0.101	0.102	1.022	1.039
4	4.2	283418.65	3027133.186	253804.57	0.896	0.326	1,000	0.084	0.094	1.025	1.039
5	5.46	269856.492	21369835.51	263752.622	0.977	0.728	1,000	0.012	0.013	1.220	1.039
...	...	...	...	...	...	...	...	...	...	...	...
106	106.6	386654.38	4318950,0	470150,0	1.216	1.242	1,000	0.109	0.09	0.98	1.039
107	107.2	424560.24	1456000,0	418322.173	0.985	0.799	1,000	0.287	0.292	1.014	1.039
108	108.3	119086.966	1512000,0	118037.415	0.991	0.804	1,000	0.078	0.079	1.015	1.039
109	109.2	4000,0	107500,0	1400,0	0.35	0.118	1,000	0.013	0.037	1.087	1.039
110	110.1	6050,0	114700,0	5700,0	0.942	0.513	1,000	0.05	0.053	1.118	1.039

FIGURE 1. Early-Stage Dataset

Note: compiled by authors

Each of the algorithms applies normalized data to the BAC. Equation (1) uses the variables BAC, EV and AC as inputs for “x”. Equation (2) uses the variables BAC, EV, AC and CPI, and Equation (3) uses the variables BAC, EV, AC, CPI and SPI. EAC is used for the dependent variable “y” which was calculated using the traditional index method. Algorithms that work with regression to predict machine learning and work based on train-test validation were selected. The test and training data are divided into 25% and 75% randomly selected projects based on the number of projects used, respectively. All data is first trained on 75% of the data, and then the remaining 25% is trained and predicted. Since the algorithm takes any 25% of the projects from the embedded database into the code, to determine the fixed MAPE range by applying algorithms to compare with the selected MAPE index method, 100 MAPE trials were obtained. The code was run five times, i.e. the study used 500 random estimates to determine the exact MAPE range. One of the distinctive aspects of implementing algorithm codes in their model is the use of hyperparameters, which help to properly tune the tool and prevent it from overfitting, leading to better results. The following will clearly show how hyperparameters raise the performance of the model. Therefore, it’s important to know which of them critically impacts on project cost. Next, we'll show how hyperparameters improve model performance.

Index method results

MS Excel was used to analyze and calculate the index method, and EAC ($) values were calculated using three equations. Table 1 shows that the values of all three index calculations differ, confirming their purpose.

TABLE 1. MAPE result for traditional EVM method

MAPE results	**Index-1**	**Index -2**	**Index -3**
Stages/Equations	*CEAC = AC + (BAC - EV)*	*CEAC = AC + [(BAC - EV)/CPI]*	*CEAC = AC + [(BAC - EV)/CPI×SPI]*
Early	12.45%	14.11%	38.59%
Average	8.32%	7.21%	13.45%
Late	2.29%	2.36%	2.51%
Note: compiled by authors			

For example, we discuss Equation (1), which shows the best results. Still, this Equation only considers the project's current cost, summing it up with the remaining cost of the work until completion. Equation (2) is calculated based on past costs, and Equation (3) considers the cost and schedule of the project. Therefore, given the focus of this study on cost forecasting, the most accurate of the three EAC ($) is Index-2 (Equation 2).

Results of ML algorithms

XGBoost algorithm results

The Python programming language was used for forecasting through the XGBoost (XGB) tool. The algorithm learns from previous mistakes, making it theoretically one of the most reliable among thousands of machine learning algorithms. Table 2 shows the resulting MAPE data using the XGB algorithm without applying the tuned hyperparameters.

TABLE 2. MAPE results for the XGBoost model without hyperparameter tuning

Equations	**XGBoost - Index-1**	**XGBoost - Index - 2**	**XGBoost - Index -3**	**Note**
Stages	Input data: BAC, AC, EV	Input data: BAC, AC, EV, CPI	Input data: BAC, AC, EV, CPI, SPI	
Early	3.51-4.05	14.51-16.22	80.79-133.29	99 projects (average actual cost overrun - 1.0392 (3.92%))
Average	6.89-7.56	13.21-14.84	24.1-25.15	107 projects (average actual cost overrun - 1.037 (3.70%))
Late	12.36-13.56	12.45-13.59	11.88-14.25	110 projects (average actual cost overrun - 1.032 (3.20%))
Note: compiled by authors				

As seen in Table 2, each algorithm has its unique hyperparameters. In this analysis, was used the reg_alpha parameter because it allows the algorithm to penalize the tree (i.e., the data) if it exceeds a specific value in the code, making the prediction line smoother. The algorithm learns from previous errors, that is, by looking at previous predicted data, which makes it theoretically one of the most reliable among thousands of ML algorithms (see Table 3).

Each stage has its reg_alpha value because each stage has different projects. For example, early has 99 projects, middle has 107, and late has 110 projects. Each stage uses different amounts of data because the data has been divided according to the scope of work. The “training test suites and evaluation criteria” portion included a percentage of the volume, which prevented the

inclusion of data that would have been in the early or mid-stages. To summarize, the algorithm's prediction becomes better and more accurate when using parameters.

TABLE 3. MAPE results with the XGB reg_alpha hyperparameter

Stages	**XGB - Index-2**	**Notes on the parameters used**
Early	6.46-9.26	reg_alpha=7 for 99 projects
Average	6.47-8.67	reg_alpha=6 for 107 projects
Late	6.22-8.32	reg_alpha=5 for 110 projects
Note: compiled by authors		

Results of the Random Forest Algorithm

This algorithm is also considered part of a consensus algorithm built from several trees. The model implemented in this algorithm also used a test and train data method, randomly taking each row for prediction. Without adjustable hyperparameters, the model produced the results shown in Table 4.

TABLE 4. MAPE results for the Random Forest model without hyperparameter tuning

Equations	**RF - Index -1**	**RF - Index -2**	**RF - Index -3**	**Note**
Stages	Input data: BAC, AC, EV	Input data: BAC, AC, EV, CPI	Input data: BAC, AC, EV, CPI, SPI	-
Early	3.26-3.78	14.82-16.08	78.30-84.15	99 projects (average actual cost overrun - 1.0392 (3.92%))
Average	6.41-6.28	12.96-14.17	22.49-23.11	107 projects (average actual cost overrun - 1.037 (3.70%))
Late	6.91-7.42	11.99-13.42	12.25-12.95	110 projects (average actual cost overrun - 1.032 (3.20%))
Note: compiled by authors				

Table 4 shows that the RF model has a more accurate MAPE than XGB, which means it performs better on small data sets. Unfortunately, RF does not have parameters that penalize like XGBoost, so we used another way to improve the prediction, such as parameters max_depth = 3;4;5 (sequentially across stacks) and n_estimators = 90. The hyperparameter max_depth is used to determine the depth of each decision tree, and n_estimators show how many generalized trees should be in the forest. Different values of both hyperparameters were tested, but only the above values showed little improvement over data without hyperparameters. Typically, these options are best for increasing and improving results, but this didn't impact performance in the analysis. The obtained data is shown by Equation (2) - Index-2.

The values changed by a maximum of 1.5%, as shown in Table 5.

TABLE 5. MAPE results with hyperparameters for RF

Stage	**RF - Index-2**	**Notes on the parameters used**
Early	13.44-14.51	max_depth=3; n_estimators=90 for 99 projects
Average	12.51-13.89	max_depth=3; n_estimators=90 for 107 projects
Late	11.84-12.92	max_depth=3; n_estimators=90 for 110 projects
Note: compiled by the authors		

However, any model can allow the data to be double-checked so the parameters are adjusted. The following patterns can be derived for MAPE by summing the results for all used algorithms. All machine learning algorithms (without tuning) are better at predicting Index-1 (Equation 1) and the formula for the early and middle sections than the traditional index method in contrast to the late stage, at which the index method predicted better; for Index-3 (Equation 3), the traditional method predicted better than the other methods (without adjustment). In the Index-2 formula (Equation 2), the performance for the early stage of the RF algorithm was better than in other models, including those based on the index method. All indicators are calculated without setting hyperparameters. However, the traditional index method predicted better in the middle stage than all algorithms without hyperparameter tuning. These comparisons may not be accurate because some parameters severely overtrain the model with errors, so the results were compared to the setting. XGB with hyperparameter tuning is the most accurate project cost predictor for all three CEAC ($) formulas used early and mid-stages. PE was calculated for each project separately, showing the deviation between the total actual value and the predicted value (EAC ($)).

The main findings of the study are as follows:

– MAPE results for XGBoost with hyperparameter tuning showed the most accurate values for all three calculations for the early and middle stages.

– When tuning hyperparameters, MAPE values were changed only in XGBoost, although in practice, RF works more with small data sets. The results also show that some of the fastest and most accurate algorithms in practice will most likely not be able to work with small databases since the tool was initially designed to process large and complex data in a matter of seconds.

– Since it was clear that XGBoost was the most accurate in predicting the value, it was compared with the index method in Equation (2) when comparing other evaluation criteria to ensure that it was expected well. Analysis of the accuracy and frequency determination among the methods confirmed the above prediction, concluding that the model using the XGB algorithm produces the best predictions.

5. CONCLUSIONS

The paper concludes highlighting two contributions to the field of project management. First, the analysis found that the ML algorithm predicts more accurately and faster than the classical EVM method. Second, although all three selected algorithms showed their high performance and applicability for cost prediction, it was found that the model with the implementation of the XGBoost algorithm showed the most accurate results. In addition, the algorithm predicts the data in a matter of seconds. Thus, the above algorithms can be used by various project-oriented organizations and enterprises implementing projects and programs in multiple fields to predict costs and budgets.

The research limitations are that only 110 projects, a small database for the algorithms, were included in this work. In addition, there is no classification of projects according to specific fields that may allow us to compare the algorithm's impact on project cost. That's why several recommendations for future research have been identified. First, expanding the database. Feeding as much data into the model as possible can help improve data forecasting, as many tools are more geared toward big data. Second, it is recommended to study to test other algorithms or types of analysis. For example, future researchers may develop a more accurate model for cost forecasting or conduct new analysis using different algorithms, such as neural network algorithms or other algorithms operating on trees. Third, they can take cluster analysis as a basis, or rather, conduct analysis only in one area (banking system, construction, etc.), since in this work, the analysis was carried out using projects of all types presented in the study database.

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Impact of Scientific Activity and Innovation on Economic Competitiveness: an Analysis of Kazakhstan

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Abstract

This study is aimed to evaluate the influence of scientific activity and innovation on the economic performance of a country, measured by Gross Domestic Product (GDP), using Kazakhstan as a case study. Employing Partial Least Squares Path Modeling (PLS-PM), a variance-based Structural Equation Modeling (SEM) approach, the research analyzed secondary data to explore the structural relationships between scientific investment, activity, and their subsequent impact on GDP and innovative organizational activity. The methodology was centered on assessing the measurement model for reliability and validity, and the structural model for the strength and significance of the relationships using path coefficients and R-squared values. Hypotheses were formulated to test the expected positive influences of scientific activity and internal R&D costs on GDP, and the role of scientific activity in driving innovative activity within organizations. The results indicated a positive relationship between scientific activity and GDP, confirming the hypothesis that science contributes significantly to economic development. Internal R&D costs were found to have a strong positive impact on scientific activity, highlighting the importance of R&D investment. However, innovative activity within organizations showed a negative association with GDP, suggesting a more complex relationship that may not lead to immediate economic gains. Scientific activity was also seen to positively influence organizational innovation. The study's findings emphasize the need for strategic planning and investment in scientific research and education to bolster economic development.

Keywords: Economic Development, Scientific Activity, Research and Development, Innovation Activity, Gross Domestic Product, Investment in Science, Kazakhstan

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JEL Code: B41, O11,O33

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1. INTRODUCTION

With globalization and lower barriers to the flow of goods, services, capital and knowledge, enhanced by the development of ICTs, economic growth is accelerating, although the benefits are unevenly distributed. Knowledge, unlike goods, can be reused and has low distribution costs, creating sustainable growth opportunities. Moreover, science is one of the most advanced forms of accumulation and systematization of knowledge and experience and is a system of dissemination, exchange and transfer of knowledge. Economic research has traditionally focused on research and development policy, Market failures, policy instruments, interdependencies with other economic policies, and the challenges of creating effective interventions in complex systems but increasing attention is being shifted to scientific and technological research.

Science is a resource or a functional tool for society. Scientific training appears to be a valuable form of human capital that increases the efficiency and productivity of the workforce. In addition, scientific research generates knowledge, innovation and technical applications that are said to improve socio-economic performance and generate new products (Schofer et al., 2000).

The modern expansion of scientific activity is not limited only to economic interests but embraces broader goals such as national development in a broader sense. Science, as an institutionalized field, covers many issues beyond its role as a tool in national economic growth. The extension of science includes knowledge and aspects that bring economic benefits.

It is necessary to emphasize the importance of defining and measuring national economic competitiveness, especially in an environment of global interdependence. Considering this, the role of human capital, especially education, in competitiveness is examined.

Particular emphasis should be placed on the importance of research and innovation to ensure sustainable economic growth. Modern development strategies highlight science and research as key factors for achieving "the most competitive and dynamic knowledge economy in the world." Therefore, states strive to allocate significant funds (3% of GDP) for research and development. Despite still low levels of investment in some countries, research remains an important tool for creating new knowledge, technology and innovation, contributing to economic growth (Kouassi, 2019). Public investment in R&D provides the necessary resources for basic and applied research. This promotes scientific progress and expansion of knowledge, which can ultimately lead to the creation of new technologies and an innovation ecosystem that brings together scientific and academic institutions, enterprises, and start-ups.

Thus, government R&D support programs create favorable conditions for the work of talented scientific researchers and engineers, which contributes to the formation of a critical mass of qualified specialists and supports the flow of knowledge and experience in regional research centers (Surana et al., 2020).

The research gap addressed in this article is related to a detailed study of the complex relationships between scientific activity, innovation activity and economic efficiency in Kazakhstan. Previous studies have paid much attention to the role of science and technology in driving economic development, but little has delved into the interplay between investment in science, innovation activity within organizations, and their collective impact on Gross Domestic Product (GDP) in the context of transition economies such as Kazakhstan. A new phenomenon discovered in this study is the unexpected inverse relationship between innovation activity within organizations and GDP. While conventional wisdom and existing literature suggest a positive correlation between innovation and economic growth, this study reveals a more complex interaction that does not always lead to immediate economic benefits, highlighting that the impact of innovation on GDP may depend on a variety of factors, including the type of innovation, its adoption in the market and wider macroeconomic conditions. This finding calls for a deeper understanding of the conditions under which innovation drives economic growth and highlights the need for a nuanced understanding of the relationship between innovation and the economy.

Overall, this work contributes to filling the identified research gap by providing empirical evidence of the complex relationships between scientific activity, innovation, and economic productivity. The overarching goal of the research is to explore and understand the complex connections between scientific and innovative activities, internal costs of R&D, and their collective influence on a country's economic performance, as measured by GDP. The specific hypotheses provide a structured framework for examining these relationships, guiding the investigation into the interplay between scientific endeavors, innovation within organizations, and the economic outcomes at the national level. By empirically testing these hypotheses, the study aims to contribute valuable insights into the nuanced dynamics that underlie the nexus of science, innovation, and economic prosperity. Ultimately, the findings may inform policymakers and stakeholders in optimizing strategies for fostering scientific and innovative environments conducive to sustainable economic growth.

2. LITERATURE REVIEW

There is a growing body of knowledge in the scientific literature devoted to the impact of science of the competitiveness of economy. With the rise of Industry 4.0 innovations and technologies have become sort of synonyms of science. Therefore, current research is devoted to the study of the construct of the process of science contribution to economy. There has been profound impact of science and technology on economic development. Studies highlight the crucial roles of entrepreneurship, patenting, and government policy in fostering an environment conducive to innovation and technological progress. The interplay between these elements has been a significant factor in shaping the economic landscape, particularly in the context of the modern economy.

Next, we showed schematically the construct of the process of science contribution to economy. This scheme is based on the work of Audretsch et al. (2002) where the authors discussed the content of science and its contribution to the development of a country and population well-being improvement (Figure 1).

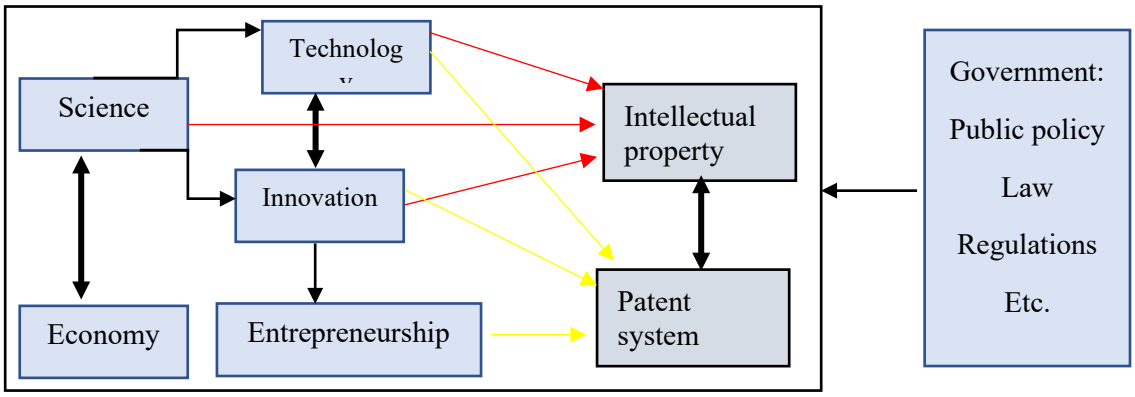


FIGURE 1. Construct of the process of science contribution to economy (a)

Note: compiled by authors

Process of science development includes technology and is closely intertwined with the progression of economic growth. Some studies stress that technological change is a crucial, if not the most significant, driver of economic growth and a determinant in the evolution of economy (Coccia, 2014; Teixeira & Queirós, 2016; Rocha, 2018). Technology applies this new knowledge to practical problems, with technological change referring to the rate at which this new knowledge

is used in the economy. The nexus between science, technology, and economy has been critical, especially in the context of the "new" economy which places greater emphasis on intellectual property and knowledge transfer (Norse & Tschirley, 2000; Czarnitzki et al., 2012). Public policy in science and technology plays a pivotal role in determining long-term economic growth (Naseem et al., 2010; Meissner, 2019) . However, there is a general lack of public understanding about the nuances and consequences of technological change. Entrepreneurship, as a process involving the organization of resources, results in innovation. This innovation, often originating as an invention, becomes economically valuable when applied or utilized. The transformation of inventions into practical applications is a core aspect of entrepreneurship. Patent laws, are crucial in securing exclusive rights to inventors and authors, thereby fostering a conducive environment for innovation and technological advancement.

The government's role in the innovation process has evolved over time, with policies aimed at stimulating the private sector's demand for R&D resources. This evolution includes initiatives like tax incentives, research collaborations, and public/private partnerships that subsidize research. Government intervention has been crucial in shaping science and technology policy, ranging from direct sponsorship of scientific endeavors to legislative measures like patent laws (Pradhan et al., 2020).

Theories of economic growth often use production functions to represent the relationship between output and the factors of production, like capital and labor. However, technological advancements, significantly contribute to economic growth. This is evidenced by Solow's analysis, showing that a large portion of U.S. economic growth was not attributable to capital and labor but rather to technological advancement (Sadik-Zada, 2021; Zhang et al., 2021). New growth theory further expands this concept by incorporating the influence of external factors, like technology spillovers and trade policies, on economic performance (Auboin et al., 2021).

It must be mentioned that throughout the studies and evolution of science contribution to the economy government participation stands out as initial stage of science development, as well as human capital is the basis for any development, scientific, technological or innovation (see Figure 2).

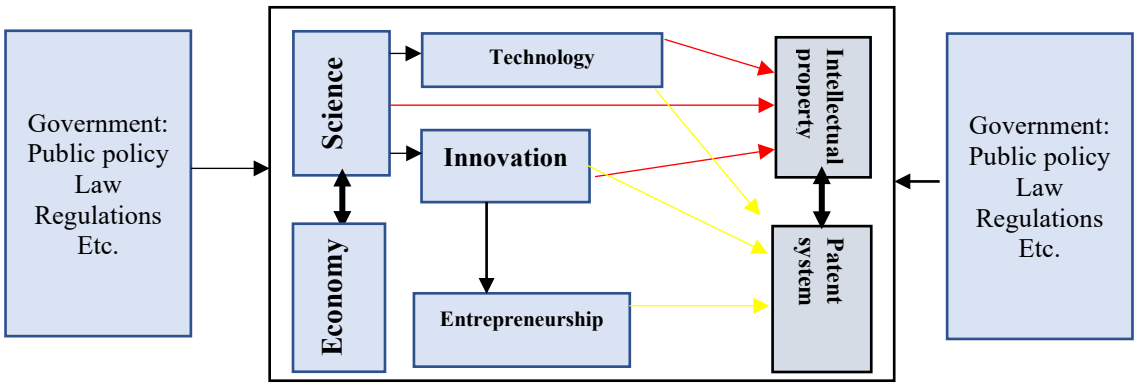


FIGURE 2. Construct of the process of science contribution to economy

Note: compiled by authors

Modern interpretations of economy development drivers have put innovation , technology and science as three separate factors, where science is regarded as a system of education. Kozma (2005) showed that in less developed countries, where problems such as lack of critical mass in

science, technology and innovation, limited commercialization opportunities and weak regional autonomy pose challenges. Education plays a key role in adapting to global changes, and ICT within education is seen as a means of changing educational practices and preparing for the information society. Governments are investing heavily in improving educational systems and introducing ICT in schools, based on the assumption that this contributes to global competitiveness and economic growth. However, the author notes that there is often no clear connection between these investments and the desired social and economic outcomes.

There is growing evidence that science contributes little to power, economic prosperity and living standards. Studies often draw attention to the limitations of mainstream economic approaches, which traditionally view "research activities" as a uniform flow of investment into the economy, creating an indeterminate flow of additions to the stock of general knowledge (Aghion et al., 2009). In countries where science is not developed, this sector is characterized by a rigid system of remuneration for scientists, reduced basic salaries, non-transparently implemented forms that determine the criteria for the productivity of scientists, "poor" academic mobility and informal links that play an essential role in career development (Newman et al., 2021). Thus, it is important to create favorable conditions for scientists in the country to prevent the outflow of qualified personnel and stimulate their return for the development of the scientific field. Anas and Wickremasinghe (2010) in their study showed that almost 71.29% of scholars wrote Sri Lanka for further education and/or skill development, while about 59.41% identified better career prospects as a factor in leaving. Problems related to lack of intellectual management, bureaucracy, and lack of incentives and recognition are also identified. According to Krammer (2017) in less developed countries, where problems such as lack of critical mass in science, technology and innovation, limited commercialization opportunities and weak regional autonomy pose challenges.

In the case of China, it is observed that an increase in government subsidies for R&D leads to a growth in overall investments in R&D. However, it simultaneously reduces private sector investments in this domain. Despite the overall increase in resources allocated to R&D due to government subsidies, private investments in this field experience a decrease. This phenomenon is interpreted as a partial crowding-out effect, wherein government subsidies partially substitute for private investments. Consequently, while the total resources dedicated to R&D witness an expansion, the impact on the private sector is noted to be negative. Nevertheless, the increase in government subsidies still contributes to the overall growth of investments in Research and Development, potentially fostering technological progress and the development of knowledge-intensive industries (Surana et al., 2020). Overall, the research underscores the intricate dynamics of science, innovation, and economic development, providing valuable insights for policymakers and stakeholders.

3. METHODOLOGY

This study employed a quantitative research design to analyze the longitudinal trends in key scientific and research indicators in Kazakhstan. In the context of our chosen methodology, our study builds upon foundational research highlighting the importance of quantitative analysis in exploring the structural relationships between scientific activity and economic growth. Specifically, our methodological approaches align with the study by Audretsch et al. (2002), which discusses the contribution of science to national development and the improvement of population well-being. We also follow the insights of Coccia (2014), Teixeira & Queirós (2016), and Rocha (2018), emphasizing the significance of technological changes as a driver of economic growth and a determinant of economic evolution. The critical link between science, technology, and the economy is further illustrated by the works of Norse & Tschirley (2000) and Czarnitzki

et al. (2012), especially relevant in the context of the "new" economy, where a greater focus is placed on intellectual property and knowledge transfer.

Our research employs the Partial Least Squares Path Modeling (PLS-PM) method, which, according to Naseem et al. (2010) and Meissner (2019), serves as a reliable tool for determining long-term economic growth, particularly in the context of state policy in science and technology. We also rely on the findings of Pradhan et al. (2020), who analyze the dynamics between entrepreneurship, innovation, and economic growth, crucial for understanding the interrelations in our study. Thus, based on the literature review, we assert that our methodology is in accord with contemporary research approaches and provides a solid foundation for analyzing the interactions between scientific investments, activity, and economic efficiency. This holds particular significance for comprehending these processes in the context of Kazakhstan.

Data for the analysis were extracted from national databases and compiled into separate datasets. These datasets encompassed a range of metrics pertinent to the assessment of research and development (R&D) progress, including financial allocations to various scientific fields and counts of individuals with advanced degrees, among other indicators (see Table 1).

TABLE 1. Data set

No.	Indicator	Code
1	Master's	MA
2	Doctoral Students	PhDSTD
3	Number of Personnel Engaged in Research and Development	RDStaff
4	Researchers (hold PhD)	PhDResSci
5	GDP	GDP
6	Internal Costs R&D	InternalCostsRD
7	Fundamental Studies (Funding)	FundStudies
8	Applied Research (Funding)	AppliedResearch
9	Natural Sciences (Funding)	NaturalSciences
10	Engineering and Technology	EngineeringTechnology
11	Medical Sciences (Funding)	MedicalSciences
12	Agricultural Sciences (Funding)	AgriculturalSciences
13	Social Sciencies (Funding)	SocialSciencies
14	Humanitarian Sciences (Funding)	HumanitarianSiences
15	Volume of Innovative Products	InnProductsVol
16	Number of Innovatively Active Enterprises	InnActiveOrg
Note: compiled by authors		

Descriptive statistics were employed to delineate the trends across the years. The study analyzed the trends for each variable within the datasets, discussing the implications of observed increases or decreases. The analysis provided insights into the overall growth and development of Kazakhstan's research and development sector.

Next, the PLS-PM approach (a variance-based SEM technique that is particularly useful for complex models with multiple constructs and paths.) was used This method is suitable for both exploratory and confirmatory research, and it is often used when the primary goal is prediction and theory development, especially in the early stages of theoretical conceptualization.

Data Analysis with PLS-PM included:

- Reliability and validity of the constructs were evaluated. Cronbach's alpha and composite reliability (rho_A, rho_C) were used to assess internal consistency reliability, while the Average Variance Extracted (AVE) assesses convergent validity. Discriminant validity is typically

assessed by ensuring that the square root of AVE for each construct is higher than its highest correlation with any other construct.

- Structural Model Assessment. Path coefficients are examined to assess the strength and significance of the hypothesized relationships between constructs. The coefficient of determination (R-squared) for endogenous constructs is used to evaluate the model's explanatory power. The f-square effect size measures the impact of a specific exogenous construct on an endogenous construct. The following hypotheses were formulated:

Hypothesis 1: The level of scientific activity (as measured by 'Science' including human capital) has a significant impact on the GDP of a country.

Hypothesis 2: Internal costs of R&D ('InternalCostsRD') significantly influence the level of scientific activity.

Hypothesis 3: The level of innovative activity within organizations ('Innov Act') has a significant positive effect on GDP.

Hypothesis 4: The level of scientific activity has a significant positive effect on the innovative activity of organizations. This hypothesis is tested by the path coefficient from 'Science' to 'Innov Act'.

4. FINDINGS AND DISCUSSION

The following analysis describes the trends in research and development (R&D) funding in Kazakhstan across various scientific disciplines and the overall internal costs of R&D. The indicators presented include Internal Costs of R&D, Fund Studies, Applied Research, Natural Sciences, Engineering Technology, Medical Sciences, Agricultural Sciences, Social Sciences, and Humanitarian Sciences. The time frame for the analysis spans from 2010 to the last available year in the dataset (see Figure 3).

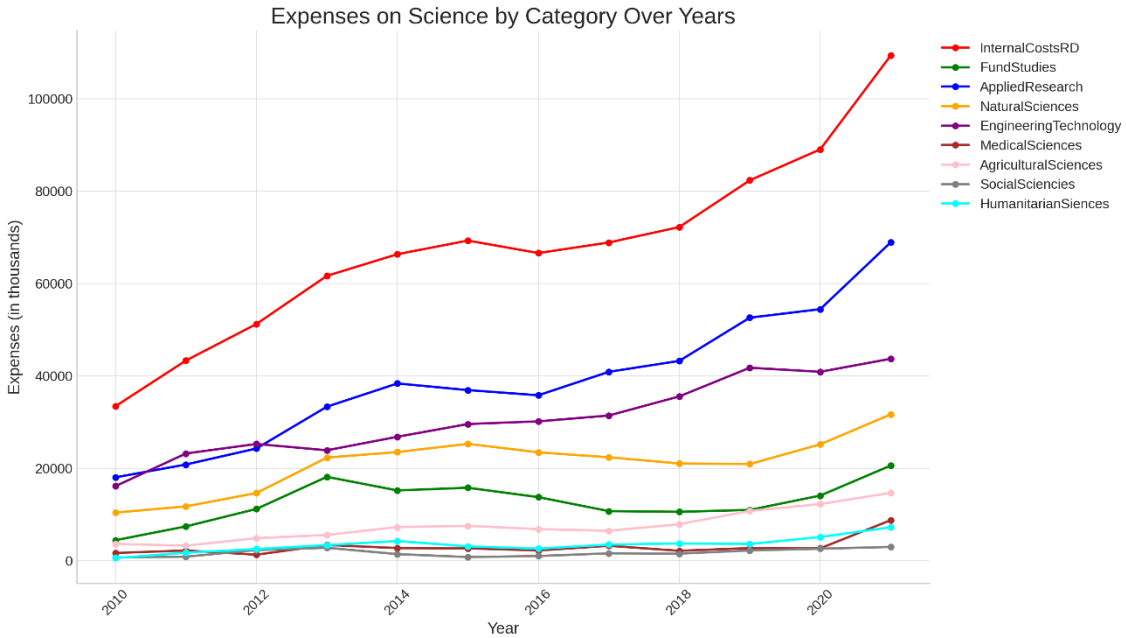


FIGURE 3. Trends in R&D funding, 2010-2021

Note: compiled by authors based on Bureau of National Statistics (2022)

The graph shows a positive trajectory in the internal costs of R&D, starting from around 33,467 thousand KZT in 2010 and rising steadily to reach higher levels in subsequent years. The dataset indicates a particularly significant increase towards the end of the period, signifying escalating investments in R&D within Kazakhstan. Applied Research, starting just below 20,000 thousand KZT in 2010, funding for Applied Research has escalated consistently, surpassing other fields by a significant margin and reaching the highest funding level in the dataset. Natural Sciences funding began at approximately 10,463 thousand KZT in 2010 and experienced a steady increase, reflecting a sustained commitment to this foundational field. Engineering and technology, starting from 16,183 thousand KZT in 2010, the funding for this field has shown growth, with some fluctuations, highlighting its importance in Kazakhstan's R&D agenda. Medical sciences, agricultural sciences, social sciences, and humanitarian sciences fields display varying levels of investment over the years, with medical sciences and agricultural sciences generally receiving more funding than the social and humanitarian sciences. Nevertheless, the latter two have seen an uptick in the most recent years. Fundamental studies category has shown a remarkable rise, particularly in the last year of the dataset, indicating an increased emphasis on foundational research. Thus, given data, allows building an overall trend for expences on science development (see Figure 4).

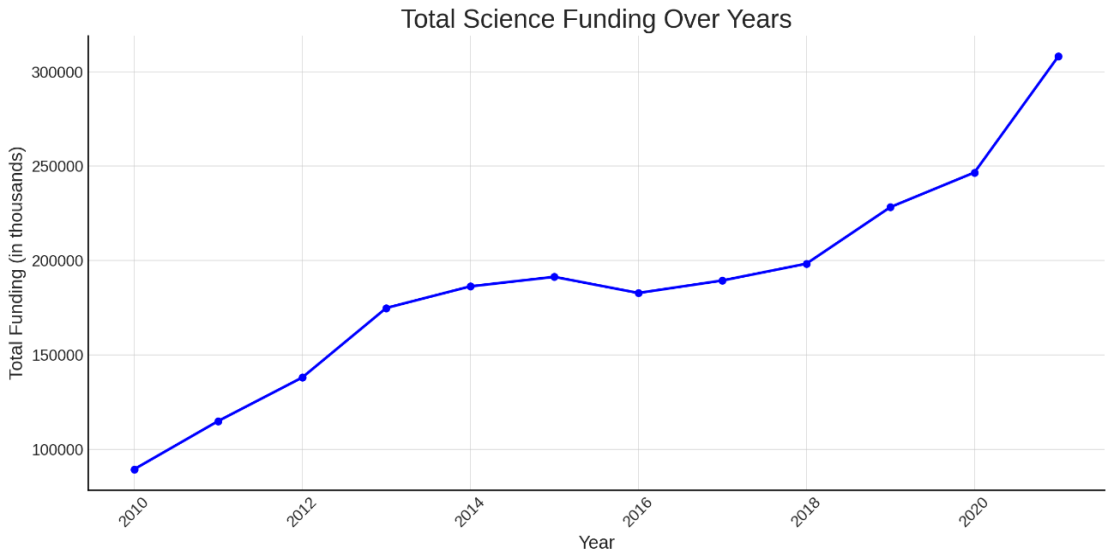


FIGURE 4. Total funding for science and research in Kazakhstan, 2010-2021.

Note: compiled by authors based on Bureau of National Statistics (2022)

The overall funding across all categories demonstrates a clear increasing trend. Starting from below 80,000 thousand KZT in 2010, the total funding surges to its peak at the end of the dataset period, with a sharp escalation evident in the most recent year.

These graphs collectively illustrate a strategic commitment to strengthening the scientific and technological landscape in Kazakhstan, with a notable focus on applied research and fundamental scientific fields. The significant increase in funding in recent years may signal a concerted effort by the nation to foster innovation and enhance its competitive edge in the global arena.

Next, the graph illustrates the trends in several key indicators of science and research in Kazakhstan over 2010-2021 (see Figure 5).

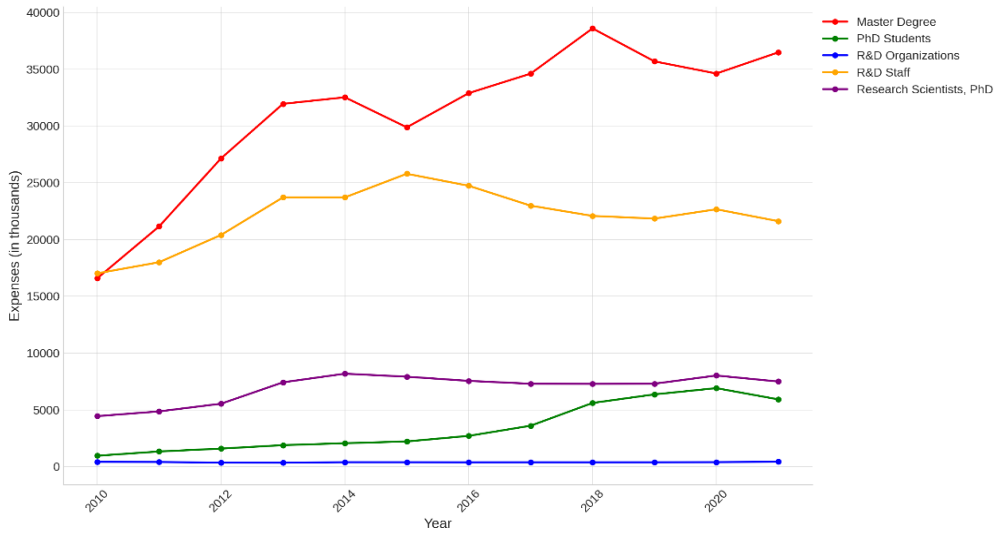


FIGURE 5. Trends is science and research in Kazakhstan, 2010-2021.

Note: compiled by authors based on Bureau of National Statistics (2022)

The depicted data elucidates a progressive trend in the development of Kazakhstan's scientific and research sectors, as evidenced by several key indicators from 2010 onwards. The quantity of Master's degree recipients has seen an upward trajectory, indicating an expansion of postgraduate education. Specifically, the figures ascend from 16,586 in 2010, peak in 2013, and then display slight variations whilst maintaining an upward trend. Simultaneously, the realm of doctoral studies has witnessed a doubling in the count of PhD students, escalating from 960 to 2,063 over the span of four years, which underscores a robust investment in advanced academic and research training. Regarding research institutions, the number of R&D organizations initially experienced a decrement, diminishing from 424 in 2010 to 345 in 2012, possibly reflecting a phase of optimization. Subsequently, a resurgence is noted, marginally increasing to 392 by 2014. The R&D personnel demonstrates a pronounced and consistent increment from 17,021 in 2010 to a plateau of approximately 23,712 by 2013, indicative of an expansion in research capacity and infrastructure. Most notably, the cohort of research scientists in possession of a doctoral degree has exhibited the most substantial relative augmentation among the surveyed indicators. Commencing at 4,447 in 2010, the number soars to 8,186 by 2014, more than doubling within the timeframe. This marked upsurge signals a strategic emphasis on cultivating advanced research expertise and a knowledge-intensive framework within the nation. Collectively, these indicators reflect Kazakhstan's strategic impetus towards reinforcing its academic and research institutions, fostering a conducive environment for scientific inquiry, and nurturing a workforce equipped with high-level qualifications. This aligns with the national vision to pivot towards a knowledge-driven economy, emphasizing innovation and scientific advancement as pivotal elements of national development.

Science Influence on GDP. The positive path coefficient suggests that there is a positive insignificant relationship between 'Science' and 'GDP'. Internal R&D Costs Influence on Science. With a path coefficient of 0.884 from 'InternalCostsRD' to 'Science', assuming statistical significance, this strong positive relationship confirms Hypothesis 2 that internal R&D costs have a positive influence on scientific activity. Innovative Activity's Influence on GDP. The negative

path coefficient of -0.764 from 'Innov Act' to 'GDP', if significant, would not confirm the expected positive relationship posited by Hypothesis 3.

Next, the research model is presented in Figure 6.

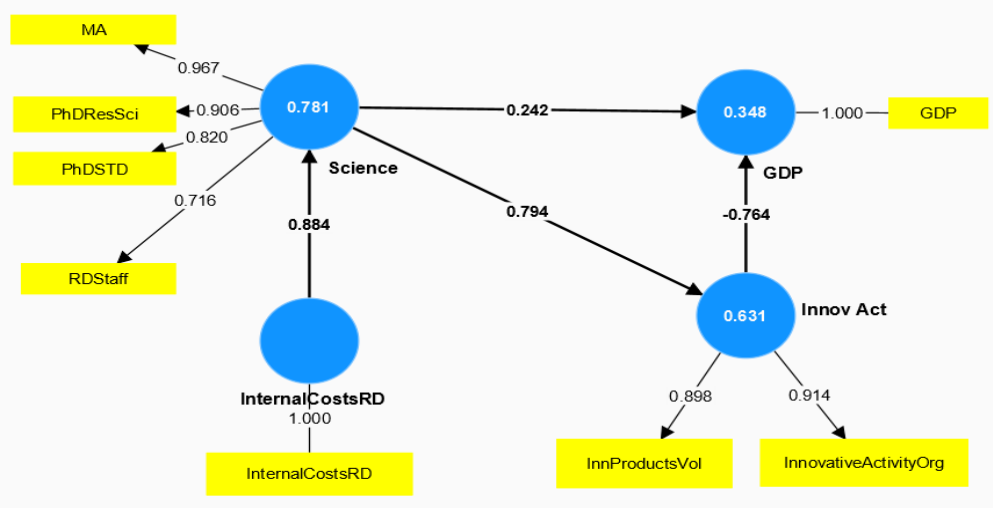
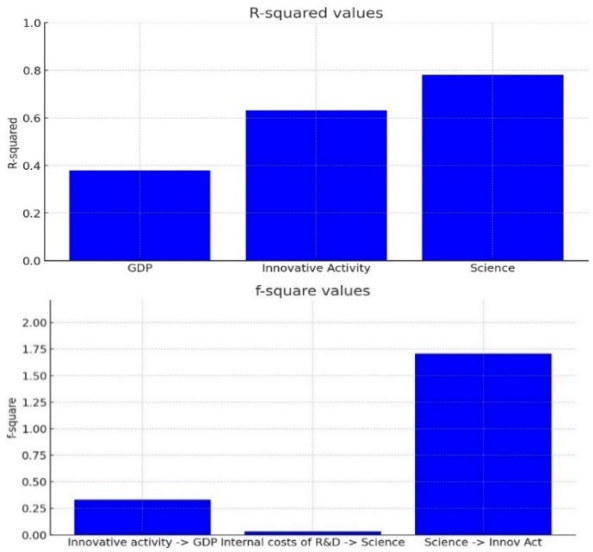


FIGURE 6. Research model

Note: compiled by authors based on calculations

It would suggest, instead, that higher levels of 'Innov Act' are associated with lower 'GDP', which could indicate that more research is needed to understand this relationship.

Science Influence on Innovative Activity. The positive path coefficient of 0.794 from 'Science' to 'Innov Act', if significant, would confirm Hypothesis 4, suggesting that scientific activity positively influences innovative activity within organizations. To fully confirm these hypotheses, it is essential to verify the statistical significance of these path coefficients (see Figure 7).



GDP, R-squared = 0.380;

Innovative Activity, R-squared = 0.631;

Science, R-squared = 0.781.

Innovative activity -> GDP f-square = 0,331;

Internal costs of R&D -> Science f-square = 0,033;

Science -> Innov Act = 1,708.

FIGURE 7. R-squared, F-squared

Note: compiled by authors based on our calculations

The coefficient of determination, denoted as R^2, for the Gross Domestic Product (GDP) is reported at 0.380. This value signifies that the model accounts for approximately 38% of the variance observed within the GDP data, indicative of a moderate level of explanatory power within an economic context (see Table 2).

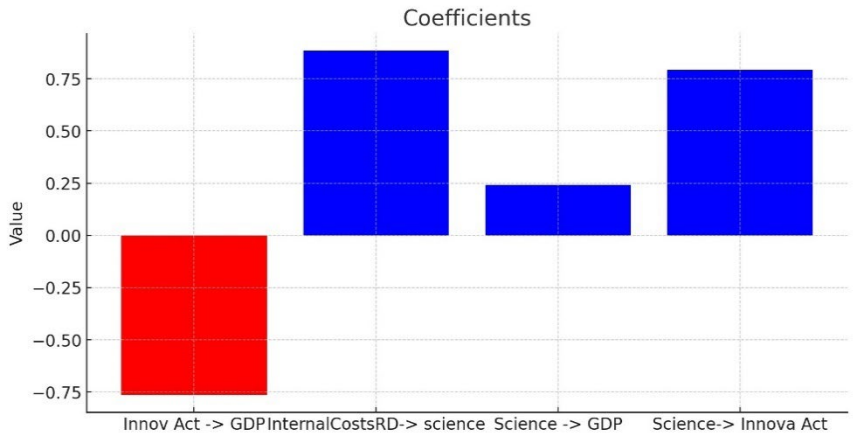
TABLE 2. Reliability coefficient

Construct	Cronbach's Alpha	Rho_A	Rho_C	AVE
Innovative Activity	0.782	0.786	0.902	0.821
Science	0.885	0.936	0.916	0.735
Note: compiled by authors				

The R^2 for the construct of 'Innovative Activity' stands at 0.631, thereby elucidating that the model explicates 63.1% of the construct's variance. The corresponding effect size, f^2, calculated for the relationship between 'Innovative Activity' and GDP is 0.331, placing it within the medium effect size domain.

An R^2 of 0.781 for the 'Science' construct underscores that a substantial 78.1% of its variance is captured by the model. The effect size f^2 for 'Internal Costs of R&D' impacting 'Science' is a relatively minimal 0.033, suggesting a marginal influence, whereas the 'Science' effect on 'Innovative Activity', with an f^2 of 1.708, denotes a profoundly robust impact.

The reliability coefficient, Cronbach's alpha, for 'Innovative Activity' is recorded at 0.782, which, in conjunction with Rho_A (0.786) and Rho_C (0.902), attests to high reliability. The Average Variance Extracted (AVE) for this construct is 0.821, indicating robust convergent validity. For the 'Science' construct, the Cronbach's alpha is 0.885, with Rho_A at 0.936 and Rho_C at 0.916, collectively corroborating excellent reliability. The AVE value of 0.735 further supports the construct's convergent validity (see Figure 8).



Innov Act -> GDP = -0,764;

InternalCostsRD-> science = 0.884;

Sciencce -> GDP= 0, 242;

Science-> Innova Act = 0, 794

FIGURE 8. Path coefficients

Note: compiled by authors based on our calculations

The path coefficient from 'Innovative Activity' to GDP is notably negative at -0.764, suggesting a substantial and unexpected inverse relationship. Conversely, 'Internal Costs of R&D' exerts a significant positive effect on 'Science', as indicated by a path coefficient of 0.884.

Additionally, 'Science' is posited to have a positive influence on GDP with a coefficient of 0.242 and on 'Innovative Activity' with a coefficient of 0.794, signaling substantial positive effects.

Expansion of the field of scientific research includes areas that do not always directly contribute to economic growth. For example, expansion into socially significant scientific disciplines (medicine, biology) may bring social benefits, but not always have immediate economic benefits. The results may also reflect the fact that funds invested in research may be allocated to areas not directly related to economic growth. For example, if most of the funds go to social research, this may reflect the fact that these resources are not directed towards innovation and technological progress (Shofer et al., 2000).

Pighly qualified specialists bring new knowledge, skills and innovative approaches to the economy, which contributes to increased productivity and, ultimately, GDP growth. Although the impact of human capital on economic growth may seem small, its long-term consequences become significant as educated and skilled workers create favorable conditions for sustainable development.

The flow of innovation not only strengthens the competitiveness of regional economies, but also attracts investment, which contributes to sustainable economic growth. Innovation generated by universities spreads throughout the economy, stimulating entrepreneurial activity and opening up new prospects for development.

Although the effects may appear relatively small in the short term, their accumulation and interaction over time lead to cumulative positive effects on economic growth. Therefore, although the magnitude of these impacts may be small individually, their combined contribution to shaping sustainable and innovative economic development becomes significant over a longer time horizon (Valero & Van Reenen, 2019).

5. CONCLUSIONS

The conclusion of the study, based on the Partial Least Squares Path Modeling (PLS-PM) analysis and the provided SEM diagram, can be summarized as follows.

The analysis revealed that the scientific activity within a country, operationalized as the “Science” construct, is positively associated with the Gross Domestic Product (GDP), indicating that higher levels of scientific engagement and output correlate with greater economic productivity. This finding supports the hypothesis that science is a vital contributor to the economic development of a nation.

Additionally, internal Research and Development (R&D) costs have a strong positive influence on scientific activities, suggesting that investments made within the domain of R&D bolster scientific pursuits. This underlines the importance of financial support for R&D in fostering a robust scientific environment.

Contrary to expectations, innovative activity within organizations, denoted by the 'Innov Act' construct, exhibited a negative relationship with GDP. This counterintuitive result suggests that there may be factors or conditions under which innovation does not directly translate to immediate economic growth, or there could be a lag effect not captured in the current model. Further investigation would be necessary to unpack the underlying dynamics of this relationship.

Lastly, the positive influence of scientific activity on innovative activity within organizations was confirmed, suggesting that a strong scientific base is instrumental in driving innovation.

In conclusion, the study's findings underscore the multifaceted role of science in economic development. The positive impact of science on GDP and innovation within organizations highlights the importance of supporting scientific research and education. However, the negative association between innovative activity and GDP warrants further exploration to understand the nuances of how innovation influences economic outcomes. The overall results point to the

potential benefits of strategic investments in scientific and innovation capacities to foster long-term economic growth.

AUTHOR CONTRIBUTION

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Sustainability Complexities in Supply Chains: a Qualitative Study utilizing Social Systems Theory

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Abstract

The purpose of this paper is to explore which sustainability complexities firms see in their supply chains. As supply chains consist of various actors and the consideration of sustainability requirements in supply chains adds to the complexity of the management of the supply chains, we apply the social systems theory as a theoretical framework enlighten inherent complexities. For investigating the research purpose, this study carried out multiple case studies with firms in the agriculture sector as these firms rely on the natural habitat and produce or source agricultural products face high expectations but also pressures from various actors. The interviewed firms were from textiles, beverages, coffee, food, non-food, cosmetics, ingredients and chemical branches. In total, this study conducted 26 semi-structured interviews with sustainability responsibles. The findings show, which different sustainability complexities firms in different branches see. By that, this study contributes to the literature as it is to the best of our knowledge the first utilizing social systems theory in the context of sustainable supply chain management. Second, for reducing sustainability complexities firms need to view and understand their relevant sustainability complexities first. Third, this paper contributes with managerial implications as firms can use our research as a starting point for identifying sustainability complexities and coping with them.

Keywords: Economic Sustainability, Supply Chain Management, Sustainability, Social Systems Theory, Complexity

SCSTI: 82.01.11

JEL Code*:* Q01, Q56, M14, M16

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1. INTRODUCTION

Sustainable Supply Chain Management (SSCM) is increasingly important for industry and therefore recognized by both practice and academia (Taylor & Vachon, 2018). Historically complex and fragmented grown supply chains (Mena et al., 2013; Zhao et al., 2019) nowadays cause firms to manage sustainability not only on a first-tier level but also moving their focus to n-tier suppliers (Grimm et al., 2014; Grimm et al., 2016; Mena et al., 2013; Tachizawa & Wong, 2014; Wilhelm et al., 2016; Wilhelm et al., 2016).

For that reason, investigate sustainability issues in supply chains has started to attract academia. Authors like Wilhelm et al. (2016) investigate the role of suppliers in SSCM while others recognize existing challenges (Dou et al., 2018; Mena et al., 2013; Pathak et al., 2007; Sarkis & Qingyun Zhu, 2018). In particular, regarding the supply chain simplification in three tiers (Grimm et al., 2014; Wilhelm et al., 2016) already shows the underlying complexity in each tier (Mena et al., 2013; Pathak et al., 2007; Zhao et al., 2019). Managing supply chains though influencing and controlling suppliers (Gong et al., 2018; Sarkis et al., 2019; Tachizawa & Wong, 2014) is already a challenging task. Extending and managing sustainability in supply chains than further 'adds complexity to an already difficult problem' (Sarkis & Zhu, 2018; Sousa et al., 2019). This increased complexity derives from the perspective's sustainability inherits due to additional stakeholder requirements and involvements, extended performance objectives, as well as further needed business activities (Dou et al., 2018).

From that point of view, one of the biggest research gap in SSCM is the lack of understanding which sustainability complexities firms view and how to cope with them for further extending sustainability in supply chains (Sarkis & Zhu, 2018; Wilhelm et al., 2016). For filling this gap, we base our research on social systems theory to explore in a first step which sustainability complexities firm view. From our point of view, the social systems theory is suitable as it offers a complexity perspective on how systems (e.g., firms) view challenges (complexities) in the environment and respond to it (Luhmann, 1995). For that reason it is particularly suitable for investigating sustainability in supply chains and we therefore adopt it in our study for the following reasons: First, sustainability and its challenges in supply chains represents high environmental complexity as it inherits various dimensions like social, economic and ecologic sustainability pillars. Second, besides sustainability, supply chain management views different actors in a supply chain and investigates their connection. Third, viewing the environmental sustainability complexity (i.e. managing sustainability in supply chains) provides a first view on the internal and collaborative complexity needed for managing sustainability efficiently.

For investigating which sustainability complexities firms view, we adopt the social systems theory and developed a multiple-case study. The multiple-case study consists of cases all related to agricultural supply chains e.g., fruits, coffee, palm oil etc. That scope best provides us with a certain range of information but still enables to compare the cases and answering our research objective which sustainability complexities firms in their supply chains see.

By answering this, our research contributes to the literature in the following: First, to the best of our knowledge this might be the first attempt utilizing the social systems theory exploring sustainability complexities in supply chains. Second, by that, we enhance the understanding of sustainability complexities in supply chains and provide a starting point for further understand how firms manage and cope with sustainability complexities internally. Third, with our empirical study we extend the knowledge of the field and existing works (Gong et al., 2018; Jia et al., 2019; Tachizawa & Wong, 2014).

The paper is structured as following. First, we provide a brief overview of the Social Systems Theory. Afterwards, we explain our course of research for the empirical study in depth in the

methods part. Following the method part, we provide the within-case analysis. A discussion and cross-case analysis follows this section. A conclusion finalizes this paper.

2. LITERATURE REVIEW

In academic literature there is a long theoretical history exploring complexity, i.e. utilizing social systems theory. Social systems theory has roots in cybernetics (Ashby, 1957). A complex system is a situation with a large number of interacting elements, where it is difficult to state the properties of the system itself (Simon, 1962). A highly used analogy analyzing complexity is Wright's"fitness landscape" (1932). It was later developed by Luhmann (1995), analyzing different areas of social life. However, Kauffman's (1991) analogy to complexity argues that this landscape can be rugged depending on the systems' distribution of fitness values and the interdependences between the parts, meaning that the more complex a system is, the more fragmented will be the landscape (Reiskin et al., 1999; Yardley et al., 1992). According to Kauffman (1991) fitness landscapes are described by the number of elements characterizing the system and the number of interactions between the components. This concept has been widely applied in organizational design studies (Levinthal & Warglien, 1999), industrial collaboration (Schuh et al., 2006), supply chain management (Choi et al., 2001), and sustainable supply chains (Matos & Hall, 2007). Thereby, authors view systems from a different perspective. Choi et al. (2001) view it from an organizational point of view regarding the number of interactions between individuals, teams, or organizations.

Matos and Hall (2007), on the other hand, view the entity from a firm`s sustainable development policy with the firm`s sustainability indicators. In modern academic works, e.g., Hall et al. (2012) suggest that sustainable supply chains can be viewed from a complexity challenge perspective as they require the coordination of different actors in the supply chain regarding various sustainability elements like environmental and social sustainability indicators. However, academia regards complexity challenges through the interactions among organizations explained by social systems theory. In addition, scholars adopted social systems theory and utilized it from macro- to micro-level perspectives (Mohe & Seidl, 2011; Seidl & Becker, 2006).

In particular, social systems theory is greatly interested in organizational research (Adler et al., 2014). In literature, most studies of complex systems discuss them using simulations. An exception is Matos and Hall (2007), who draw on qualitative data to identify elements and interactions. Similarly, we rely on qualitative interview data identifying the complexities as elements in sustainable supply chains.

Central in Social Systems Theory is complexity. Complexity describes the number and the relationship of the elements of a system or the environment it consists of (Luhmann, 1995). Hence, the complexity increases as the number of the elements, the system consists of, increases. However, this increase in elements (i.e., complexity) could result from new requirements like sustainability indicators needed for managing the supply chain accordingly (Hall et al., 2012). To deal with these complexities firms need a sufficient amount of requisite variety, which could be understood as the measures available to a system (firm) (Ashby, 1957; Luhmann, 1995). Therefore, firms can either create internal complexity or utilize collaborative complexity available to them (Schneider et al., 2017). Internal complexity is understood as an organization's internal structures and processes (Daft & Lengel, 1986; Damanpour, 1996), whereas collaborative complexity is structures and processes between organizations (Schneider et al., 2017). Organizations can combine internal and collaborative complexity viewing environmental overlap and available collaborative complexity. Environmental overlap is the relevance to which an issue concerns more than one organization whereas available collaborative complexity is the requisite variety created by other organizations (Schneider et al., 2017).

From our point of view utilizing Social System Theory to understand sustainability complexities in supply chains is valuable for three reasons. First, sustainability and its challenges in supply chains represent high environmental complexity as it inherits various dimensions like social, economic, and ecologic sustainability pillars (Baumann-Pauly et al. 2013). Second, besides sustainability, supply chain management views different actors in a supply chain and investigates their connection (Yang et al., 2023; Muñoz-Torres et al., 2023) and third, viewing the environmental sustainability complexity (i.e. managing sustainability in supply chains) provides a first view on the internal and collaborative complexity needed for managing sustainability efficiently (Rasche et al. 2013; Baumann-Pauly et al. 2013; Reinecke et al., 2016). Therefore, by conceptualizing sustainability complexity utilizing social systems theory, we are interested in sustainable supply chain management of firms and, in particular, which sustainability complexities firms see in their respective supply chain (industry).

2. METHODOLOGY

More and more firms address sustainability issues in their supply chain management to stay competitive. This increases the complexity they must manage. So far, it remains unclear how firms can manage these sustainability complexities. For this end, we abductively explore which sustainability complexities firms face by conducting a multiple-case study (Locke et al., 2008).

A case-study approach in general allows first, to study a phenomenon in its natural setting (Dubois & Gadde, 2002; Dubois & Salmi, 2016; Meredith, 1998) and second it enables the researcher to understand the nature and complexity of the phenomenon itself (Benbasat et al., 1987; Stuart et al., 2002). Third, compared to large-scale-theory-testing methods, a case study additionally enables us to get closer to a theoretical construct and uncover the intrinsic relationships (Siggelkow, 2007). In order to ensure rigorousity in terms of validity and reliability, we applied quality measures proposed by Yin (2018). For a detailed overview of the quality measures, refer to Table 1.

TABLE 1. Quality measures for qualitative research

No.	Quality measures	Research phase			
		Design	**Case selection**	**Data gathering**	**Data analysis**
1	Reliability (demonstrates operations of the study and, if replicated, leads to same results)	-develop case study protocol -development and use of case study database	documentation of selection criteria in case study protocol case selection/ based on the study database	semi-structured interview-guide shared semi-structured interview guide with interviewees prior to the interview	rigorous coding process of transcripts using qualitative data analysis software involve researchers not involved in the data gathering process
2	Internal validity (establish a causal relationship, which is believed to lead to other outcomes/ conditions)	research model builds on previous literature and theoretical considerations (builds a theoretical framework for study)	expert interviews refining and acknowledging considerations sampling criteria noted in the case study protocol	most knowledgeable informants interviewed utilization of multiple sources of data	pattern matching of previous literature/ research triangulation of multiple sources of data
3	Construct validity (identification of suitable	building on and adapting previous research	not applicable	multiple sources of data (semi-structured	review of transcripts by key

	operational measures for the study)	questions in the field of sustainable supply chain management		interviews, sustainability reports, press articles, and reports)	informants/ interviewees
4	External validity (showcase generalizability of findings)	comparative multiple case studies	theoretical sampling	gathering data on the case context	tbd: details on case study context considered
Note: compiled by authors based on references Yin (2018), Gibbert et al. (2008)					

Research Design

To study which sustainability complexities firms face and to understand the underlying theoretical constructs in depth, we use an abductive multiple case study approach (Alexander et al., 2014; Dubois & Gadde, 2002; Dubois & Salmi, 2016; Locke et al., 2008; Siggelkow, 2007; Yin, 2018). This approach best fits for the following reasons. First, qualitative research on which sustainability complexities firms face remains scarce and fuzzy, which makes it possible to validate existing theoretical considerations. Therefore, the abductive approach guides our research process on the one side prior the data analysis as we rely on theoretical considerations. Conversely, it supports the data analysis in the collection phase and helps complement our understanding (Ketokivi & Choi, 2014). Second, the case study approach is best suited for investigating the phenomena in its natural setting. Contrary to a quantitative approach, it allows for the interaction between the researcher and the informant. It thereby draws on not just one source of information instead of relying on multiple data sources, which leads to higher information richness (Yin, 2018). Moreover, by studying the phenomena in its natural setting and drawing on insights from informants' statements, we can develop and modify a theoretical contribution of high practical relevance (Gibbert et al., 2008). Third, as the topic of sustainability remains unclear and the resulting understanding of complexity fuzzy, we ensure with interviewing informants the clarification of the terms and, subsequently, the internal validity of our study. Fourth, by utilizing and triangulating multiple data sources, we reduce the social desirability bias of sustainability firms usually applied by window-dressing or greenwashing (Carter & Easton, 2011; Crane, 1999). According to our abductive approach, our research is thereby guided by the theoretical considerations based on Social Systems Theory. Again, the Social Systems Theory assumes that systems increase their internal complexity and build up collaborative complexity with others to cope with environmental complexity. As we build on preliminary theoretical considerations but are, to the best of our knowledge, not aware of the research regarding our research objective, a priori hypotheses cannot be derived. This led to a pre-selection of interview questions related to the preliminary considerations adopted from previous research in the field of mostly SCM and SSCM (Gong et al., 2018; Mena et al., 2013; Meqdadi et al., 2017; Morali & Searcy, 2013; Scandelius & Cohen, 2016; Wolf, 2011; Zhang et al., 2017).

Theoretical sampling and case selection

The sampling was carried out twofold: looking for potential industries and selecting potential companies. In the following, we outline our theoretical sampling and case selection reasons.

First, in particular, industries relying on the natural habitat and produce or source agricultural products face high expectations but also pressures from various actors (e.g., customers, governments, and NGOs) to implement a sustainability agenda in their supply chains (Hartmann & Moeller, 2014; Lee & Kim, 2009; Maloni & Brown, 2006; van Tulder & Kolk, 2001; Yu, 2008).

Because of this pressure and awareness, we assume that these firms are more likely to improve their sustainability agendas, enabling us a higher generalizability of the empirical findings.

Second, firms that process and source agricultural products are typically criticized for their and their supplier's harm to the environment (e.g., deforestation or wastewater), but also for their harm on humans both related to processing and sourcing (e.g., child labour or working conditions) as well as living in the natural environment nearby (The Guardian, 2015; Hofmann et al., 2014). Climate change has recently moved up the agenda, with more and more customers and other stakeholders holding companies accountable for their sustainability management. In addition, firms operating in supply chains focusing on agricultural products face a high vertical and horizontal supply chain complexity (Wilhelm et al., 2016).

Third, assuming that these very different actors (e.g., customers, NGOs, governments) expect the firms and their suppliers to continuously improve their sustainability agenda and actions, we focused on a diverse set of firms out of the agricultural industry regarding their size (number of employees) and purchasing categories. This suits the qualitative approach, building on high variance and looking for differences between firms and their respective purchasing categories.

Fourth, we focused on firms based in and operating from Germany to increase the comparability of external factors like governmental regulations. To refine and further develop our sampling frame and the developed semi-structured interview guide, we engaged in expert interviews with for- and non-profit organizations prior to our data collection phase. For this end, we contacted a diverse set of organizations.

The interviewed for and non-profit organizations are very diverse in their size and purchasing categories. Prior to the interviews, we pre-selected one or two purchasing categories (e.g., cacao, palm oil, cotton) from each firm's sourcing portfolio and agreed upon with the according interviewee. A general criterion was that we supposed that the selected purchasing category was significant for their total revenues and typical for why the company is publicly well known.

Finally, we managed to interview 20 organizations and conducted 26 interviews. However, we sampled six purchasing categories/industries, which coincides nicely with Eisenhardt (1989) suggested sample size of 4-10 cases. For a detailed list of the pre-tests and interviews, please refer to Table 2 and Table 3.

TABLE 2. Overview of Cases & Interviews

Case/ Supply Chain	Organization	Head-count	Branch	Respondent position	Duration in (min.)	Interview type
Production/ retail textiles	For-profit 2	3,600	Textiles	Manager Supplier Management & Sustainability	40	Call
	For-profit 2	3,600	Textiles	Manager Supplier Management & Sustainability	90	Face-to-face
	For-profit 3	2,600	Textiles	Head of Sustainability	25	Call
	For-profit 3	2,600	Textiles	Head of Sustainability	75	Face-to-face
	For-profit 4	15,000	Textiles	Director Global Sustainability	35	Call
	For-profit 4	15,000	Textiles	Director Global Sustainability	45	Call
	For-profit 6	50	Textiles	General Manager	90	Face-to-face
	For-profit 6	50	Textiles	General Manager	35	Call
	For-profit 9	1,200	Textiles	Team Leader Corporate Responsibility	80	Video-Call

Production beverages	For-profit 8	141	Beverages	Manager Sustainability	90	Call
	For-profit 16	394	Beverages	Manager CSR	75	Face-to-face
	For-profit 18	1,700	Beverages	Head of Sustainability & Safety	50	Call
Retail food/ non-food	For-profit 5	4	Coffee	General Manager	20	Call
	For-profit 5	4	Coffee	General Manager	85	Face-to-face
	For-profit 10	33,437	Food	Head of CSR	60	Face-to-face
	For-profit 15	12,100	Food/ Non-food	Lead Manager Sustainability	80	Call
	For-profit 23	5,222	Food/ Non-food	Director Sustainability Strategy	100	Face-to-face
	For-profit 24	152,000	Food	Head of Corporate Responsibility	50	Face-to-face
Production/ retail cosmetics	For-profit 22	24,000	Cosmetics	Creative Buyer (Buyer sustainability)	110	Face-to-face
Production food	For-profit 11	1,600	Food	Manager Work Safety & Sustainability Management	60	Call
	For-profit 13	9,800	Ingredients	Manager Corporate Sustainability	30	Call
	For-profit 14	9,800	Ingredients	Manager Corporate Sustainability	20	Call
Production cleansing	For-profit 17	1,050	Chemistry	Head of Sustainability and Organizations Management	40	Call
Note: compiled by authors						

TABLE 3. Additional interviews for background information

Case/ Supply Chain	Organization	Head-count	Branch	Respondent position	Duration in (min.)	Interview type
Retail food/ non-food	For-profit 1	20	Coffee	General Manager	35	Call
Non-specific	Non-profit 1	2,000	Services	Manager Public Affairs	35	Call
Production/ Retail Timber	Non-profit 2	12	Timber	Manager Market Services	35	Call
Note: compiled by authors						

Data Collection

The multi-disciplinary and cross-functional management of sustainability in supply chains led to varying informants (CEO, sustainability manager, purchasing manager) in each case. Using a semi-structured interview guide, we sampled the cases between August 2019 and March 2020. We sent a shortened version of our semi-structured interview guide to the interviewees before our interview. We assumed that this improved the quality of our interviewees' answers as they had the chance to develop notes, drafts, and first ideas on our research questions. Furthermore, we expected to shape the interviewing process and enhance the flow of the interview conversation. We deepened our understanding and questions of the study objective based on the notes. During the course of the research, we refined and adjusted our semi-structured interview questions to ensure that we included new and interesting facets (Yin, 2018). In addition, interview questions from previous research in the field were revised and adopted (e.g., from Chen et al., 2004; Vachon

& Klassen, 2006; Zhu & Sarkis, 2004). With that step, we further increased the quality of our research and, in particular, our semi-structured interview guide. All the interviews were conducted in German and were assured of being treated anonymously. Therefore, the descriptions in the following tables include anonymized information only, which prevents tracing back to the firms. The interviews lasted 60 minutes on average and were carried out by one researcher. Prior to the interviews, we gained further information to follow the sampling step regarding the purchasing categories by using publicly available sources of information like corporate websites, sustainability reports, and supplier/supply chain codes of conduct. The audiotaped interviews were transcribed afterward. In total, we conducted 26 interviews with 20 organizations during the course of the research. Due to the unstructured information and, in part, missing audio material, we do not include the pre-tests in this study. However, we report them in this method section for the sake of completeness and, more importantly, see them as additional background information and interviews for further context (see table). However, this reduces the number of interviews included in the analysis section to 23 interviews with 17 different for-profit firms. During the interviews, notes were taken, and immediately after the interviews, these notes were added to a protocol (e.g., date of interview, information of interviewee, interview setting (face-to-face or phone call), and other comments). This accounts for reliability and supports the following data analysis (Gibbert et al., 2008; Yin, 2018). To ensure validity, we further collected information from multiple sources of data (sustainability reports, information from the firm website, supplier/supply chain code of conduct, press articles, and other reports freely accessible) for later triangulation (Gibbert et al., 2008). After the interview was transcribed, we shared the interview transcripts with the interviewees for verification and to ensure reliability (Ellram, 1996). No interviewee intervened or asked for changes in the statements. As a last step, we established a case database consisting of the transcripts, notes, and other sources of data for triangulation (Yin, 2018).

The data analysis consisted of two parts. First, the within-case analysis allows understanding case-specific sustainability complexities, whereas the cross-case analysis is utilized to identify sustainability complexities as patterns across the cases as commonalities.

The first step was to provide the within-case descriptions. This section aims to provide internally consistent descriptions of the cases. For that end, we try to capture all information relevant – the sustainability complexities.

Afterward, we executed open coding of our interviews. In that step, we also tried to arrange the codes in categories. This step was followed by axial coding, which supports the anchoring of the data analysis in theory. By that, it helps to refine the concept and leads to better reliability of the data.

In particular, we reviewed the data and looked for the sustainability complexities indicated in our literature review on Social Systems Theory. This step led to adjustments, e.g., economic sustainability was less relevant due to our pre-defined semi-structured interview guide, and ecological sustainability was split as it is more relevant to view it from a waste and emission perspective.

3. FINDINGS AND DISCUSSIONS

Within-case-analysis/Case Production/ Retail Textiles

Production and retail in the textile industry have a long history of sustainability complexities (e.g., the Rana Plaza collapse.) Due to this history and major incidents, the textile industry has gained a high interest from the public worldwide. To meet these sustainability complexities the industry has set up sustainability goals affecting all actors in its related supply chain. Due to its

relatively long and fragmented supply chain, we investigated a diverse set of firms ranging from small to large and multi-national firms. In addition, the firms are diverse in their position in the supply chain, as some of them rather have a connection to end-customers while others are instead in a business-to-business relationship as producers and retailers. Due to their relationship with customers and size, some of these firms are internationally well-known for their high-quality and prized premium products. Smaller firms, however, are at least famous in the German textile market. In total, we conducted nine interviews with five different firms.

From a generic perspective, we see a relatively low number of codes in the textile industry. From our point of view, this is because the textile industry has a long-standing history of sustainability, as it was the industry that sped up the discussion, in particular on human rights. The team leader of corporate responsibility of for-profit 9 said:

> *I'll start with the social challenges. This is an issue that companies have been working on for a very long time.*

However, in our analysis we see that ecological & social complexities are are even distributed showing that despite its long history the textile industry still working on all sustainability complexities. During the interviews, the Director of Global Sustainability of for-profit 4 states it like this:

> *In between, of course, there is still an area that is a black box for most companies. So I'll say social conditions at spinning mills, that's where we are now, that's where we're slowly getting to. There are now also initial projects to make the spinning sector a little better. But in between, there are still one or two stages of area setting, weaving, knitting and all the wet processing, which still need to be developed more*.

In addition, the General Manager of for-profit 6 calls it like this as well:

> *And the big problem is that there is still a great deal of concern, and many people are still doing this, that the whole issue of sustainability is being treated as a fig leaf. Greenwashing, and many, many people do it. And that's the problem, and I see it as being very widespread in our market. So that's one of the biggest problems.*

Zooming in the social complexity perspective, we see that, in particular, the issue of working conditions is of major interest and in focus of firms. The team leader corporate responsibility of for-profit 9 describes it as follows:

> *It is tough to make progress in this area [edit: social sustainability] in the countries where we work. Where we work. We really do work in high-risk countries. Bangladesh, Turkey, China. Simply because of the legal situation. It's difficult to measure.*

On the other hand, ecological issues are even distributed, showcasing that all problems are of concern currently. In particular, the Director of Global Sustainability of for-Profit four states that there are just a few issues regarding sustainability:

> *I mean the, the, the ecological and social challenges, we can count them on five fingers. So in the environmental area, it's the whole issue: resources, competition for land, exposure to harmful chemicals, the whole issue of water use and water utilization, the whole issue of climate and climate protection, the whole issue of plastics, microplastics, landfills, that kind of thing*.

Within-case-analysis/Case Retail Food/ Non-Food

Retail food and non-food is one of the biggest industries in Germany, too. Besides sourcing and selling German-crown food, the German market depends on many imported and non-food foods. This characteristic we kept within this case. Two of the firms are the largest food and non-food retailers in Germany, selling food products like fruits and wheat products but also some textiles and households. The other firms are known for their coffee retail business activities in

Germany. In particular, as this industry has a direct relationship with end customers and the public, its sustainability complexity awareness is high. In particular, customers increasingly rate the retailers not just regarding their sustainability activities but also specifically buy sustainable products. However, to get a broad overview of the industry, we conducted a set of interviews ranging from a tiny firm to huge firms. In total, we conducted six interviews with five different firms. This enables us to have a high contrast for analysis.

In our analysis, we see that the retail food & non-food industry has relatively many codes, indicating that there is a high focus and urgency to speak about the issue. From our point of view, this comes also from a customer perspective as these products are dealt with by customers on a daily basis, meaning that they have a high awareness. Customers do not only have a high understanding of the products themselves but also certain sustainability complexities. For-profit 5s General Manager states it like this:

> *Today, many consumers are aware that it is the top issue even before the climate crisis, which, of course, means: How do we deal with it now? Do we want to deal with - and this is, of course, a very fundamental question for the group - how do we deal with plastics now?*

In particular, this is the case for our interviewed firms as they are highly known in the market. Regarding the sustainability complexities we see an even distribution. However, social complexities, in particular, arise with coffee as a specific product. The Lead Manager of Sustainability of for-profit 15 exemplaries describes this in our interviews:

> *Another huge problem with coffee is that the coffee grower, i.e., the farmer, and the next instances have a totally shifted balance of power.*

This is highlighted by issues regarding people at the sourcing locations. Both the Lead Manager Sustainability of For-profit 15 and the Head of Corporate Responsibility of For-profit 24 state:

> *Our rule is that every factory that slips onto our portfolio has to be audited once, which means that the majority of them don't even get in, and we are extremely strict about this. And then, we set up a long-term social program in the factories with which we work, and we try to raise this to 100%, where the main focus is on solving the social problems in the factory.*
>
> *Yes, the issue of indigenous peoples is, of course, closely linked. In other words, the expulsion of indigenous peoples who used to live in those same primeval forests. But of course, there is also the issue of human rights in the supply chain, i.e., working conditions, safety, health, and safety measures. This is an incredibly critical challenge, which has already been partially addressed, including in the commodities we have just discussed.*

On the other hand, ecological complexities are less specific. In our analysis, we see an even distribution.

Within-case-analysis/Case Production Food

In contrast to the retail food and non-food industry, there is a limited number of German-producing food firms in terms of revenue volume. However, the German market has some internationally operating and selling firms. Due to this fact, the firms are both of interest for sustainability complexities internationally and in Germany. In this case, we tried to copy this market structure and interest in sustainability complexities. We conducted three interviews with two different firms. One of these firms is internationally well-known for its chocolate, and the other, in contrast, is less known but one of a small group of ingredient providers. In this case, we contrast, in particular, the publicly known firms and their position in the supply chain.

The food production industry has a high number of codes as well. From our point of view, this

is due to the fact that food has a high awareness as it is a product which customers deal with daily. In particular, as the products come from the global south where sustainability complexities are known to Western customers. The high amount of codes also signals the high awareness of the firms we interviewed in the market. The high awareness is also seen in the sustainability complexities identified. We see an even distribution of ecological & social complexities. However, impact as a keyword was striking in our analysis. From our point of view, using the keyword impact and its synonyms is due to the intrinsic awareness the firms have as well as the awareness the market gives them. For example, the Manager of Work Safety & Sustainability Management of for-profit 11 said:

> *We would have no opportunity because the quantities we source are far too small, even though this is our main raw material. That's exactly the challenge that everyone says you have to be there. Yes, I like to say that, but the problem is that if I cough, someone has to get a sniffle. Because if that doesn't happen, I have no impact.*

In addition, the Manager of Work Safety & Sustainability Management of for-profit 11 said:

> *Because we think the actions it takes are important and we are represented there by the Central Association of the Food Industry. That's how we see ourselves represented there because they also have an impact.*

On the contrary, the Manager Corporate Sustainability of for-profit 13 highlight impact as a keyword as he said:

> *This is recorded in the scorecard, which is why there are no ecological or health impacts of raw materials.*

Within-case-analysis/Case Production Beverages

Beverages and their production are of high interest as Germany has a very diverse but high-volume beer industry. In addition, the German market has some well-known non-alcoholic beverages firms. These German-market-specifics are expressed in this case. In particular, the beverages industry is fascinating as the sourced ingredients are either sourced internationally or even pre-produced at their source of origin, placing sustainability complexities internationally and in Germany on the public agenda. Besides this fact, the further refinement is quite energy intensive (e.g., for cooling and heating processes), and the logistics of the goods is a major sustainability complexity as well. Three interviews with three different and well-known German firms were conducted to build up knowledge.

The beverages industry has a rather

limited amount of codes. From our point of view, it is not directly regarded as a sustainability complexity issue but instead included in foods overall. However, the history of sustainability complexities is quite short, so we argue that the problems will rise, too.

Looking in particular in the sustainability complexities, we see an almost even distribution between ecological and social complexities too. However, as there are no focus issues in social complexities, we see a focus in environmental issues like emissions and waste. The Manager CSR of For-profit 16 specifies it like this:

> *So, there are two topics that are currently super-hot topics: the one is the climate, and the other is the packaging.*

Within-case-analysis/Case Production/ Retail Cosmetics

In recent years, the cosmetics industry has gained awareness due to its critical sourced ingredients. In addition, due to its direct use on the skin, customers are increasingly concerned about the ingredients and their skin effects and environmental impacts, e.g., micro-plastics. However, as the market is very fragmented due to the product portfolio, we focused on conducting

interviews with large firms only. For the cosmetics industry, we got the chance to interview one of the most well-known cosmetics and daycare firms worldwide. In addition, this firm is internationally known for its high engagement regarding sustainability complexity, focusing on the products naturally ingredients both, protecting people, customers, and the environment.

The cosmetics industry is of high relevance to sustainability complexities. In particular, in our analysis, we see that supported by the brand awareness of our interviewed firm. This high awareness was noticed due to quite a lot of codes regarding sustainability complexities. In particular, one statement of the Creative Buyer (Buyer sustainability) of For-profit 22 shows that the high awareness of sustainability comes from inside due to a lot of environmental activists in the firm:

> *So, the fact that pesticides are an issue certainly comes from the environmental activists in the company. Well, we have many activists in the company, it has to be said.*

In addition, the interviewee proportionally said more regarding ecological rather than social complexities. However, the ecological issues are even distributed.

Within-case-analysis/Case Production Cleansing

Similar to the cosmetics industry, the cleansing industry is also highly focused on. In particular, the cleaning industry is focused on as their products have a high impact on the environment and the user's skin/body due to potentially hazardous ingredients. Due to this fact, we were able to interview one of Germany's most well-known firms regarding environmentally friendly cleaning products.

The production of cleansing products has a relatively low amount of codes. From our point of view, this is due to the rather limited size of the market. In addition, the firm we interviewed is well known for its sustainability complexity initiatives and performance. When asking the Head of Sustainability and Organizations Management of For-Profit 17 about possible partners to cooperate with regarding sustainability, they said:

> *Well, the thing is that For-Profit 17 is a medium-sized company and we are relatively alone in that respect, at least as far as our sustainability standards are concerned. That means that what the big players do, in this case [examples of peer-group firms], is nowhere near what we want, and that's why we haven't really seen any partners that we could team up with, at least not from the same industry.*

This could be an indication that the firm did not exaggerate the sustainability complexities. However, we see that only ecological complexities exist for the interviewee. One explanation for the missing social complexities is that the cleaning products industry is highly integrated in chemicals utilization. This issue is rather concerned with ecological impacts than, as by now, with social issues.

Within-case-analysis/Discussion & Cross-Case Analysis

This section presents the discussion & cross-case analysis while comparing it to the existing literature. To answer our research question, this section summarizes the constructs of the social systems theory utilizing the case description and cross-case analysis.

As expected, all firms in our sampling approach actively managed sustainability in their supply chains. All firms therefore regarded sustainability as a very important issue in their supply chains and actively worked on that. However, we observed differences in how these firms view sustainability complexities in their supply chains.

While all investigated firms view sustainability and the resulting sustainability complexities in their supply chains as very important issues, they differently weigh it in their views. In some

cases, they tend to focus on ecological sustainability complexities, while in others cases firms focus primarily on social sustainability complexities.

In order to identify patterns in the view of sustainability complexities, we compared the cases for similarities and differences to enable a contrastive analysis.

We reorganized cases according to industry branches that we linked to supply chain archetypes (e.g., production and retail of textiles) (Mena et al., 2013; Tachizawa & Wong, 2014).

Based on our preliminary conceptualization and emerging themes, we could compare the cases in terms of their sustainability complexities (ecological VS social). We will explain these patterns in the following and extend the discussion based on our coded information.

As expected, sustainability complexities are relatively equally distributed across the cases. However, we found two exceptions. In the case of production/ retail cosmetics and production cleansing firms, they view more ecological sustainability complexities than social sustainability complexities. In particular, in the case of Production/ retail cosmetics, we would have expected an equal weight of the sustainability complexities due to the similarity of cases to food or textiles. We would have expected similarity due to the products as, in both cases, products are directly used for the body either as an intake or dressing. From our point of view, we explain the overweight in these cases from a sustainability awareness perspective. Ecological sustainability complexities and their resulting impacts directly emerge on a rather global level. This is, e.g., the case for global warming effects but also ocean heating and rising sea levels. Contrary to that, and hard to say, social sustainability complexities and their resulting impact mostly occur exclusively on a local level. Because of this effect, the discussions regarding ecological sustainability complexities predominantly occur in public and on a global level rather than in discussions regarding social sustainability complexities.

Another interesting pattern emerged is the rather dominant view of social sustainability complexities in the case of Production/ retail textiles and case of Retail food/ non-food but less in the case of Production beverages or case of Production/ retail cosmetics. From our point of view, this is interesting as these cases are dealing with natural products and therefore show a similarity. However, we explain these differences due to the visibility and history of the industries. As textiles and coffee (beans) are non-food products, they appear very prominent in public discussions. Contrary to these discussions, the beverage industry still revolves around ecological sustainability complexities.

When comparing the cases (respective industries), we can summarize that overweight regarding codes emerge in highly visible or historically younger industries like Retail food/ non-food, Production/ retail cosmetics, and Production food. In particular, we argue that the textile industry is an obvious industry resulting from e.g., Rana Plaza incident, chemicals utilization during production processes, but also as textiles are worn daily, particularly for fashion purposes. On the contrary, Production/ retail cosmetics could be seen as a relatively historically younger industry as cosmetics and frequent use is a rather young phenomenon even though cosmetics are not daily used as compared to the case of textiles.

5. CONCLUSIONS

This research enhances the knowledge of sustainability complexities in supply chains and its overarching theme of SSCM. Investigating sustainability in supply chains empirically provides a novel perspective utilizing social systems theory.

Based on the discussion and cross-case analysis conducted in this study, it is evident that sustainability is a concern for firms in managing their supply chains. All the firms included in our sampling approach regarded sustainability as a crucial issue and actively engaged in sustainable practices within their supply chains. However, there were notable differences in how these firms perceived and prioritized sustainability complexities.

Our analysis revealed that while all investigated firms recognized the importance of sustainability in their supply chains, their focus varied. Some firms emphasize ecological sustainability complexities, while others prioritize social sustainability complexities. This differential view shows that firms approach sustainability from different perspectives based on their industry, visibility to and in the market, and historical context.

By comparing industry branches linked to supply chain archetypes, we identified patterns in the distribution of sustainability complexities. Industries such as the production and retail of textiles and retail food/non-food exhibited a dominant view of social sustainability complexities, whereas the production of beverages or cosmetics showed a greater emphasis on ecological sustainability complexities.

In conclusion, these findings show the need for firms to adopt a holistic approach to sustainability management, considering both ecological and social dimensions. Moreover, firms should recognize the influence of visibility and historical context on sustainability priorities and adapt their strategies accordingly.

Based on the findings of our study, several managerial implications and recommendations can be derived to help firms effectively address sustainability complexities in their supply chains.

First, firms should adopt a balanced approach to address both ecological and social sustainability complexities. This means that firms should not only integrate sustainability in their operational processes but start at the top and integrate sustainability in their overarching strategy.

Second, firms should acknowledge the influence of industry visibility and historical context on their sustainability priorities. This acknowledgment comes from consideration and acknowledgment of the firms' respective stakeholders.

Third, based on the acknowledgment and visibility of the firms' respective stakeholders, firms should consider collaboration with stakeholders to implement sustainable practices and drive positive change in their supply chains externally but also internally.

And last, by continuously monitoring and evaluating sustainability performance, firms enable themselves to identify areas for improving their sustainability performance and innovations of their respective business models.

This paper makes the following contributions. First, to the best of our knowledge, this paper might be the first to utilize social systems theory in the context of sustainable supply chain management. By doing so, we enhance our knowledge of the field.

Second, this paper empirically investigates sustainability complexities in supply chains. To reduce sustainability complexities, firms need to view and understand their relevant sustainability complexities first. By that, they take the first step to stay viable and continue participating in the market.

Third, besides our theoretical contributions, this paper also has managerial implications. By utilizing the social systems theory, we adopt a rather organizational view providing firms identify themselves with. Firms can use our research as a starting point for identifying sustainability complexities and coping with them.

This paper also has limitations and provides future research directions as well. First, as this paper empirically investigates sustainability complexities with a multiple-case study on agricultural firms there might be shortcomings in the identified sustainability complexities. As industries might view sustainability complexities differently, we call for further qualitative research utilizing multiple-case study methodology. By that future research can extend the knowledge of the field.

Second, as this paper relies on a case study methodology, it is by far not exhaustive in data. This shortcoming also constraints the generalization of the findings. However, future research could apply quantitative studies to test and refine the results. For that, large sample studies could be used.

Third, as we only focus on a certain scope of firms and time, there might be changes of which sustainability complexities firms view. In particular, this could be the case regarding the development of firms in their context. We could imagine, that firms might view different sustainability complexities while grow in size, but also in terms of time. For example, due to the change of public concerns we can imagine that years ago first ecological sustainability complexities were relevant while in the future more social sustainability complexities are relevant for firms.

Fourth, we call for further application of social systems theory in the context of sustainable supply chains management. As highlighted in the beginning of the paper, we argue that social systems theory might be a valuable theoretical basis for investigating sustainability in supply chains as it provides a modern complexity perspective, which perfectly fits in an increased complex world.

AUTHOR CONTRIBUTION

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Impact of Economic and Social Factors on Urban Development: A Comprehensive Analysis of Cities in Kazakhstan

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Abstract

This study presents a comprehensive analysis of the development dynamics of cities in Kazakhstan, focusing on the interplay between economic and social factors and their impact on the Gross Regional Product (GRP). Employing a dataset encompassing a range of indicators, cities were categorized into development groups (Highly Developed, Moderately Developed, Less Developed) based on normalized composite scores. The study aimed to test two central hypotheses through Partial Least Squares Regression (PLSR) analysis: firstly, that economic factors are significant positive determinants of GRP, overshadowing the influence of social factors; and secondly, that social factors significantly influence GRP, with economic factors playing a lesser role. The analysis revealed that economic factors, including SME activity, retail trade, fixed capital investment, and tax revenue, exhibited a substantial impact on GRP, whereas social factors like population growth, average salary, and income levels showed relatively less influence. The findings underscore the predominance of economic determinants in shaping regional productivity, providing critical insights for strategic urban development planning and policy-making. By highlighting the differential impacts of economic and social factors on urban development, this study contributes to the broader understanding of regional growth dynamics and offers a data-driven foundation for targeted developmental initiatives in Kazakhstan's urban centers.

Keywords: Urban Development, Economy, Economic Factors, Social Indicators, Regional Productivity

SCSTI: 06.61.53

JEL Code*:* O11, O31, O32, O33

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1. INTRODUCTION

The study of metropolitan development and economics is a critical area of research, especially in the context of rapid urbanization and globalization. Understanding how urbanization and economic processes influence each other. Moreover, the pandemic has exposed new challenges and emergencies in densely populated areas, highlighting the importance of redefining urban policies and services based on local characteristics and needs. Personalization of services and trusting relationships between sellers and buyers make a significant contribution to social interactions and define the identity of neighborhoods. Understanding how local commercial activities can contribute to sociality and sustainable communities is also key. Personalization of services and trusting relationships between sellers and buyers make a significant contribution to social interactions and define the identity of neighborhoods (Tricarico & De Vidovich, 2021). Understanding these interactions is critical to developing sustainable development strategies that promote economic growth, social stability, and improved quality of life in metropolitan areas. This is particularly relevant in the context of current global challenges such as climate change, urban growth and migration, which require an integrated and multidisciplinary approach to research and planning.

In the evolving landscape of urban development, understanding the intricate balance between economic vitality and social well-being is crucial for sustainable growth. This is particularly pertinent in the context of Kazakhstan, a nation experiencing rapid urban transformation and economic diversification. This study delves into the developmental dynamics of Kazakhstan's cities, aiming to unravel the complex interplay between economic and social factors and their cumulative impact on urban prosperity, as measured by the Gross Regional Product (GRP). The urban centers of Kazakhstan present a unique canvas for this exploration. Ranging from bustling metropolises like Almaty and Astana to emerging cities such as Kokshetau and Konaev, these urban areas are at varying stages of development, each contributing uniquely to the nation's economic and social fabric. This diversity offers an ideal setting to investigate the multifaceted nature of urban development.

The primary aim of this analysis is to investigate the relative influence of economic and social factors on the Gross Regional Product (GRP) of cities in Kazakhstan. This objective stems from two central hypotheses crafted to understand the dynamics of urban development within the country. The first hypothesis posits that economic factor—encompassing aspects like small and medium enterprise (SME) activity, retail trade, fixed capital investment, and tax revenue—have a significant and positive impact on the GRP, whereas social factors—such as population growth, income levels, and average salaries—are expected to exert an insignificant, possibly negative or neutral, impact.

In many countries, SMEs constitute a significant part of the economy, contributing to job creation, innovation and economic dynamism. Conversely, the second hypothesis inverts this relationship, proposing that social factors are the significant drivers influencing the GRP, with economic factors playing a less consequential role.

Through robust statistical methods, including Partial Least Squares Regression (PLSR) analysis, this study aims to dissect these hypotheses, providing empirical insights into the economic and social dynamics shaping urban centers in Kazakhstan. By doing so, the analysis endeavors not only to contribute to the academic understanding of regional development but also to offer practical guidance for policymakers in prioritizing areas for investment and intervention to stimulate regional growth and prosperity.

2. LITERATURE REVIEW

Research on the development of megacities and the impact of various economic factors is key to understanding current trends in urbanization and economic growth. Urbanization is usually accompanied by an increase in population density, which creates larger markets for informal businesses. More potential customers in urban areas increases sales and revenue for businesses. Urban areas typically have higher income levels and a diversity of economic activities, which creates favorable conditions for the growth and development of informal enterprises. Understanding the dynamics of urbanization and urban concentration allows us to formulate effective urban policies and development strategies that promote optimal resource allocation, sustainable growth, and avoidance of the negative consequences of over- or under-concentration of population in cities. This is especially important for developing countries, where urbanization processes are occurring against a backdrop of rapid economic and social change (Henderson, 2003).

Atawodi and Ojeka (2012) studied the relationship between tax policy, the growth of small and medium enterprises (SMEs) and its impact on the Nigerian economy. The results showed that there is a significant negative relationship between taxes and the ability of a business to self-sustain and expand. Thus, for the prosperity and growth of small and medium-sized enterprises, an adequate tax policy is necessary, which is not an obstacle to their development. Thus, favorable tax policies can not only strengthen the growth of these businesses, but also contribute to overall economic development and improvement of life in metropolitan areas by providing jobs, increasing access to services and improving income distribution. Effective taxation is critical to ensure sufficient funding for local budgets. Woodward et al. (2021) highlighted the importance of SME development, particularly in the informal sector in developing country economies, especially in the context of promoting economic growth and poverty reduction. Moreover, using the example of Africa, the authors showed that urbanization externalities play a significant role in determining the success of informal microenterprises.

Agglomeration is beneficial in cases where the agglomeration economy (the positive benefits from it exceed the additional costs) is realized. Shmidt et al. (2016) conducted a comparative analysis of the regional center and the entire region according to the main socioeconomic indices in static and dynamic conditions and made conclusions about the position of the city and the region based on such socioeconomic indices as the average monthly nominal accrued wages, the cost of fixed assets, investments in fixed capital, new housing construction, the volume of retail trade turnover, the volume of self-produced goods shipped, work performed and services performed in the region. Retail in the process of urbanization contributes to the development of infrastructure, attracting investment and improving the business environment in cities and regions (Voroshilov, 2020). Economic activity concentrated in a specific geographic area leads to the formation of strong economic networks and clusters (Ascani et al., 2020). The spatial concentration of economic activity in urban agglomerations creates conditions for increased productivity, innovation and economic growth (Liu & Zhang, 2021). This is driven by ease of access to markets, resources, information and technology, as well as the ability for businesses and organizations to collaborate and collaborate more closely. This principle emphasizes the importance of agglomerations as engines of economic development and innovation.

Another factor is population density in urban agglomerations, which affects social and economic processes (Huang et al., 2020). Compact living of the population in agglomerations helps to increase the efficiency of infrastructure use, reduce transport and communication costs and create conditions for strengthening social ties (Yao et al., 2022). It can also lead to improved quality of life through access to educational, cultural and health care facilities.

Thus, spatial interaction occurs, which is a particularly significant indicator in regional urban development policy. Moreover, Tan et al. (2016) considered spatial interaction to be one of the key socioeconomic drivers of urban growth. This indicates that, over time, interactions represented by population migration, flows of information and goods play a more important role than the individual socioeconomic drivers of an individual city (Surya et al., 2020; Lei et al., 2021).

The significant role of SMEs in the city's economy is noted, in particular in the volume of investments, the number of jobs, the share in the formation of the regional product and tax revenues. SMEs make a significant contribution to the city's economy, especially in terms of investment, job creation, and in generating regional domestic product and tax revenue (Obaturov, 2014). SMEs are one of the main driving forces of the economy, increasing GDP and contributing to economic diversification. influencing the level of employment and are able to reduce social tension. Also, the development of entrepreneurship contributes to the innovative development of the economy. Thus, industrial development and entrepreneurship affect sustainability of urbanization and growth of cities (Alpatov & Yakushkina, 2017).

To summarize, the literature review indicated key factors which affect the economy development. The indicators include economic (GRP, SME, retail) , financial (taxes, investments) and social indicators (population growth, population income).

3. METHODOLOGY

This study employed a mixed-method approach to analyze the development levels of cities in Kazakhstan. The research process included four main stages (see Figure 1).

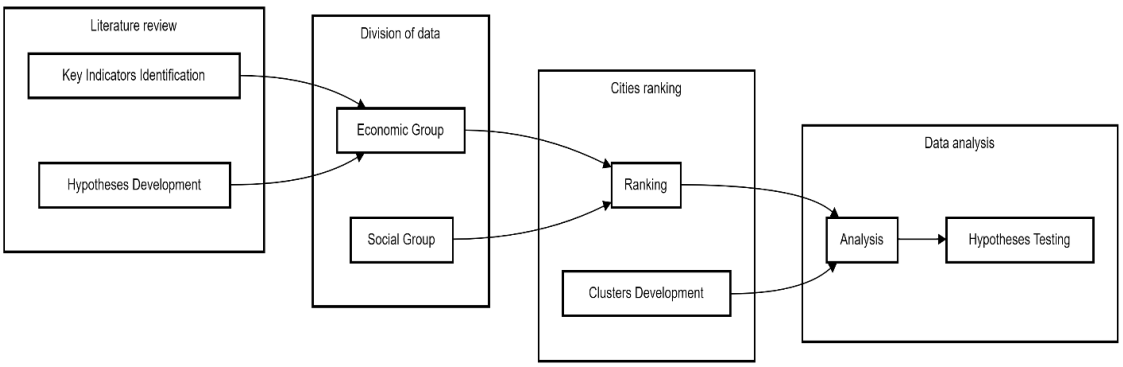

FIGURE 1. Stages of the research

Note: compiled by authors

The study employed descriptive statistics and Partial Least Squares Regression (PLSR). The dataset comprised indicators for different cities across multiple years, including variables such as population growth, average salary, and various economic metrics. The data was normalized using the Min-Max Scaler, facilitating a balanced comparison across various indicators. Next, cities were classified into three development categories - highly developed, moderately developed, and less developed - based on composite scores calculated from the normalized indicators. Scatter plots were generated, visually depicting the trends and development levels of different cities. For the final phase, PLSR analysis was conducted to test two hypotheses related to the impact of social and economic factors on the Gross Regional Product (GRP) of the cities.

The conducted literature review allows to identify key indicators for the study of urbanization process development. The indicators were then divided into two main groups economic and social (see Figure 2).

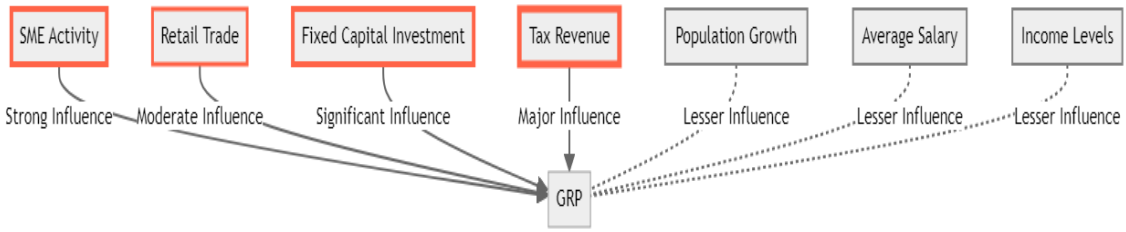

FIGURE 2. Hypotheses

Note: compiled by authors

By offering a comprehensive analysis of the economic and social indicators and their correlation with urban development, this study aims to contribute to the broader understanding of urban growth dynamics. It seeks to provide a nuanced perspective on how cities in Kazakhstan can leverage their unique economic and social assets to foster a thriving, resilient urban environment. This research not only adds to the academic discourse on urban development but also serves as a guide for policymakers and urban planners in strategizing future developmental initiatives.

4. FINDINGS AND DISCUSSIONS

In Kazakhstan urban population accounts for 57.4% of the country's total population living in cities. Three large cities with a population of over a million include Almaty, Astana and Shymkent, where 22% of the country's population lives. Over the past five years, there has been a positive trend in the main socio-economic indicators of urban development, especially in Almaty, Astana and Shymkent. Residents' welfare, gross regional product, economically active population, and wages have all improved, with cities also witnessing increases in industrial production and fixed investment. Almaty and Astana, the largest cities, play an important role in the socio-economic development of the country, serving as centers for business, cultural, innovation, financial, and political activities. Shymkent is also important in the fields of oil, chemical, food industry and mechanical engineering, although the socio-economic state of the city is characterized by moderate development due to high density (Kangalakova & Satpayeva, 2023).

This plot illustrates varying trends in population growth across different cities. While some cities exhibit a steady increase, others show more fluctuating patterns. Cities with significant population growth might be experiencing urbanization, often associated with economic opportunities, better infrastructure, and services. This can lead to increased economic activity and development. Rapid population growth can strain city resources and infrastructure, necessitating careful urban planning and investment in public services, housing, and transportation.

In Figure 3, we are providing dynamics of average salary trends and population growth trends in cities for 2010-2020. The data, analyzed over a decade, indicates a clear pattern: cities with higher salary growth rates tend to experience more significant population increases.

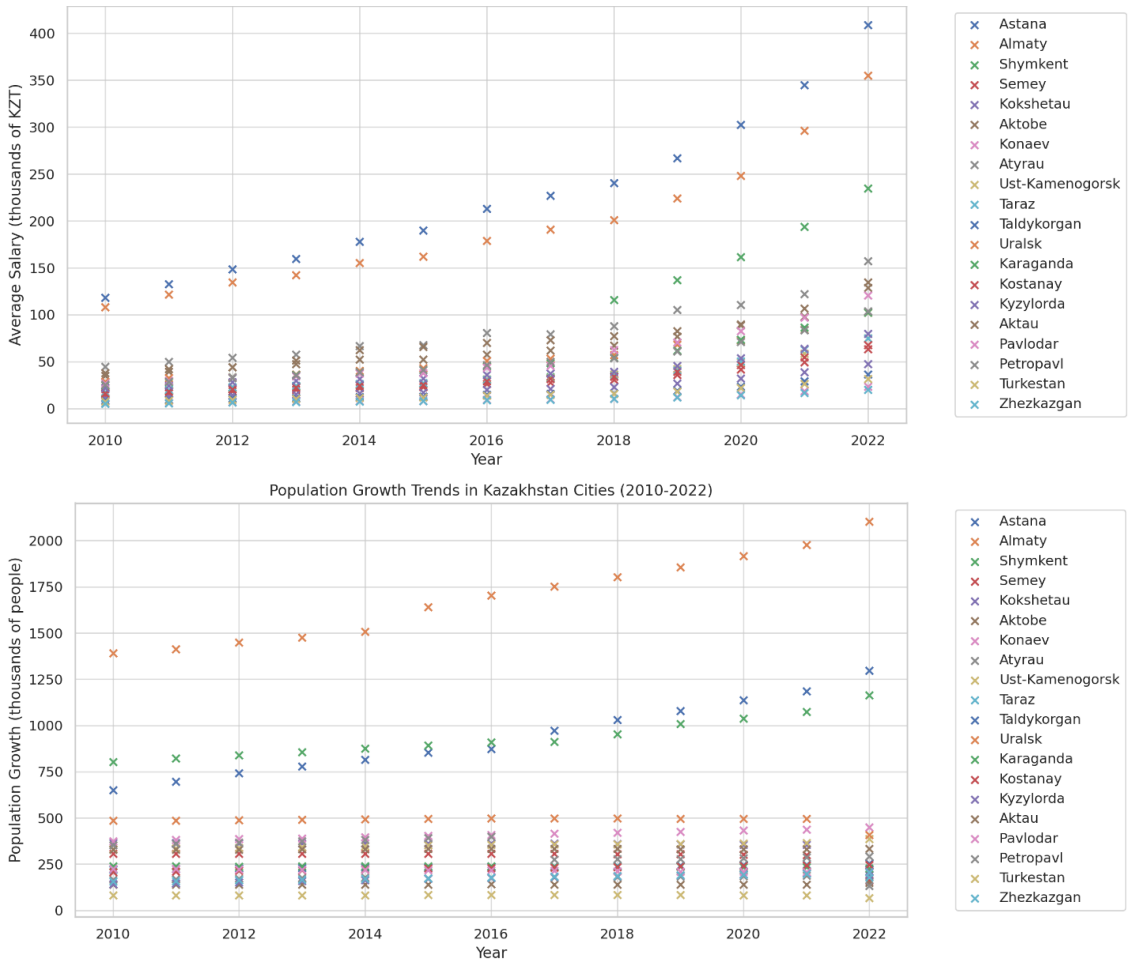

FIGURE 3. Dynamics of average salary trends and population growth trends in cities for 2010-2020

Note: compiled by authors based on Bureau of National Statistics (2022)

The scatter plot generally shows an upward trend in average salaries across most cities over the years. This indicates economic growth and possibly an increase in the standard of living in these cities. The scatter plot also reveals significant variations in average salaries between cities. Some cities consistently show higher average salaries (like Astana and Almaty), which might be due to a concentration of high-paying industries, better job opportunities, or a higher cost of living. Increasing average salaries can attract more skilled workers to these cities, potentially leading to urbanization and economic development. However, it could also indicate rising income inequality if the growth is not uniform across different sectors or regions.

This plot illustrates varying trends in population growth across different cities. While some cities exhibit a steady increase, others show more fluctuating patterns. Cities with significant population growth might be experiencing urbanization, often associated with economic opportunities, better infrastructure, and services. This can lead to increased economic activity and development. Rapid population growth can strain city resources and infrastructure, necessitating careful urban planning and investment in public services, housing, and transportation.

This trend underscores the attractiveness of economically booming areas, as individuals migrate towards cities offering better employment opportunities and living standards. Further

statistical analysis, suggesting that salary trends are a significant predictor of population growth in urban areas. This analysis provides valuable insights for policymakers and urban planners in understanding the interplay between economic incentives and urban migration patterns, aiding in the formulation of strategies for sustainable city development.

Figure 4 shows the dynamics of the population with an income below the subsistence level and trends in the development of small and medium-sized businesses for 2010-2022.

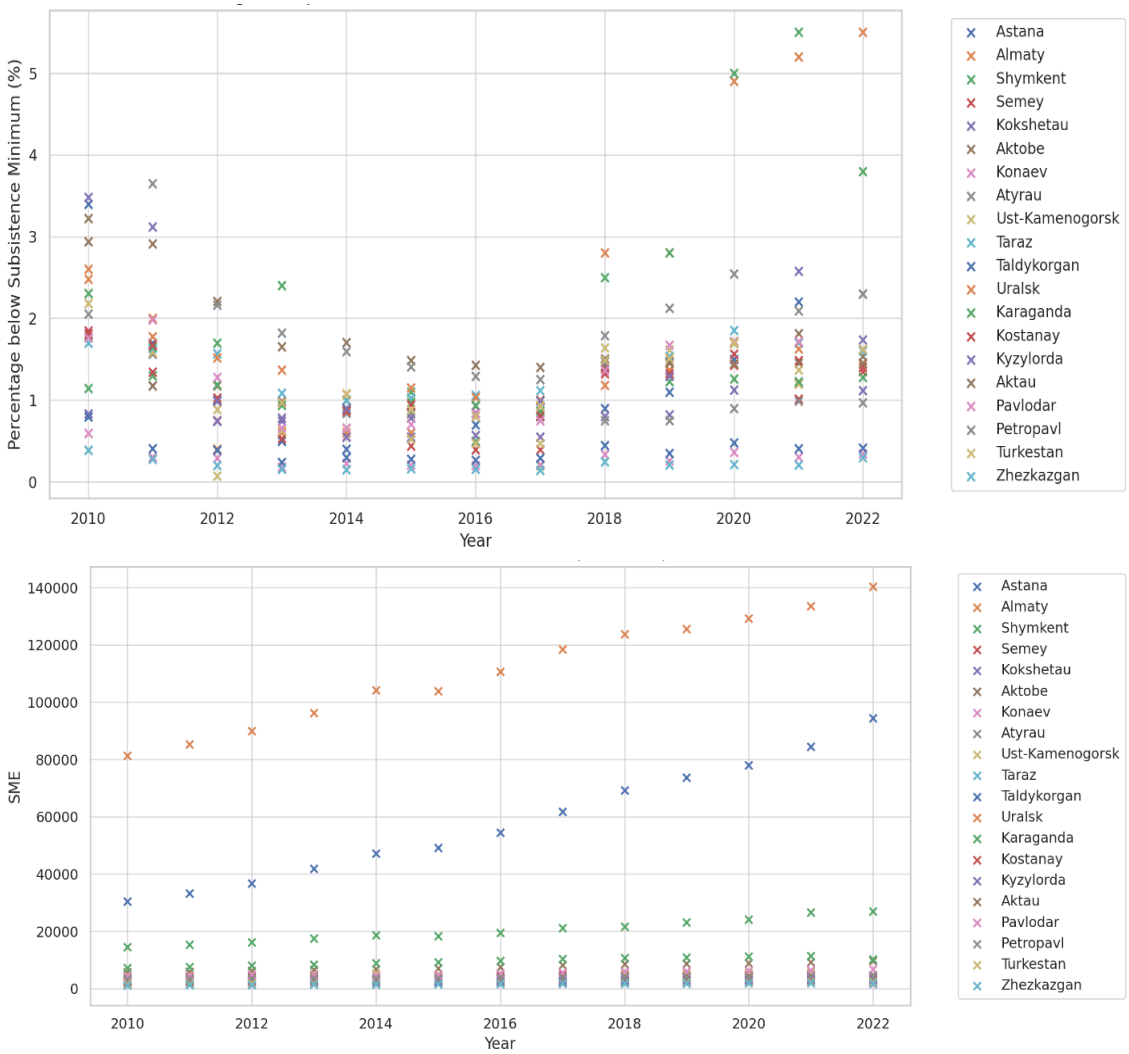

FIGURE 4. Dynamics of the population with an income below the subsistence level and trends in the development of SME in cities for 2010-2022

Note: compiled by authors based on Bureau of National Statistics (2022)

The plot shows the percentage of people with income below the subsistence minimum in each city over the years. Data analysis shows that with an increase in the number of SMEs in the region, there is a tendency to decrease the proportion of the population living below the poverty line. An increasing trend in this percentage can be a cause for concern, indicating growing poverty or economic hardship. A higher percentage of the population below the subsistence minimum in a city suggests economic challenges, such as insufficient job opportunities, low wages, or high living costs. This can also point towards increasing economic inequality within the city. Policy

implications: For policymakers, a rising trend in this indicator may necessitate interventions like social welfare programs, employment initiatives, and efforts to control the cost of living.

An upward trend in SME activity indicates economic growth and diversification. SMEs are often crucial for job creation, innovation, and contributing to the GDP. Variations among cities suggest that some areas may have more favorable conditions for SMEs, such as better access to finance, markets, or supportive local policies. A robust SME sector can enhance economic resilience, particularly in facing economic downturns, as SMEs can adapt more quickly to changing market conditions.

In Figure 5, we are providing data on retail trade and fixed assets in cities, between 2010 and 2022.

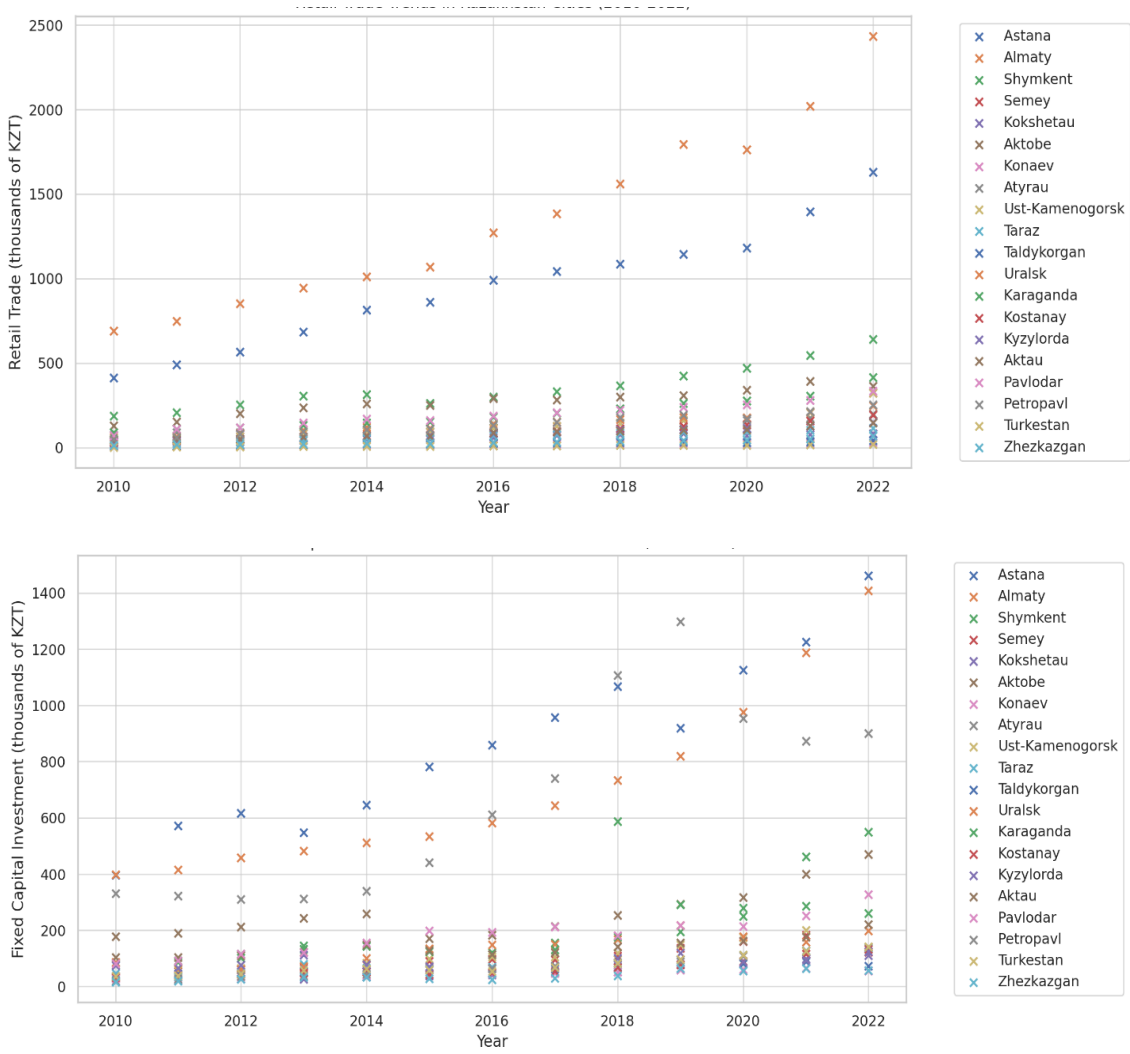

FIGURE 5. Dynamics of retail trade trends and fixed assets in cities, Kazakhstan 2010-2022

Note: compiled by authors based on Bureau of National Statistics (2022)

An analysis of data over the past ten years shows that cities with active development of fixed assets often experience higher growth rates in retail trade. This indicates that investments in fixed assets, such as infrastructure, technology and production facilities, contribute to strengthening the

retail sector, improving the availability of goods and services to the population. An increase in retail trade typically indicates higher consumer spending, which is a sign of economic health and consumer confidence. Differences in retail trade volumes between cities can reflect varying levels of economic activity, disposable income, and population density. Growing retail trade can signal broader economic development, as it often correlates with improvements in infrastructure, increased urbanization, and higher standards of living.

An increase in fixed capital investment is a strong indicator of economic development. It suggests that businesses are investing in physical assets like machinery, buildings, and infrastructure, which can boost productivity and economic growth. Higher levels of fixed capital investment can also indicate business confidence in the economic environment, reflecting expectations of future profitability and growth. Variations between cities in terms of investment levels can highlight regional disparities in economic development. Cities attracting more investment typically offer better infrastructure, a skilled workforce, and business-friendly policies.

In Figure 6, we are providing data on tax revenue budget trends in Kazakhstan between 2010 and 2022.

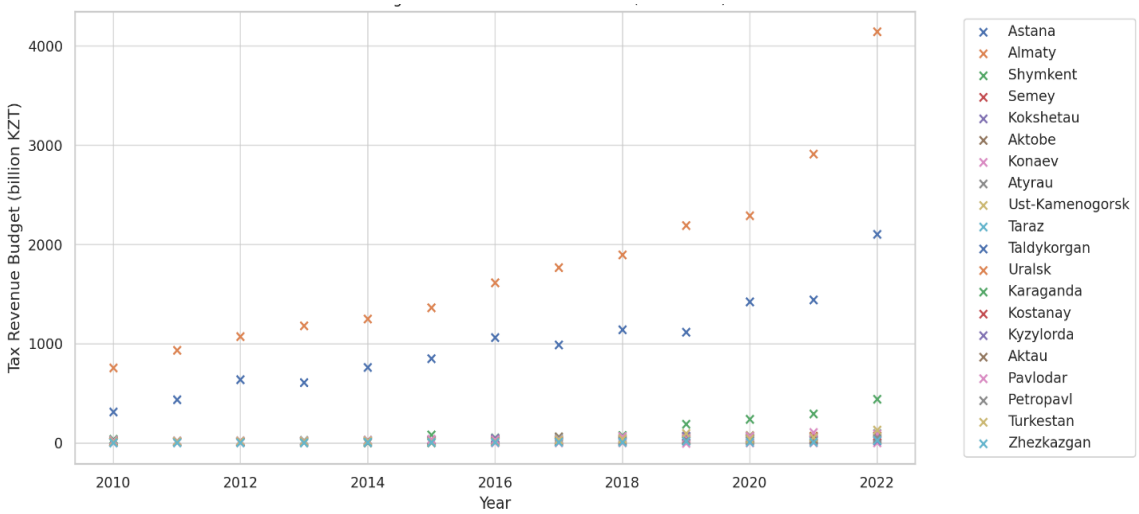

FIGURE 6. Tax revenue budget trends in cities for 2010-2022

Note: compiled by authors based on Bureau of National Statistics (2022)

Tax revenues are a direct indicator of economic activity. Higher tax revenues suggest increased business activity, higher employment rates, and greater consumer spending. Increasing tax revenues imply more resources for local governments, which can be used for public services, infrastructure development, and social programs. This, in turn, can contribute to further economic growth. Variations in tax revenue among cities can indicate the relative economic health of these regions. Cities with consistently higher tax revenue may have more diverse and robust economies.

The analysis encompassed a diverse array of cities across Kazakhstan, each unique in its economic and social characteristics. The cities were evaluated on a spectrum of indicators, both economic (such as SME activity, retail trade, fixed capital investment, and tax revenue) and social (like population growth, average salary, and income levels). Based on these indicators, each city was assigned a composite score, reflecting its aggregate performance across all metrics (see Table 1).

TABLE 1. Categorial ranking composite score

City	Pop. Growth	Income above Sub.Min.	Avg Salary	SME	Retail Trade	Fixed Cap. Investment	Tax Revenue	Composite Score
Astana	0.528	0.530	1.000	0.516	0.725	0.530	0.551	0.689
Almaty	1.000	1.000	0.853	1.000	0.755	0.753	1.000	0.952
Shymkent	0.530	0.968	0.326	0.171	0.219	0.067	0.067	0.365
Semey	0.132	0.370	0.092	0.026	0.020	0.015	0.015	0.114
Kokshetau	0.166	0.296	0.058	0.008	0.011	0.010	0.011	0.084
Aktobe	0.037	0.556	0.262	0.055	0.080	0.089	0.021	0.199
Konaev	0.204	0.038	0.004	0.002	0.003	0.001	0.000	0.038
Atyrau	0.057	0.382	0.340	0.017	0.062	0.056	0.019	0.236
Ust-Kamenogork	0.169	0.457	0.117	0.033	0.057	0.084	0.019	0.139
Taraz	0.093	0.576	0.119	0.020	0.051	0.043	0.020	0.131
Taldykorgan	0.096	0.083	0.032	0.010	0.013	0.010	0.014	0.039
Uralsk	0.252	0.580	0.204	0.097	0.097	0.097	0.012	0.183
Karaganda	0.096	0.497	0.194	0.143	0.143	0.143	0.015	0.168
Kostanay	0.091	0.490	0.107	0.063	0.063	0.063	0.019	0.118
Kyzylorda	0.058	0.662	0.140	0.056	0.056	0.056	0.014	0.143
Aktau	0.155	0.760	0.282	0.056	0.056	0.056	0.011	0.201
Pavlodar	0.083	0.515	0.211	0.136	0.136	0.136	0.026	0.169
Petropavl	0.156	0.863	0.194	0.095	0.095	0.095	0.010	0.196
Turkestan	0.000	0.381	0.025	0.009	0.008	0.000	0.022	0.068
Zhezkazgan	0.061	0.000	0.000	0.017	0.043	0.017	0.005	0.020
Note: compiled by authors								

This comprehensive table includes both social and economic indicators, offering a more holistic assessment of each city's overall development. The "Composite Score" reflects an average of all these indicators, providing a single measure to compare and contrast the cities' development levels.

Higher Composite Scores. Cities like Almaty and Astana rank high, suggesting strong performance and showcased strong economic foundations coupled with robust social indicators. These cities not only excelled in generating higher GRP but also demonstrated significant achievements in social aspects, making them leaders in urban development within the country.

Moderate Composite Scores. Cities such as Aktobe, Atyrau, and Uralsk displayed a balanced mix of economic and social development, though not at the same level as the top-tier cities. They had moderate scores in economic activities and social parameters, indicating steady but slower growth and development.

Lower Composite Scores. Cities at the lower end of the spectrum, such as Zhezkazgan and Taldykorgan, may face significant challenges in both social and economic aspects and may require targeted interventions for development. Kokshetau, Konaev, and Zhezkazgan had lower composite scores, suggesting challenges in both economic and social domains. They lagged behind in key areas such as economic activity, income levels, and population growth, highlighting a need for targeted developmental strategies.

The overall ranking and composite scores of these cities provided a clear picture of the urban development landscape across Kazakhstan. This ranking served as a crucial tool for identifying areas of strength and opportunities for growth, enabling policymakers and stakeholders to strategize development efforts more effectively.

The results from the Partial Least Squares Regression (PLSR) analyses for both hypotheses are as follows (see Table 2).

TABLE 2. Regression analysis results

Hypothesis	MSE	R^2 Score	Coefficient (Economic Factors)	Coefficient (Social Factors)
1	182,172.11	0.926	1507.64	46.25
2	182,172.11	0.926	1507.64	46.25

Hypothesis 1 (Economic Factors' Impact on GRP). The high coefficient for economic factors (1507.64) in comparison to the social factors (46.25) indicates a strong and significant influence of economic factors on GRP. The R^2 Score of 0.926 implies that the model, including both economic and social factors, can explain about 92.6% of the variance in GRP, which is quite substantial. The relatively small coefficient for social factors suggests that their impact on GRP is less significant compared to economic factors.

Hypothesis 2 (Social Factors' Impact on GRP). Similarly, the coefficient values remain the same, which reiterates that economic factors have a more substantial impact on GRP than social factors. The identical R^2 Score further confirms that the model's explanatory power is primarily driven by economic factors. The consistent results across both hypotheses underline the predominant role of economic development in influencing GRP, while social factors play a lesser role.

Nevertheless, it must be considered that the size of firms has crucial impact. Bartlett Bukvič (2001) showed that smaller firms grow faster than larger ones. This means that as the size of the firm increases, the growth of their activities decreases. Rajesh Raj and Mahapatra (2009), supported that SMEs, especially in the manufacturing sector, provide a significant portion of the total number of jobs. Even though SMEs contribute only about 30% of the value added in the manufacturing sector, they alone create 80-85% of the total number of jobs in this sector. This highlights the key role of SMEs in absorbing labor and increasing employment levels, especially in rural areas.

Population and income levels are more important determinants of economic growth than tax revenues and fixed investment. Population growth and rising income levels increase consumer demand and the overall economy, leading to an increase in GDP. On the other hand, tax revenues, although necessary to finance government functions and promote economic development, can have a negative impact on economic growth, since high taxes can reduce investment and discourage entrepreneurial activity. At the same time, investment, including both domestic and foreign direct investment, stimulates economic growth because it contributes to the development of production, the creation of new jobs, the introduction of new technologies and increased labor productivity (Nabi et al., 2020).

The PLSR analyses affirm that economic factors are significantly more influential in determining the GRP of cities in Kazakhstan compared to social factors. This suggests that initiatives focusing on economic development, such as investment in business, trade, and infrastructure, might be more effective in boosting regional productivity and growth. While social factors do contribute to GRP, their impact is comparatively minor in the face of economic influences. This does not diminish the importance of social development but highlights the stronger linkage of economic factors to regional economic output.

5. CONCLUSIONS

This research embarked on a comprehensive exploration of the developmental dynamics of cities in Kazakhstan, rigorously examining the influence of economic and social factors on the Gross Regional Product (GRP). The findings are pivotal in unraveling the complex interplay between these factors and their collective impact on urban development.

The analysis, underpinned by Partial Least Squares Regression (PLSR), tested two hypotheses.

The first posited that economic factors, including SME activity, retail trade, fixed capital investment, and tax revenue, have a significant and positive impact on the GRP. The second hypothesis contrasted this, suggesting that social factors such as population growth, average salary, and income levels are the significant drivers of GRP. The results indicated a pronounced impact of economic factors on GRP, affirming the first hypothesis. In contrast, social factors, while contributing to GRP, had a less substantial influence, lending partial support to the second hypothesis.

These outcomes have profound implications for urban policy and planning. They highlight the crucial role of economic development initiatives in enhancing regional productivity and suggest that investment in economic growth drivers could yield more substantial dividends in urban development. However, the contribution of social factors, albeit smaller, underscores the need for a balanced approach that also addresses social aspects like healthcare, education, and living standards to ensure holistic urban development.

The study's findings provide a valuable framework for policymakers, urban planners, and stakeholders in Kazakhstan. They offer a data-driven foundation for prioritizing economic growth while not overlooking the essential role of social development in crafting sustainable, inclusive urban environments.

In conclusion, this research contributes significantly to the understanding of urban development in Kazakhstan, laying the groundwork for future studies and policy formulations aimed at fostering thriving, resilient urban centers in the country.

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Higher Education and Urban Development: Market Dynamics and Gender Differences

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Abstract

The study is devoted to analyzing the impact of higher education on urban development, with an emphasis on the cities of Kazakhstan. The paper examines the role of universities in economic growth and the social and cultural life of cities, as well as the impact of the quality of educational programs on the employment of graduates in the context of meeting the requirements of the labor market. The problems of obsolescence of the theory of human capital development against the background of the development of artificial intelligence and changes in the employment structure caused by digitalization are highlighted. The authors draw attention to the contradictions between urban development and the decline of small settlements caused by heterogeneity in access to the Internet and digital technologies. The issue of gender disparity in access to education and its impact on employment is raised. The study presents the results of an initial survey of Kazakhstan students to identify their expectations of university education and its role in future employment. Hypotheses about the perception of the competitiveness of diplomas, the correlation between accessibility and quality of education, and gender differences in the assessment of these aspects are analyzed. The study's results emphasize the importance of cooperation between the state and educational institutions for the development of cities and the training of qualified specialists capable of meeting the needs of the modern labor market.

Keywords: Higher Education, Urban Development, Economic Development, Accessibility of Education, Gender, Migration

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1. INTRODUCTION

The influence of the role of higher education on urban development is a relevant topic for study. The intersection of this topic with accessibility to urban areas and better conditions for training specialists shows that an increase in the quality of labor resources leads to the development of human capital and production and increases cash flow. It is important to note that universities directly influence the sustainable growth of the economy and perform social and cultural functions. Still, training personnel without taking into account the requirements of the labor market is of little use. If universities do not study the latest changes in the labor market and do not interact with employers and business structures in their country, then educational programs become outdated, and university graduates do not have the necessary set of knowledge and the quality of the qualified workforce is reduced, which leads to an increase in unemployment.

The theory of human capital development, which has been studied for the last 50 years, is also becoming outdated due to the emergence of the era of intelligent machines. Artificial intelligence is replacing the strategic labor resource in some areas (Brown et al., 2020). Some professions are already endangered because the required knowledge relates to digital skills. In remote regions of Kazakhstan, the Internet has slow speed and limited coverage. The cost of installing a communication tower is not economically feasible, which forces specialized specialists to move to areas provided with a stable Internet connection. Such zones are cities. It turns out to be a contradiction: on the one hand, recent trends are aimed at the growth of cities. On the other hand, villages are dying out. The need to seek a balance also arises against the background of the outflow of young people from small towns to larger ones, the overpopulation of the latter, and the deterioration of the environmental situation.

Along with the problems discussed, one can notice a dichotomy and disparity in the field of higher education, manifested in access to education among boys and girls in different countries and in the ability of parents to pay for education. In some countries, higher education is still provided for a fee, and more often, the source (university) is located within the city. This creates difficulties for rural youth in accessing higher education since paying for tuition is an additional burden on parents' finances.

In any case, much analytical work is based on secondary data, but in this work, a primary study was conducted on respondents' opinions regarding the quality of education in Kazakhstan. Such a study will reveal the expectations of young people from universities, which are subsequently associated with employment. An attempt is also made to identify whether there are gender biases regarding employment opportunities in the city..

2. LITERATURE REVIEW

The rapid pace of urban development in the process of industrialization led to the emergence and development of such a science as urbanism. This direction previously studied the correct location of buildings, ease of movement along city streets, geographical location of the leading engineering systems, construction, etc. At the beginning of the current century, not only architecture and transport accessibility but also economic, social, and other factors began to be studied (Spasskaya, 2006). Moreover, to analyze the level of development of cities located in different regions or countries, scientists used comparison factors of different types. Education is one of these factors, and to compare some indicators, available statistics collected on the same indicators in different countries (number of schools and other educational institutions, number of students, etc.) were studied.

It is important to note that recently, many works have appeared that show that education is not only a source of knowledge and education for young people but has a social and urban planning

function, improves the culture of any locality, is a strategic object, and develops the economy in cities. In addition, educational institutions in small towns help maintain population size and reduce internal migration (Zborovsky & Ambarova, 2018; Addie, 2017). Below is a table that contains a logical analysis of previously conducted studies and shows the main factors for assessing urban development that were considered in previous studies (see Table 1).

TABLE 1. The main factors used to compare and assess the level of urban development

Factor	Key findings	Authors
Industrial, infrastructure, public	Increasing the size of a city does not always lead to an increase in productivity equal to the percentage increase.	Melo, P. C., Graham, D. J., & Noland, R. B. (2009)
Social, economic, environmental	The gap between urban and rural populations is growing.	Bobylev, S. N., Kudryavtseva, O. V., & Solovyova, S.V. (2014)
Economic, educational, digital	Changes in the employment structure indicate the need to revise educational programs.	Namiot, D. E., Kupriyanovsky, V. P., Samorodov, A. V., Karasev, O. I., Zamolodchikov, D. G., & Fedorova, N. O. (2017)
Social, economic	The development of higher education prevents migration from cities.	Zborovsky, G. E., & Ambarova, P. A. (2018)
Social, innovative, technological, demographic, media, scientific, healthcare, transport development	When assessing the level of development of smart cities, it is necessary to move away from technocratic and geographical approaches and use a sociological approach.	Popov, E. V., & Semyachkov, K. A. (2020).
Social, economic	Preservation of small towns helps strengthen depressed regions of the country.	Kireyeva, A. A., Nurlanova, N. K., & Kredina, A. (2022)
Note: compiled by authors		

The authors' findings show the main trends related to the need to change educational programs. As you can see, various indicators are used to assess the level of development of cities located in the territory of the former CIS. Other authors pointed out that city development must be thoughtful since the growth of urban agglomeration does not always proportionally increase the leading indicators of the city's economic growth. The state is interested in the development of urban areas, and it is essential that the population of cities does not decrease and that there are no imbalances in the population size. The outflow of population from the city can lead to mass unemployment, a shortage of specialized specialists, and problems with access to quality medicine; on the other hand, the arrival of too many people leads to overpopulation. In the future, problems may manifest in a lack of places in schools or universities, a low number of teachers, and reduced access to education.

In some regions, in order to maintain the influx of population over a long period, universities use educational tourism. Students who come to study in international programs are at least interested in the city's entertainment sector and are also interested in employment, which, in both cases, increases the city's economy (Tomasi et al., 2020). The influx of highly qualified immigrants leads to them occupying leading positions in the labor market, which is reflected in the standard of living of the local unskilled population; as the unemployment rate increases, costs rise, and quality of life decreases.

For the countries of Vietnam, India, China, Kazakhstan, and Russia, on the contrary, there is a risk of youth outflow through education abroad. This trend reduces the working-age population and increases the burden on households, particularly the elderly and women (Punch & Sugden, 2013). The authors pointed out the risks of losing knowledge about ecology since the new professions that young people are mastering are related to digital skills. The outflow of the young working population from the provinces of Northeast China continues, and authorities are concerned about the brain drain from the region (Jiang, 2017).

On the other hand, the population of Kazakhstan must have modern competencies and skills to achieve high academic performance and increase the diversity of digital skills (Kerimkulova & Kuzhabekova, 2017). University graduates with such skills are better employed and have higher life satisfaction. Of course, such a goal is challenging to achieve when the government does not interact with universities and employers and there is no understanding of the necessary competencies required in the labor market. There is also a problem with the skewed acquisition of problem-solving skills using digital resources and simultaneous loss of reasoning skills (Bietenbeck, 2014; Bennett et.al., 1999).

Schoolchildren studying in high school in Kazakhstan are interested in obtaining higher education in cities. It is noted that the expectations of schoolchildren and their parents are aimed at state support in the form of an educational grant, since most parents do not have the opportunity to pay for their children's education (Kurmangalieva & Abdrakhmanova, 2012). Also, the education received gives the opportunity to choose a place of work in the future, which expands the opportunities of young people. Interestingly, parental education predicts children's educational attainment (Kalyuzhnova & Kambhampati, 2007). This trend does not have gender stereotypes in large cities of Kazakhstan since, in most cities, both men and women are employed. However, suppose we are talking about rural settlements or small towns. In that case, it is essential to take into account gender characteristics in the labor market, where there is vertical discrimination as well as in large-scale production, where primarily men work (Atakhanova & Howie, 2022).

At the moment, few studies would allow us to identify issues of expectations from the labor market among young people who study in large cities. There is especially little research on gender. In this work, hypotheses will be formulated, and then, based on a preliminary questionnaire, the results will be checked, and the responses received will be analyzed.

3. METHODOLOGY AND DATA

Data and hypotheses

This work aims to study the expectations among young people receiving education in the cities of Kazakhstan from higher education received in a gender context. To check students' opinions about higher education in cities and career prospects, it was decided to collect primary and secondary data. Secondary data were selected from the electronic portal of the Bureau of National Statistics of Kazakhstan, and primary data were collected through questionnaires. Thus, the research hypotheses are presented in Table 2.

TABLE 2. Research hypotheses

Hypothesis	Contents
H*1*	Diplomas obtained in Kazakhstan are perceived as less competitive in the international labor market compared to diplomas from foreign universities (question 5)
H*2*	There is a positive correlation between the level of accessibility of higher education and the assessment of its quality (question 3)

H*g1*	There are gender differences in assessing the accessibility of higher education in Kazakhstan (question 4)
H*g2*	Men and women rate the importance of having a degree for a successful career differently (question 8)
H*g3*	Perceptions of the impact of a diploma on work and income in Kazakhstan differ between men and women (question 6)
Note: compiled by authors	

Primary data collection was carried out from September 17 to December 13, 2023, at the University of Almaty (University of International Business named after K.Sagadiyev). Table 1 below shows the survey questions.

TABLE 3. Questionnaire

No.	Questions
1	What is your gender?
2	Please indicate your age group.
3	Are you satisfied with the quality of education in Kazakhstan?
4	How do you assess the accessibility of higher education in Kazakhstan?
5	Do you think that a diploma obtained in Kazakhstan contributes to further development in work not only in Kazakhstan but also in other countries?
6	What do you think is the impact of a diploma on the jobs and incomes of workers in Kazakhstan?
7	How do you think raising tuition prices affects the demand for training?
8	Assess how important it is to have a diploma for a successful career in modern Kazakhstan.
9	How important do you think it is for the government of Kazakhstan to develop the higher education sector?
10	How do you assess the future of the education market in Kazakhstan, given the growth in the number of new professions?
11	Do you believe that education contributes to the development of youth and helps in future jobs?
Note: compiled by authors	

For the convenience of respondents, ready-made answer options were provided, which were subsequently convenient for interpretation. The first question is nominal. The second and third are ordinal. To vary the answers for all other questions, a Likert scale from 1 to 5 was used, where 1 meant the minimum indicator, and 5 meant the maximum indicator. The seventh question has two answer options: “Increases demand” and “Decreases demand.”

The methodology of this article is based on a survey of respondents who directly receive educational services, namely students. This study contains a preliminary analysis of data from 104 students. A total of 107 questionnaires were collected, of which three were incomplete and were not included in the analysis. Thus, the sample is (N=104).

The hypotheses posed relate to the perceptions and evaluations collected through the survey. To test the hypotheses, the following research steps will be taken: dividing data into groups by gender; checking the normality of the distribution of scores in each group for each question of interest; depending on the results of the normality test, select a statistical test (Shapiro-Wilk test, t-test or Mann-Whitn test, Wilkonson test); conducting a statistical test; verification and description of the results obtained.

(a) The Shapiro-Wilk test is used to test the hypothesis that the sample comes from a normal distribution. Formula 1 is presented below:

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}, \quad (1)$$

where: $x_{(i)}$ – i smallest value in the sample;
a_i – coefficients obtained from a particular table based on sample order and size;
$\bar{x}$ – sample mean;
n – sample size.

(b) The Mann-Whitney test (or Wilconson test for two independent samples) is also non-parametric; calculations are carried out according to the formula 2:

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1, \quad (2)$$

where: $n_1 n_2$ – the sizes of each of the two samples;
R_1 – sum of ranks of sample 1 in a combined ranked data set.

All observations in both groups are ranked, after which the ranks for each group are summed. The U statistic is calculated for each group separately, and the smallest U value is used to determine the p-value.

(c) Spearman's correlation coefficient is used to measure the strength of association between two variables. The formula 3 is below:

$$r_{xy} = 1 - \frac{6\Sigma d^2}{n\,(n^2-1)}, \quad (3)$$

where d2 – the sum of squared variations between ranked levels;
n – the number of function arguments in the ranking;
x – unmeasured variable;
y – measured variable.

These formulas allow you to conduct analysis and test statistical hypotheses based on the collected data.

4. ANALYSIS AND RESULTS

Table 1 contains the descriptive statistics of the variables employed by the study. The table shows that the mean gross fixed capital formation (GCF) is 13.96 while the average commercial bank deposit ratio to GDP (CBD) is 14.751. Loan to deposit ratio (LTDR), Non-interest income to interest income ratio (NIY/NY) and Interest rate spread (IRS) have 61.456, 51.83 and 40.003 as their respective averages.

According to the Bureau of National Statistics, at the beginning of the 2023–2024 academic year, there are 112 universities in Kazakhstan, including 44 state-owned, 67 privately owned and one foreign university. Below is the number of universities in the regional context (see Figure 1).

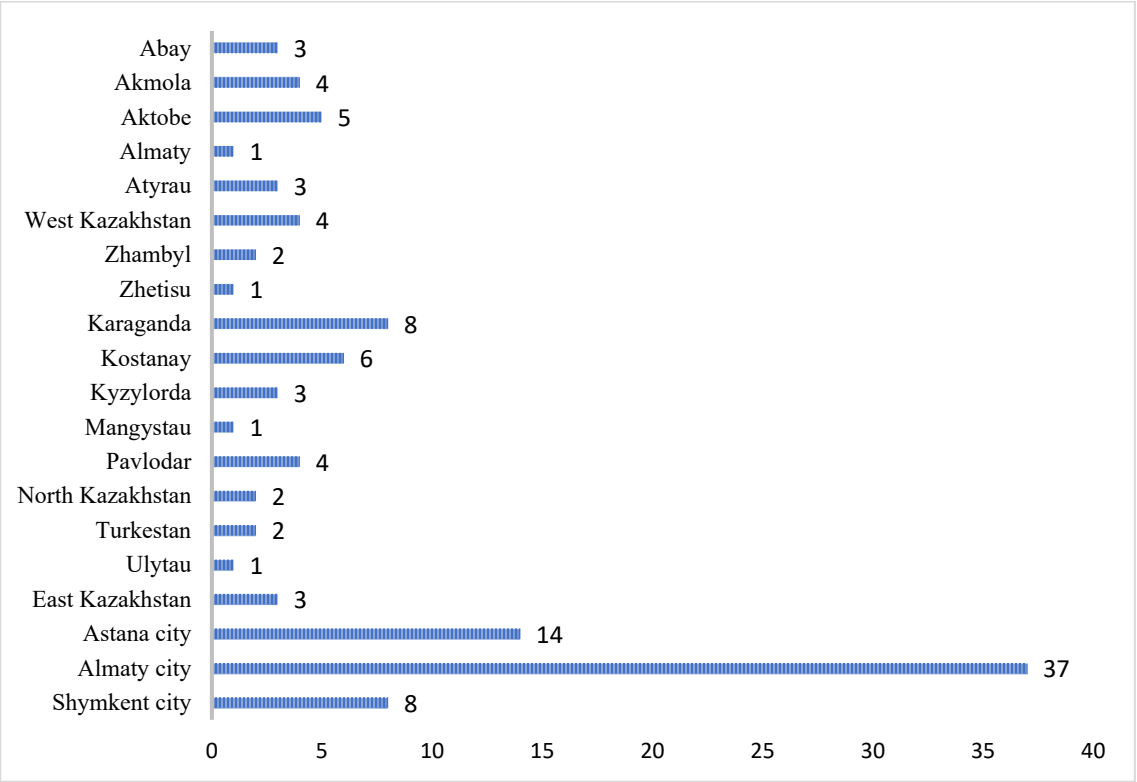


FIGURE 1. Number of independent educational institutions in Kazakhstan for 2023-2024

Note: compiled by authors

As can be seen from the table presented, 53% of educational institutions are located in the largest cities of Kazakhstan - Almaty city (37), Astana city (14) and Shymkent city (8). Of the regions, Karaganda, Kostanay, and Aktobe have 8, 6, and 5 universities, respectively. The regions of Almaty, Zhetisu, Mangystau and Ulytau each have one university. The most significant number of universities is in Almaty city, so it was decided to conduct the survey based on universities in this large city, especially since the cities of Kazakhstan currently form more than 60% of GDP.

Furthermore, description about respondents presented in Table 4.

TABLE 4. Information on respondents

Gender	Under 20 years old	20-25	Total
Female	62 (84%)	12 (16%)	74
Male	26 (87%)	4 (13%)	30
Total	88	16	104
Note: compiled by authors			

The majority of respondents were students less than 20 years old (85%). The remaining 15% of respondents are 20-25 years old. It should also be noted that 71% of the respondents were female students, and 29% were male students. This shows that girls are more likely to complete the questionnaire since the questionnaire was voluntary. Questions 7, 9, 10, and 11 were analyzed by gender (see Figure 2).

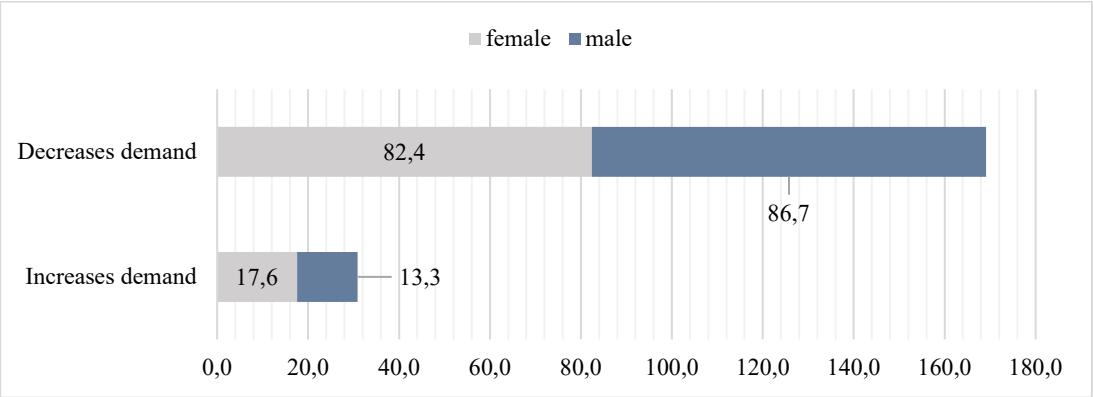
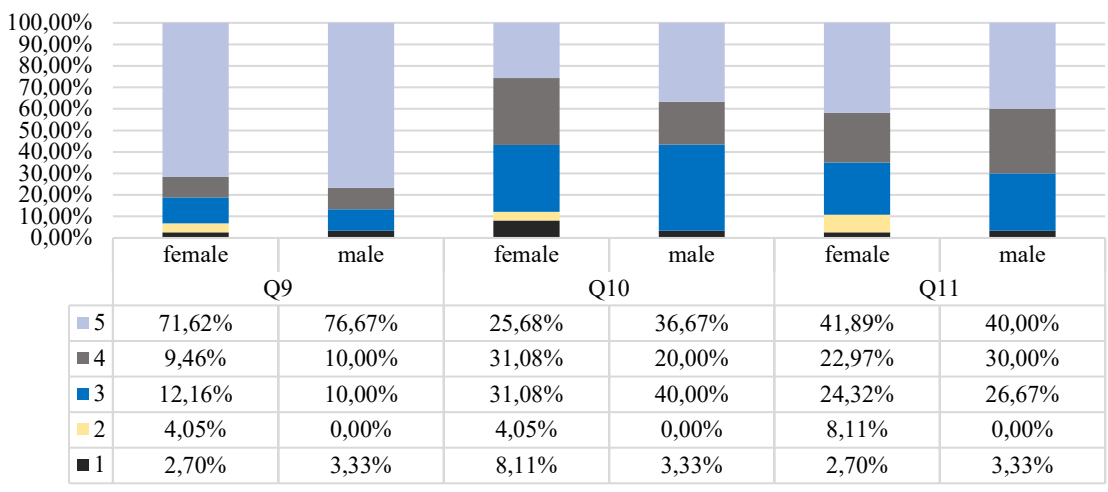


FIGURE 2. Respondents' opinion on raising tuition prices

Note: compiled by authors

The majority of respondents (71%) answered question 7, "How do you think raising tuition prices affects the demand for training?" and believe that increasing tuition prices reduces the demand for higher education. This may be related to the ability of parents to pay for university since the burden on the family budget varies from family to family. Among male students, 13.3% believe that demand will not fall; among female students, 17.6% have this opinion.

The Likert scale shows the attitude of respondents to question 9, "How important do you think it is for the government of Kazakhstan to develop the higher education sector?" question 10 "How do you assess the future of the education market in Kazakhstan, given the growth in the number of new professions?" and question 11 "Do you believe that education contributes to the development of youth and helps in future jobs?" (see Figure 3).



	Q9		Q10		Q11	
	female	male	female	male	female	male
5	71,62%	76,67%	25,68%	36,67%	41,89%	40,00%
4	9,46%	10,00%	31,08%	20,00%	22,97%	30,00%
3	12,16%	10,00%	31,08%	40,00%	24,32%	26,67%
2	4,05%	0,00%	4,05%	0,00%	8,11%	0,00%
1	2,70%	3,33%	8,11%	3,33%	2,70%	3,33%

FIGURE 3. Opinion of respondents to questions 9-11

Note: compiled by authors

The results show that the majority of respondents consider the development of education in Kazakhstan to be an important strategic issue. Of all the answer options to question 9, 71.62% of

female students chose option 5, among male students 31.08%. The answers to question 10 are interesting - female students have different opinions, including negative ones. This may be due to the opinion that new digital professions do not always make a total contribution to economic development. At the same time, almost 96.6% of male students consider the innovations positive. Opinions on the last question were almost unanimous: more than 40% chose option 5, which indicates confidence that obtaining a higher education contributes to youth development and better employment. In general, the answers of female students have a more comprehensive range compared to the answers of male students, who are more likely to answer positively.

Testing hypotheses H1, H2

Descriptive statistics will be used to test the first hypothesis. In the case of an even number of observations, the median will be the average of the two central values. The test statistic is calculated from the sample data presented in Table 5.

TABLE 5. Testing hypotheses H1

Hypothesis	Median	Test method	Result	Interpretation
H1	The value that splits the distribution in half	Descriptive Statistics	~ 3.14	Neutral Perception
Note: compiled by authors				

The average perception of the competitiveness of diplomas obtained in Kazakhstan in the international labor market is about 3.14 (on a scale of 1 to 5). This indicates that the average student opinion tends to be neutral regarding the competitiveness of Kazakhstani degrees at the international level (see Table 6).

TABLE 6. Normality of distribution of H2

Variable	Statistic value W	p-value	Normality of distribution
Competitiveness of diplomas	0.95	0.02	Not confirmed
The quality of education	0.96	0.05	On the verge
Note: compiled by authors			

The value of the W statistic shows how well the data fits into a normal distribution. A p-value less than 0.05 indicates. The test statistic is calculated from the sample data presented in Table 7.

TABLE 7. Testing hypotheses H2

Hypotheses	Correlation Coefficient	p-value
H2	0.641185	2.27e-13
Note: compiled by authors		

Testing hypotheses Hg1, Hg2, Hg3.

This test was used to assess the normality of the distribution of scores in the groups of men and women. Normality of distribution is necessary to determine whether parametric methods (e.g., t-test) can be used or whether non-parametric methods (e.g., Mann-Whitney test) should be used.

The Shapiro-Wilk test is calculated from the sample data presented in Table 8.

TABLE 8. Shapiro-Wilk test

Group	Availability Shapiro-Wilk p-value	Importance of diploma Shapiro-Wilk p-value	Diploma Influence Shapiro-Wilk p-value
Male	0.002112	0.000564	0.001573
Female	0.000040	0.000006	0.000007
Note: compiled by authors			

In the Shapiro-Wilk test table, the p-value for all groups is below 0.05, which indicates the normality of the data distribution. Because normality tests indicated that the data were not normally distributed, the nonparametric Mann-Whitney test was used to compare median values between two independent groups (men and women). This text makes no assumptions about the distribution of the data and is appropriate for comparing data ranks between groups.

Next, the Mann-Whitney test is calculated from the sample data presented in Table 9.

TABLE 9. Mann-Whitney test

Mann-Whitney test	U-statistic	p-value
Availability	1210.0	0.458391
Importance of diploma	1211.5	0.457687
Diploma Influence	1246.5	0.316911
Note: compiled by authors		

In the table of Mann-Whitney test results, the p-value for all tests is above 0.05, which means that there are no statistically significant differences between the groups of men and women in all three aspects considered. The results of the Spearman correlation analysis between assessments of the accessibility of higher education and satisfaction with the quality of education.

Further, the Spearman Correlation is calculated from the sample data presented in Table 10.

TABLE 10. Spearman Correlation

Correlation between	Spearman Correlation Coefficient	p-value
Availability and Quality of Education	0.641	2.27e-13
Note: compiled by authors		

Spearman's correlation coefficient is about 0.641, which indicates a strong positive correlation between access to higher education and satisfaction with its quality. The p-value is high and less than 0.05. We can conclude that increasing the accessibility of higher education leads to increased satisfaction with its quality.

An example of a beneficial interaction between the state and education is the opening of school complexes in Russia starting in 2020, which made secondary and vocational education more accessible and increased the number of students at universities (Gladilina et al., 2020). The number of skilled laborers increased and internal migration processes began to decline, and employment stability appeared. The presence of a large amount of high-quality human capital could contribute to Kazakhstan's entry into the top 30 most developed countries by 2050 (Kerimkulova & Kuzhabekova, 2017).

As a result, the hypothesis that higher education helps to preserve and develop cities is true.

The findings substantiate the hypothesis that higher education plays a significant role in the preservation and enhancement of cities. This result underscores the pivotal contribution of educational attainment to urban sustainability and growth, highlighting the importance of integrating educational policies within urban development strategies.

As a result, three hypotheses testing the relationship to the influence of completed education on the opportunity to start a career in a large city depending on gender are rejected.

The implication of this finding is twofold: firstly, it indicates a level playing field for both genders in terms of career opportunities in major urban centers post-education, and secondly, it calls for further research to understand the underlying factors that influence career initiation in large cities.

5. CONCLUSIONS

The aim of this work was to study the expectations among young people receiving education in the cities of Kazakhstan from higher education received in a gender context. The first conclusion is that the preservation of cities depends on close cooperation between higher education organizations and national government agencies (using the example of city akimats). The government needs to strive to develop national strategies that indirectly influence the development of urbanism. To do this, the interconnection system must be two-way and satisfy the basic expectations of young people from the educational services they receive. High-quality education leads to the appearance of qualified personnel on the labor market, which contributes to the economic development of the city, and population migration is reduced.

The next conclusion is that there is no difference in the expectation of influence on future employment between male and female students. It turns out that in large cities of Kazakhstan (using the example of Almaty) there is no segregation in the employment of young people. At least this is the opinion of students who do not expect gender bias in the labor market. It can be noted that male students more often give positive answers to questions.

It should be noted that the study is preliminary and was conducted on the basis of one city and with a larger number of respondents. This is a limitation of this work and further full research may show a different result. Also, a recommendation for future researchers is to focus on research in small cities, where there are a small number of universities and there are difficulties in finding employment for university graduates.

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Formal analysis and investigation: Anna Kredina.
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Development of research methodology: Anna Kredina.
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Software and supervisions: Anna Kredina, Aisulu Dzhanegizova.
Data collection, analysis and interpretation: Anna Kredina, Aisulu Dzhanegizova.
Visualization: Anna Kredina.
Writing review and editing research: Anna Kredina.

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RESEARCH ARTICLE
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Reduction of Inequality of Regions as a Factor of Sustainable Development: the Case of Western Macro-region of Kazakhstan

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Abstract

The most critical Sustainable Development Goals (SDGs) are the promotion of sustainable economic growth, the eradication of poverty, and the reduction of inequality within countries. The hypothesis of the study is the assumption that the achievement of the SDGs in the country depends on the reduction of socio-economic inequality in the West Kazakhstan regions, which includes four regions of the country: Mangistau, Atyrau, Aktobe, and West Kazakhstan. This formulation of the question is because earlier studies by the article's authors indicate a discrepancy between the level of social well-being of a given region and the actual contribution to the development of the country's economy. The aim of the article is to study the dynamics and degree of socio-economic development inequality of the Western Kazakhstan region and to develop recommendations on measures of state regulation to reduce it. To achieve this goal, the methods of generalization, concretization, economic-statistical, index, and comparative analysis were used. The result was a system of indicators for measuring the level of socio-economic stability of regions, taking into account country specifics, a study of trends, and an assessment of the degree of inequality in the socio-economic development of the regions of Western Kazakhstan, and recommendations for improving regulatory methods to reduce regional disparities. The authorities can use the recommendations to make decisions on achieving the Sustainable Development Goals in the regions of Western Kazakhstan.

Keywords: Econome, Economic Growth, Sustainable Development, Regional Inequality, Macro-Region, Western Kazakhstan

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JEL Code: E63, R10, O11

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1. INTRODUCTION

The modern development of the world economy is taking place in the context of global economic, energy and food crises, technological shifts, and climate change. In this regard, the focus of economic science has become the concept of sustainable development, which is the problem of overcoming inequality in countries, regions, and groups of people. Kazakhstan also approved the Concept of Kazakhstan's transition to a green economy, ratified the 2015 Paris Climate Agreement (UN, 2015), and developed an Environmental Code (2023). The Republic of Kazakhstan's Strategy for achieving carbon neutrality until 2060 has been approved.

The specifics of Kazakhstan's development are significant regional differences in economic potential in the population's level of well-being and quality of life. These differences were due to the wide variety of natural and climatic conditions and the prevailing economic specialization of the regions. To reduce regional imbalances, Kazakhstan has adopted the National Development Plan until 2025 and the National Project "Strong Regions – drivers of the Country's Development" [ ], which set tasks to ensure people's well-being and form a strong economy based on balanced territorial development. However, these documents do not solve the problems of sustainable development in all regions of Kazakhstan and do not consider the impact of modern global challenges. Therefore, it is of particular importance for Kazakhstan to achieve widespread social well-being, sustainable economic growth, and reduction of regional inequality, which correspond to the Sustainable Development Goals (SDGs)

This problem is especially acute in the Western Kazakhstan macro-region, whose branches of specialization are gas and oil production and processing of extracted hydrocarbons. The Western macro-region occupies a special place in the economy of Kazakhstan and includes 4 territories - Aktobe, Atyrau, Mangystau, and West Kazakhstan regions. Their contribution to forming the country's gross domestic product (GDP) reaches 27%. At the same time, these regions are characterized by high poverty levels. For example, in the Mangystau region, it reaches 8.1%. Despite the region's economic contribution, social stability and environmental sustainability are serious problems. Therefore, comprehensive studies of the sustainable development of socio-economic systems of the Western Kazakhstan macro-region are necessary.

The article aims to study the dynamics and degree of inequality in the socio-economic development of the territories of Western Macro-region and develop recommendations for its reduction. The study hypothesized that achieving the SDGs in the country largely depends on reducing socio-economic inequality in the territories of Western Macro-region.

To achieve this goal, a review of the literature on the inequality of economic and social development in different territories of the country, the problems of regional stratification of the population in terms of standard and quality of life as an essential factor in the sustainable development of regions, was carried out, as well as an analysis of the leading socio-economic indicators. The proof or refutation of the hypothesis was carried out by determining regional differences in indicators of social and economic sustainability of the Western Macro-region of Kazakhstan.

The methods of generalization, concretization, economic and statistical, index, comparative analysis, and ranking were used. To monitor the sustainability of the socio-economic development of the Western macro-region of Kazakhstan, the authors proposed a modified system of indicators for achieving the Goals and objectives of sustainable development, including economic and social ones.

The result of the study was a well-founded system of regional indicators of social and economic sustainability, an assessment of the main trends in the socio-economic development of the regions of Western Kazakhstan, and a determination of the degree and risks of maintaining inequality. It is concluded that the high level of social and economic inequality in the territories of Western Macro-region hinders the achievement of SDGs in the country. Recommendations are

proposed for government authorities to improve regulatory methods to reduce regional inequality and increase the socio-economic sustainability of regions.

The scientific and methodological significance of the results consists in substantiating a system of indicators for assessing the level of socio-economic stability adapted to the specifics of Kazakhstan. The practical significance lies in the development of recommendations to reduce regional inequality.

2. LITERATURE REVIEW

Sustainable development has become the focus of economic science in recent years. However, it is still being studied more at the country level and, to a lesser extent, at the regional level. Nevertheless, there are different points of view on the problems of sustainable regional development, approaches to measuring its level, directions, and mechanisms for ensuring it. Thus, Glinskiy et al. (2017) consider the impact of the European "convergence policy" aimed at overcoming regional inequality, bringing the socio-economic indicators of poor regions closer to more developed ones. They assess the correlation between the level of differentiation and the level of stability of the regional economy and conclude that high regional differentiation leads to social upheaval, and low differentiation leads to stagnation. The authors come to a conclusion about the growing influence of intraregional differentiation of the minor territories, the limits of the stimulating effect of territorial differentiation, and its negative impact on the economic growth of a country or region.

Panzera and Postiglione (2022) explores the relationship between economic growth and regional income inequality, as well as the role of space in measuring inequality and implementing convergence policy. The authors draw attention to the effect of spatial dependence and note that regional growth can be influenced by inequality within a region and in neighboring areas. The authors examined spatial interactions and geographic location's role by analyzing 245 areas in 22 countries. They concluded that growth rates in a regional economy depend positively on inequality in the region and negatively on inequality in neighboring regions.

Tian et al. (2010) explore the challenges of economic convergence, noting the importance of focusing on low- and lower-middle-income regions to overcome the poverty trap due to spatial effects. Costanza et al. (2016) draw attention to the interconnectedness of SDG goals and targets and propose the use of aggregate indicators of human and ecosystem well-being to replace gross domestic product (GDP) growth as the primary development goal of countries since the focus on GDP growth has exacerbated inequality and environmental damage in many countries. Increased income inequality, environmental damage, and other costs could offset the positive benefits of GDP growth. Haughton and Counsell (2004) note the importance of regional planning as a component of regional institutional architecture in connection with the actualization of goals and objectives of sustainable development.

Bolcarova and Kolosta (2015) are considering the possibility of creating an aggregated sustainable development index for the 27 EU countries. At the same time, the indicator of economic growth was not considered since it did not lead to positive changes in the social, economic, and environmental areas. A comparison of the aggregate index with economic growth indicators showed a negative correlation for most EU countries. Cobb and Daly (1989) proposed an alternative method to GDP for assessing well-being in 1989. The Index of Sustainable Economic Welfare (ISEW) includes social and environmental components. Stiglitz et al. (2009) also criticize GDP as an indicator of progress and well-being since it ignores household labor, natural and human capital, and environmental degradation. Chelli et al. (2013) developed the idea of using alternative indicators to assess the well-being of society, adapting and offering options for the Index of Sustainable Economic Welfare (ISEW) for Italian regions. Cortinovis &van Oort

(2015) apply the concepts of linked and unlinked diversity to analyze cross-regional data and the relationship between employment and unemployment growth and knowledge spread across sectors, diversification, and specialization levels.

Other scientists believe that prioritizing the equality of territories at the expense of developing "growth points" can lead to economic stagnation. Therefore, it is essential to correctly assess the degree of differentiation and the level of sustainability of the socio-economic development of regions. These issues have received the attention of scientists from many countries.

In the context of the global challenges of the 21st century, the problem of achieving sustainable development has worsened, which requires in-depth research in this area. Under the influence of Industry 4.0, digitalization of economic activity, unstable geopolitical situation, energy and food crises, climate change, the unfavorable conjuncture of world markets is developing, technological chains and established foreign economic relations of states and regions are disrupted. Inertial development in this scenario leads to a situation where the exhaustion of natural resources limits economic growth, the growth of wealth is accompanied by an increase in the number of poor, deepening inequality of countries and regions, and regional stratification of the population in terms of standard and quality of life. In many commodity-based economies, significant contradictions exist between achieving sustainable economic growth and abandoning technologies with high greenhouse gas emissions.

This development cannot be called sustainable. Therefore, experts from international organizations began to develop new economic development models. For example, Harari (2019) believes that the post-labor economy model is adequate in the context of digitalization. Other scientists, in particular Jeffrey (2019), Ranieri and Ramos (2013), Ifzal and Hyun (2007) argue the need to switch to an inclusive growth model and believe that a compromise between fairness and efficiency of economic development can provide an inclusive development model. The same opinion is shared by experts from ESCAP (2015) and OECD (2016). Raheem et al. (2018) investigated the interrelationships of inclusive growth, human capital development, and in-kind rent.

However, there is an alternative point of view on the effectiveness of this model. Lee (2018) believed this idea is romantic, has a declarative character, and serves as a tribute to socialist trends. In our opinion, the problem lies in the fact that many countries have not yet developed criteria and effective mechanisms for achieving sustainable economic growth from a regional perspective based on the effective use of existing resources without prejudice to future generations. Moreover, there is currently no clear concept or tools underlying the definition of the limits of economic growth that can be used to achieve sustainable development.

In Kazakhstan, which has a predominantly commodity-based economy, the problems of sustainable economic and social development have also been insufficiently studied. The imperatives of sustainable development are still poorly seen in regional studies and regional policy of Kazakhstan. It is mainly aimed at forming regions - "points of growth". However, focusing on sustainable development requires the creation of conditions and prerequisites for balanced economic and social development in all regions.

Meanwhile, reducing regional differences in the levels of socio-economic development will contribute to achieving the Sustainable Development Goals for the elimination of poverty in all its forms, steady, inclusive, and sustainable economic growth, full and productive employment, reducing inequality within the country, and, as a result, improving the level and quality of life of its population, social sustainability of regional development. Therefore, research on various issues related to reducing socio-economic inequality in regions and the transition to sustainable development has excellent prospects.

3. RESEARCH METHODS

The methodological basis of the study was made up of theoretical and empirical research methods and modern information technologies of scientific research. The research algorithm can be presented schematically in Figure 1.

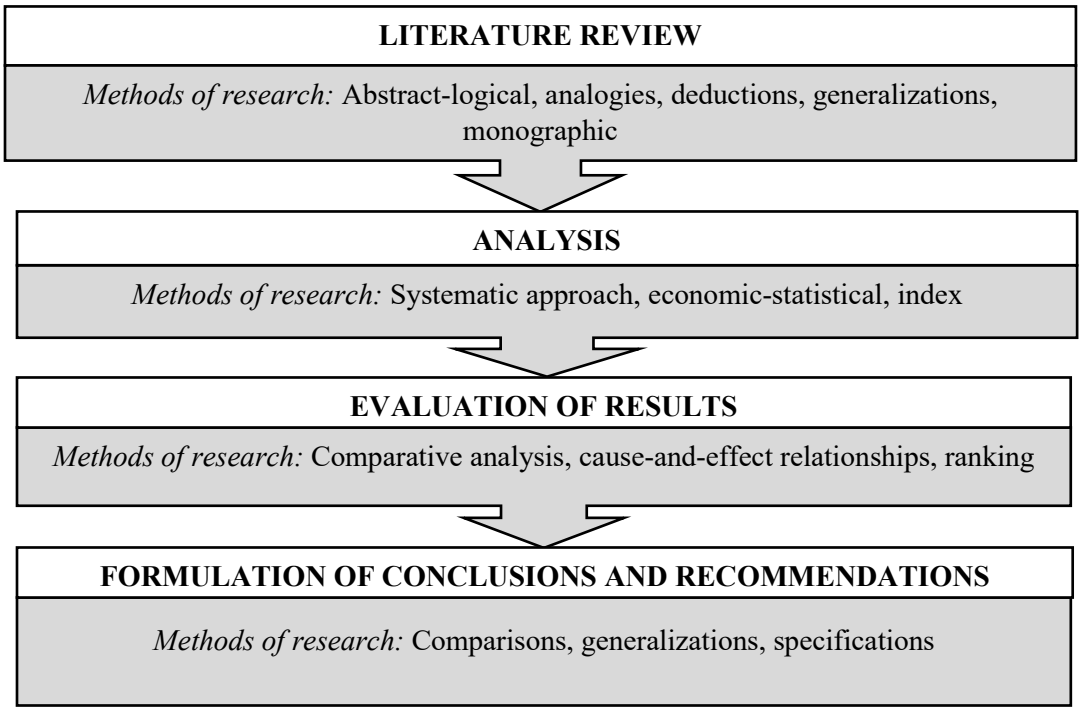

FIGURE 1. Stages and methods of research

Note: compiled by authors

A study of the content of the Sustainable Development Goals and the objectives aimed at their implementation showed that the level of achievement of each Goal and objectives can be measured by a system of 278 global indicators (Global Goals for Sustainable Development, 2015). Different countries that have committed to achieving the SDGs determine the national economic and statistical indicators system. Such a system of indicators for monitoring the Sustainable Development Goals, including 262 indicators, was developed in Kazakhstan (Monitoring of the Sustainable Development Goals until 2030, 2016). However, it includes national-level indicators, not all of which are available at the local level and are applicable for monitoring the level of SDG achievement of individual regions of the country.

Identifying the main risks of achieving the Sustainable Development Goals was made possible by comparing such indicators of regional development, such as the dynamics of GRP per capita, investments in fixed assets per capita, the level of vulnerable employment, average monthly wages and per capita nominal incomes. As a result of the comparative analysis, differences in the regions of the region in terms of contributions to the country's GRP and economic and social sustainability were revealed, confirming the existence of inequality in the socio-economic development of the regions of Western Kazakhstan.

To monitor the sustainability of the socio-economic development of Western Kazakhstan regions, we propose applying a system of indicators, tested earlier. The modified system of

indicators for achieving the Goals and objectives of sustainable development is presented (see Table 2).

TABLE 2. Modified indicator system

Indicators	
Economic	Social
(1) gross regional product (GRP) per capita; (2) average annual volume of investment in fixed capital per capita; (3) vulnerable employment, %.	(1) average monthly salary, including by gender; (2) average per capita nominal income; (3) poverty level (the share of the population with incomes below the subsistence level); (4) real income of the population used for consumption in urban and rural areas, on average per capita; (5) fund ratio (the ratio of the 10% most and 10% of the least affluent population).
*Note: c*ompiled by authors based on reference Nurlanova et al. (2023)	

Based on the use of analysis and synthesis methods, theoretical conclusions were drawn, and measures were formulated for practical use to overcome the identified inequality, allowing to increase in the socio-economic stability of the regions of the Western macro-region in the interests of the SDGs.

Visualization of the research results is provided by tabular and graphical methods, which made it possible to compactly reflect the complexity of the entire set of indicators in 6 tables and one figure, identify trends in the development of phenomena, their level and structure, and typical relationships and connections.

The information base was from literary and Internet sources, as well as the scientific developments of domestic and foreign scientists on the problem of sustainable development of the economy and society. The calculations were based on data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of Kazakhstan, regional statistical services, and the national platform for reporting Sustainable Development Goals.

4. FINDINGS AND DISCUSSION

The level of economic stability of Western Macro-region of Kazakhstan is primarily characterized by the dynamics of gross regional product (GRP) per capita (see Table 3).

TABLE 3. Dynamics of the gross regional product per capita and the share of the Western Macro-region

Region	**GRP per capita, thousand USD**						**The share of regions in GRP, %**
	2016	**2017**	**2018**	**2019**	**2020**	**2022**	
Kazakhstan	7,71	9,25	9,81	9,81	9,12	11,48	100
Aktobe	7,20	8,43	9,1	8,87	8,06	10,4	4,3
Atyrau	25,29	29,71	36,16	38,10	28,78	43,38	13,2
West Kazakhstan	9,29	11,13	12,46	11,76	10,05	14,05	4,3
Mangystau	11,34	15,52	16,48	13,98	10,5	12,63	4,2
Note: compiled by authors based on Bureau of National Statistics (2022)							

An analysis of the dynamics of GRP per capita in the regions of Western Macro region for 2016-2022 indicates, firstly, the growth of this indicator during this period; secondly, about a significant increase in the growth rate of per capita GRP, compared to the indicator for the country as a whole. The exception is the Aktobe region, where this indicator is comparable to the national average. The apparent leader is Atyrau region. This region also contributes the most significantly

to Kazakhstan's GRP - 13.2%, and four western regions provide more than a quarter of GRP - 27%. The gap between the maximum GRP per capita in the Atyrau region and the minimum in the Aktobe region in 2022 was 4.2 times.

To assess the level of economic sustainability of Western Macro-region were calculated indicator of investment in fixed capital per capita and the level of vulnerable employment (see Table 4).

TABLE 4. Indicators of economic stability of the Western Macro-region in 2022

Region	GRP per capita, thousand USD	Investments in fixed assets per capita, thousand USD	Vulnerable employment, %
Kazakhstan	11,48	1,68	
Aktobe	10,4	2,25	15,3
Atyrau	43,38	9,44	12,3
West Kazakhstan	14,05	1,70	27,5
Mangystau	12,63	2,23	5,3
The gap between the maximum and minimum	4,2	5,6	5,2
Note: compiled by authors based on Bureau of National Statistics (2022)			

According to the investment indicator in 2022, all regions of Western Macro region were ahead of the national average. However, the differences between regions in this indicator are also high – 5.6 times. The letter is from Atyrau region. A different picture emerged regarding the level of vulnerable employment, including the self-employed population. Here, a higher value indicates a worse situation; it is typical for the West Kazakhstan region - 27.5%. In other words, more than a quarter of the region's workforce lacks permanent, productive jobs.

The analysis showed the relative economic stability of the Western Macro region. However, economic growth is not always accompanied by increased social sustainability, which creates risks for the sustainable development of Kazakhstan. To prove this assumption, consider the leading indicators of social development (see Table 5).

TABLE 5. Differences in indicators of social sustainability of the Western Macro region in 2022

Region	Average monthly salary, USD	Poverty level, %	The ratio of funds, times	Nominal income per capita, USD
Kazakhstan	672,9	5,3	5,61	388,9
Aktobe	595,9	4,4	5,55	285,2
Atyrau	1136,2	3,3	3,25	681,4
West Kazakhstan	599,8	4,2	3,38	313,9
Mangystau	998,9	8,1	2,77	444,9
The gap between the maximum and minimum	1,9	2,5	2.0	2,4
Note: compiled by authors based on Bureau of National Statistics (2022)				

Judging by social indicators, Atyrau region is also characterized by the best social sustainability. Thus, the average monthly salary and average per capita nominal income exceed the national average and indicators of other regions of Western Kazakhstan.

At the same time, the gap between the maximum value of these indicators in 2022 in the Atyrau region was 1.9, and the minimum values in the Aktobe region were 2.4 times.

A difficult situation in terms of poverty level is observed in the Mangistau region (8.1%). This indicator is one of the worst in the country despite the relatively high GRP per capita. The poverty gap in economically stable regions reaches 2.5 times. Even more striking evidence of the social instability of the oil-producing regions of Western Macro-region is the analysis of the poverty level over time (see Table 6).

TABLE 6. Dynamics of the poverty level in the Western Macro-region (the share of the population with incomes below the subsistence minimum)

Region	Share of the poor population, %							Change 2016-2022 (+,-)
	2016	2017	2018	2019	2020	2021	2022	
Kazakhstan	2,5	2,7	4,3	4,3	5,3	5,2	5,2	+2,7
Aktobe	1,9	1,9	2,9	3,0	3,5	3,7	4,4	+2,5
Atyrau	3,1	2,8	2,5	2,5	3,0	3,3	3,3	+0,2
West Kazakhstan	2,8	2,7	3,2	3,7	3,9	4,4	4,2	+1,4
Mangystau	2,8	3,3	4,9	4,3	5,7	8,1	8,1	5,3
Note: compiled by authors based on Bureau of National Statistics (2022)								

Poverty rates increased in all regions between 2016 and 2022, especially during the pandemic period of 2020-2022. There is also a big difference in the dynamics of the poverty level, which has increased over the past three years due to the growth of poverty in the Mangistau region. A more detailed study of the poverty level in the Western Macro-region in the urban-rural context shows that the increase in the Mangistau region in 2022 resulted from an increase in rural poverty - up to 12.9%. In 2022, poverty levels increased significantly in the other areas of the Western Macro-region, especially in the Aktobe region (8.2%).

Next, comparative level of poverty in urban and rural areas in the Western Macro-region presented in Figure 1.

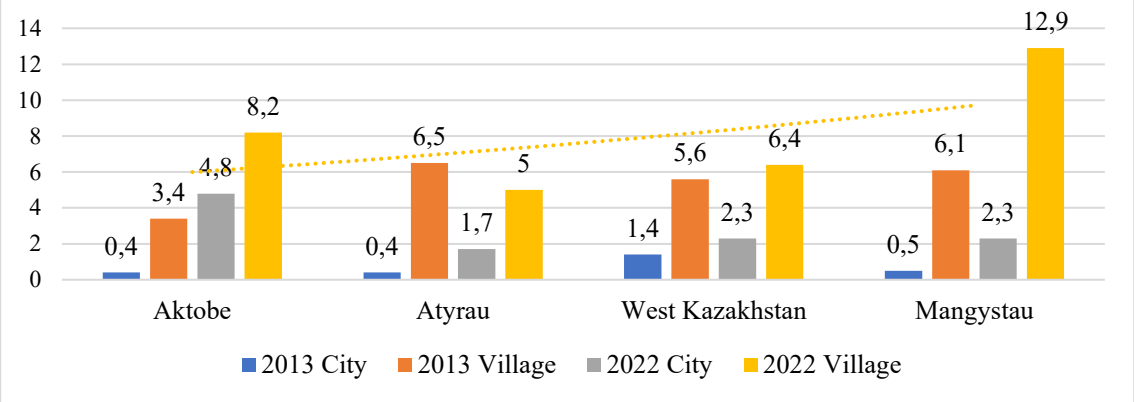

FIGURE 1. Comparative level of poverty in urban and rural areas in the Western Macro-region, %

Note: compiled by authors based on Bureau of National Statistics (2022)

On average, in the Western Macro-region, the share of the rural population with incomes below the subsistence level exceeds the exact figure for the urban population by 2.89 times. A record excess (almost ten times) was recorded in the Atyrau region. This situation is explained by

the influence of the difference between high wages in the oil and gas industry and low wages in agriculture, as well as the high share of self-employed in rural areas.

For greater clarity, let's consider the real income of the population used for consumption in urban and rural areas, on average per capita in the Western Macro-region (see Table 7).

TABLE 7. Real incomes of the population used for consumption in urban and rural areas of Western Macro-region, on average per capita, US dollars

Region	2016		2020		2021		Growth rates, 2021/2016, %	
	City	Village	City	Village	City	Village	City	Village
Kazakhstan	139	107	162	126	176	136	155,1	156
Aktobe	121	109	141	115	154	120	155,3	133,9
Atyrau	128	100	132	120	142	121	135,1	148,2
West Kazakhstan	129	97	141	114	152	125	144	157,4
Mangystau	126	108	133	120	137	124	132	140,7
Note: compiled by authors based on Bureau of National Statistics (2022)								

It is obvious that the growth rates of household incomes used for consumption in rural areas of Atyrau, West Kazakhstan, and Mangystau regions outstripped the growth rates of pay of urban households; in absolute terms, incomes in villages were significantly lower than in cities. For example, if in the Aktobe region, the incomes of urban households in 2021 amounted to 154 US dollars, then in the village – only 120 US dollars, in the Atyrau region - 142 US dollars and 121 US dollars, in the West Kazakhstan region - 152 US dollars and 125 US dollars, in the Mangystau region – 137 US dollars and 124 US dollars, respectively. Thus, during the analyzed period, the incomes of rural households in absolute terms remain lower than citizens' incomes in all regions.

Furthermore, the great interest is the analysis of wages of workers of the Western Macro-region by gender (see Table 8).

TABLE 8. The ratio of nominal wages of men and women in the regions of Western Macro-region in 2016 and 2021

Region	2016			2021		
	Average nominal salary, USD		The ratio of male and female salaries, %	Average nominal salary, USD		The ratio of male and female salaries
	Male	Female		Male	Female	
Kazakhstan	514	361	70,2	652	510	78,3
Aktobe	397	299	75,4	559	445	79,6
Atyrau	1050	539	51,3	1144	628	54,9
West Kazakhstan	572	329	57,4	592	464	78,3
Mangystau	1006	464	46,1	1005	563	56
Note: compiled by authors based on Bureau of National Statistics (2022)						

Analysis of nominal wages by gender in the Western Macro-region indicates a significant difference between men and women. At the same time, the situation changed for the better only in the West Kazakhstan region. If in 2016, women's wages were only 57.4% of men's wages, then in 2021, this ratio increased to 78.3%. More opportunities for women's work with decent pay are observed in the Aktobe region. In the leading regions of Atyrau and Mangistau regions, the share of women's wages is the lowest, amounting to 54.5% and 56%. This paradox is explained by the

fact that men living in these areas are predominantly employed in the sector of economic specialization (oil and gas production), where wages are higher.

5. CONCLUSIONS

The aim of the article is to study the dynamics and degree of socio-economic development inequality of the Western Kazakhstan region and to develop recommendations on measures of state regulation to reduce it. Based on the conducted research, the following results were obtained.

Firstly, Western macro-region makes a significant contribution to the economy of Kazakhstan (27% of GRP) and occupies a leading position in economic growth, which ensures its economic sustainability.

Secondly, despite the region's economic successes, there are problems in social development and achievement of SDGs in the region and Kazakhstan as a whole. This is manifested, firstly, in the growth of poverty levels in all regions of the Western MACRO-REGION in 2016-2022; secondly, in the development of inequality and the poverty gap by up to 2.5 times; thirdly, insufficient social sustainability due to the growth of rural poverty (in the Mangystau region up to 12.9%, in the Aktobe region - 8.2%); fourthly, in the substantial gender gap in wages.

Thirdly, the hypothesis is confirmed that the high level of inequality in the social and economic development of the Western Macro region hinders the achievement of SDGs in the country.

For the regions of the Western Macro-region, it is proposed:

(1) introduce a system of incentives and preferences for the diversification of the economy and the development of the manufacturing industry.

(2) stimulate the development of the digital economy and IT technologies, the spread of high-speed broadband Internet, and the increase of digital literacy in rural areas.

(3) creating practical women's jobs by encouraging small businesses based on the use of local raw materials.

(4) tourism development, especially in the Mangystau region, with natural conditions and historical monuments favorable for these purposes.

(5) development of livestock farming and support of small-scale industries for processing dairy, wool, and meat products.

(6) development of crafts.

The proposed measures will overcome significant regional inequality and increase the socio-economic sustainability of the regions of the Western Macro region in the interests of the SDGs. It is planned to continue research in this direction to develop a map of measures to reduce regional socio-economic inequality in the territories of the West Kazakhstan Macro region together with government representatives.

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The Role of Economic Investments in Mitigating Poverty Across Urban and Rural Kazakhstan

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Abstract

This study employed a comprehensive analytical approach to examine the relationships between investments in healthcare, education, and other economic sectors and their impact on poverty levels in Kazakhstan in urban and rural contexts, allowing for nuanced insights into the differential impacts of investments across these settings. The analysis was structured around evaluating correlations, regression modeling, and ANOVA tests to assess the significance of the observed relationships. Results revealed significant positive correlations between investments in healthcare and education and poverty reduction, with these investments demonstrating a powerful impact in urban areas. Investments in other economic sectors, such as agriculture, industry, and construction, also showed correlations with poverty levels, underscoring the importance of integrated investment strategies. However, regional disparities in investment impacts were evident, highlighting the need for tailored approaches to address the unique challenges and opportunities in specific areas of Kazakhstan. Notably, the study identified particular regions requiring more focused attention due to fluctuations in sectoral contributions to the Gross Regional Product (GRP), variations in investment levels, and the distinct challenges rural areas face. The findings support the hypotheses that investments in healthcare and education significantly affect poverty reduction, with implications for policymakers and regional development strategies.

Keywords: Regional Economy, Healthcare, Education, Urban Area, Rural Area, State Budget, Socio-Economic Development

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1. INTRODUCTION

In developing countries, there is now increasing international recognition of the importance of both the content of economic policies and the process of their implementation, especially about poverty reduction strategies. Poverty is seen as a multidimensional phenomenon affecting human life's economic, social, and cultural aspects. The leading causes of poverty include lack of capital, remote geographical location, fragile ecological environment, lack of infrastructure and public services, and political disadvantage (Bird et al., 2002). Factors such as governance, ownership, participation, and the interactions of the four main dimensions: growth, distribution of income and assets, quality of institutions, and type of political system become the main elements of development programs (Aloui2019). Solving the problem of poverty can effectively improve national happiness and reduce the gap between the poor and the rich. The complexity of the problem of poverty requires integrated policies and strategies, such as programs to increase productive employment opportunities, strengthen human resources, and ensure access to existing socio-economic opportunities. Some countries, including Africa, Brazil, China, Costa Rica, and Indonesia, are demonstrating that rapid economic growth can lift significant numbers of people out of financial poverty. However, reducing poverty requires economic growth and social and political measures such as fiscal policy and social safety nets (Singh & Chudasama, 2020). One of the main reasons for the slow socio-economic development of poor and underdeveloped areas is the slow or ineffective development of productive factors and infrastructure construction in these areas, which makes local poverty alleviation measures extremely difficult. Poverty also contributes to environmental degradation, such as land degradation, due to low-input agriculture (Yang et al., 2020).

Thus, poverty reduction is becoming a significant focus for many countries and a primary goal for governments. With good governance and a favorable investment environment, increased fiscal expenditure can stimulate economic growth and development, which in turn can lead to poverty reduction. Breaking the cycle of spatial poverty traps requires a comprehensive approach that includes improving infrastructure, access to education and health care, creating economic opportunity, and strengthening resilience to natural disasters.

Economic development creates new jobs, increases incomes, and improves access to resources and services, which can help reduce poverty (Surya et al., 2021). One of the key ways to measure the effect of fiscal spending on poverty reduction is the change in poverty levels as a result of the measures taken (Ebenezer et al., 2021). If poverty levels decline following increases in fiscal spending on related programs and policies, this may indicate that the spending is effective.

The issue of poverty reduction remains a central challenge in global development strategies, reflecting its critical importance for enhancing the quality of life and ensuring sustainable economic growth. This study aims to examine the impact of economic development on poverty reduction processes. In the context of Kazakhstan, regional disparities and varying levels of investment across sectors present unique challenges and opportunities for poverty alleviation and economic growth. Understanding these dynamics is essential for designing targeted interventions that can effectively address poverty and foster sustainable development across different regions of the country.

The study's primary goal is to analyze the impact of investments in healthcare and education on poverty reduction, focusing on the differentiation between urban and rural areas and identifying regional disparities in Kazakhstan. GDP per capita is a measure of economic development, highlighting significant differences between countries. Higher GDP per capita correlates with lower poverty rates, highlighting the importance of economic growth in anti-poverty efforts. Economic growth is generally seen as the main driver of poverty reduction, as an increase in a country's overall output and income creates the potential to improve the population's

living standards. However, this process does not always automatically lead to poverty reduction or an equal distribution of economic benefits among different population segments.

2. LITERATURE REVIEW

Economic growth has a significant impact on poverty levels. When a country's economy grows, the production of goods and services increases, which should theoretically lead to the creation of new jobs and increased incomes. Ideally, this should reduce poverty as more people earn enough to meet their basic needs. Sustainable economic development thus stands out as an essential factor for poverty reduction, highlighting the need for targeted growth-oriented policies (Eisenmenger et al., 2020).

However, it is worth noting that a combination of several factors, including remote location, lack of access to markets, educational and health facilities, insufficient infrastructure, limited income opportunities and unfavorable environmental conditions can lead to the formation of "spatial poverty traps". Christiaensen and Martin (2018) stressed that developing economic activities, such as agriculture or small-scale trade, in remote rural areas has no impact on poverty reduction. In fact, due to global trade development, local businesses are usually not in demand as foreign goods are. These are situations where certain geographic, economic, and social conditions create a cycle in which poverty is self-perpetuating and difficult to escape. Such conditions can limit the ability of residents of these areas to achieve economic growth and social development, thereby perpetuating the cycle of poverty over many generations (Zhou & Liu, 2019).

For example, remote rural areas where residents have limited access to education and healthcare due to lack of infrastructure. This results in low levels of education and poor health, which limits their ability to find decent-paying jobs outside of agriculture. Low incomes, in turn, prevent investment in children's education, which continues the cycle of poverty. Additionally, if an area is prone to environmental problems such as soil erosion or frequent natural disasters, this further deteriorates living conditions and reduces opportunities for escape from poverty (Kaiser & Barstow, 2022). At the same time, technological development and productivity growth in agriculture, industry, and services have different impacts on poverty reduction. In particular, agricultural productivity growth has been found to be generally more effective in reducing poverty compared to similar non-farm growth (Ivanic & Martin, 2018).

However, economic growth can lead to increased income inequality when the benefits of growth are unevenly distributed. This means that most of the income increase may go to the already affluent segment of the population, while the poor segments of society will not experience a significant improvement in their situation. Economic growth can reduce poverty and widen income gaps, putting economic benefits out of reach for people experiencing poverty (Amar et al., 2020).

Recent research highlights the complex interaction of socio-economic factors in shaping poverty dynamics and highlights the importance of an integrated policy approach to addressing poverty in different regional contexts. Mansi et al. (2020) suggested that tackling income inequality, promoting economic growth, and improving governance are key policy measures to reduce poverty in the EU and the Western Balkans. Unemployment has been identified as a significant factor influencing poverty, emphasizing the importance of job creation and labor market reform (Nae et al., 2024).

Regions with limited economic opportunities have high unemployment rates, influencing poverty. Education has also been highlighted as essential for increasing social mobility and economic prosperity. Investing in education is essential for long-term poverty reduction strategies. According to Dinh Thanh et al. (2020), regions with mixed economies reflected in autonomous budget management perform positive and fruitful outcomes compared to state financial transfers. Centralized budget management impacts the development of the economy,

which governments with weak institutional capacity explain as they have difficulty converting public spending into the efficient provision of public goods. However, improving the level of public health services helps narrow the gap in access to services between different regions and urban and rural areas. Public education and health services have a greater impact on poverty reduction than other public services. The importance of public investment in basic education and health care, as well as the provision of low-cost or free public services to low-income groups, reduces economic inequality and reduces regional disparities (Yang et al., 2022).

Increased economic growth reduces unemployment and poverty, which in turn increases welfare and productivity. Modern conditions provide for special attention to finance and active participation of the state. In particular, it is necessary to increase the minimum wage to improve welfare and reduce wages (Harsono, 2023). A number of studies supported that state policy in poverty reduction has been achieved through the interference of government. According to Liu et al. (2019) strategies included providing credit financing to poor households, agricultural construction, food-for-work programs, and promoting agricultural infrastructure and technology. Wang et al. (2023) noted that success in poverty reduction is impossible without attracting financial investment, especially guaranteed fiscal support. Cao et al. (2023) noted that in rural India, this has an impact on poverty levels for access to education and health care. The multidimensional nature of poverty points to the need to consider various factors when developing strategies to reduce it. Commercialization, education, health, and living standards improvements, increased agricultural productivity, improved labor utilization, and diversified livelihood options can significantly reduce multidimensional poverty. However, to effectively reduce poverty, it is necessary to consider each country's social and economic characteristics and pay attention to measures that promote social inclusion.

3. METHODOLOGY

The analysis employs a combination of descriptive and statistical techniques to assess the relationships between various socio-economic indicators and their impact on poverty levels, with a particular focus on healthcare and education investments. It integrates both rural and urban contexts to understand these dynamics across different regions comprehensively.

Based on the conducted literature review, state investment in economic activities affects the level of poverty. Therefore, the research methodology for this study is based on the works of Harsono (2023), Wang et al. (2023), and Cao et al. (2023) There were identified critical indicators such as average income of the population (average monthly salary) and fiscal policy (which is reflected in state investment of social sector, including education and healthcare). Some studies stated that industrial development does not contribute to the overall poverty reduction but contributes to the wealth of an already affluent population. On the contrary, agriculture was regarded as the indicator that contributed to reducing poverty in rural areas. Furthermore, incorporating a quantitative analysis through regression models or a qualitative assessment through case studies can enrich the understanding of these dynamics.

Therefore, current research is focused on the analysis of the impact of state investment in economic activities on the overall poverty level and in the context of urban and rural areas. The research methodology includes the following stages which presented in Figure 1.

The inferential analysis used regression modeling to quantify the relationship between poverty levels and investments in healthcare and education, incorporating autocorrelation and multicollinearity checks. Three models were constructed to analyze the data in general and specifically within urban and rural settings. The significance of the models and their predictors was assessed using the coefficient of determination (R^2), correlation coefficient (R), F-statistics, p-values, and analysis of variance (ANOVA).

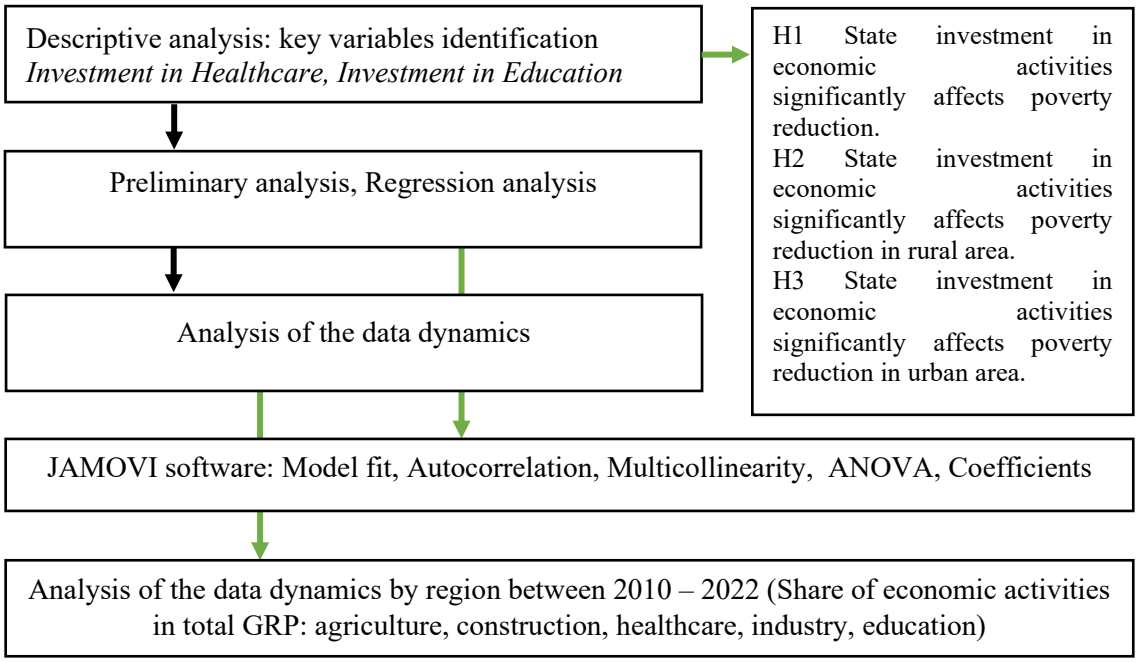

FIGURE 1. Research stages

Note: compiled by authors

4. FINDINGS AND DISCUSSION

The initial phase of the analysis examines the correlations between specific indicators related to healthcare and education. Additional indicators, such as the number of doctors and hospitals, were considered for healthcare. Similarly, for education, internal expenditure on R&D and the number of higher educational institutions were included. Figure 2 shows a preliminary analysis of the correlation between indicators. There were taken healthcare and education. Two additional indicators were taken for healthcare: number of doctors and hospitals. For education, additional indicators were taken, as well as internal expenditure on R&D and a number of higher educational institutions. Nevertheless, according to the provided results, investment in health and a number of higher educational institutions have a significant positive linear correlation. In contrast, investment in education has a moderate positive correlation.

The relationship between poverty levels and investments in health care. There is a clear inverse relationship: as poverty levels increase, investments in health care decrease. This may indicate that poorer regions may suffer from a lack of healthcare funding.

The relationship between the number of doctors and investments in healthcare. There is a positive correlation: regions with many doctors have more significant investments in healthcare. This may indicate that investments are being used effectively to attract health workers.

The relationship between the number of hospitals and investments in health care. There is also a positive correlation: more hospitals correspond to higher investments in healthcare, which may indicate the development of healthcare infrastructure.

Distribution of variables. Histograms show the distribution of each variable along the diagonal. The number of doctors and hospitals is close to normal, while the distribution of poverty and investment in health care appears skewed.

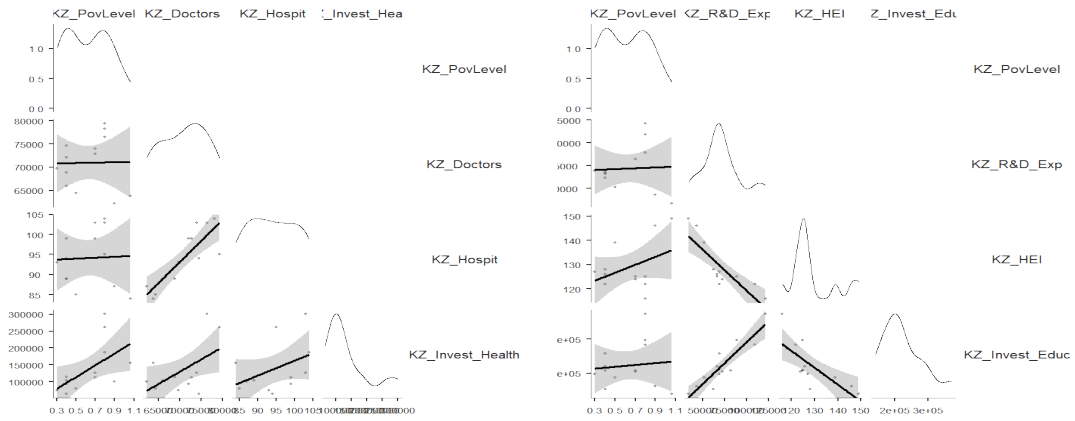

FIGURE 2. Descriptive Analysis Education and Healthcare

Note: compiled by authors

Poverty level and domestic R&D expenditures. The graph shows an inverse relationship: as the poverty level increases, R&D expenditures decrease. This may indicate that poorer regions need to invest more in research and development, limiting their long-term economic growth and innovation potential.

Poverty level and number of higher education institutions. The relationship could be clearer, but it can be assumed that as the poverty level decreases, there is an increase in the number of educational institutions. This may indicate that education is a priority in more prosperous regions.

Poverty level and investment in education. The graph shows an inverse relationship: poverty levels. Next, in Figure 3, there are results for the rest of the indicators: average monthly pension and salary, economic activity (industry, construction, and agriculture).

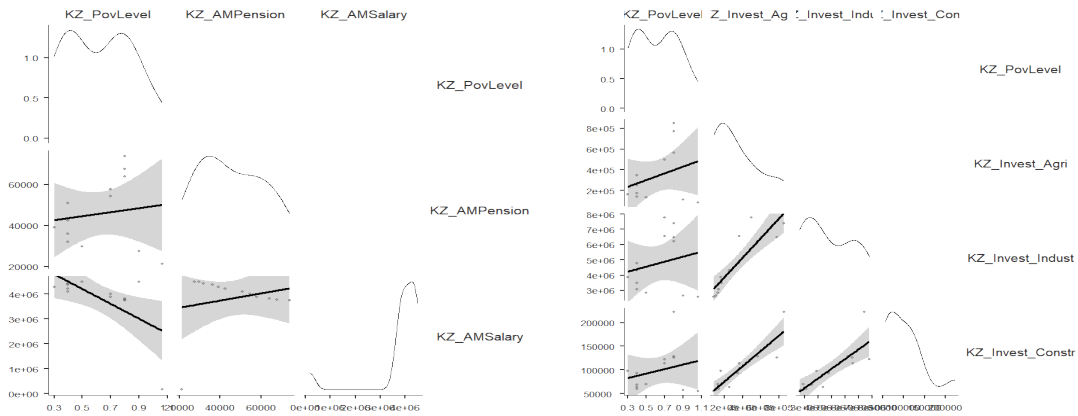

FIGURE 3. Descriptive analysis, Industry

Note: compiled by authors

Investment and Poverty Level. A negative relationship exists between poverty levels and agriculture, industry, and construction investment. As poverty levels increase, investment in these

sectors decreases. Because investments in agriculture are often linked to basic needs, poverty reduction may be more sensitive to changes in this sector. Higher investment in industry and construction can help create jobs and economic growth, which can help fight poverty.

Investments between Sectors. The graphs also show a positive correlation between investments in different economic sectors, indicating possible synergies or alignment of regional investment policies.

According to the conducted literature review, investment in economic activities is a part of fiscal policy, and therefore, it contributes to the reduction of poverty level. However, the results of descriptive analysis showed that local government provides financial support when there is an urgent need. Therefore, the poverty level increases along with state investment in construction, agriculture, and industry.

According to the descriptive analysis, two key indicators of investment in health and education were identified. Due to this, the hypotheses were corrected :

H1: Investment in healthcare and education significantly affects poverty reduction.

H2: Investment in healthcare and education significantly affects poverty reduction in rural areas.

H3: Investment in healthcare and education significantly affects poverty reduction in an urban area.

The regression analysis was conducted considering the context of urban and rural areas. The results for the model's fit for the relationship between poverty levels and investments in health and education are given in Figure 4.

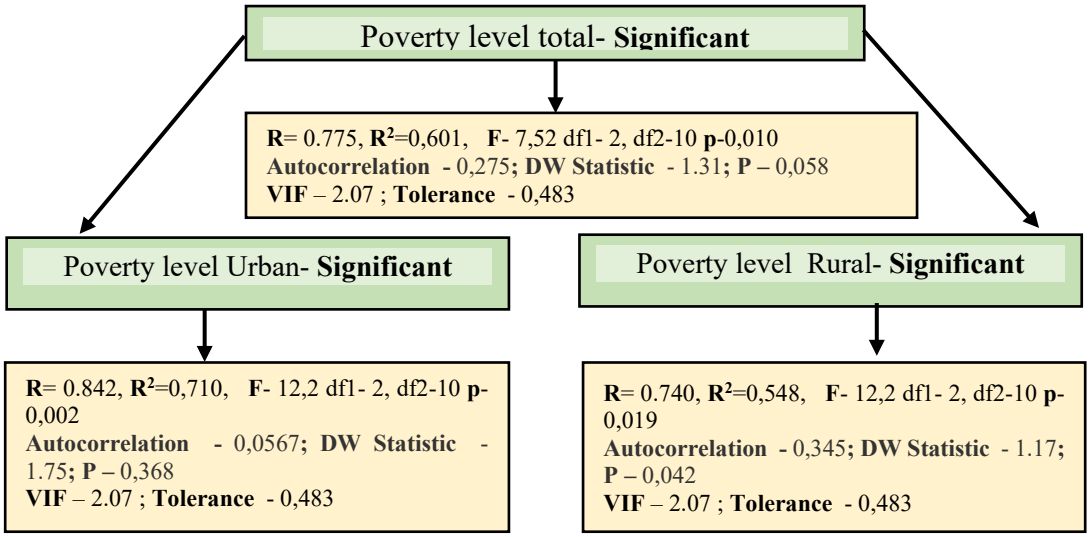

FIGURE 4. Model fit

Note: compiled by authors

Model 1. The coefficient of determination (R^2) is 0.601. This means that approximately 60.1% of the variation in the dependent variable (poverty rate) can be explained by our independent variables (investment in health and education). In the context of socio-economic research, this is a reasonably high figure, indicating a significant impact of our predictors on poverty levels.

The correlation coefficient (R) is 0.775, indicating a strong positive relationship between the explanatory and dependent variables. This suggests that poverty levels tend to fall as investment in health and education increases. F-statistics equals 7.52 with degrees of freedom df1=2 (number of predictors) and df2=10 (N - number of observations - number of predictors - 1). With a p-value

of 0.010, well below the standard threshold of 0.05, we reject the null hypothesis that all coefficients on the independent variables are simultaneously equal to zero. This indicates the statistical significance of our predictors overall. The autocorrelation of errors measured using the autocorrelation coefficient (-0.275) and DW statistics (1.31) does not show apparent autocorrelation (DW close to 2), although it is on the edge of the acceptable range (1.5-2.5). The P-value for autocorrelation (0.058) also indicates that there is no statistically significant autocorrelation, although it is close to the significance threshold. Multicollinearity, assessed by VIF (2.07) and tolerance (0.483), does not appear to be a problem in this analysis. A VIF below 5 indicates the absence of serious multicollinearity, which is confirmed by a tolerance value exceeding the threshold value of 0.2. Based on the analysis, it can be concluded that investments in health and education are significantly associated with poverty, which is confirmed by both statistical tests of significance and the adequacy of the model.

Model 2. The results indicate an even stronger relationship between urban poverty rates and investments in health and education. The coefficient of determination (R^2) increased to 0.710, indicating that 71% of the variation in poverty rates in urban areas can be explained through investments in health and education. This is a significant improvement over the previous analysis, highlighting the importance of these factors in an urban context. The correlation coefficient (R) is 0.842, indicating a very strong positive relationship between the independent and dependent variables. This suggests that significant progress can be made in reducing urban poverty through increased health and education investment. The F-statistic increased to 12.2 with a p-value of 0.002, providing even more substantial evidence of the statistical significance of the model. The error autocorrelation and DW statistics show an improvement in the autocorrelation situation (DW = 1.75, which is within the acceptable range, indicating that there are no severe problems with error autocorrelation). The P-value of 0.368 for autocorrelation confirms that there is no statistically significant autocorrelation. The results highlight that investments in health and education significantly impact poverty reduction in urban areas.

Model 3. The coefficient of determination (R^2) is 0.548, which means that investments in health and education can explain 54.8% of the variation in rural poverty. This indicates a significant, but not as strong, influence of these factors on the poverty level in rural areas compared to urban ones. The correlation coefficient (R) is 0.740, indicating a strong relationship between the explanatory variables and the dependent variable, although less than in the urban context. The F-statistic has a value of 12.2 with degrees of freedom df1=2 and df2=10, with a p-value of 0.019. This indicates the statistical significance of the model as a whole, confirming that although the impact of the predictors on poverty in rural areas is noticeable, it is less pronounced than in urban areas. Error autocorrelation, shown through an autocorrelation coefficient of 0.345 and a DW statistic of 1.17, indicates the presence of positive autocorrelation (DW well below 2). Because insignificant positive autocorrelation is quite common, we can accept this result, although it is on the border of the permissible range (1.5-2.5). The P-value of 0.042 for autocorrelation confirms the statistical significance of this effect, warranting further consideration. All models multicollinearity measures (VIF and tolerance) remain unchanged, indicating no significant multicollinearity between the predictors.

Next, ANOVA data for three models are provided, reflecting the relationship between poverty level and investments in health and education in general, in urban and rural areas, in Table 1.

Model 1. Investment in health significantly affects poverty with a sum of squares of 12.46, F-statistic of 14.59, and p-value of 0.003, indicating statistical significance of this predictor. Investment in education also affects poverty, but to a lesser extent, with a sum of squares of 4.43, an F-statistic of 5.19, and a p-value of 0.046, which is also statistically significant.

Model 2. Healthcare investment has a more significant impact in urban areas than overall, with a sum of squares of 7.292, an F-statistic of 17.01, and a p-value of 0.002. Investment in education

TABLE 1. ANOVA: poverty level models

Model	Predictor	Sum of Squares	df	Mean Square	F	p
Total	Investment_Healthcare	12.46	1	12.460	14.59	0.003
	Investment_Education	4.43	1	4.430	5.19	0.046
	Residuals	8.54	10	0.854		
Urban	Investment_Healthcare	7.292	1	7.292	17.01	0.002
	Investment_Education	0.490	1	0.490	1.14	0.310
	Residuals	4.286	10	0.429	17.01	
Rural	Investment_Healthcare	22.6	1	22.56	12.09	0.006
	Investment_Education	13.1	1	13.11	7.03	0.024
	Residuals	18.7	10	1.87		
Note: compiled by authors						

in urban areas does not have a statistically significant effect on poverty, with an F-statistic of 1.14 and a p-value of 0.310, which is more than the alpha level of 0.05. Investment in health is essential in reducing poverty in both urban and rural areas, with the most significant impact in rural areas.

Model 3. Investment in rural health significantly impacts poverty, with an F-statistic of 12.09 and a p-value of 0.006. Investment in education is also significant in rural areas, with an F-statistic of 7.03 and a p-value of 0.024.

Investments in education have a more minor but still significant impact on poverty, and their impact is more pronounced in rural areas than urban areas. Residuals indicate that some unexplained variance remains in the models, particularly in rural areas, which may indicate other influencing factors.

Next, results for the models' coefficients are provided in Table 2.

TABLE 2. Coefficients: poverty level models

Model	Predictor	Estimate	SE	t	p
Total	Intercept	4.36	0.973	4.48	0.001
	Investment_Healthcare	2.02e-5	5.28e-6	3.82	0.003
	Investment_Education	-1.34e−5	5.89e-6	-2.28	0.046
Urban	Intercept	1.28	0.690	1.85	0.093
	Investment_Healthcare	1.54e-5	3.74e-6	4.12	0.002
	Investment_Education	-4.46e−6	4.17e-6	-1.07	0.310
Rural	Intercept	7.86	1.44	5.46	< .001
	Investment_Healthcare	2.72e-5	7.81e-6	3.48	0.006
	Investment_Education	-2.31e−5	8.71e-6	-2.65	0.024
Note: compiled by authors					

In the overall model, the significance of investment in health is confirmed by the F-statistic of 14.59 and p-value of 0.003, indicating its high impact on poverty reduction. Investment in education also has a significant effect, although to a lesser extent, with an F-statistic of 5.19 and a p-value of 0.046, demonstrating a weak but statistically supported impact on poverty reduction.

In the model for urban areas, healthcare investment is even more significant, with an F-statistic of 17.01 and a p-value of 0.002, highlighting its critical role in reducing urban poverty. However, investment in education in this model did not show a statistically significant effect, as reflected in the F-statistic of 1.14 and p-value of 0.310, indicating no direct impact on poverty rates in urban areas.

In rural areas, both types of investments have significantly impacted poverty reduction. Investment in health, with an F-statistic of 12.09 and p-value of 0.006, and investment in education, with an F-statistic of 7.03 and p-value of 0.024, were both confirmed to be highly significant in the rural context.

H1 Investment in healthcare and education significantly affects poverty reduction – supported.

H2 Investment in healthcare and education significantly affects poverty reduction in rural areas – supported.

H3 Investment in healthcare and education significantly affects poverty reduction in urban areas - partly supported. Investment in healthcare has an insignificant impact on the poverty level reduction in urban areas.

An analysis of the dynamics of the Gross Regional Product (GRP) in the agricultural sector of the Republic of Kazakhstan for the period from 2010 to 2022 reflects the significant growth of this sector in the country's economy (see Figure 5).

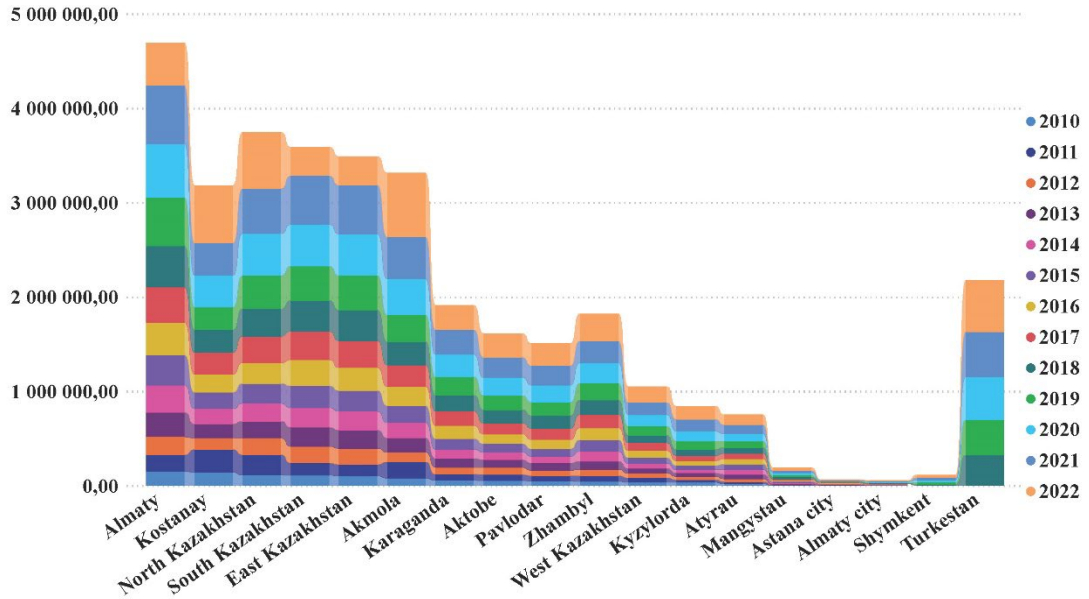

FIGURE 5. Share of agriculture to GRP (Kazakhstan), 2010-2022

Note: compiled by authors

The total GRP of the agricultural sector increased from 983,994.9 billion tenge in 2010 to 4,101,844.0 billion tenge in 2022, which indicates this sector's significant contribution to the country's economic development. Almaty has seen an increase in the share of the agricultural industry from 152,470.7 billion tenge in 2010 to a peak of 620,978.6 billion tenge in 2021, followed by a decrease to 449,856.4 billion tenge in 2022. This may indicate volatility or changes in the region's GRP structure. In the West Kazakhstan region, there has been a steady increase in the share of the agricultural sector from 35,006.5 billion tenge to 168,667.9 billion tenge over the period under review, which indicates the sustainable development of this sector. In the South Kazakhstan region, there is also an increase, but in 2022, there is a sharp drop from 517,445.5 billion tenge in 2021 to 304,346.6 billion tenge, which requires additional analysis.

To assess the impact of the construction industry on the economy of the Republic of Kazakhstan in the context of gross regional product (GRP), the presented data should be analyzed

by year and region. The table displays the volumes of GRP in the construction sector in thousands of tenge from 2010 to 2022.

The volumes of the construction sector of the economy of the Republic of Kazakhstan in the context of gross regional product (GRP) are presented in Figure 6.

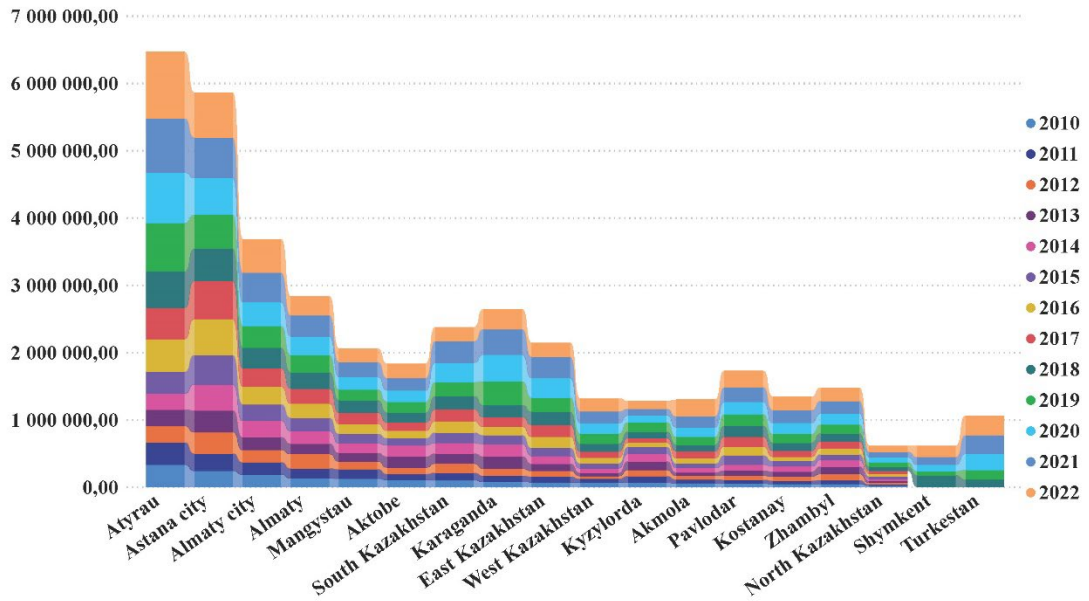

FIGURE 6. Share of construction to GRP (Kazakhstan), 2010-2022

Note: compiled by authors

On a nationwide scale, there is a visible upward trend in the GRP of the construction industry, starting from 1,680,502.5 million tenge in 2010 and reaching a peak of 3,408,585.1 million tenge in 2020. However, in 2021, there is a decline to KZT 2,889,183.3 million, followed by a resumption of growth to KZT 3,788,406.2 million in 2022. These fluctuations may be associated with cyclical economic factors, changes in government policy in the construction sector, and foreign economic conditions. Almaty shows a constant increase from 126,989.1 million tenge in 2010 to a maximum of 313,095.2 million tenge in 2021, followed by a decrease in 2022 to 284,342.9 million tenge. This likely reflects the overall economic activity in the region, where construction plays a significant role. Atyrau shows the most pronounced growth over the entire period, from 329,459.5 million tenge in 2010 to 988,449.5 million tenge in 2022, which may be due to the active development of infrastructure and industrial projects, especially in the oil and gas sector. Karaganda is experiencing volatile growth, with a sharp peak of 356,229.0 million tenge in 2019 and a subsequent decline to 296,060.0 million tenge in 2022. This may indicate the completion of major construction projects and the transition to the operation phase of completed facilities.

Many regions, such as East Kazakhstan and South Kazakhstan, also experience significant fluctuations, which requires a detailed analysis of influencing factors such as regional economic policies, the volume of investments in capital construction, and changes in the structure of regional economies.

Kazakhstan as a whole shows a steady increase in education funding from 1,125,456.2 million tenge in 2014 to a peak of 1,769,450.5 million tenge in 2022. Notably, in 2019, there was a

decrease of 697,467.3 million tenge, followed by recovery and growth in financing. Almaty has one of the highest growth rates - from 74,081.2 million in 2014 to 263,110.8 million in 2022. This may be due to the city's development as a significant educational center of the country. Southern Kazakhstan and Eastern Kazakhstan show similar trajectories with increasing funding, with the exception of a decrease in 2022. This decline could be due to several factors, including changes in budget priorities or the completion of specific major education projects.

Changes in the volume of education financing in different regions of Kazakhstan from 2014 to 2022 are displayed in Figure 7.

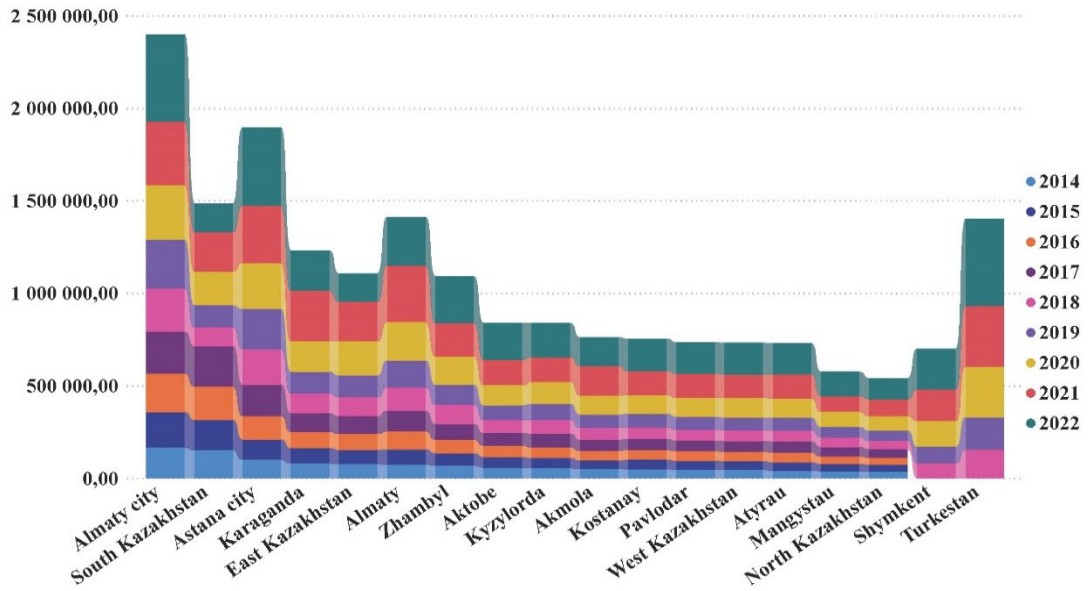

FIGURE 7. Share of education to GRP (Kazakhstan), 2010-2022

Note: compiled by authors

Of most significant interest are Almaty and Astana cities, where education funding shows the most tremendous increase, reaching 471,552.4 million tenge and 422,875.1 million tenge, respectively, in 2022. These data may reflect increased educational infrastructure investment in the country's capital and largest city.

The share of healthcare and social services in the GRP of the Republic of Kazakhstan grew from 666,308.4 million tenge in 2014 to a peak of 1,075,843.5 million tenge in 2017. After declining to KZT 459,961.3 million in 2019, the industry recovered to reach KZT 1,044,984.0 million in 2022, which may reflect increased public investment in health and social services or increased private spending in this area.

In Almaty, the share of healthcare in GRP also shows an increase until 2019, followed by a significant decrease to 83,574.2 million tenge in 2022. This may be due to changes in the structure of regional GRP or redistribution of budgetary resources. Astana and Almaty cities are showing significant growth in healthcare and social services investments, reaching 560,937.8 million tenge and 574,729.6 million tenge, respectively, in 2022. This underlines their status as large administrative and economic centers where the need for social services is exceptionally high. In regions such as Aktobe and West Kazakhstan region, there is also an increase in the share of healthcare in GRP, reaching 109,362.7 million tenge and 99,529.6 million tenge, respectively, by 2022.

Figure 8, provided data on the share of healthcare and social services in the gross regional product (GRP) of the Republic of Kazakhstan for the period from 2014 to 2022.

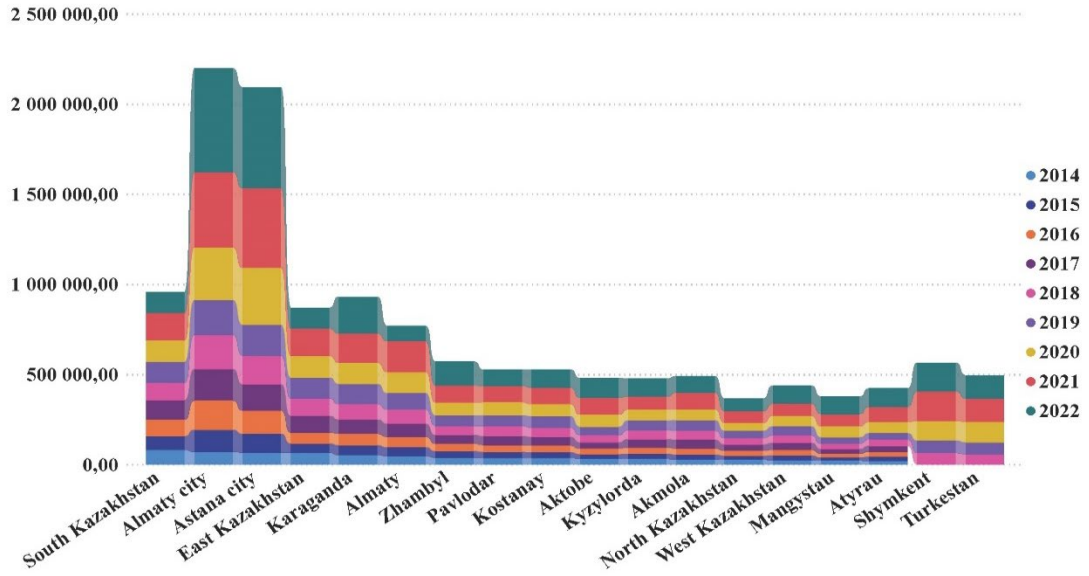

FIGURE 8. Share of Healthcare and Social Services to GRP (Kazakhstan), 2010–2022

Note: compiled by authors

These data may reflect the strengthening of health infrastructure and population growth or rising levels of wealth, which entail increased demand for health and social services. There is a slight decrease in the share of healthcare and social services in GRP in the South Kazakhstan region from 116,830.5 million tenge in 2019 to 115,408.8 million tenge in 2022. This decline may result from several factors, including economic transitions or reorganization of the health care system.

Interestingly, Shymkent shows an increasing share of investment in healthcare and social services, reaching KZT 159,388.1 million in 2022. This may indicate the development of this region as a new center for the provision of quality medical services.

The share of industry in the gross regional product (GRP) of various regions from 2010 to 2022 is shown in Figure 9.

The share of industry in the country's GRP shows steady positive dynamics, starting from 7,177,125.8 million tenge in 2010 and reaching 20,293,589.1 million tenge by 2022, which reflects the strategic development of the industrial sector in the country's economy. Atyrau stands out among other regions as a leader in the GRP industry share, which is likely due to the development of the oil and gas industry, large industrial projects, and infrastructure. In Aktobe and the West Kazakhstan region, there is a significant increase in industry in the structure of GRP, which may be due to the development of the metallurgical, mechanical engineering, and mining industries. Karaganda is traditionally known for its industrial capacity, especially in the mining industry, which is reflected in the high share of industry in the region's GRP. Almaty city and Astana show an increase in the industrial sector's share in GRP, which may be a consequence of the expansion of the industrial base and efforts to diversify the economy, including through the development of high-tech industries.

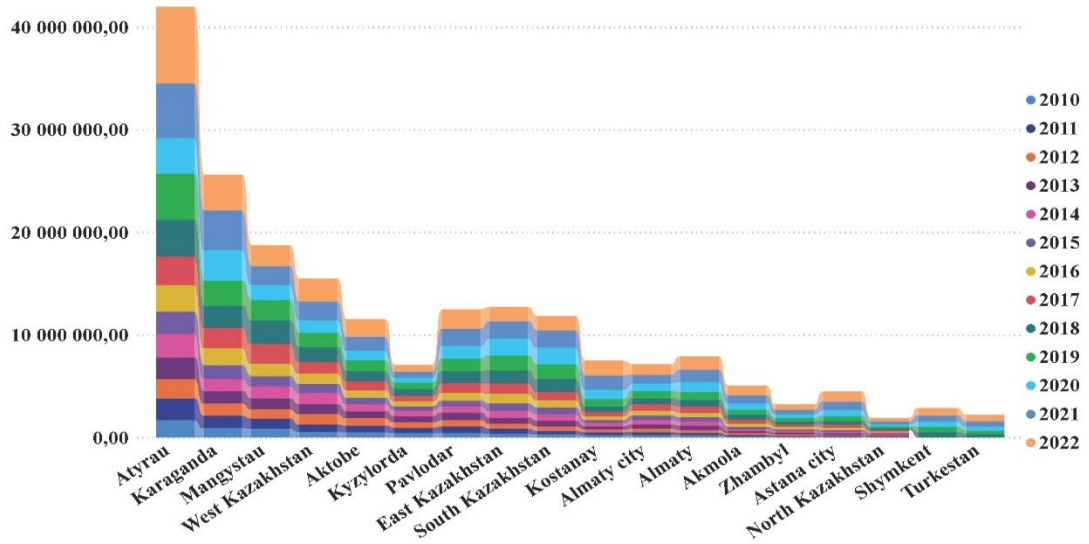

FIGURE 9. Share of Industry to GRP (Kazakhstan), 2010–2022

Note: compiled by authors

Healthcare and education investments are significantly associated with poverty reduction, highlighting the critical role of these sectors in socio-economic development. The impact of healthcare and education investments on poverty reduction is more pronounced in urban areas ($R^2 = 0.710$) compared to rural areas ($R^2 = 0.548$), suggesting that urban settings may offer more leverage for these investments to influence poverty levels.

Positive correlations were observed between investments in different economic sectors (agriculture, industry, and construction), indicating synergies or alignment of investment policies. However, investments in these sectors tend to decrease with increasing poverty levels, emphasizing the need for targeted fiscal policies to support impoverished regions. The analysis reveals significant regional disparities in the contributions of agriculture, construction, education, healthcare, and industrial sectors to Kazakhstan's Gross Regional Product (GRP) from 2010 to 2022. While investments in health and education significantly impact poverty reduction, their effectiveness is less pronounced in rural areas than in urban settings.

6. CONCLUSIONS

These research findings illustrate not only the importance of investments in health and education as tools for poverty reduction but also the differences in their impact depending on the regional context. The identified differentiation in the impact of predictors between urban and rural areas highlights the need to develop targeted policy measures tailored to the specifics and needs of each environment.

Based on the analysis, several regions in Kazakhstan require more focused attention due to their specific challenges and opportunities in poverty reduction and regional development.

Despite significant increases in investments in healthcare, education, and agriculture, Almaty experienced a decrease in the share of the agricultural sector in 2022 and a decline in the construction sector's GRP. These fluctuations may indicate volatility in the regional economy, requiring targeted interventions to stabilize and promote sustainable growth. Additionally, the high growth rates in education funding reflect its development as a significant educational center,

suggesting further investment could bolster this advantage. In recent years, there has been a considerable decrease in healthcare and social services' share of GRP in Almaty. This decline could impact public health outcomes and social welfare, necessitating focused interventions to reverse the trend and ensure adequate funding and infrastructure for healthcare services.

South Kazakhstan showed a sharp drop in the agricultural sector's contribution to its GRP in 2022, alongside a decrease in education financing. Such trends may hinder long-term economic growth and innovation potential, making it imperative to investigate the underlying causes and address them through targeted fiscal and development policies.

West Kazakhstan showed a steady increase in the share of the agricultural sector, indicating sustainable development. It's essential to ensure that this growth translates into broader economic benefits for the region, including poverty reduction and job creation.

As a region showing an increasing share of investment in healthcare and social services, Shymkent represents an opportunity for development as a new center for quality medical services. Strategic investments here could enhance healthcare access and quality for the surrounding areas, contributing to overall regional development.

Policymakers should prioritize investments in healthcare and education as critical strategies for poverty reduction, focusing on maximizing the impact in both urban and rural areas. Regions showing significant growth or decline in specific sectors should explore strategies for economic diversification to stabilize and enhance regional economic development. The positive correlation between sectorial investments suggests that coherent and aligned fiscal policies can amplify the impact of these investments on poverty reduction.

Regions require a multi-faceted approach that includes enhancing infrastructure, ensuring stable and diversified economic growth, improving access to quality healthcare and education, and developing targeted fiscal policies encouraging investment and development in underperforming sectors. Such targeted strategies are vital for mitigating regional disparities, enhancing socio-economic development, and effectively reducing poverty across Kazakhstan.

AUTHOR CONTRIBUTION

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Funding acquisition and research administration: Aruzhan Jussibaliyeva.
Development of research methodology: Gaukhar Kenzhegulova.
Resources: Aruzhan Jussibaliyeva.
Software and supervisions: Gaukhar Kenzhegulova, Aruzhan Jussibaliyeva.
Data collection, analysis and interpretation: Gaukhar Kenzhegulova, Aruzhan Jussibaliyeva, Dinara Mussabalina.
Visualization: Gaukhar Kenzhegulova.
Writing review and editing research: Gaukhar Kenzhegulova, Aruzhan Jussibaliyeva.

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Evaluating Public-Private Partnership Dynamics: the Kazakhstan Toll Road Case

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Abstract

The holistic collaboration between the government and business through public-private partnerships (PPPs) is crucial in developing economies in transition. With the help of the PPP mechanism, emerging economies realize new and maintain existing social and economic infrastructure projects in education, energy, transportation, and healthcare. This lessens the funding burden on the state budget and attracts private investment and expertise into the economy. However, one of the critical tasks is to engage a suitable private partner with whom a long-term relationship can be built for mutual benefit. The most vital issue in establishing and maintaining the PPP collaboration with such a partner is related to the appropriate management of business risks. This study focuses on the success of an infrastructure project for a private partner by analyzing the critical risks inherent in PPP projects. The research uses system dynamics (SD) modeling, which qualitatively and quantitatively determines how each risk affects the project realization. The study examines the largest PPP project in Central Asia, the Big Almaty Ring Road. This toll road project is taken as a case to demonstrate the impact of the most critical risks on the success of the PPP projects. For the simulation, the "hard tolls" form, which is one of the popular payment mechanisms in the global PPP practice, is considered where the private partner bears most of the risks. The findings show the riskiness of such a payment mechanism in implementing toll road projects with existing traffic and tariffs under conditions of uncertainty typical for Kazakhstan and other similar developing countries.

Keywords: Economics, Economic Infrastructure, Project Management, Public-Private Partnership, Risk, System Dynamics, Toll Road

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1. INTRODUCTION

Attracting private investment and resources through public-private partnerships (PPPs) is becoming an increasingly popular method of infrastructure development in developing countries (Wang et al., 2019; Charman & Narbaev, 2017). This practice of long-term partnership between the government and private business allows to reduce the budget load on the government, successfully manage socially essential projects, and increase efficiency in the renovation and maintenance of infrastructure facilities due to the professionalism and experience of the private sector (De Marco & Narbaev, 2021). Also, implementing infrastructure projects through the PPP mechanism allows for the most optimal distribution of risks among all participants in implementing PPP projects (Castelblanco et al., 2024). Therefore, proper qualitative and quantitative risk assessment in long-term PPP projects at the project negotiation stage plays a crucial role in risk allocation between private and public partners, where traditional risk assessment methods may not always be practical (Boateng et al., 2012).

In Kazakhstan, PPP was enacted in the early 2000s to attract private financing, build management capacity, and fill a niche in the infrastructure development gap (Law on PPP, 2015). As of January 01, 2023, there are 1,244 PPP projects in the country (of which are being implemented – 1055, at the bidding stage – 189) valued at 2,522.4 billion tenges. Most of these projects are in the social sector, including education, healthcare (hospitals, sports, and recreation centers), housing and communal services, and large-scale transport and road infrastructure projects. To stimulate PPPs, the state is implementing several strategic initiatives. For example, under the initiative related to the establishment of competence centers for Industry 4.0 of the strategic development plan of the Republic of Kazakhstan until 2025 (Kazakhstan PPP Center, 2023), the government plans not only to modernize economic infrastructure with local and foreign developer companies but also based on this infrastructure, to create competence centers to facilitate further industrial production. In addition, under the initiative related to the development of PPP and attraction of private investment into education, it is planned to create new or modernize existing infrastructures in education. The most important strategic document of Kazakhstan, Strategy "Kazakhstan-2050" (Akorda, 2012), in addition to the above, aims to improve entrepreneurship and increase the competitiveness of the local market through PPPs.

However, the management of PPP projects encounters multiple risks, such as inefficient project delivery, immature regulatory framework, poor concessionaire selection, complexity in attracting investment, lack of government guarantee, and vague technical-economic specifications of projects (Narbaev et al., 2020). In addition to such poor risk management, the government and PPP participants do not adequately consider the capabilities of critical success factors, which can increase the successful completion of PPP projects.

The current study aims to analyze the risks peculiar to PPPs in delivering infrastructure projects. To achieve its purpose, the study employs the system dynamics (SD) modeling, which helps to understand the risk dynamics. The SD method is a simulation approach to model the risks pertinent to the PPP projects. SD, created at MIT in the 1950s by Jay Forrester, is a method of computer modeling complex systems' actions and behavior. It studies the dynamic relationships of constantly changing variables, flows, and levels linked by feedback loops, constituting a system of circular causes and effects (Sterman, 2000). The case of the toll road project from Kazakhstan is used to demonstrate the applicability and practicability of the proposed model.

The concession agreement for the toll road case project included an "availability payment" mechanism, where the government bears the risks for user demand and the optimal tariff. On the other hand, this study using SD will examine the risks for the SPV under the scenario of

implementing the "hard tolls" mechanism to demonstrate the project's profitability for private investors in a specific investment environment.

The study brings original contributions to the PPP literature. The proposed methodology, based on the SD simulation, can be used to solve the problems related to a comprehensive assessment of risks, which would enhance the likelihood of the successful completion of PPP projects in developing countries. The study models can help assess the impact level of various risks for the more effective operation of a particular purpose vehicle (SPV) company in delivering PPP projects. In such large projects, the consortium members establish an SPV, which manages all processes at all stages of PPP project delivery, assuming financial, legal obligations and risks under the signed concession agreement (Mittal et al., 2023).

The paper is structured as follows. Next, the pertinent literature on PPPs and SPV performance risks is reviewed. Then, the study methodology is presented, including the toll road PPP project case, the selection of the risks for the study, and the input data for the SD simulation. The following section presents the simulation results and discusses the study's main findings. Lastly, the conclusion section summarizes the study and highlights the future research directions.

2. LITERATURE REVIEW

In the last decade, there has been an increase in research in PPP in social (economics, finance, public administration, project management) and engineering (construction engineering, transport engineering) sciences, both globally (Chou & Pramudawardhani, 2015; Osei-Kyei & Chan, 2015; Hodge & Greve, 2017; Narbaev et al., 2020) and in Kazakhstan (Chikanayev, 2016; Mouraviev & Kakabadse, 2017; Oinarov et al., 2019). The international academic experience suggests that the three main areas of research in the field circumvent the assessment of risks and critical success factors for effective risk allocation between the owner (public authority) and the private partner (Bing et al., 2005). Also, the literature emphasizes the need to study an SPV organization's economic and management aspects. In this regard, the SPV organization is responsible for constructing and operating a PPP infrastructure project, therefore allowing for the successful completion of a PPP agreement with the government.

The most critical research issue in the literature was understanding the nature of PPP project risks. So, the study by Boateng et al. (2012) examined the main social and environmental risks affecting the construction of megaprojects using the Edinburgh Tram Network project as an example through a case study. In their empirical study, Nasirzadeh et al. (2008) analyzed risks in construction projects using SD modeling.

Second, the emphasis was on critically analyzing critical success factors in PPPs. Ahamd et al. (2018) studied successful PPP projects in Malaysia and noted that some of the essential issues for SPV are meeting construction deadlines and not exceeding construction and operating costs. Meeting construction timelines is significant because cash flow for the SPV as user fees starts when the facility is commissioned. At the same time, debt repayments must be made at a particular time, regardless of the start of service delivery. Cost overruns or high operating costs (which may result from design errors or poor-quality construction) also significantly impact cash flow and profitability, as the SPV bears all additional fees and is usually not reimbursed by the owner.

Lastly, another line of research was around understanding the successful operation of the SPV organization, which is the primary stakeholder in the PPP agreement with governments. To understand the vital critical tasks of an SPV, Sainati et al. (2020) investigated economics and management functions in delivering infrastructure megaprojects. Conversely, Alasad and Motawa (2015) analyzed large PPP infrastructure projects that did not achieve the expected outcome. A 3.6 km long tunnel project in Sydney (Lane Cove Tunnel) was found to be

unprofitable and sold to a new operator after three years. The reason for the loss was low traffic, with approximately 50,000 actual users against 120,000 in the original estimates. Another example is Sydney Cross Tunnel, which opened for general tolling in August 2005 and was declared insolvent in December 2006. Actual traffic was 30 percent less than the original forecasts.

Among the approaches used to understand the dynamics of PPP project realization, SD modeling, which involves a simulation, has received significant attention (Alasad et al., 2013). This tool is widely used in modeling complex economic and business systems such as infrastructure projects and megaprojects (Boateng et al., 2012). For example, Castelblanco et al. (2024) proposed an SD framework with causal diagrams of Kazakhstan's PPP portfolio as a closed-loop system where different variables, such as social attractiveness, economic growth, and infrastructure shortage, interact. The authors noted from the analysis that private investors submit most PPP projects as unsolicited proposals, which may not meet the needs and direct interests of the public partner. Also, using the SD approach, an analysis of the real estate market of Almaty was undertaken, where Jumasseitova et al. (2023) found that such factors as economic growth, infrastructure development, demographic dynamics, government policy, and bank interest rate critically influence the real estate market and housing costs.

Our brief literature review of the PPP market shows a lack of knowledge to investigate risks and critical success factors, specifically in emerging markets like Kazakhstan. There are also insufficient studies at the micro-level (aimed at studying the SPV company itself and the PPP project), in contrast to studies at the macro-level (PPP market analysis, PPP public administration issues). Therefore, in the current paper, the SD approach is used to close this research gap and bring an original contribution to the PPP literature by understanding the relationship between various risks and critical success factors that can have a positive or negative impact on the success of the SPV company which realizes a PPP project. In the long term, a proper understanding and management of risks and critical success factors in delivering social and economic infrastructure contribute to the economic development of a country. The expected economic effects can be related to a more rational use of budgetary funds, a reduction in the financial burden on the government, the adoption of foreign experience in PPP management, and the implementation of projects on time and within the budget.

3. Methodology

The toll road case

The Big Almaty Ring Road (BAKAD) project was selected as a case study to implement an SD modeling to analyze the risks. An SPV organization investigated in this study is the BAKAD Investments and Operations LLP, established by a Turkish-Korean consortium (Alsim Alarko, Makyol, SK Ecoplant, Korea Expressway) to manage the project. In February 2018, a 20-year concession agreement was signed, which included the construction and operation phases of the project. The BAKAD project is the first PPP infrastructure megaproject in Kazakhstan and Central Asia in the form of a concession agreement (Smagulova et al., 2023). It is a 66-kilometer toll bypass road encircling the city of Almaty from west to east on the northern side and is part of the Western Europe-Western China trans-Eurasian transport corridor. The purpose is to increase international transit traffic while relieving the city's streets of lorries, reducing traffic jams and thus improving the environmental situation (Nugmanova et al., 2019). According to the studies, infrastructure megaprojects are an ideal subject for investigating risks and critical success factors influencing the success of a PPP project (Sainati et al., 2020).

The main inputs for the study modeling are the following: length of the road - 66 km (4-6 lanes), including interchanges bridges; project cost - $750 mln; concession period - 20 years (5

years construction, 15 years operation); construction cost - $540 mln; concession agreement type - Build-Transfer-Operate (BOT); public partner - Ministry of Transport of the Republic of Kazakhstan; private partner – the SPV, the BAKAD Investments and Operations LLP; lenders - the European Bank for Reconstruction and Development, the Islamic Development Bank, the Eurasian Development Bank; the consortium own funds - $165 mln (circa 22%); borrowed funds - $585 mln (circa 78%).

The major milestones of the project are the signing of the concession agreement (07.02.2018), the establishment of the SPV (28.06.2018), the operation and maintenance agreement (27.05.2020), financial close (11.08.2020), completion of construction (31.03.2023), and the BAKAD case into operation (15.06.2023).

Selection of the risks

The risks for the study were taken from the recent survey of Serikbay et al. (2023), who routinely studied the impact of risks on PPP projects in Kazakhstan. They analyzed the risk based on a survey of PPP practitioners from the private and public sectors and academics who previously published studies on PPPs. They identified the top 10 most critical risks for PPP projects in Kazakhstan (Table 1). The detailed methodology of their survey, risk analysis, and risk ranking are thorough in their paper. For the current study, the authors selected five risk variables: exchange rate fluctuation, inflation rate fluctuation risk, construction cost overrun, high financing cost, and change in demand.

TABLE 1. Top 10 most critical risk factors in PPPs in Kazakhstan

Risk rank	Risk name
1	Exchange rate fluctuation
2	Inflation rate fluctuations
3	Delays in approvals and permits
4	Changes in legislation
5	Poor decision-making by the government authority
6	Construction cost overruns
7	High cost of financing
8	Political interference
9	Interest rate fluctuations
10	Corruption
Note: compiled by authors Serikbay et al. (2023)	

The SD model inputs

Appropriate risk allocation and sharing are critical success factors affecting the efficiency of an SPV, among which the most crucial role is played by the chosen mechanism of payment and return of private partners' investments and financial obligations. Therefore, Burke Demirag (2019) emphasized three payment mechanisms for an SPV. They include the one based on: "availability payment", where the government bears the risk of demand and there is no additional income; "shadow payments", where each toll is paid from the state treasury (the risk of demand lies either with an SPV company or the state); and "hard tolls", where an SPV company bears the risk of demand and there is an opportunity to receive additional income (by increasing traffic or fares).

The authors limit the scope of the current study, considering the scenario based on the "hard tolls" only. In this model, the private partner bears all financial and economic risks. The most likely risks in this model for the private partner are exchange rate fluctuations that affect construction costs, repayment of borrowed funds, and risks related to user demand. Low traffic may be due to incorrect calculations in forecasting at the planning stage, high toll costs that do not compensate for time and fuel costs, and the availability of alternative travel options. Proper estimation of demand and, consequently, future traffic is a success factor that is essential for a private partner in such a toll collection mechanism. All data for modeling, such as the number of users (only two tariff types were used instead of 6), traffic growth, fare, exchange rate, and payment index, were taken from public sources.

The data for the five risks were taken from open sources or privately from the SPV company upon their agreement to use the data for research purposes only. The exchange rate of the US dollar, one of the currencies used to make settlements in the BAKAD project, was taken based on the National Bank of Kazakhstan exchange rate statistics from 2018 to 2023. The BAKAD toll included a tariff of 0.07 of one payment index (the monthly estimated rate) for passenger cars and 0.14 of one monthly estimated rate for trucks, KZT241.5 and KZT483.0 for 2023, respectively. The model includes two tariffs for the main modes of transport (passenger car and lorry). The forecast on tariff growth is based on the dynamics of the payment index growth from 2018 to 2023, which is an average annual increase of 1.075.

The Vensim software, released in 1990 by Ventana Systems and with a circa 54% market share among simulation software in the systems thinking field (Kedir et al., 2023), was used to create the simulation models. Vensim provides a graphical simulation interface with stock, flow, and cause-and-effect diagrams. It is user-friendly and allows, when running a simulation, a real-time visual representation of system changes and the behavior of individual elements as variables change.

4. Results and Discussion

The model incorporates a dynamic pricing strategy for toll collection, aimed at optimizing revenue generation while maintaining affordability for users. Figure 1 shows the model with the SPV's mechanism for charging users of the BAKAD tolls, the "user fees" or "income from tariff" scenario.

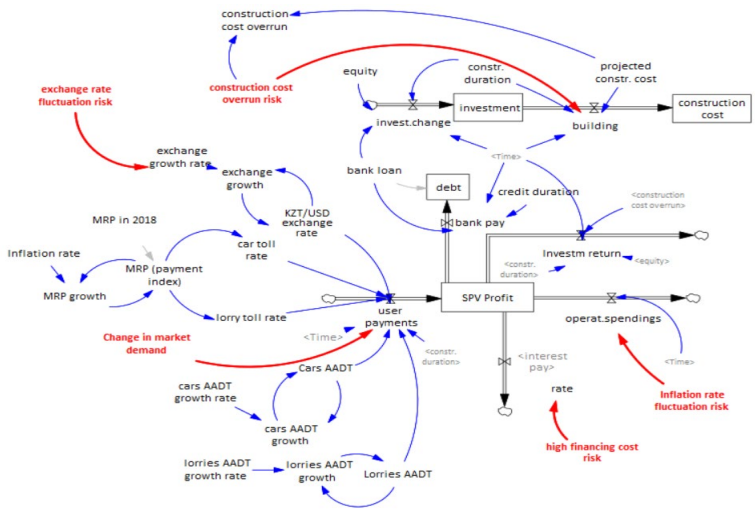

FIGURE 1. SD diagram of the SPV efficiency model under the mechanism of "charging tariff to users"

Note: compiled by authors

In the simulation model with a tolling mechanism, where the SPV charges the toll road, the selected risks (construction cost overruns, fluctuations in inflation, changes in market demand, exchange rate fluctuations, and high financing costs) impact the SPV's performance.

Figure 2 shows how each risk affects the project's profitability.

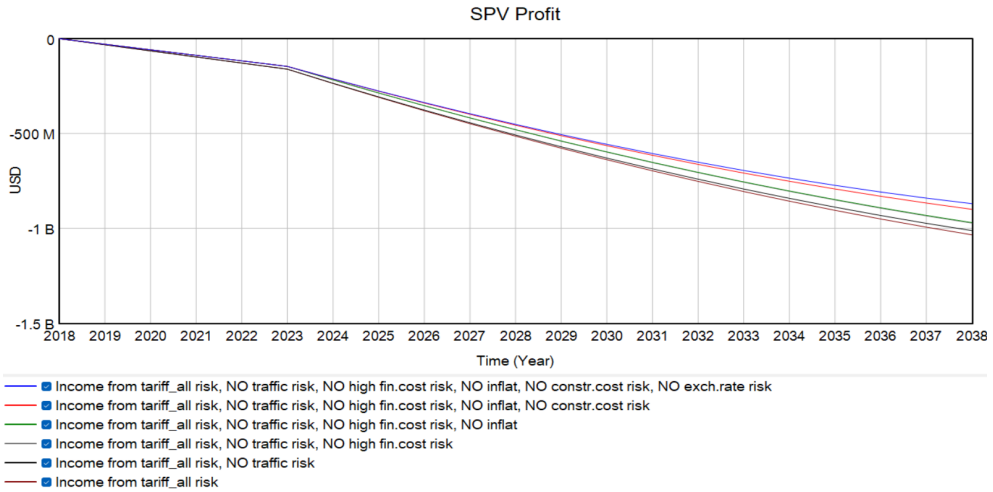

FIGURE 2. Impact of risks on SPV profit

Note: compiled by authors

When each risk is removed from the model, its effect on the variables is canceled. The success rate of the SPV increases. However, the break-even point of the project has still not been reached. This model, even without all risks, is inefficient due to low traffic and insufficient tariffs. From the model with negative development, where all the risks given in the model will have an impact, the SPV will not be able to cover its obligations to creditors banks due to the shortage of cash due to the projected traffic and actual tariff. Two factors affect the increase in toll road revenue: the annual average daily traffic (AADT) and the increase in the toll rate.

For the SPV to break even (Figure 3), the simulation shows that annual traffic growth must be increased from the projected 5% to 16%.

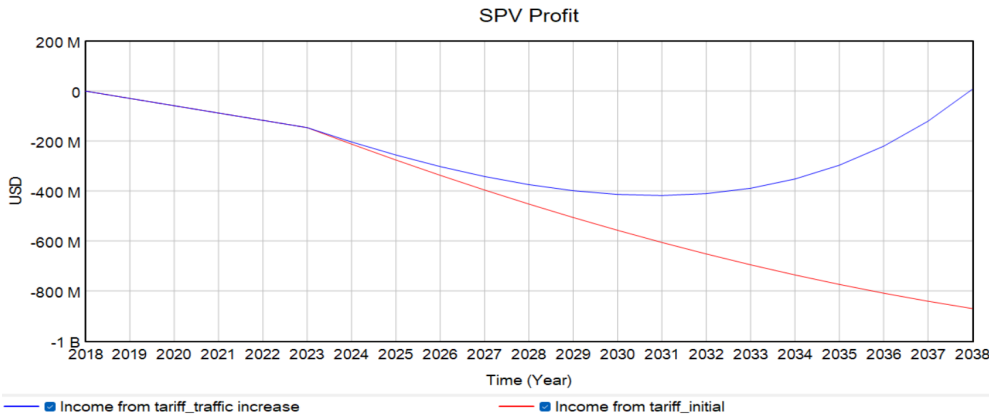

FIGURE 3. SPV profit graph when annual average daily traffic grows by 5% and 16%

Note: compiled by authors

This simulation shows that for the project to be profitable (without changing the tariff increase dynamics), the total BAKAD users, including all modes of transport, should reach approximately 872,000 vehicles per day by 2038.

In the model where a toll rate increase is required for the project, the simulation showed that an annual toll increase of 20.0 percent was needed (Figure 4). Considering the dynamics of payment index growth from 2018 to 2023 (1.075 per year), the estimated base fare 2038 will be 718 tenge per passenger car and 1,435 tenge per lorry. According to the simulation, for the effective operation of the SPV in 2038, the passenger car fare should increase from 718 Tenge to 6,410 Tenge and the lorry fare from 1,435 Tenge to 12,820 Tenge (Figure 4).

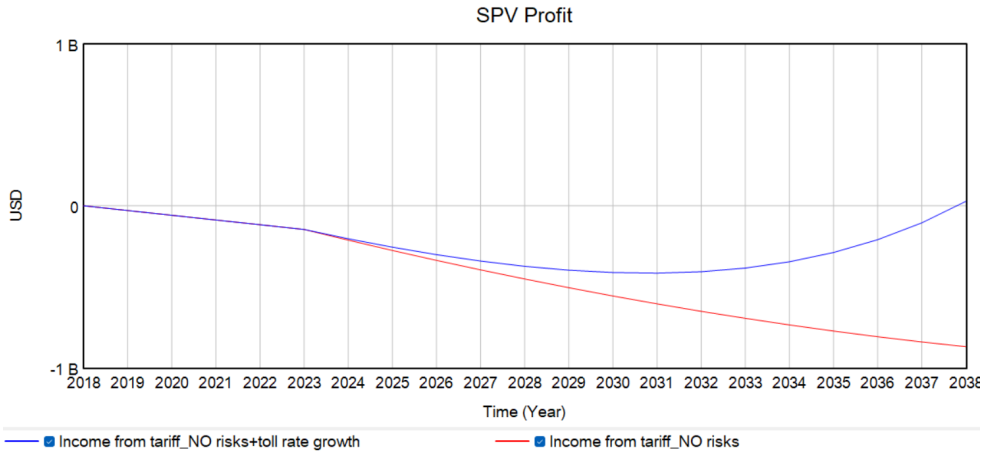

FIGURE 4. Graph of SPV profit with annual tariff increase by 20%

Note: compiled by authors

The SD model showed that with the current tariff and the predicted traffic of the toll road, such a project could not be attractive for private investment due to the risk of not covering its debt obligations in the presence of critical risks, such as unsatisfactory demand from users, currency and inflation fluctuations, excess construction costs. The simulations demonstrated that increasing the tariff and the number of users is necessary for the project's profitability. Thus, the simulation of an increase in the tariff required for the profitability of the project showed the need to increase the tariff by 20 percent annually instead of 7.5 percent included in the project, which will undoubtedly affect the attractiveness of this road, demand from motorists, and the choice of alternative routes. Also, the simulation of the traffic growth necessary for the profitability of the project showed the need to attract toll road users to ensure continuous annual traffic growth of 20 percent instead of the projected 5 percent, which, given the demographics of the Almaty conglomeration and the number of cars in it, shows that this scenario is unlikely.

5. Conclusion

This study analyzed the risks typical to infrastructure PPP projects in developing countries, using the toll road infrastructure case by modeling the “hard tolls” payment mechanism. The SD

simulation model considered the five risks from the comprehensive study conducted earlier in the PPP area in Kazakhstan. The paper considered the data on the cost and duration of construction, liabilities, traffic, tariff, growth forecasts, and other indicators necessary for the equations from the reports and other open sources. The SD modeling addressed the profitability of the SPV under the "hard tolls" mechanism if the project partners had chosen it as a return on investment.

Using available data from open sources for computer modeling, this study demonstrated the financial insolvency of a payment mechanism where the private partner covers its investment, debt, operating, and maintenance costs by collecting tolls from road users. The simulation showed that a 20-year concession, where five years are spent on construction (investment) and 15 years on operating (return on investment), is not enough to cover all the liabilities and costs of the private investor.

This study has shown the importance of adequately allocating all critical risks among all partners of a PPP project where private capital and a long-term return on investment are expected. Given the high probability and impact of financial risks (currency fluctuations, low traffic, high bank rate, and inflation) in Kazakhstan's economy, accepting such risks will incur additional costs for the private partner. This, in turn, will lead to an increase in the project's price, and where the transfer of these risks to the public partner can be an alternative in the current investment climate and uncertainty.

Since the current study only addressed the analysis of project success under the existing risks in the "hard tolls" mechanism scenario, further research will address the scenario under the "availability payment" mechanism. It is noted that this scenario is the actual mechanism of payments to the SPV company by the government in the BAKAD project used currently. Also, future researchers and SD practitioners can explore the "shadow tolls" mechanism in PPP projects and highlight all the risks and success factors for SPV, considering the flexibility of the distribution of responsibility between public and private partners under this payment mechanism.

AUTHOR CONTRIBUTION

Writing – original draft: Andrey Samoilov, Timur Narbaev, Gabriel Castelblanco.
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Software and supervisions: Andrey Samoilov, Timur Narbaev.
Data collection, analysis and interpretation: Andrey Samoilov, Yerzhan Mukashev.
Visualization: Andrey Samoilov, Gabriel Castelblanco.
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