Using Supply Chain Management Strategy for Regional Economic Clusterization in Kazakhstan's Chemical Industry

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***Abstract*- This article develops an approach to forming innovative development clusters in Kazakhstan's chemical industry as an opportunity to promote the effectiveness of the sector's development and to increase its competitive advantage based on the supply chain management. An expert evaluation method is used to form a system of indicators for assessing innovative development in the country's regional chemical industry. A scaling technique was also incorporated to distinguish these clusters according to the quality levels of innovative development among the chemical industry regions in a modern context, with industrial gas production as an example. Two chemical clusters of innovative development in Kazakhstan's regions were formed though a cluster analysis – and their economic efficiency substantiated – using multivariate linear regression modeling. The efficiency from creating Chemical Cluster No. 0 for innovative development indicates that its total regional product would grow by 0.68%, while Cluster 5 exhibited an efficiency of 4.23%. The presented methodological approach is based on a horizontal integration of the manufacturers and suppliers of chemical products, and considers specific characteristics of the industry's operation; this allows for the creation of chemical clusters with highly efficient communication in the innovation process. The research findings contribute to modernizing the country's chemical industry and increasing its competitive capacity in the international market.**

Keywords- *Chemical industry, supply chain management, cluster analysis, innovative activity, innovative development.*

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1. Introduction

The chemical industry is a fundamental branch in modern economy of the Republic of Kazakhstan (RK). This industry's products are widely used to manufacture various consumer goods, and are used in virtually all other areas in the country's economy [1]. Chemical products are considered among the most promising business avenues in the RK due to high demand in both domestic and foreign markets. Chemical manufacturers' profits grew 30.3 times from 2013 to 2017, while the number of industrial facilities increased by 22% and the chemical production output increased by 79.2% over the same period [2, 3]. The nation's "Kazakhstan-2050" supply chain strategy strategy indicated Kazakhstan's ambition to be among the top 30 industrialized countries in the world that mainstream the chemical industry to further their goals [4].

The RK has vast natural resources, and ranks among the top 20 raw hydrocarbon producers worldwide. Simultaneously, 94% of the country's necessary petrochemical products are imported, which indicates a high potential for the industry's development in the country. Additionally, Kazakhstan has the opportunity to not only manufacture petrochemical products to meet its own needs, but also to export them to foreign markets. The petrochemical and energy industries are known as the country's priority areas; according to the [2], the investment in fixed assets within the petrochemical industry increased by 22% from 2012 to 2018, contributing to the industry's competitiveness. Moreover, Kazakhstan has all the necessary preconditions for its development: abundant natural resources, experience in manufacturing traditional chemical product types, and domestic chemical sciences educational facilities. In 2017, chemical products dominated mutual trade between Kazakhstan and the Eurasian Economic Union (EAEU) member states. However, the total import volumes of chemical products in Kazakhstan are nearly four times the export volumes [5]. While the assortment of chemical products that the RK exports and imports is largely similar, the imported chemical products include those not manufactured in Kazakhstan, indicating a relatively narrow range of products manufactured by the domestic chemical industry [6]. However, the imported chemical products have a high added value, in that the value in their degrees of processing far outweighs the Chemical products Kazakhstan exports [5]. Overcoming this trend is a primary objective of the State Program for Industrial and Innovative Development of the Republic of Kazakhstan for 2015–2019 [2]. Given the dominance of imported chemical products in Kazakhstan, the industry is also characterized by a low degree of competitiveness in the global market, driven by increasing pressure from the Russian Federation, the United States, Saudi Arabia, India, China, Qatar, and other countries; this creates a special environment to develop chemical production and enhance exports of chemical products [5]. A high degree of equipment wear also occurs in the chemical industry. The effectiveness of the chemical industry's innovative activity is primarily determined by its innovation infrastructure [7]. Therefore, innovation infrastructure is a basic component of innovation development and the forming of innovative potential. Based on introduction of new ideas, scientific knowledge, technologies, and types of products in various areas of production and management, the innovation infrastructure forms systems that include the most important factors in the chemical industry's development [7]. However, in a modern context, Kazakhstan's chemical manufacturers exhibited levels of innovation passivity amounting to 84.8% as of 2017, while the volume of the industry's innovative products was only 21.4 billion tenge, or 6.4% of the sector's total output [2]. Poor manufacturing standards in terms of creating innovative, science-intensive, and high-technology products as well as technologies to decrease production costs have led to the search for new approaches to the development of Kazakhstan's chemical industry in a modern context. Given that [8] forecasts that the chemical industry's market will double by 2035, and developing countries will remain engines for global growth – for example, 53% of global sales will come from emerging markets by 2020 – it becomes particularly relevant to establish a foundation for innovative development in Kazakhstan's chemical industry. The cluster approach to managing the manufacturing sector's development provides a new alternative to traditional sectoral industrial policy, which is also reflected in the nation's Concept for the Formation of Promising National Clusters in the Republic of Kazakhstan Until 2020 (2013). In the modern global economy, the cluster approach substantiates companies' economic strategies and policies and increases their competitive capacity. Specifically, these clusters establish a foundation for economic development in virtually all industrialized countries [9, 10, 11]. The urgency of cluster creation is increasing in a climate of competition among participants, who aim to gain access to new technologies and market niches. This technique provides for the coordination and integration of participants' financial and investment resources to create new products and ensure economic efficiency in their financial and operating activities [11, 12]. Consequently, a cluster activity, with its coordinating economic agents, is a diffusion of innovative activity [13]. Therefore, clusters as innovative growth points may establish the foundation for an innovative system in both the national and regional economies, as well as in Kazakhstan's chemical industry [14]. This study develops an approach to clusterization in chemical industry regions within the RK to increase the efficiency of the industry's innovative development. The study addresses the following issues through scientific inquiry: the justification of a system for the clusterization of Kazakhstan's chemical industry regions and indicators of innovation development; the classification of chemical clusters by levels of innovative development indicators among the RK's regions by considering the specific characteristics of the chemical industry's operations; the substantiation of expediency in forming innovative development clusters in the RK's chemical industry in a modern context; and the assessment of the formed chemical clusters' economic efficiency.

2. Literature review

Studying clusters has a key place in recent literature [15-23]. Further, the process of globalization has influenced regions' role in national economies, and these regions are currently economic actors who actively participate to enhance their competitiveness. They gain "positive dynamics of regions' development and new job formation" [24, 25, 26]. Many studies explain why and how cluster systems favor the development of innovation in enterprises and firms [27]. Frequently, regional competitiveness is grounded in the concept of clusters because they are regarded as a significant factor in innovative development [28, 29, 30]. They often positively influence not only the regions in which they are formed, but also the country as a whole. Innovative development is often based on a maximization of the regional entity's inner economic potential, in certain cases due to the state's participation in research and technology innovation by creating technology parks and incubators. Forming cluster systems improves the interconnections between business entities and provides a new motivation toward regional development. Authors analyzing clusters' impact on firms' innovation performance reveal "who benefits the most and how and why they benefit, how companies access and use external knowledge within their clusters to generate and develop innovative projects" [27]. Scientific works dedicated to cluster analysis indicate that modelling is a key method to investigate this issue [28]. Cluster models are used to ensure the economy's competitiveness and demonstrate the effectiveness of regional strategies as well as their advantages and disadvantages. A spatial network model can be built and applied as a leading method to elaborate upon competitive enterprises' integration in clusters. Further, a model to comprehensively evaluate regional-level clustering potential assumes the application of "a method of calculation and analysis of the parameters relating to production and resources, manpower, investment, and financial potential". This also considers the possibilities of cluster formation in certain regions and industries.

Clusters form to manage and improve the sustainable development of different industrial sectors within regional innovation systems [27], for example, in the telecommunications and tourism industries [18], among enterprises in the petrochemical sector, and in the automotive and aviation industries. Research has also considered the advantages of using the cluster approach in creating inter-industry connections. Thus, building cluster linkages is important. Literature has reviewed inter-cluster connectedness from social, geographic, and sectoral perspectives by considering "mechanisms and potentialities; coopetition or cooperation; network relationships" [27], as well as opportunities and forms of further economic integration. In some cases, regional leaders and outsiders can be identified. It is necessary to mention that "the level of clustering may differ depending on the life cycle of the sector in question." The main techniques for identifying clusters in Europe, the United States, and Russia primarily involve either qualitative or quantitative methods. [27]. Previous studies confirm that the formation and further evolution of regional clusters provide certain advantages for the regional economy, among which are the creation of new job locations and new product types, the development of a regional infrastructure, improvements in various levels of research and development. Further, "the social and business networks binding firms in clusters are excellent vehicles for the flow of knowledge that eases innovations, but different types of clusters may lead to different outcomes" [15]. Clustering systems promote long-term relationships and direct contact, and allow enterprises and firms to rapidly identify new technological possibilities. Clusters also improve firms' access to information, knowledge, and other institutions [27]. Many studies confirm the theory that clusters can influence their members' long-term development in global markets [13, 25]. This proves that international clusters are another subject of innovation policy. Considering international economic globalization from the cluster system perspective "appears to be one of the main components in the growth of the competitive capacity of enterprises in a region" [15].

3. Materials and methods

This study uses the expert method to create estimates based on the opinions of experts on Kazakhstan's technological development; the scaling technique to obtain the numerical characteristics to assess the clusterization indicators of Kazakhstan's regions; the multidimensional cluster statistical procedure to collect data about a sample of objects and to arrange these objects into relatively homogeneous groups; and a regression analysis to detect the most important factors that affect the dependent variable. The multidimensional cluster analysis method was used to divide the values of indicators describing the RK's regional innovative development into innovating cluster levels and definitions. The cluster analysis principle ultimately involves the search for such a combination of clustering objects to minimize the values of Euclidean distances between the objects included in one cluster, as in Equation (1):

$$d_{ij} = \sqrt{\sum_k^n (x_{ik} - x_{jk})^2}, \qquad (1)$$

where d_{ij} is the distance between the ith and jth objects;

x_{ik} is the value of the *k*th indicator of the *i*th object; and

x_{jk} is the value of the *k*th indicator of the center of the *j*th cluster.

A cluster is a group of geographically adjacent, correlated objects with the same dynamics of development [9, 10]. The first principle of clustering is geographic proximity, which ensures economic efficiency. If clustered, non-adjacent areas increase the costs associated with production, such as transportation and other related costs, thereby decreasing the cluster's efficiency. Low labor force mobility also negatively affects the potential for cluster formation with non-neighboring regions. The second clustering principle involves the same dynamics of development, which are important in public policy for regional development, as regions of diverse development require different government measures to support and encourage them. The expert method was used to assess the feasibility and thoroughness of using indicators to define innovative clusters. Accordingly, the authors determined the total points for each indicator as provided by 10 experts who were representatives of the National Agency for Technological Development of the RK; a scale from one to five was used to represent the feasibility of using a particular indicator in the analysis. The higher the score the expert gave, the more appropriate it was to include the indicator in the analysis. The thoroughness of indicator use was similarly determined, although this was done at an aggregate level and not for each indicator individually. The validity of the results of the expert method was determined by the experts' proficiency level and a concordance coefficient. The experts work for the National Agency for Technological Development of the RK, which engages in innovation popularization, professional expert and brokerage support services for business technology transfer, and finances innovation grants and business incubation. The experts determined that all proposed indicators had high feasibility and thoroughness. The concordance coefficient value of 0.88 indicates consistency in their opinions. The expert opinions' consistency level was assessed by the concordance coefficient as calculated in Equation (2):

$$W = 12 \times \frac{s}{[m^2 \times (n^3 - n) - m \times t_e]}, \qquad (2)$$

where *m* is the number of experts;

n is the number of indicators;

s is the quadratic sum of the ranked differences (or the deviation from the mean); and

t_e is the sum of the ranks' same values.

The concordance coefficient can vary in the range of 1 > W > 0; if W = 0, this indicates no consistency among expert opinions, but W = 1 indicates absolute consistency, and consistency is high with W ≥ 0.5 (Ponto, 2015). A scaling technique was used to determine the qualitative level of feasibility and thoroughness in using these indicators. A Fibonacci scale was incorporated to reveal the levels of the indicators under study, as in Formula (3):

$$\begin{cases} e_1 = e_{min} + 0.38\left(e_{max} - e_{min}\right) \\ e_2 = e_{min} + 0.62\left(e_{max} - e_{min}\right) \end{cases} \qquad (3)$$

where e_{min} is the minimum possible number of total expert points (0 points);

e_{max} is the maximum possible number of expert points (50 points);

$[e_{min}; e_1]$ denotes a low level of feasibility and thoroughness in indicator use;

$(e_1; e_2]$ denotes average feasibility and thoroughness in indicator use; and

$(e_2; e_{max}]$ denotes high feasibility and thoroughness in indicator use.

The Fibonacci scale was used to determine the qualitative levels of feasibility and thoroughness in using the innovative development indicators from Kazakhstan's chemical-producing regions, based on the lowest possible score of 0 and the highest possible score of 50. The scale indicates a total score range 0; 19 that equals a low indicator level, while 19; 31 is average, and 31; 50 is high. The authors also used a regression analysis to assess the economic efficiency of creating innovative development clusters in Kazakhstan's chemical industry. Generally, a multifactorial linear regression model follows the form in Equation (4):

$$Y = 1.11 \times X_1 + 1.37 \times X_2 + 0.95 \times X_3 + 0.52 \times X_4 - 0.01, \quad (4)$$

where Y is a standardized value of the gross regional product;

X_1 is the innovation concentration indicator;

X_2 is the production concentration indicator;

X_3 is the labor resources concentration indicator; and

X_4 is the financial resources concentration indicator.

The statistical significance of regression model (1) is indicated by a determination coefficient ($R^2 = 0.89 > 0.8$), which demonstrates that no multicollinearity exists among the independent variables of the model. Further, the F-ratio test has a higher calculated value than the tabulated (12.46 > 3.84), with no heteroscedasticity (t =2.306 > 0.81) is $i = 1,2, \ldots, N$.

3.1 Data

The horizontal integration concept considers the option of uniting Kazakhstan's chemical-producing regions, and was considered as a basis for constructing a cluster identification model. The analysis incorporated indicators of innovation concentration, chemical production concentration, and the concentration of labor and financial resources for 2017. The concentration of regional chemical production was calculated as the ratio of the total value of industrial gas production in a region under study to Kazakhstan's total industrial gas production. The labor resources concentration indicator was calculated as the ratio of the population in a region under study to the RK's total population. The financial resources concentration indicator is the ratio of the volume of fixed capital investment in a region under study to the RK's total fixed capital investment. As the research aims to define innovation clusters, the innovation concentration indicator was selected as the primary indicator for analysis, as this refers to the ratio of the value of innovation in a particular region to the total innovation in the RK. While innovation clusters can be defined, consolidated companies and regions operate only under the industrial principle that a region's innovative activity is determined by its chemical industry's production capacity. This implies that clusterization can also occur based on indicators reflecting production capacity, such as indicators of chemical production concentration; labor resources ensuring production support, or the concentration of labor resources; and the financial possibilities of expanded reproduction, or the concentration of financial resources.

The choice of structural (percentage) rather than absolute indicators in the analysis was determined by economic and mathematical necessity. Thus, in economic terms, using concentration indicators would allow one to rank the RK's regions by their contribution to the chemical industry's development, which involves determining priority areas to create regional clusters. From a mathematical perspective, using relative numbers reconciles variables and improves the adequacy of the developed models as well as the reliability of the obtained results. The regression model was built using statistical data from clustering indicators decomposed by Kazakhstan's regions for the period 2005 to 2017. A standardized value of the gross regional product was used as a response variable, while concentration indicators were used as independent variables [2; Kazakhstan Industry Development Institute, 2017).

4. Results

Table 1 presents the feasibility of using the indicators that most exhaustively describe the innovative development of Kazakhstan's chemical industry clusters based on an expert assessment. These experts determined that the proposed list of indicators has high feasibility and thoroughness (innovation concentration indicator: 50, production concentration indicator: 48, labor resources concentration indicator: 41, financial resources concentration indicator: 45). The analysis indicates seven regional clusters according to the full set of concentration indicators using the Deductor software program. The software also determined the median values by which to analyze Kazakhstan's chemical industry clusters. Figure 1 illustrates the ranges of indicator values for the clustering objects included in all clusters. As these ranges may partially overlap for various clusters, the three-level grading as presented in the below Table 2 was used to analyze concentration indicator levels. This table considers the concentration of the indicators of innovation, production, and labor and financial resources to determine it is expedient to distinguish three clusters, as this number of clusters minimizes learning, test, and control errors (ε → 0). This cluster analysis determines the indicator levels, as it enables an indicator to be divided not artificially into levels, but instead based on indicator values for different objects (regions), the differences in these values, and the concentration of facilities.

Table 1. Expert assessment of indicators to define the chemical industry's innovative development clusters

Significance indicator	Clusterization rate			
	Innovation concentration indicator	Production concentration indicator	Labor resources concentration indicator	Financial resources concentration indicator
The total score, indicating the indicator's feasibility in defining innovative clusters	50	48	41	45
% of maximum possible score	*100*	*96*	*82*	*90*
Indicator's qualitative level of feasibility	*High*	*High*	*High*	*High*
The total score, indicating the thoroughness of using this list of indicators to define chemical clusters	47			
% of maximum possible score	*94*			
Indicator's qualitative level of thoroughness	*High*			

Table 2. Chemical clusters in regions in Kazakhstan by levels of resource concentration indicators

RK Region	Innovation Concentration Indicator	Cluster	Production Concentration Indicator	Cluster	Labor Resources Concentration Indicator	Cluster	Financial Resources Concentration Indicator	Cluster
Akmola	0.0330	Low	0.0035	Low	0.0407	Low	0.0137	Low
Aktobe	0.0390	Low	0.0094	Average	0.0472	Low	0.0212	Low
Almaty	0.0491	Low	0.0034	Low	0.1111	High	0.0230	Low
Atyrau	0.0309	Low	0.0005	Low	0.0342	Low	0.4289	High
West Kazakhstan	0.0165	Low	0.0179	Average	0.0356	Low	0.0257	Low
Zhambyl	0.0323	Low	0.0022	Low	0.0615	Low	0.0138	Low
Karaganda	0.0864	Average	0.4301	High	0.0760	Average	0.0271	Low
Kostanay	0.0562	Average	0.0090	Average	0.0482	Low	0.0158	Low
Kyzylorda	0.0299	Low	0.0015	Low	0.0431	Low	0.0166	Low
Mangystau	0.0134	Low	0.0085	Average	0.0364	Low	0.0316	Low
South Kazakhstan	0.0545	Average	0.0277	Average	0.1613	High	0.2367	High
Pavlodar	0.0377	Low	0.0644	Average	0.0416	Low	0.0138	Low
North Kazakhstan	0.0387	Low	0.0023	Low	0.0308	Low	0.0084	Low
East Kazakhstan	0.1019	Average	0.3853	High	0.0762	Average	0.0209	Low
Astana	0.1957	High	0.0001	Low	0.0569	Low	0.0566	Average
Almaty (City)	0.1849	High	0.0343	Average	0.0992	Average	0.0463	Average

The cluster analysis of Kazakhstan's chemical industry regions in terms of innovation development indicators, which include the concentration of innovation, production, labor, and financial resources reveals three clusters: those with low, medium, and high levels of the indicator, respectively (Table 2). These clusters of innovative development in the chemical industry were identified using industrial gas production as an example, as differences in the indicator levels of innovative development in the chemical industry are most clearly evidenced with this number of regional locations; this maximizes intergroup dispersion, which indicates the cluster analysis' reliability. Figure 1 presents the clusterization results for all four indicators in the aggregate. The discrepancy between the number of clusters in Figures 1–3 and the number of clusters in Table 2 occurs due to the greater number of indicators. As the number of indicators increases, the more combination options for the indicator levels in terms of objects increases, and therefore, this increases the number of potential clusters.

The RK's chemical industry regions were then clusterized according to a set of innovative development indicators (Figures 1–3).

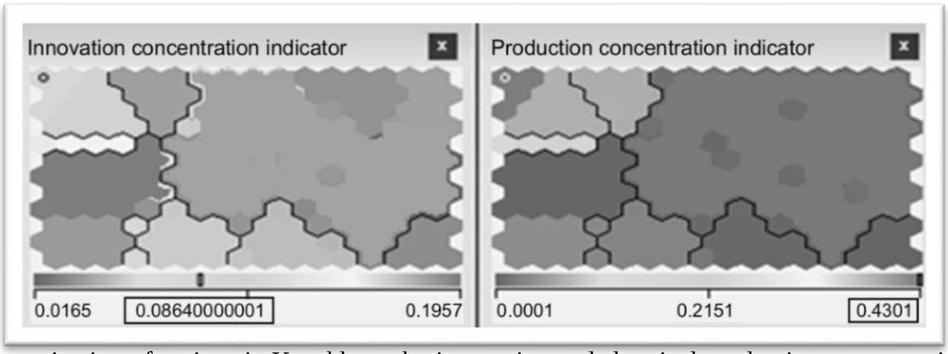

Figure 1. Clusterization of regions in Kazakhstan by innovation and chemical production concentration indicators

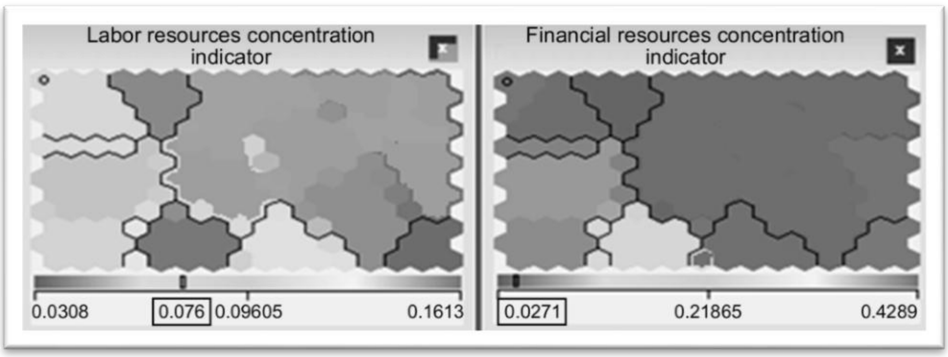

Figure 2. Clusterization of regions in Kazakhstan by labor and financial resources concentration indicators

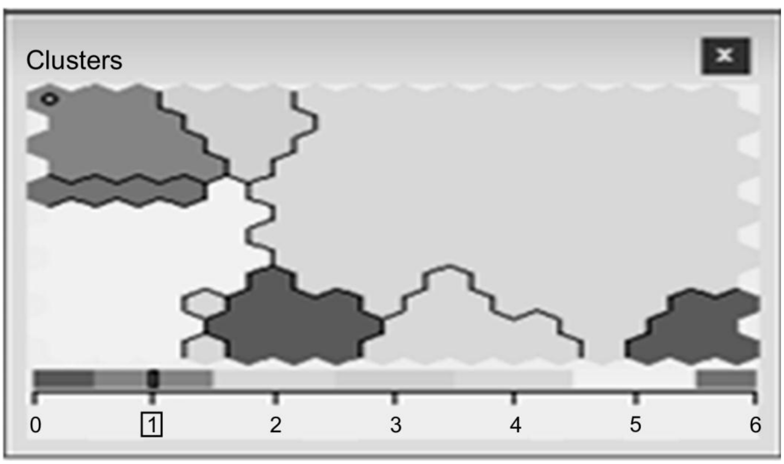

Figure 3. Clusterization of regions in Kazakhstan by innovative development indicators

Six homogeneous locations of innovative development within the chemical industry were allocated based on the RK regions' clusterization. Chemical Cluster 0 includes Karaganda and East Kazakhstan, regions with the strongest innovative potential for industrial gas production; they also have a sufficient (medium) level of innovation and labor resources. Geographically, they are neighbors, and cluster formation would thus develop the chemical industry effectively in these regions. Chemical Cluster 1 consists of the Almaty region, which has only high levels of potential labor. Chemical Cluster 2 is the South Kazakhstan region, which is self-sufficient, as it has medium levels of innovation and production development and a high level of concentration of labor and financial resources. Cluster 3 comprises the neighboring Akmola, Aktobe, Kostanay, and Kyzylorda regions; this proximity enables them to build partnerships. Regarding Chemical Cluster 4, all the development indicators for the city of Almaty are average, except for innovation concentration, which is high. The city has sufficient industrial, labor, and financial resources to develop such chemical industry sectors as industrial gas production. Chemical Cluster 5 includes the West Kazakhstan, Mangistau, Pavlodar, and North Kazakhstan regions. It seems feasible to unite the Pavlodar and North Kazakhstan regions due to this cluster's territorial remoteness. The formation of Chemical Cluster 6 seems impossible for the same reasons that characterize Cluster 5 (Table 3).

Table 3. Potential clusters of innovative development in Kazakhstan's chemical industry as of 2017

RK Region	Cluster Number
Karaganda	0
East Kazakhstan	
Almaty	1
South Kazakhstan	2
Akmola	3
Aktobe	
Kostanay	
Kyzylorda	
Almaty (City)	4
West Kazakhstan	5
Mangystau	
Pavlodar	
North Kazakhstan	
Atyrau	6
Zhambyl	
Astana	

Table 4 presents the calculation results for the indicators of efficient innovation development cluster formation in Kazakhstan. The efficiency of creating Cluster 0, comprising the Karaganda and East Kazakhstan regions, is 0.68%. Consequently, creating this innovative development cluster in the chemical industry will increase the two regions' total regional production by 0.68 %. The efficiency indicator for Cluster 3 is -38%, and thus, creating this cluster will decrease the gross regional product by 38%. The efficiency of Cluster 5 is 4.23% (Table 4). The empirical research indicates that it is economically feasible for the RK under these present-day conditions to create two innovative development clusters for the chemical industry: Cluster 0 in the Karaganda and East Kazakhstan regions, and Cluster 5 in the Pavlodar and North Kazakhstan regions

Table 4. Indicators of the efficiency of innovative development cluster formation in Kazakhstan's chemical industry

Innovative Cluster	Efficiency Indicator Value (%)
Cluster 0	0.68
Karaganda	
East Kazakhstan	
Cluster 3	-38
Akmola	
Aktobe	
Kostanay	
Kyzylorda	
Cluster 5	4.23
Pavlodar	
North Kazakhstan	

The manufacturers that form chemical Cluster 0 for the innovative development of industrial gas production include: Trek, LLP; Reg Eko, LLP, an engineering company; Uglesintez, LLP; JSC Temirtau Steel Plant, a chemical company; Reagent, LLP; JSC Kenzher; Intellprom, LLP; Nitrotekh, LLP; Skat MS, LLP; ZChM Khimzavod, LLP; Kaz-Optimum, LLP; Kaz-friz, LLP; Mining Industry Solutions, LLP; Kazsibvzryvprom, LLP; Tsentrkhim, LLP; Karmetallprom, LLP; 3G-Met, LLP, in the RK's Karaganda region; Irtysh Rare Earths Company, Ltd.; Radon+ LLP; Zhartas VK, LLP; Semkhimprom, LLP; Taiga, LLP, a territorial branch of Sorbent, Ltd.; Khivus, LLP; JSC Ulba Metallurgical Plant; Auta, LLP; Cap Kz, LLP; Concord Invest, LLP; and Aziya-z, LLP, in the East Kazakhstan region.

Cluster 5 consists of the following chemical manufacturers: Kazcoal, LLP; Yemelya Apeks, LLP; Tekoil, LLP; Tekhno 21, LLP, in the North Kazakhstan region; JSC Kaustik; Kazsoda, LLP; Berkut ST, LLP; Kerekukhim, LLP; Polikremniy, LLP; Polikhimprom, LLP; Pavlodar Plant for Industrial Chemistry, LLP; Production Association Ascor, LLP; Chemical Technology and Innovation, LLP; Khimprompavlodar, LLP; Fosforan, LLP; Aspan LTD-2, LLP; and Gumatprom KZ, LLP, in the Pavlodar region.

5. Discussion

These innovative development clusters were formed in the RK's chemical industry by considering the industry specialization among chemical manufacturers and the spatial interactions among different subsections of the chemical industry. Experience indicates that the chemical industry clusters' efficiency and operation depend on the efficiency of the interactions among them in the innovation process. In this regard, these chemical innovation clusters include industrial gas producers as well as the companies involved in gas sales, which consequently increases the clusters' economic efficiency.

Cluster formation and creation also involves the modernization of integration processes and cooperative economic resources among cluster participants. One specific feature of a cluster is the fairly wide range of activities performed by its constituent economic entities, which makes it difficult to record and evaluate the results of its operation not only across the entire cluster, but also individually among its members. Simultaneously, all organizational and administrative issues should be addressed in conjunction and compliance with the cluster's central goal, with the rational allocation of resources. The task of individually modeling the spatial structure of these territorial entities includes a set of connections, with all the elements of entities arising in the formed cluster's territory to contribute to innovative development across the chemical industry. This determines the locations, purpose, and siting of industrial and scientific infrastructure facilities. A competitive environment influences the interaction between the internal and external elements in a cluster, and this leads to the emergence of a synergistic effect that manifests as increased competitiveness as an economic entity by the cluster as well as its structural units.

The synergistic effect on regional production demonstrates that the presence of vertical and diagonal intercommunications between industrial gas suppliers and producers within a cluster, which are also part of a common value-added chain, makes them more competitive than companies located in regions with low clustering potential. Suppliers also benefit economically from cooperating with many manufacturers located within a small area (region). Coordination mechanisms should improve these chemical clusters' efficiency. Further, the regional differences observed in creating chemical clusters can be minimized by special coordination entities to implement innovative programs, establish fixed time limits for partnership agreements' terms of validity within cluster initiatives, and form key funding sources. Simultaneously, the government should have a differentiated approach to participating in the forming of chemical clusters within public research institutions, and establish framework terms – such as creating cluster development programs – to support regional cluster mechanisms. Framework programs can include both direct financial support (subsidies) and the creation of a preferential tax regime for enterprises that participate in innovative chemical industry development clusters within the RK. Choosing a cluster development strategy as a concept within the state's regional industrial policy would enhance the advantages of clusters formed by organizing industrial enterprises as "growth areas." This would also promote competitive companies into the world market, which is especially important in the context of ongoing globalization and increased international competition in the chemical industry.

Superficially, it seems possible to determine a chemical cluster's economic efficiency by summing the individual effects obtained for each innovative project as well as each enterprise developed and operating in the industry cluster, which appears to be one limitation in this study. However, this is not necessarily the case, as a chemical cluster is a more complex form of the development and organization of innovation and production in general. However, all the chemical cluster entities' interconnectedness reveals the possibility – as a first approximation – to begin analyzing its structural efficiency. This may involve the economic evaluation of options for forming innovative projects regarding a particular kind of chemical product that may have been previously considered in isolation; for example, the current study evaluated industrial gas production. Formed clusters of chemical manufacturers are similar in their types of chemical products, regional terms, production structure, and development rates. Such a differential cluster analysis applied to particular projects in the chemical industry's innovation process would facilitate its evolution to sequentially analyze all innovation in the industry at subsequent iterations under a specific type of chemical production. This would also allow for an evaluation of chemical clusters' efficiency, and their national-level contributions to the production sector in the RK. However, this would become possible only through a consistent methodology for evaluating and selecting efficiency criteria at all research stages, which is a promising strand of further research on innovative development within Kazakhstan's chemical industry.

The presented approach to clustering the chemical industry regions in Kazakhstan and developing the formed chemical clusters should contribute to the following: sustainable national economic growth; chemical manufacturers' increased productivity and operating efficiency; a growth in exports, the production of high value-added products, and the unit value of exports; increased domestic investments in the chemical industry; and increased optimization of external economic relationships with neighboring countries. All these contributions would establish a foundation for the international recognition of Kazakhstan as a competitive country.

While this study does not review competitive differentiators among the formed clusters due to its limited scope of research, the authors' further priority regarding scientific developments will involve a study of prospective competitive capacity among Kazakhstan's presented chemical clusters.

6. Conclusion

In the context of ensuring innovative development in Kazakhstan's chemical industry, it was determined that the key indicators for innovative chemical cluster formation in the RK's regions should include the concentration of innovation, chemical production, supply chain management and labor and financial resources. This is because a region's innovative activity in the chemical industry is determined by the production potential of its industry players, and by considering horizontal integration. The identified levels of innovation development indicators throughout the chemical industrial regions allowed for an allocation of three chemical clusters for industrial gas production – "high," "medium," and "low" – in terms of the level of innovation activity under current operating conditions. The cluster analysis proves that no region has an absolute advantage in all clusterization indicators, as each region's innovative development indicators range from "medium" to "high" levels. Considering the presently conditions in Kazakhstan's chemical industry operations, the expediency of forming two innovative development clusters of the chemical industry is justified: Cluster 0 includes the Karaganda and East Kazakhstan regions, and Cluster 5 includes the Pavlodar and North Kazakhstan regions. The efficiency of creating Chemical Cluster 0 for innovative development is clear; with its operations, the total regional production would increase by 0.68%, while Cluster 5 exhibits an efficiency of 4.23%.

One specific feature in developing innovative clusters in Kazakhstan's chemical industry within this study is that the clusters were considered from the perspective of the research processes occurring in the regional innovation supply chain strategy. This ensures their adaptation to market and technological conditions within internal and external operational environments, and considers participants' economic interests. The cluster approach is advantageous to develop innovation in Kazakhstan's chemical industry because of increased availability of borrowed capital, as the concentration of firms provides a conducive environment for generating aggregate domestic credit resources. This subsequently contributes to attracting venture capital investors, foreign direct investment resources, and new technological developments. Further, the cluster formed to include regional chemical companies would promote the creation of an aggregate innovative product in the RK. This is because consolidation into an integration-based cluster does not simply form a concentration of various inventions, but rather a system for disseminating new knowledge and technologies through the formation of stable links among all regional participants. However, the need currently exists for Kazakhstan to actually form clusters throughout the chemical industry, including creating the financial resources needed to supply the missing elements – primarily infrastructure – to fully develop these chemical clusters. At the domestic level, the nation's leadership in its cluster policy should be clarified by connecting it with other key focus areas, as various clusters' formation and operation also serves as an actual means of regional self-development and a powerful mechanism to increase their competitive ability. This mechanism should be at the forefront when the nation implements its overall regional development strategy.

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