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Master's Thesis in Engineering

Analysis on the decision-making process for petrochemical industry development in the case of Kazakhstan

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Analysis on the decision-making process for petrochemical industry development in the case of Kazakhstan

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Abstract

Analysis on the decision-making process for petrochemical industry development in the case of Kazakhstan

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The main value of the Kazakhstan economy is in its oil and gas reserves and production. Kazakhstan's Oil and gas industry share in total GDP was 10.4 % in 2016, according to the Ministry of National Economy of the Republic of Kazakhstan. However, despite huge reserves of hydrocarbons, 94 % of the country's needs for petrochemical products are imported (Yakubovskaya, 2010). This indicates a high potential for the development of the domestic petrochemical industry. Thus, Kazakhstan government announced the petrochemical industry as one of the key areas of development within the framework of the State Program of Industrial and Innovative Development. For efficient and effective development, however, elaborate research is needed on decision-making process for the development.

This study aims to analyze the decision-making structure in Kazakhstan

government, which defines the essential criteria for the petrochemical industry development. For the purpose of this study Analytical Hierarchy Process (AHP) model was applied. Ten key factors were identified through extensive literature reviews and then were classified into three main criteria: economic, technical and regulatory criteria. For AHP survey, this study chose two groups of respondents, government officials and non-government sector experts, for the main and sub criteria. In addition, they were asked if they would change their opinion taking into account possible impact of the COVID-19 pandemic in the next 5-10 years. Responses for the criteria were weighted and prioritized using AHP model, and answers from two groups were compared.

Foreign direct investments, commercial competitiveness, technology transfer, and infrastructure development are found to be the top factors for petrochemical industry development in the context of Kazakhstan. While government officials gave weights more on economic factors, non-government experts gave more weights on technical factors. However, both groups agree that the foreign direct investments to be the most important factor. Moreover, all the respondents did not change their opinions regarding the question about possible influence of the COVID-19 pandemic on the future industry development.

Keywords: economic diversification, petrochemical industry, AHP, decision-making process, Kazakhstan.

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Chapter 1. Introduction

This chapter of the thesis research contains a research background, problem statement and motivation, research objective, and question, as well as its novelty.

1.1 Research background

Diversification of the economy is very important in order to build sustainable economic growth (Hvidt, 2013). While some countries that have a strong base of resources could manage to diversify their exports and economies, a majority still could not. In this way, they can have some options, whether to increase the volume of primary exports or move to deep processing and value-added chains (Gelb, 2010). According to Albassam (2015), those economies that are dependent on income from natural resources are in high risk in terms of economic instability or even collapse.

Kazakhstan has rich energy potential. In particular, the country includes in the group of states, possessing significant hydrocarbon reserves, which influence the creation and position of the world energy market. Thus, the main value of the Kazakhstan economy is its oil and gas production. In 2009, Kazakhstan increased its level of oil and gas condensate production to 78.5 million tons, natural gas to 35.6 billion cubic meters, and became the 19th oil producer in the world. The country is the largest oil producer in the Caspian region, which forms the third world largest oil basin after the Persian Gulf and Russia. In addition, Kazakhstan takes 12th place in the world on the proven oil reserves and 15th place on gas and gas condensate reserves. According to the Statistics

committee of the Ministry of national economy of the Republic of Kazakhstan based on the results of 2016, the oil and gas industry share in total GDP was 10.4 % (Yakubovskaya, 2010).

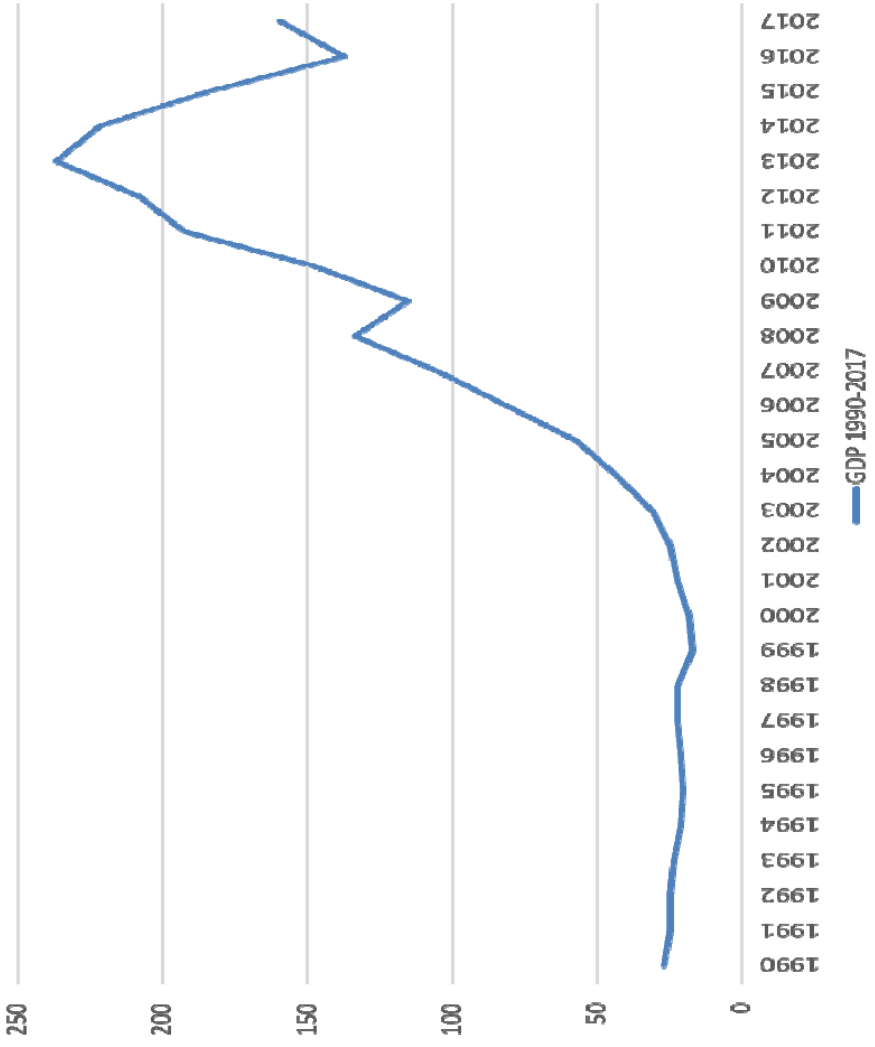
The main oil reserves in Kazakhstan (more than 90%) are concentrated in the 15 largest oil fields: Tengiz, Kashagan, Karachaganak, Uzen, Zhetybai, Zhanazhol, Kalamkas, Kenkiyak, Karazhanbas, Kumkol, Buzachi Severnye, Alibekmola, Prorva Tsentralnaya, and Vostochnaya, Kenbai, Korolevskoe. Further development of the resource potential of the oil and gas industry in Kazakhstan is facilitated by the large-scale analysis of subsurface areas in the waters of the Caspian and Aral seas. Prospects for oil and gas exploration are associated with unexplored deep-submerged structures in the Caspian basin, the Aral sea region, as well as with objects identified as a result of regional seismic work in Northern, Central, and Southern Kazakhstan (Shaihutdinova, 2012).

Hydrocarbon raw materials are processed domestically at three oil refineries and three gas processing plants, but there is no need to talk about the deep processing of raw materials yet (Shaihutdinova, 2012).

During the years of independence, Kazakhstan has focused on the export of mineral resources of the country. Thus, since the early 2000s, the Kazakhstan economy has been showing obvious symptoms of the Dutch disease (Petrick, Raitzer, & Burkitbayeva, 2018). Moreover, in recent years, the fall in world prices for hydrocarbons has led to a decrease in the country's export income and GDP (Figure 1).

Figure 1. Kazakhstan GDP growth

Source: The World Bank



In this way, the petrochemical industry is one of the country's priority sectors for economy diversification. However, despite huge reserves of hydrocarbons, 94% of all the country's needs for petrochemical products are now imported. This indicates a high potential for the development of the industry. Thus, in order to diversify the economy, Kazakhstan announced the petrochemical industry as one of the five key areas of development within the framework of the State program of Industrial and Innovative Development. In this way, for further development of the industry in the country, the State program of accelerated industrial and innovative development of Kazakhstan for 2010-2014 was adopted, which became the main strategic document. In addition, the Government adopted the Concept of development of the petrochemical and chemical industry of Kazakhstan until 2015 and a 15-year General plan. The development of petrochemicals can become an effective mechanism for diversification (Shaihutdinova, 2012). In addition, according to the Committee of statistics of the Republic of Kazakhstan, the volume of investments in the main capital of the petrochemical industry for 2012-2015 amounted to 219 billion tenge.

Moreover, the petrochemical sector is one of the most effective branches of international business. Since the work in this sector is tightly connected to the oil and gas industry, the petrochemical industry represents remarkable examples of hydrocarbon resources' rational use and production of products with high levels of added value. High return on investment and a threefold multiplier effect on related industries are making businesses in the petrochemical sector highly attractive for investment. Indicators such as

growing consumer demand and high labor productivity determine the promising future of the industry. It is considered one of the key sectors of the manufacturing industry. The products that it produces, we use almost every minute in almost all areas of human life (clothing, building materials, packaging, cosmetics, etc.). Even today, the average global consumer purchases petrochemical products for an average of $600 per year (IEA, 2018).

Those developing countries that managed to create the petrochemical complex were able to carry out the first phase of technical development, which helped them later move to the high technologies introduction in the electronics and telecommunications fields. Currently, in advanced technically developed countries, 8-10% of total produced oil, and more than 5% of gas are consumed by the petrochemical industry. Regarding developing countries, the level of this share remains below 2.5 - 5.0%. The world's biggest oil and gas companies, such as Exxonmobi1, BP, To1a1, Shell, Soposo Philips, Chevron Texo, and several others, have the share of the petrochemical industry at the level of about 10% of total revenue (IEA, 2018).

The need for a systematic development of the chemical and petrochemical industries was a fundamental factor in the creation of a separate company in Kazakhstan in 2009 the "United chemical company" LLP. Since 2010, the company has been operating in accordance with the adopted Strategy of Industrial and Innovative Development, which provides for the organization of chemical production, attracting investment and service support for the activities of industry enterprises. Within the framework of the state program of infrastructure development "Nurly Zhol", a phased

construction of external, internal, and industrial infrastructure is being carried out on the territory of special economic zones (SEZs) in Atyrau and Zhambyl regions. In Kazakhstan, such support tools as state in-kind grants, tax and investment preferences, tax incentives for investment projects, interest rate subsidies, leasing financing, and others are provided for attracting investment. Overall, the measures of state support and additional financing, as well as the results of research on the potential of the industry, indicate good prospects for enterprises in the petrochemical sector ("United chemical company" LLP, n.d., adilet.zan.kz, n.d.).

In general, there is a tendency of the petrochemical market's increasing globalization on the level of new technologies spread, markets, as well as raw materials accessibility. Nevertheless, it is important to note that companies in the sector usually face common problems, as, for example, legislative regulation, and so on. However, due to differences in initial positions and historical circumstances such as some advantages and disadvantages, the petrochemical industry's future in different areas differs considerably (IEA, 2018).

1.2 Problem statement, motivation, and novelty

Since 1997, Kazakhstan has been actively developing the extractive sector – the oil and gas industry, which currently accounts for 10.4% of the country's GDP. Thus, the main value of Kazakhstan economy is in its oil and gas reserves and production. However, despite huge reserves of hydrocarbons, 94 % of the country's needs for petrochemical

products are imported. This indicates a high potential for the development of the domestic petrochemical industry. Despite all the potential for developing the deep processing and value-added production, petrochemical and chemical production is currently at an initial level of development and accounts for 3% and 1% of the total volume of industrial production in 2014, accordingly. Thus, the share of the petrochemical industry in the country's GDP is about 0.1% (Yakubovskaya, 2010).

In this way, every year the country loses both potential profits from the production of high added-value products, as well as raw materials. For example, burning millions of cubic meters of associated petroleum gas in a field will not bring as much profit and benefit as dehydrogenating ethane obtained from the same volume of gas, followed by the production of polyethylene.

Meanwhile, over the same period of time, other countries, in particular countries in the Asian region (China, Iran, Korea, Malaysia, Singapore), have shown an active development of the petrochemical industry. It should be noted that the industry was developed even in countries where there is no enough resources and modern technologies. Thus, it is important to understand and analyze the global experience in this field.

Nevertheless, Kazakhstan has good prospects and opportunities for economic diversification through the development of this industry. Factors such as growing domestic and external demand, proximity to significant markets, and significant natural resources can contribute to the industry development.

In this way, Kazakhstan government announced the petrochemical industry as one of the key areas of development within the framework of the State Program of Industrial and Innovative Development. For efficient and effective development, however, elaborate research is needed on the decision-making process for the development.

There are plenty of studies on the identification and ranking of important criteria and factors for different sectors and industries in the economy of various countries. However, still no analogous research has been done on analyzing and prioritizing the factors for petrochemical industry development in the context of Kazakhstan. Thus, this study tried to identify and prioritize the factors that have the most important influence on the petrochemical industry development in the country.

The research motivation is to identify the main factors for the development of the petrochemical industry, as well as to help policy-makers making decisions and planning more accurate ongoing steps in the sector's development.

Thus, the study will have an important academic contribution by filling the research gap in this field through formulation and analyzing the main criteria and sub-criteria for the industry development. Moreover, the study may also be implemented in the case of other developing countries with a similar economy.

In this way, I purpose in this study to analyze the main criteria for petrochemical industry development in the context of Kazakhstan.

1.3 Objectives and research questions

The research objective is to identify the main criteria for the development of the petrochemical industry in the context of Kazakhstan and to understand what the government should pay attention to.

In accordance with the objective and motivation, the research question of the study is as follows:

What are the main factors for the development of the petrochemical industry in the context of Kazakhstan?

In order to achieve this objective, the research analyzes experts′ opinions from a multi-dimensional viewpoint. Thus, the influential factors were analyzed and ranked according to experts′ points of view. The Analytical hierarchical process (AHP) was applied in this research. This method is considered a popular tool for decision-making based on subjective judgments.

Chapter 2. Literature Review

This research follows an extensive literature review. Thus, this chapter of the thesis research contains a literature review related to the methodology framework, the global experience of petrochemical industry development, the case of Kazakhstan, as well as the impact of COVID-19 on the global petrochemical industry.

2.1 Studies related to methodology

The question of how people make or should make certain decisions has been studied for a long time. In turn, not all of these studies were defined by the strict scientific methods that we see in modern literature. In this regard, it is not surprising that we have many different methods and the literature in this area is constantly increasing. Many scientists and researchers are still searching for the perfect decision-making method (Triantaphyllou, 2000). Each method uses numerical techniques so that the decision-maker can make a choice among a discrete set of alternative solutions. In general, there are three stages in using any decision-making method that includes numerical analysis of alternatives:

1) Identification of the related criteria and alternatives;

2) Apply numerical measures to the relative importance of the criteria and to the influences of the alternatives on these criteria;

3) Process the numeric values to determine the ranking of each alternative.

The analytic hierarchy process (AHP) methodology that was proposed by Saaty

(Saaty, 1987) is a more recent development that has recently become more popular among researchers. The main feature of the AHP methodology is the use of the pair-wise comparisons that are applied in order to make a comparison between alternatives for different criteria, as well as to evaluate the weights of the criteria. Thus, it is “a theory of measurement through pairwise comparisons that relies on expert judgment to produce priority scales”. (Velasquez & Hester, 2013).

AHP methodology is one of the most popular Multi Criteria Decision Making (MCDM) methods that has plenty of advantages. The simplicity of use is one of the advantages the method has. The paired comparison usage allows decision-makers to weigh criteria and make a comparison between alternatives easily. Due to the hierarchical structure of the issue, the importance of each criterion becomes clear. In addition, the method is flexible, intuitive, checks inconsistencies, and there is no bias in decision making (Velasquez & Hester, 2013; Aruldoss, 2013).

The significance of AHP, its variety, as well as the pairwise comparisons usage in the decision-making process is best demonstrated by over 1000 references introduced by Saaty (Saaty, 1987). There are a number of certain issues in peer-reviewed journals that were devoted to such a method as AHP and the usage of paired comparisons for decision-making processes. Thus, AHP methodology showed a high level of application in performance-type issues, such as management of resources, political strategy, and planning, corporate policy and strategy, as well as public policy, etc. (Velasquez & Hester, 2013).

There are plenty of studies that have been done on estimating and ranking criteria, barriers, or factors in different fields of research and countries. The majority of the studies used AHP for making comparisons, then weighting, and rankings criteria. Having criteria and alternatives, AHP has been able to handle numerous measures and perspectives. While constraints such as the bias of self-assessment that may affect the internal validity were definitely in the presence, Velasquez & Hester (2013) concluded that the performance of this method is far exceeded previous methods.

Keeley & Matsumoto (2018) in their research were using AHP for determining the significance of such factors as a foreign direct investment (FDI) in terms of renewable energy development in developing countries. In this way, the method was chosen as a decision-making tool for determining the importance of a set of criteria and sub-criteria that constituted the multi-criteria problems.

Dweiri, et al. (2016) in their research were identifying a decision support model in order to select a supplier in the automotive industry. The AHP methodology was selected to design this model. This methodology has shown widespread usage in decision-making issues, considering a set of criteria in multi-level systems. According to the authors, one of the strongest characteristics of AHP is that it provides opinion priorities in numerical terms from subjective knowledge represented in paired comparison matrices. Thus, this methodology is valuable in the evaluation of the suppliers' weights from the point of view of various factors.

There are plenty of other works considering the method as the most effective

and appropriate in terms of evaluating and ranking criteria and factors, and decision-making. For example, Ghimire & Kim (2018) and Amantay (2020) evaluated factors and barriers to the development of renewable energy in the context of Nepal and Kazakhstan respectively, applying AHP methodology. Heo, Kim, & Boo (2010) in their work analyzed the assessment factors for the evaluation of renewable energy dissemination program by applying the fuzzy AHP method. Another example is a study on the decision-making process of the Myanmar government for a national oil and gas development plan that was conducted using AHP methodology as well (Htet, 2020).

The mentioned studies' results are summarized as follows. Heo et al. (2010) in their research established five main criteria for renewable energy dissemination program – technological, market-related, economic, environmental, and policy-related – and seventeen factors. The research outlines four main conclusions: 1) the importance of economic feasibility, 2) the improvement of the target technology in the global market, 3) the disagreement between the specialist group and the policymakers, and 4) the application of the results.

Dweiri et al. (2016) established four main criteria – price, quality, delivery, service – and twelve barriers for supplier selection in automotive industry. The suppliers are chosen and ranked based on sub-criteria. Analysis of sensitivity proposes the impacts of changes in the main criteria on the ranking of suppliers. The AHP methodology used in the selection of suppliers provides the decision-maker with consistency confidence and robustness all over the process.

Ghimire & Kim (2018) in their research established six main criteria – social; policy and political; technical; economic; administrative; geographic – and 22 barriers to renewable energy development in the context of Nepal. According to results, policy and political barriers (27.8%) most highly affect RES development in Nepal, followed by economic barriers (24.7%), geographic barriers (15.3%), administrative barriers (13.5%), social barriers (9.91%), and technical barriers (8.9%).

Keeley & Matsumoto (2018) in their study the relative significance of the determinants of foreign direct investment was clarified. Thus, they established four main criteria – macroeconomic environment, institutional environment, natural conditions, and renewable energy policy categories, and 18 sub-criteria. The results show that adding to the usual determinants of FDI, including the macroeconomic environment, the institutional environment, and natural conditions, policies that support renewable energy development, have equal or more influence as location determinants of FDI. The study also emphasizes that some of the conventional determinants, for example, exchange rate volatility, access to land, and an efficient and transparent administrative procedure, are also very significant in terms of determinants of FDI in the wind and solar energy.

Kim (2019) in his research analyzed four main criteria – socio-political; technical; economic; environmental, and 12 sub-criteria for decision-making process for the development of nuclear power plant in Kazakhstan. The economic criterion is the most crucial for decision-makers from the Ministry for Investments and Development. At the same time, the Environmental criterion was selected as the most significant in the

point of view of decision-makers from the Ministry of Energy.

Amantay (2020) analyzed barriers for renewable energy development in Kazakhstan. Thus, author established and analyzed four main criteria – socio-political; technical; economic; regulative, and 12 sub-criteria. For government experts - economic barriers (low levels of investment), and for private experts - technical barriers (lack of infrastructure and transmission system) are of major importance.

Htet (2020) analyzed four main criteria – economic, social, technological and environmental, and 12 sub-criteria for decision-making process on Oil and Gas Development Plan in Myanmar. According to the results, economic criteria (income tax, royalty, and cost recovery) are the most important in the Oil and Gas Planning Department for the development of the oil and gas industry in Myanmar. Then followed by social, technological, and environmental criteria.

Overall, the AHP methodology development and its role in MCDM analysis have become more widely used in real-world application examples (Velasquez & Hester, 2013).

2.2 Studies related to global experience

Investigating and acquiring the experience of countries with similar economies whose national wealth has benefited from the diversification of their economies is one of the steps needed to create a sustainable economy (Albassam, 2015).

There are a number of works regarding the development of the petrochemical

industry in the context of different countries and economies. One of the most striking examples of the active petrochemical industry development and economic growth is China. Thus, according to Halova et al. (2015), the main factors contributing to the petrochemical industry development in the country are proximity to demand markets, access to raw materials, access to technology, and government incentives. Moreover, the authors highlight that it was foreign participation that prompted the major reorganization of the industry structure, resulting in the creation of large centralized corporations (such as Sinopec) to facilitate work with foreign companies. The main investors in the Chinese economy were both international organizations (the World Bank, the United Nations development program), and foreign countries. The main part of foreign investment was directed to technical advice for projects. With the advent of state-owned corporations, relations between China and foreign companies have intensified in the field of exchange of experience at the highest level, and further modernization of the industry has increased. The problems of that period included the lack of harmonized standards for manufactured products, which hindered the development of trade. In general, a fundamental transformation towards the internationalization of the Chinese chemical and petrochemical industry occurred during the 1990s, with the widespread adoption of international norms, practices, and standards. This was a big push to reform the industry (Halova et al., 2015).

Another great example is South Korea. In this case, government participation was the key factor for success. According to a study by Enos (1984) starting from the

early concept of the national petrochemical industry at the beginning of 1960s, through selecting suppliers of needed technology, specifying the conditions for technology provision, building and operating the plants, and expanding capacity, to the ownership change in 1982, the Korean government constantly has been on the scene. In this way, the Korean government has taken part in planning, developing policies, negotiating, organizing, controlling, and intervening at all stages of foreign technology adoption. In order to produce petrochemicals, South Korea has decided to use modern technology in developed countries by creating joint ventures with foreign firms. Moreover, the government's policy on training local qualified personnel also was an important step (Enos, 1984).

On the other hand, objective researches show that technological integration can develop only in a favorable innovation environment, where there are prerequisites and conditions for the development and implementation of related complex technologies. Over the past years, scientists have been paying special attention to finding solutions related to the formation of an innovative strategy focused on the use of R&D results (Gilyazutdinova & Ponikarova, n.d.).

The cluster model of inter-economic relations can be considered as a factor contributing to technological integration and accelerated innovative development (Kuznetsov et al., 2019). This type of industrial and research capital combination is positively differentiated by "efficient organization of domestic markets with a low degree of monopolization, high level of competition, and strict consistency of the supply chain".

Thus, the cluster model is important for technological integration. However, achieving these parameters largely depends on solving the problems of technological backwardness, the complexity of expanding transport and logistics infrastructure, low level of technical regulation system, industry standards, as well as quality human resources (Kuznetsov et al., 2019; Kadyrbergenova et al., 2017).

The intensification of innovation activity in the petrochemical cluster and in the industry as a whole is possible only if it is provided with appropriate investments. Taking into account the current global integration processes, including in the field of scientific and technical cooperation, particular attention should be paid to expanding the attraction of foreign direct investment, foreign venture, and banking capital, and the development of schemes for their introduction to the world market, encouraging the use of global business practices and partnership between the state and the private sector (Galeyeva, 2012).

International, as well as domestic practices show that at the stage of fundamental transformations of the entire economy, state-owned enterprises and institutions, as well as the business sector, benefit from a public-private partnerships. Moreover, states whose economies are most remote from the technological border especially need institutions that can facilitate the implementation of long-term investment projects based on the borrowing of modern knowledge and advanced technologies (Morozova & Nesterenko, 2011).

Moreover, external factors of strategic development of a petrochemical

enterprise include social factors (demographic processes in the country, socio-cultural development of society, level of education development); regulatory factors (the system of legislation, taxation, state policy); factors of industry development (barriers to entry into the industry, competition development, the impact of inflation, etc.) (Gayfullina, 2018). Many factors, which allow countries to manage their resource abundance efficiently, are identically significant for their diversification possibility. One of the essential criteria is the ability of a country to smooth out the large macroeconomic volatility, which can be transmitted to monoexporters through big fluctuations in export prices. Otherwise, it might be much more complicated to support investments for non-resource trade sectors that can be destroyed by big fluctuations in the real exchange rate. Thus, serious macroeconomic instability as well makes it difficult to diversify exports, as real exchange rate volatility caused by shocks in concentrated export markets will lower incentives for risk-averse investors in non-commodity trading sectors (Gelb, 2010).

Some researches for cross-country also show that resources influence on economic growth is not similar. This depends on how well a country is provided with two different kinds of capital, which is possible to be considered as additional to natural resources: human capital and “governance or institutional capital”. Without these kinds of capital, a country is more likely to be vulnerable to the “resource curse”. There is also widespread corroboration that if a country has a lower level of the mentioned additional assets, it will be more complicated to maintain the diversification, as well as to improve the export technology border. In this regard, it is suggested that in the long-term, a

balanced set of factors is needed for sustainable growth. Resource abundance provides for countries such opportunities as building up institutional and human capitals, however, the majority of these countries are still far behind (Gelb, 2010).

The importance of foreign direct investment (FDI) for the industries development, especially at the initial stage, is also highly empathized in many pieces of literature. For example, Keeley & Matsumoto (2018) in their research analyzed the foreign direct investment importance for renewable energy development in developing countries. Thus, the importance of FDI has been highly admitted. Many countries have developed a number of different measures in order to bring FDI to the sector. The authors also note that some conventional determinants, such as exchange rate volatility, as well as access to land, are also very important factors for FDI.

The mentioned studies' results are summarized as follows. Enos (1984) in his work focused on the case of South Korea regarding the selection and adoption of modern industrial technologies imported from abroad. According to his findings - starting from the early concept of the national petrochemical industry through selecting technology suppliers, specifying the conditions, building and operating the plants, the government constantly has been on the scene.

Ren (2009) analyzed the drivers and barriers to innovation in petrochemical processes in terms of energy efficiency. The results showed that from the point of view of strategic scenario planning, the feedstock economics of new processes is of strategic significance.

Gelb (2010) examined the issue of diversification from a specific point of view – countries with a very strong comparative advantage in a particular natural resource, especially in minerals. The results showed that macroeconomic instability (real exchange rate volatility) makes it difficult to diversify exports due to a reduction in incentives for risk-averse investors.

Morozova & Nesterenko (2011) analyzed the necessity of forming of state-private partnership institutes for innovative spheres with a view of realization of strategic national priorities of the country and innovative growth. International, as well as domestic practices showed that states whose economies are most remote from the technological border especially need PPP that can facilitate the implementation of long-term investment projects based on the borrowing of modern knowledge and advanced technologies.

Galeyeva (2012) investigated the innovative development of the petrochemical cluster of the Republic of Tatarstan, as well as identified the main trends and factors of increasing its competitiveness. According to the results, special attention should be paid to expanding the attraction of foreign direct investment, foreign venture, and banking capital, and the development of schemes for their introduction to the world market, encouraging the use of global business practices and partnership between the state and the private sector.

Gilyazutdinova & Ponikarova in their study analyzed an industrial risk management of innovation activities in the petrochemical industry. According to their findings the main factor of economic growth in modern conditions is innovation.

Halova et al. (2015) analyzed the development of the petrochemical industry in China. According to the results, the main factors contributing to the development of the petrochemical industry are proximity to demand markets, access to raw materials, access to technology, and government incentives.

Gayfullina & Nizamova (2018) in their research analyzed the impact of factors on the strategic development of a petrochemical enterprise. Thus, following factors are important – social factors (demographic processes in the country, socio-cultural development of society, level of education development); regulatory factors (the system of legislation, taxation, state policy); factors of industry development (competition development, the impact of inflation, etc.).

Keeley & Matsumoto (2018) studied the relative significance of the determinants in the location decisions of foreign wind and solar energy investors. This research is not related to the petrochemical industry. However, the study showed the significance of FDI for the development of another new industry – renewable energy in developing countries. The authors also note that some determinants, such as exchange rate volatility, also important factors.

Kuznetsov et al. (2019) investigated prospects for the development of technology integration. The study considered technological integration as one of the most effective measures to increase the level of technological efficiency of enterprises. The cluster model of inter-economic relations can be considered as a factor contributing to technological integration and accelerated innovative development.

Overall, access to technology, investments, innovation, infrastructure, competition development, global business practices and partnership between the state and the private sector, human capital are of strategic importance (Ren, 2009; Galeyeva, 2012; Enos, 1984; Gayfullina, 2018, Prokopenkov, 2007; Gelb, 2010).

2.3 Studies related to Kazakhstan case

Nowadays, the growth of Kazakhstan becomes dependent on investment in new technologies (Macerinskiene & Sakhanova, 2011). Despite the obvious attractiveness of prices for hydrocarbon raw materials, and costs for transportation, some factors have made it complicated for local companies in the petrochemical sector to remain in business. Thus, Tugut & Lee (2007) in their work analyzed opportunities, challenges, and suggestions of doing business in Kazakhstan. According to their findings, high transportation costs and inefficient production facilities are among influential factors. The country's government encourages the attraction of foreign direct investment to maintain the huge potential of growth in the industry.

The need for the systematic development of the industry was a fundamental factor in the creation of a company "United chemical company" LLP in Kazakhstan in 2009. Since 2010, the company has been operating in accordance with the adopted Strategy of Industrial and Innovative Development, which provides for the organization of chemical production, attracting investment and service support for the activities of industry enterprises. Within the framework of the state program of infrastructure

development “Nurly Zhol”, a phased construction of external, internal, and industrial infrastructure is being carried out on the territory of special economic zones (SEZs) in Atyrau and Zhambyl regions. In Kazakhstan, such support tools as state in-kind grants, tax and investment preferences, tax incentives for investment projects, interest rate subsidies, leasing financing, and others are provided for attracting investment. Overall, the measures of state support and additional financing, as well as the results of research on the potential of the industry, indicate good prospects for enterprises in the petrochemical sector ("United chemical company" LLP, n.d., adilet.zan.kz, n.d.).

On the other hand, the need for technology transfer, transport infrastructure development, as well as the high capital intensity of projects, and the shortage of local specialized personnel are among the main factors that may influence the industry development (Smirnov S., 2019).

According to the State program on the industrial development of Kazakhstan for 2015-2019, availability of skilled human resources; infrastructure (transport and logistics, etc.); a level of competition in the manufacturing industry; competitiveness of the innovation system; a level of resource efficiency and energy intensity of the industry; technical regulation system; structural problems in the economy ("Dutch disease", etc.) are in strategical importance for industrial development.

In addition, according to OECD (2015), there are three main issues in the way of petrochemical and chemical industries development in Kazakhstan: 1) insufficient technologies for deep processing; 2) a transportation infrastructure is not appropriate for

transporting raw materials or finished products; and 3) major skill gaps and underqualified staff (OECD, 2015).

Overall, it can be noticed that all the above researches agree on the general factors and criteria for the petrochemical industry development.

2.4 The impact of COVID-19 on the global petrochemical industry

The COVID-19 pandemic is making many companies to rethink on the future of the petrochemical industry. According to McKinsey & Company (2020), despite the financial crisis in 2008, the petrochemical industry showed significant growth from 2010 to 2018. During this period, the value pool increased by 8 percent per year. This period was characterized by a high level of consumption and favorable raw material dynamics.

In general, the indicators of the petrochemical industry were influenced by the following factors:

- increased margin; increased demand for ethylene (from 84 % in 2008-2009 to 90 % in 2017-2018);

- production capacity continued to grow (from 62 million tons per year in 2008 to 102 million tons in 2018),

- a significant increase in demand from emerging markets in the period from 2010 to 2018.

COVID-19 provoked a decline in both demand and oil prices. In 2019, the growth of production capacity and the decline in consumption were already the reasons for the recession of the industry. Thus, this trend received more impulse in 2020 due to the COVID-19 pandemic. However, it should be noted that the impact of coronavirus on demand in the petrochemical industry was not same across all value chains. For example, while construction and automotive sectors may have experienced a significant decline, the demand for packaging (especially in the food and medical industries) remains stable. This can be explained by the fact that this pandemic has caused a jump in demand for products in the health care sector.

Despite the fact that some factories were still forced to stop operations, in general, most industry players managed to cope with the impact of the pandemic at a short-term level. At this stage, it is necessary to focus on plans and strategies aimed at the medium and long term (McKinsey & Company, 2020).

Chapter 3. Methodology

This chapter of the thesis research explains the methodological framework, AHP methodology, criteria and sub-criteria identification and description, the hierarchy structure, questionnaire, and process of the survey.

3.1 Methodological Framework

As was discussed in the previous chapter the Analytical hierarchical process (AHP) methodology has been chosen and applied in order to achieve the objective of the study, as well as estimate and rank the factors for petrochemical industry development in the context of Kazakhstan.

The AHP is a structured method of organizing and analyzing complex decisions. It was first designed by Thomas L. Saaty in the 1970s. This method is an accurate approach aimed to quantify the weights of criteria. The experience of individual experts is used to assess the comparative values of factors via paired comparisons. Each respondent should make a comparison of the relative significance between two factors in a specially designed questionnaire.

The methodology framework covers several major steps that have been done in order to answer the research question (Figure 2).

In this way, the research started by conducting an extensive literature review on the related studies (see Chapter 2) and then identifying the main influential factors for

petrochemical industry development. Thus, various studies, reports, programs were analyzed. This step of the research took around two months from July to the beginning of September. Further, the identified factors were then sorted into three main relevant criteria: economic, technical, and regulatory. Thus, the first hierarchical structure was formed (see Table 4).

The next step was preparing the questionnaire in order to conduct a preliminary survey with some experts from the relevant fields from the Ministry of energy of the Republic of Kazakhstan. Then after receiving comments and feedback from the pilot survey, the criteria and sub-criteria were modified and improved, at the same time correction were made to the hierarchical structure and questionnaire. This step was conducted during September.

Thus, the revised and finalized questionnaire was again sent to the relevant experts from the government, as well as non-government sectors. After conducting the actual survey and receiving responses from the experts, analyses on the results and conclusions were made.

In addition to the main questions of paired comparison of main criteria and sub-criteria, the questionnaire included questions about the possible impact of the COVID-19 pandemic on the future development of the industry: “Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you change your priority of choice?”. As it known, the COVID-19 pandemic has affected almost all sectors of the economy and is making

many companies to rethink on the future of the petrochemical industry. In this way, it is also necessary to understand the opinion of experts regarding this issue.

The details of the methodology steps, criteria description, hierarchical structure, and survey process will be described in the following subsections of this chapter.

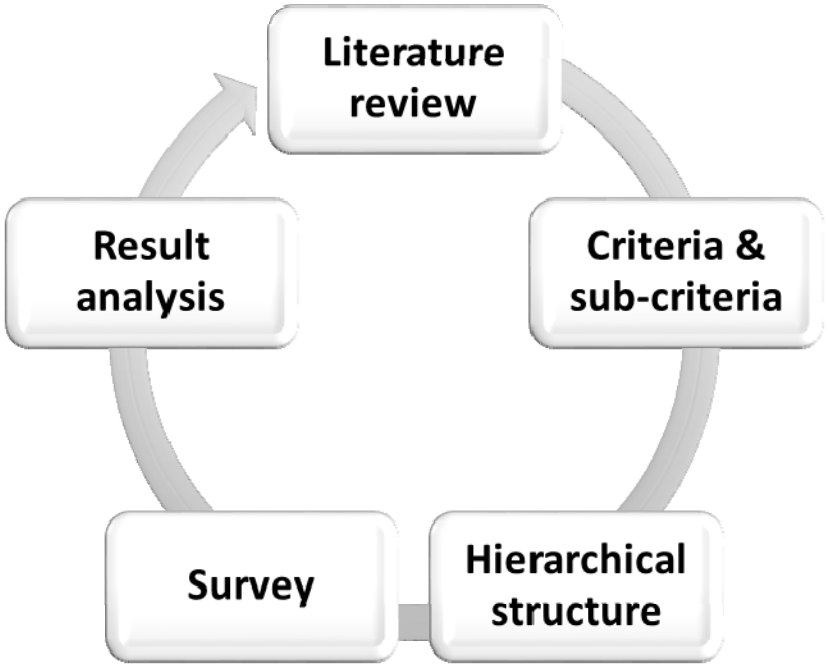


Figure 2. AHP model

3.2 AHP methodology

There are five steps needed to be done according to the AHP methodology. These steps are described below in more detail (R. W. Saaty, 1987; T. L. Saaty, 1990).

1. The first step is formulation of the hierarchical three based on the defined problem (goal), and then identifying the main criteria at the second level, and then on the third level – specific factors within each main criteria, that is sub-criteria.

These levels are described as follow:

Level 1: The main research goal. That is, the goal of this research is 'petrochemical industry development in the case of Kazakhstan'.

Level 2: According to the goal, the main criteria can be identified. That is, the main criteria for petrochemical industry development are identified in this level two.

Level 3: In this level, specific criteria, that is sub-criteria, are identified and listed within each main criteria. For example, one of the main criteria is the Economic criteria, which can include specific factors. Thus, a number of specific sub-criteria can describe this Economic criterion.

In this way, we identified our goal as – development of the petrochemical industry. The following step was – identification of the sub-criteria, which will be described in more detail in the next part of this chapter (subsection 3.3). After sub-criteria were identified then they were sorted into main relevant criteria. Thus, the hierarchical three was formulated for this research, which also will be described in detail in the following part of this chapter (subsection 3.4).

The structure of the hierarchical three is shown in Figure 3 below.

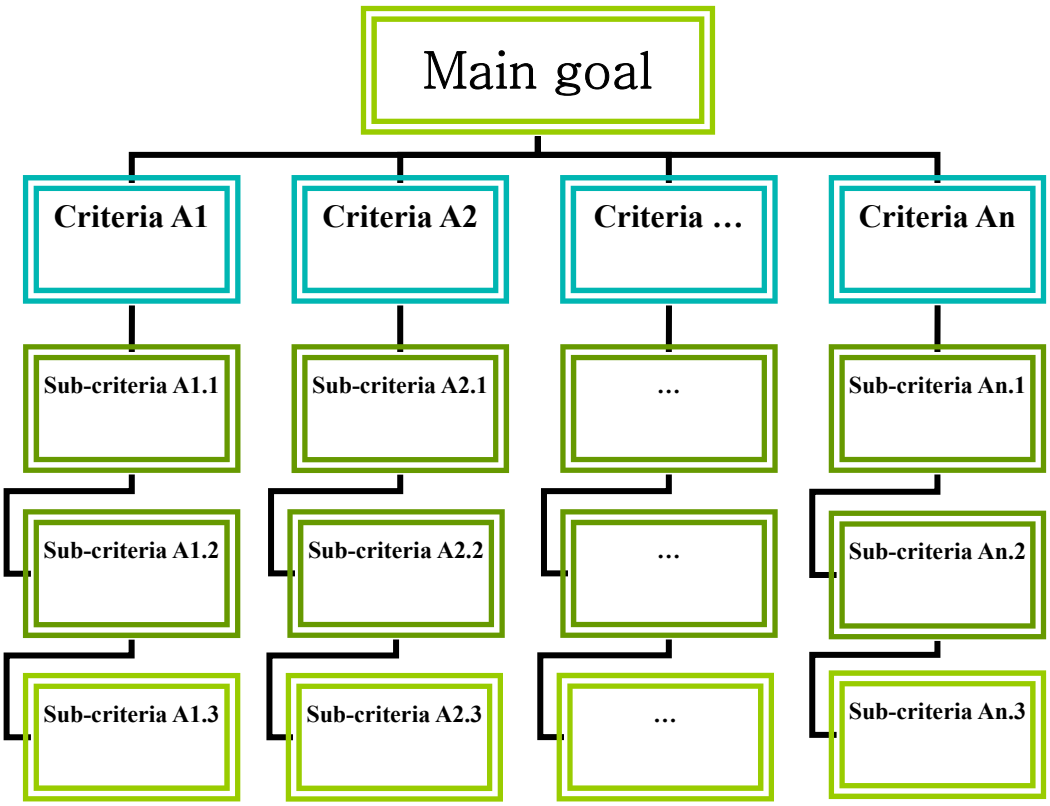


Figure 3. Hierarchical three in AHP

2. On the next step, the questionnaires of pair-wise comparison for experts were formulated in order to obtain their judgments based on the nine-point scale (Table 1).

In this step, the respondents evaluated the given criteria by using a numerical method. Thus, respondents need to estimate the importance of factors/criteria comparing them with each other, and using the nine-point scale as is introduced in Table 1. Criteria A and criteria B are used as an example in Table 1.

Table 1. AHP nine-point scale

Definition	**Description**	**Scale (Intensity of significance)**
Criteria A and B are equally important	Equally	1
Criteria A is moderately more important than criteria B	Moderately more	3
Criteria A is strongly more important than criteria B	Strongly more	5
Criteria A is very strongly more important than criteria B	Very strongly more	7
Criteria A is extremely more important than criteria B	Extremely more	9
A is more important than criteria B but at intermediate values of importance scale	Intermediate values	2, 4, 6

Thus, in accordance with (Saaty, 1987) qualitative information can be converted into a quantitative one by using these numerical values (Table 1). The comparison made between all the criteria by respondents then can be represented as a comparison matrix.

3. Then a pair-wise comparison matrix was created covering the results of all pairwise comparisons between all the criteria. Thus, this comparison matrix was formulated within each criteria level in accordance with the goal, and similarly, a sub-criteria comparisons matrix was created with respect to each main criteria. The example of the matrix is shown below (Table 2), where A_1, A_2, ..., A_n are the main factors determining the object.

Table 2. Comparison matrix in AHP

	A_1	A_2	…	A_n
A_1	1	a_{12}		a_{1n}
A_2	a_{21}	1		a_{2n}
…			1	
A_n	a_{n2}	a_{n2}		1

Thus, in order to obtain the matrix from the pair-wise comparison between criteria A and B using value 1 to 9, the result of comparison between criteria B and A is the reverse value. For example, considering the matrix element a_{ij}. When comparing these factors i with j, then $a_{ij} = b$, and consequently when comparing j and i, then $a_{ij} = 1/b$.

4. The next step is computing the weights for each criteria at both level two (main criteria) and level three (sub-criteria).

$$Aw = \lambda max * \text{w} \quad , \qquad (1)$$

where A – the comparison matrix, w – Eigenvector or priority weight, λmax – maximum Eigenvalue.

In this way, the major rule for this comparison matrix is the reciprocal system. Thus, it is important to note that this matrix is the inverse symmetric matrix, and all numbers that are used, need to match the 9-point scale of relative importance.

Next, after the matrix is structured, we need to obtain the normalized-comparison matrix using the following equation (2):

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \quad , \qquad (2)$$

After this, we need to calculate the normalized eigenvector for each row using the following equation (3). This normalized eigenvector presents final weight of each main criteria with respect to the main goal, as well as final weight of each sub-criteria with respect to the main criteria. According to this, we can judge the relative importance of the criteria.

$$W_j = \frac{\sum_{i=1}^{m} \bar{a}_{jl}}{m} \quad , \qquad (3)$$

5. The final step is a calculation of the degree of consistency (Consistency Ratio, CR). This measure gives information regarding the degree of deviation from consistency.

This deviation should be less or equal to 0.1 (10 % of inconsistency) in order to accept the judgment. Otherwise, the respondents' answers whose results are CR > 0.1 cannot be reliable and they should double-check their responses. CR is calculated according to the following equation (4):

$$CR = \frac{CI}{RI}, \qquad (4)$$

where CI – consistency index, RI – random index (standard values, shown in Table 3).

CI can be calculated according to the following equation (5):

$$CI = \frac{\lambda \max - 1}{n - 1}, \qquad (5)$$

And Random index (RI) has standard values according to a number of criteria (n) as shown in Table 3:

Table 3. Random index standard values

Number of criteria	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

3.3 Criteria and sub-criteria description

According to the literature review, various reports and policy programs, as well as communication with experts in the relevant sector, sub-criteria for petrochemical industry development in the context of Kazakhstan were identified (Figure 4) and then sorted into main criteria: economic, technical, and regulatory. Thus, this part of the chapter contains a description of the main criteria and sub-criteria.

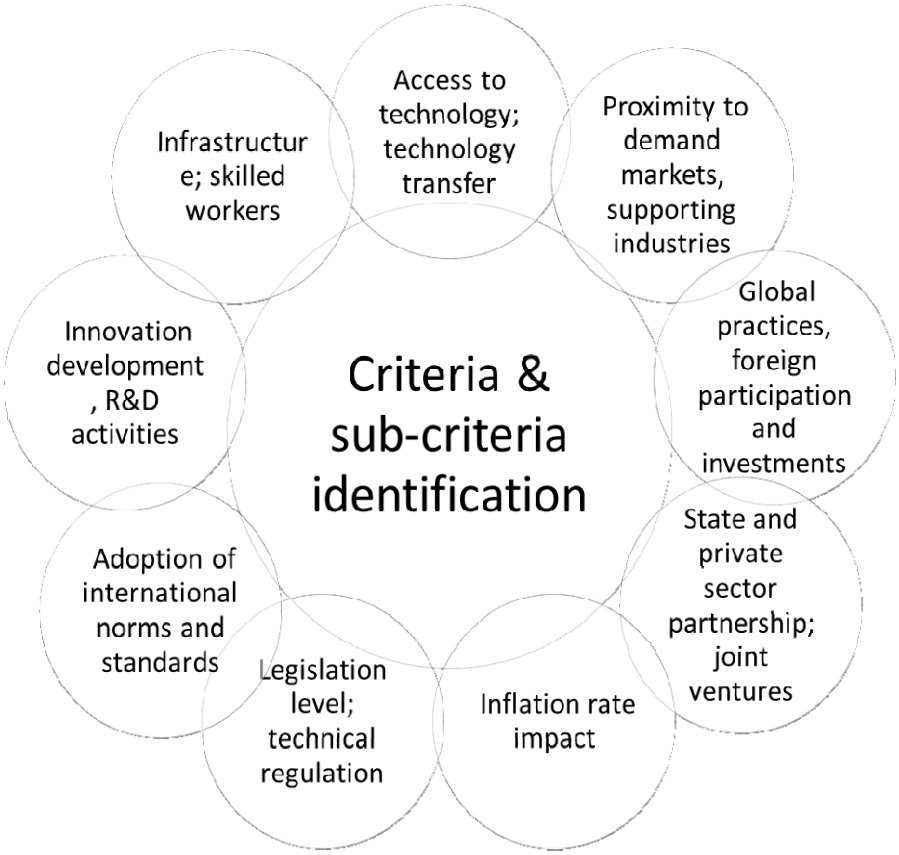


Figure 4. Criteria and sub-criteria identification

As was mentioned in section 3.1 of this chapter, the identified from the literature factors were then sorted into the first hierarchical structure (Table 4) and then a preliminary survey was conducted with some experts from the relevant field from the Ministry of energy of the Republic of Kazakhstan.

Table 4. Pilot version of criteria and sub-criteria

Criteria	Sub-criteria
Economic	Cluster development
	Investments
	Market size
Technical	R&D
	Technology transfer
	Infrastructure
	Skilled workers
Regulatory	Legislative framework
	Public-private partnership development
	Standardization

Thus, after receiving comments and feedbacks from the pilot survey, the criteria and sub-criteria were consequently modified and improved. The following sub-sections of section 3.3 will describe the main criteria and sub-criteria in detail.

3.3.1 Economic criteria

Economic criteria describe various economic factors for petrochemical industry development. Three sub-criteria were identified for economic criteria: commercial competitiveness, foreign direct investments, and inflation rate. In Table 5, a brief description of the sub-criteria is provided. In more detail, each of the sub-criteria is explained below.

Commercial competitiveness

This factor was mentioned as an important factor for many researchers. Thus, competition level in the manufacturing industry and its development are of strategical importance for industrial development (Gayfullina, 2018; State program for 2015-2019).

The foundation that enables to create a competitive world-class industry in the country is the existence of some important factors as related and supporting industries, the market, conditions, the strategy, and structure to achieve stable competitiveness (Amantay, 2020). In addition, according to Halova et al. (2015), the main factors contributing to the petrochemical industry development are proximity to demand markets (market), access to raw materials and technology, and government incentives.

Foreign direct investment (FDI)

Investigating and acquiring the experience of countries with similar economies whose national wealth has benefited from the diversification of their economies is one of the steps needed to create a sustainable economy (Albassam, 2015). For example, taking into account the current global integration processes, such successful global practices as the creation of large centralized state-owned corporations and foreign participation are considered as key factors (Enos, 1984; Galeyeva, 2012; Halova et al., 2015; Kuznetsov et al., 2019).

The importance of FDI for the development of industries, especially at the initial stage, is highly empathized in many pieces of literature. For example, Keeley & Matsumoto (2018) in their research emphasized the significance of the foreign direct investment for renewable energy development in terms of developing countries. Many countries have developed, as well as have been trying to develop various measures in order to attract FDI to the sector.

Inflation rate

Another important criterion for many industries is the inflation rate. According to some researches, the country′s ability to smooth out the large level of macroeconomic volatility caused by big fluctuations in export prices has been always considered a crucial factor for development. Otherwise, it might be much more complicated to support investments for non-resource trade sectors that can be destroyed by big fluctuations in the real exchange rate (Gelb, 2010; Gayfullina, 2018).

Keeley & Matsumoto (2018) also note that exchange rate volatility as some traditional determinants is of major importance for any industrial development.

Table 5. Economical sub-criteria

N	Sub-criteria	Description	Source
1	Commercial competitiveness	Conditions, market, related and supporting industries	Halova et al. (2015); Gayfullina (2018); Amantay (2020)
2	FDI	Foreign direct investments	Enos (1984); Morozova & Nesterenko (2011); Galeyeva (2012); Albassam (2015); Halova et al. (2015); Keeley & Matsumoto (2018); Kuznetsov et al. (2019)
3	Inflation rate	An impact of inflation rate on industry development	Gelb (2010); Gayfullina (2018); Keeley & Matsumoto (2018)

3.3.2 Technical criteria

Technical criteria describe technical factors for petrochemical industry development. Four sub-criteria were identified for technical criteria: research &

development, technology transfer, infrastructure development, and skilled workers. In Table 6, a brief description of the sub-criteria is provided. In more detail, each of the sub-criteria is explained below.

Research & development

Some researches show that technological integration can develop only in a favorable innovation environment. Thus, innovation activities are one of the important factors for industry development (Gilyazutdinova & Ponikarova, n.d.).

Technology transfer

Achieving success largely depends on solving the problems of technological backwardness (Kuznetsov et al., 2019; Kadyrbergenova et al., 2017). Thus, according to OECD (2015), ineffective technologies for deep processing of oil and gas and petrochemical companies is among key challenges for the industry development in the country.

Infrastructure development

Moreover to technological transfer development, the complexity of expanding transport and logistics infrastructure is an important issue as well (Kuznetsov et al., 2019; Kadyrbergenova et al., 2017). In the case of Kazakhstan, insufficient transportation infrastructure is among key challenges for industry development (OECD, 2015).

Skilled workers

Human capital may be considered as additional to natural resources, and countries with an insufficient level of this capital will have more difficulties to maintain

diversification of their economies and to improve the export technology border (Enos, 1984). Quality of human resources is very important and another challenge for Kazakhstan is an underqualified staff and major skill gaps in the sector (OECD, 2015; Kuznetsov et al., 2019; Kadyrbergenova et al., 2017).

Table 6. Technical sub-criteria

N	Sub-criteria	Description	Source
1	Research & development	A level of innovation in the petrochemical industry and research activities	Gilyazutdinova & Ponikarova, n.d.
2	Technology transfer	An incentives for the transfer of advanced technologies	OECD (2015); Kadyrbergenova et al. (2017); Kuznetsov et al. (2019); State program for 2015-2019
3	Infrastructure	A development of transport, logistics, energy and other infrastructure	
4	Skilled workers	A level of qualified local personnel in the industry, both at the construction and operation stages	Enos (1984); OECD (2015); Kadyrbergenova et al. (2017); Kuznetsov et al. (2019); State program for 2015-2019

3.3.3 Regulatory criteria

Regulatory criteria describe regulatory factors for petrochemical industry development. Three sub-criteria were identified for regulatory criteria: legislative framework, cooperation mechanisms, and technical regulation and standardization. In Table 7, a brief description of the sub-criteria is provided. In more detail, each of the sub-criteria is explained below.

Legislative framework

External factors of strategic development of a petrochemical industry include regulatory factors such as the system of legislation. Thus, it is significant to note, that the level of legislation framework in the context of the industry development should be taken into account (Gayfullina, 2018; adilet.zan.kz).

Cooperation mechanisms

Taking into account the current global integration processes, special attention should be paid to expanding the attraction of foreign direct investment, foreign venture, and the development of schemes for their introduction to the world market, encouraging the use of global business practices and partnership between the state and the private sector (Enos, 1984; Galeyeva, 2012; Halova et al., 2015; Kuznetsov et al., 2019).

Technical regulation & standardization

Low level of technical regulation system, as well as industry standards, is among important challenges that needed to be decided (Kuznetsov et al., 2019; Kadyrbergenova et al., 2017; State program for 2015-2019). For instance, in the case of China, the

problems of industry development included the lack of harmonized standards for manufactured products, which hindered the development of trade (Halova et al., 2015).

Table 7. Regulatory sub-criteria

N	Sub-criteria	Description	Source
1	Legislative framework	A level of legislative and regulatory framework	Gayfullina (2018); adilet.zan.kz, n.d.
2	Cooperation mechanisms	A development of the public-private partnership mechanism and creation of state-owned centralized corporation	Enos (1984); Morozova & Nesterenko (2011); Galeyeva, (2012); Halova et al. (2015); Kuznetsov et al. (2019)
3	Technical regulation & standardization	A level of harmonization of state standards with international requirements	State program for 2015-2019; Halova et al. (2015); Kadyrbergenova et al. (2017); Kuznetsov et al. (2019)

3.4 Hierarchical Structure of the Research

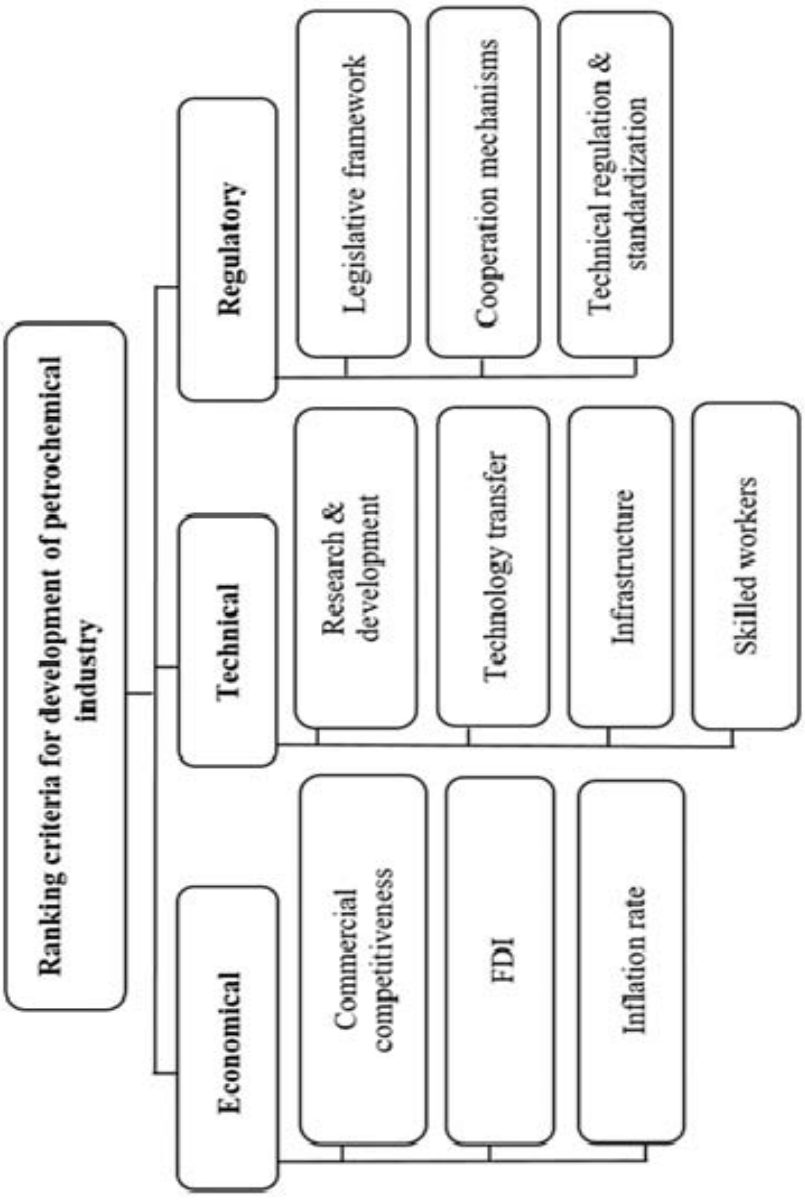
As was explained in the previous section, extensive literature reviews have been done for identifying the criteria and sub-criteria for petrochemical industry development in the context of Kazakhstan. Those criteria formed a hierarchical structure tree in order to rank them. Thus, according to the main goal, three criteria and ten sub-criteria were identified. The hierarchical structure is shown below (Figure 5).

As is shown in Figure 5, factors for the petrochemical industry development in the context of Kazakhstan are classified into three main criteria:

- Economic,
- Technical,
- Regulatory.

The mentioned above criteria then consist from 10 sub-criteria overall. As was mentioned before, these 10 sub-criteria were then sorted into main criteria. In particular, there are three sub-criteria for Economic criteria, four sub-criteria for Technical sub-criteria, and three sub-criteria for Regulatory criteria. In this way, hierarchical structure of this research was formulated.

Figure 5. Hierarchical Structure of the Research



3.5 Hypothesis development

According to the research question, identified main criteria, as well as taking into account possible influence of COVID-19 pandemic, hypotheses were formulated as follows (Table 8).

Table 8. Research hypothesis

Hypothesis	Description
Hypothesis 1	Economic criteria related factors are the most important for the petrochemical industry development in Kazakhstan
Hypothesis 2	Technical criteria related factors are the most important for the petrochemical industry development in Kazakhstan
Hypothesis 3	Regulatory criteria related factors are the most important for the petrochemical industry development in Kazakhstan
Hypothesis 4	The COVID-19 pandemic outcomes will influence the priority of the factors for petrochemical industry development
Hypothesis 5	The COVID-19 pandemic outcomes will not influence the priority of the factors for petrochemical industry

	development

In order to confirm or reject the above hypothesis, AHP model was applied in this research.

3.6 Survey and Data

As has been mentioned in previous sections of this chapter, AHP methodology was applied for this research in order to construct a questionnaire, collect data from various experts in the petrochemical, as well as oil & gas industries, and analyze it (R. W. Saaty, 1987, T. L. Saaty, 1990). The questionnaire was developed after extensive literature review, as well as discussion with relevant experts (Appendix 1). Further, this questionnaire was introduced to relevant experts in the government and non-government sectors, who took part in the research by providing their opinions.

The AHP questionnaire that was introduced to energy experts consists of three parts. The first is an introduction where the description and purpose of the research were explained.

In the second part pair-wise questions, as well as an explanation on how to answer them, were introduces to the respondents. Additionally to main questions, respondents were asked to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry: "Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you change your priority of choice?"

Finally, the third section consisted of the questions about respondents' demographic information (Figure 6). Thus, the questionnaire consists of three sections – introduction, pair-wise questions, and general information about the respondents, for example, age, experience, organization type, etc. The second part of the questionnaire also includes questions regarding the respondents' opinion on COVID-19 pandemic impact on future of the industry development.

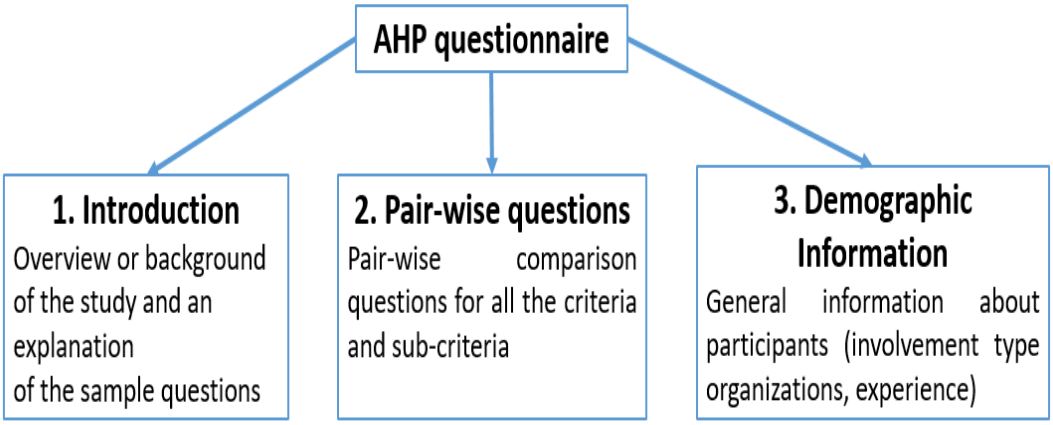


Figure 6. AHP questionnaire

The survey was conducted by sending questionnaires and collecting experts' opinions through a request via email, as well as phone calls. The responses were received from 25 energy experts from government and non-government sectors of the Republic of Kazakhstan. In particular, 15 responses were obtained from government sector' experts, and 10 responses – from non-government sector' experts (Table 9).

Table 9. Data collection

Respondents	Number of respondents
Government experts from the Ministry of energy	15
Non-government experts from oil & gas sector (National Company “KazMunaiGas”, National Welfare Fund “Samruk-Kazyna”, SEZ “National Industrial Petrochemical Techno park” or “NIPT”)	10
Total	25

These two major groups of respondents were selected as the most important stakeholders in the industry that playing a crucial role in the decision-making and its development.

After the survey, obtained results were analyzed by calculating and comparing all the answers.

Chapter 4. Results and discussion

This chapter of the thesis research contains empirical results of the study, as well as results discussion.

4.1 Empirical Results

As was described in the previous chapter, there are five steps in the AHP model. Thus, according to the AHP model creation, a hierarchical tree was constructed. In order to calculate the results, pair-wise comparison data that was obtained from experts were inputted and combined using the Expert Choice program. Finally, the results were synthesized according to all of the data.

4.1.1 Consistency Ratio (CR)

Table 10 below shows the participants of different groups and overall consistency ratios in both groups.

The Consistency Ratio is a very important index that gives information regarding the degree of deviation from consistency. The CR should be less or equal to 0.1 in order to accept the judgment. Otherwise, the respondents' answers whose results are CR > 0.1 cannot be reliable and their responses should be double-checked.

The results of overall inconsistency for both groups of respondents are presented in Table 10 below.

Table 10. All Groups' Inconsistency Results

Groups	**Group 1: Government sector**	**Group 2: Non-government sector**
No. of respondents	15	10
CR	0.00	0.01
Overall CR	0.005	

Overall, the Consistency Ratio (CR) for both groups of respondents is less than 0.1, which indicates good results, and that the judgments of the experts can be accepted. Moreover, CR regarding each main criteria for both groups of respondents are indicated in the next section (see sections 4.1.2, 4.1.3).

4.1.2 Results of the main criteria ranking

Below the ranking of the main criteria for the petrochemical industry development, from both groups of respondents is shown.

Thus, government respondents' opinion on the main criteria ranking is introduced in Table 11, and non-government respondents' opinion on the main criteria ranking is introduced in Table 12 respectively.

Tables 11 and 12 show the results of main criteria ranking according to government and non-government respondents respectively.

Table 11. Ranking of main criteria

(Government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
Economic	0.478	47.8%	1
Technical	0.348	34.8%	2
Regulatory	0.174	17.4%	3

Consistency Ratio (CR) < 0.1 (0.038)

Table 12. Ranking of main criteria

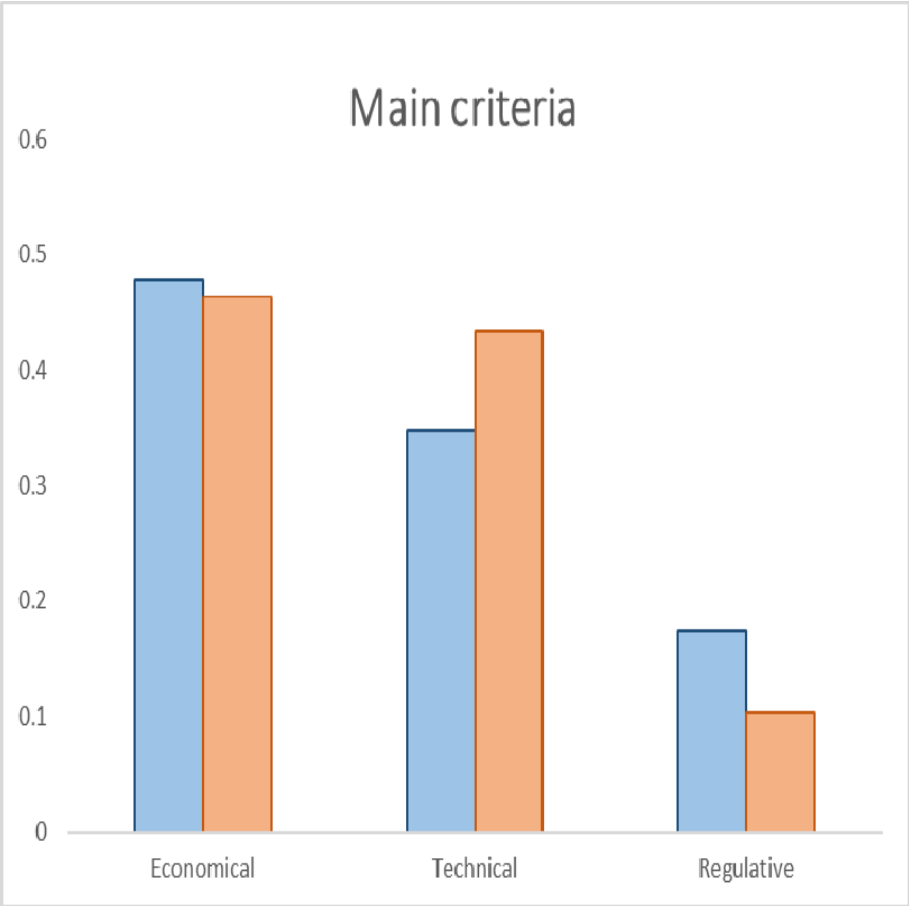
(Non-government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
Economic	0.463	46.3%	1
Technical	0.434	43.4%	2
Regulatory	0.103	10.3%	3

Consistency Ratio (CR) < 0.1 (0.076)

Figure 7 below shows the graphic comparison of both groups' opinions on the main criteria.

Figure 7. Comparison of groups' opinions on main criteria



4.1.3 Results of the sub-criteria ranking

Tables 13 and 14 show the results of sub-criteria ranking within Economic criteria according to government and non-government respondents respectively.

Table 13. Ranking of Economic sub-criteria (Government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
Commercial competitiveness	0.297	29.7%	2
FDI	0.526	52.6%	1
Inflation rate	0.176	17.6%	3

Consistency Ratio (CR) < 0.1 (0.076)

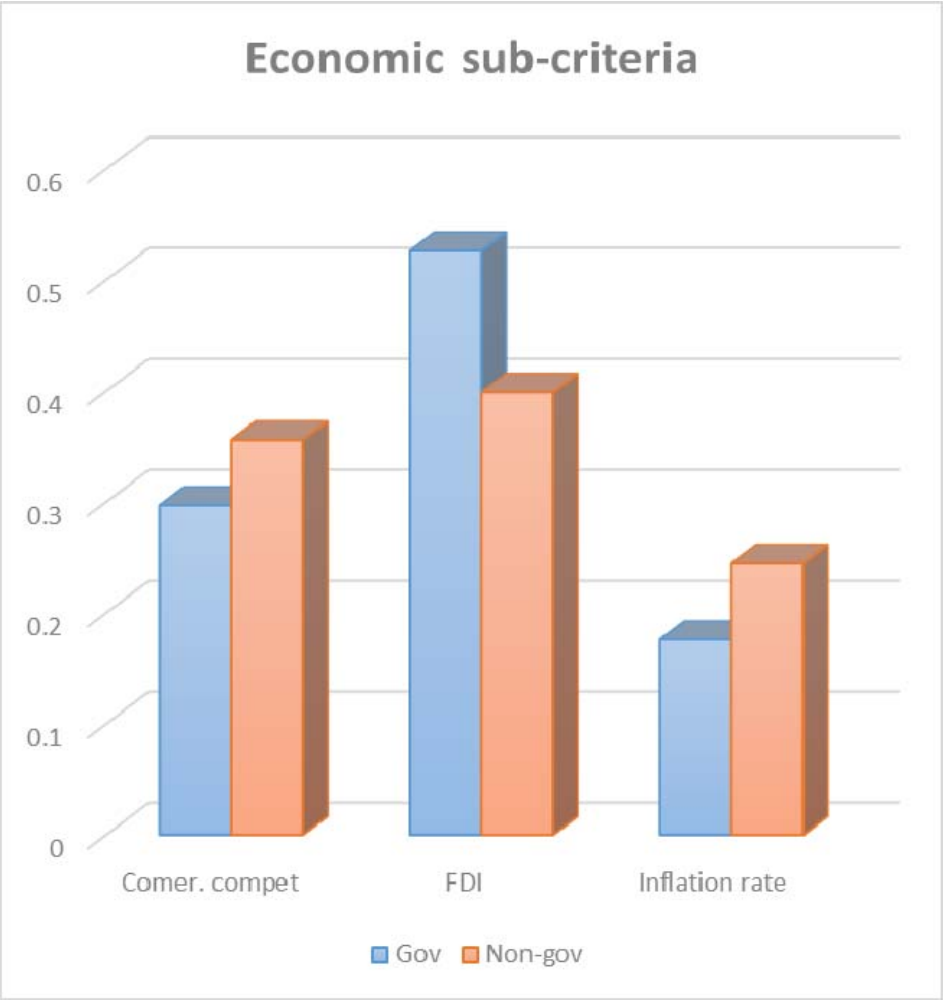
Table 14. Ranking of Economic sub-criteria (Non-government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
Commercial competitiveness	0.356	35.6%	2
FDI	0.399	39.9%	1
Inflation rate	0.245	24.5%	3

Consistency Ratio (CR) < 0.1 (0.066)

Figure 8 below shows the graphic comparison of both groups' opinions on Economic sub-criteria.

Figure 8. Comparison of groups' opinions on Economic sub-criteria



Tables 15 and 16 show the results of sub-criteria ranking within Technical criteria according to government and non-government respondents respectively.

Table 15. Ranking of Technical sub-criteria (Government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
R&D	0.203	20.3%	4
Technology transfer	0.346	34.6%	1
Infrastructure	0.211	21.1%	3
Skilled workers	0.239	23.9%	2

Consistency Ratio (CR) < 0.1 (0.073)

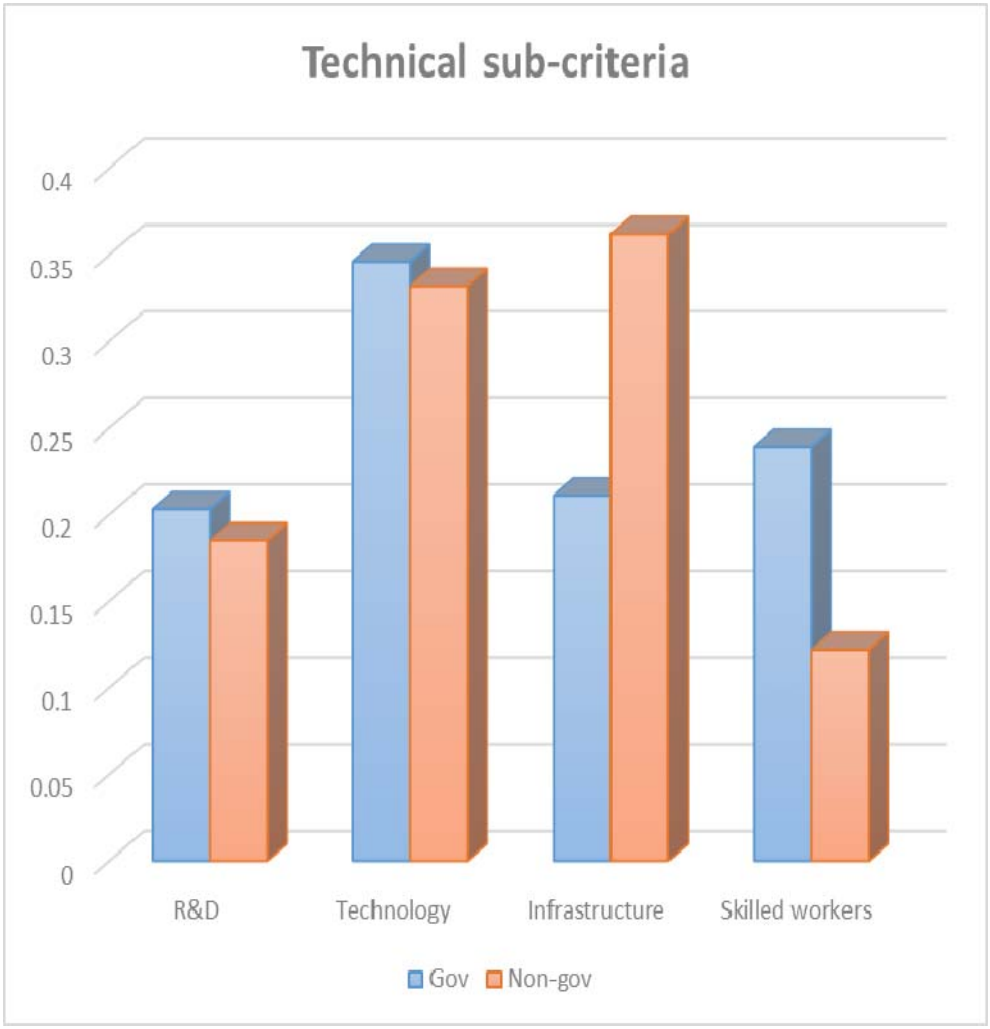
Table 16. Ranking of Technical sub-criteria (Non-government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
R&D	0.185	18.5%	3
Technology transfer	0.332	33.2%	2
Infrastructure	0.362	36.2%	1
Skilled workers	0.122	12.2%	4

Consistency Ratio (CR) < 0.1 (0.07)

Figure 9 below shows the graphic comparison of both groups' opinions on Technical sub-criteria.

Figure 9. Comparison of groups' opinions on Technical sub-criteria



Tables 17 and 18 show the results of sub-criteria ranking within Regulatory criteria according to government and non-government respondents respectively.

Table 17. Ranking of Regulatory sub-criteria (Government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
Legislation framework	0.381	38.1%	1
Cooperation mechanisms	0.269	26.9%	3
Technical regulation & standardization	0.350	35%	2

Consistency Ratio (CR) < 0.1 (0.063)

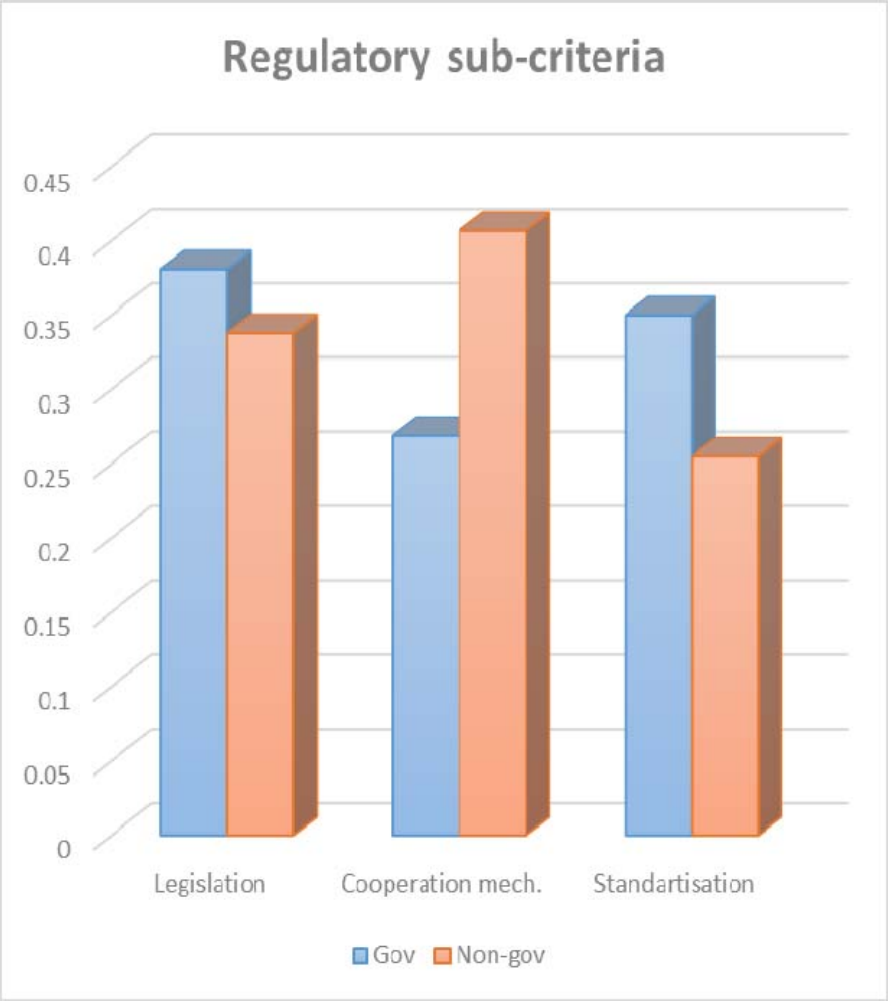
Table 18. Ranking of Regulatory sub-criteria (Non-government experts)

Criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
Legislation framework	0.338	33.8%	2
Cooperation mechanisms	0.407	40.7%	1
Technical regulation & standardization	0.255	25.5%	3

Consistency Ratio (CR) < 0.1 (0.062)

Figure 10 below shows the graphic comparison of both groups' opinions on Regulatory sub-criteria.

Figure 10. Comparison of groups' opinions on Regulatory sub-criteria



4.1.4 Results of overall ranking of criteria

Results of the overall ranking of sub-criteria are presented in Table 19 and 20, as well as Figures 11 and 12 below. In addition, Figure 13 shows a comparison between both groups of experts' opinions.

Thus, Table 19 shows the results of overall ranking of sub-criteria according to government sector respondents.

Table 19. Overall ranking of sub-criteria (government experts)

Sub-criteria	Weight	Share, %	Rank
FDI	0.202	20.2%	1
Technology transfer	0.148	14.8%	2
Commercial competitiveness	0.114	11.4%	3
Skilled workers	0.101	10.1%	4
Infrastructure development	0.090	9%	5
R&D	0.089	8.9%	6
Legislation framework	0.075	7.5%	7
Technical regulation and standardization	0.069	6.9%	8
Inflation rate	0.068	6.8%	9
Cooperation mechanisms	0.053	5.3%	10

Figure 11 represents the graphical results of overall ranking of sub-criteria according to government sector respondents.

Figure 11. Overall ranking of sub-criteria (government experts)

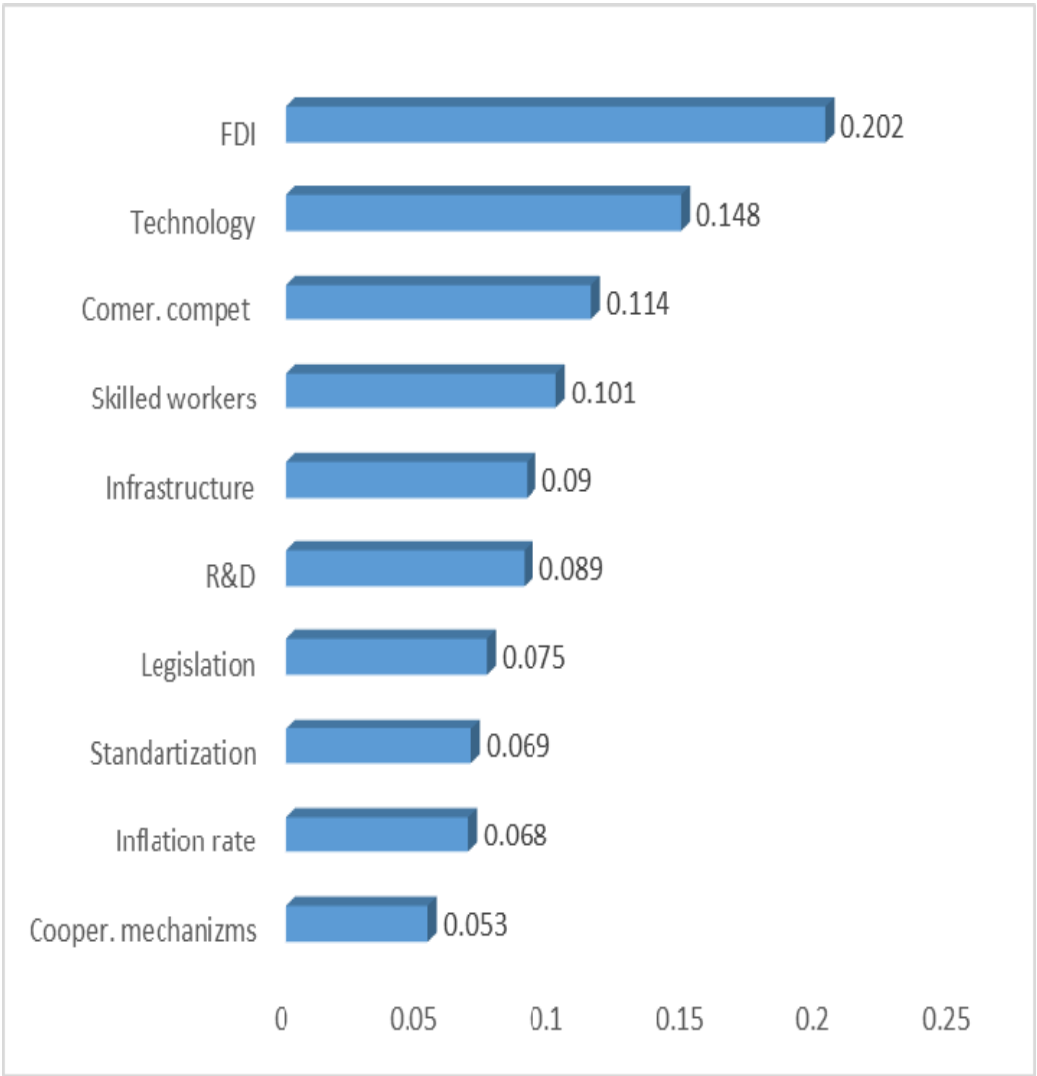


Table 20 shows the results of overall ranking of sub-criteria according to non-government sector respondents.

Table 20. Overall ranking of sub-criteria

(Non-government experts)

Sub-criteria	**Weight**	**Share, %**	**Rank**
FDI	0.177	17.7%	1
Infrastructure development	0.166	16.6%	2
Commercial competitiveness	0.158	15.8%	3
Technology transfer	0.152	15.2%	4
Inflation rate	0.109	10.9%	5
R&D	0.085	8.5%	6
Skilled workers	0.056	5.6%	7
Cooperation mechanisms	0.039	3.9%	8
Legislation framework	0.033	3.3%	9
Technical regulation and standardization	0.025	2.5%	10

Figure 12 represents the graphical results of overall ranking of sub-criteria according to non-government sector respondents.

Figure 12. Overall ranking of sub-criteria

(Non-government experts)

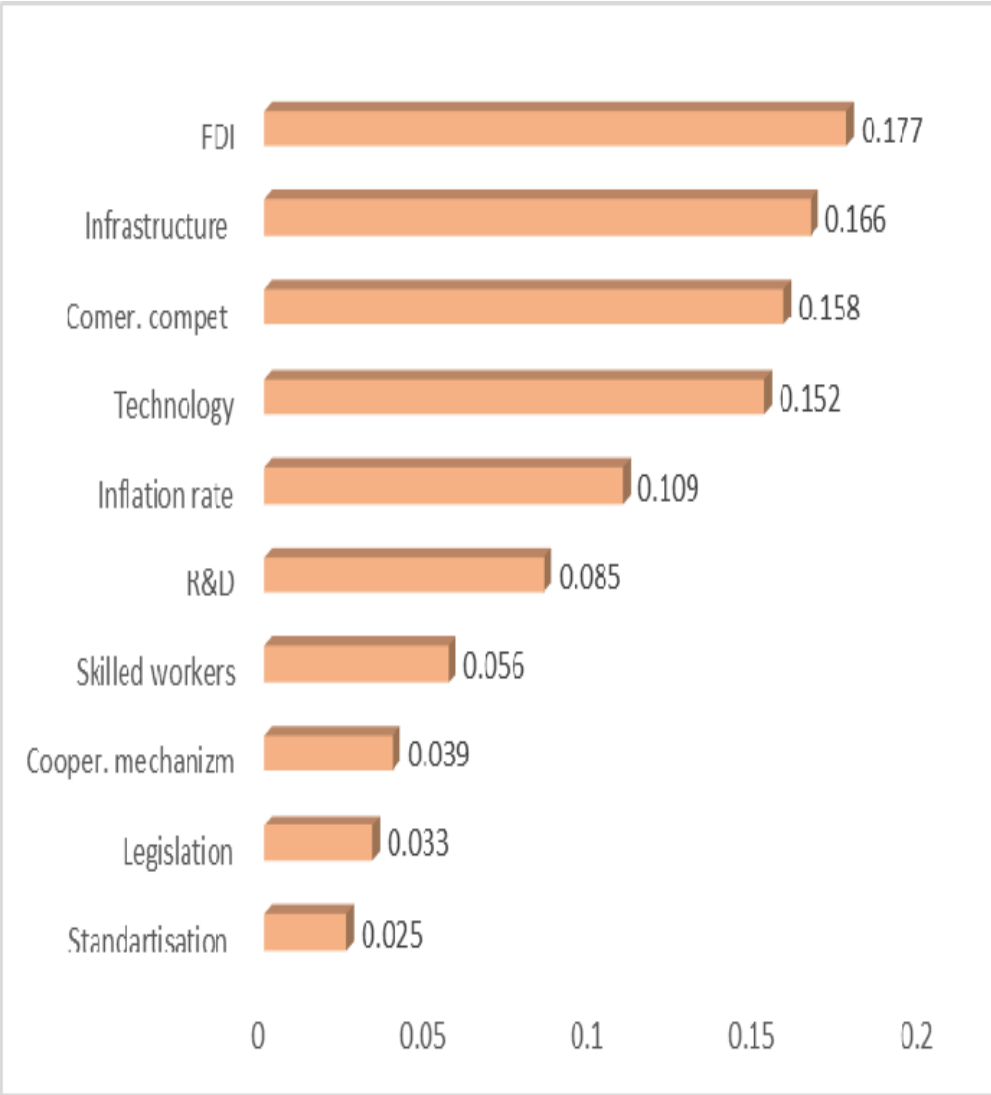
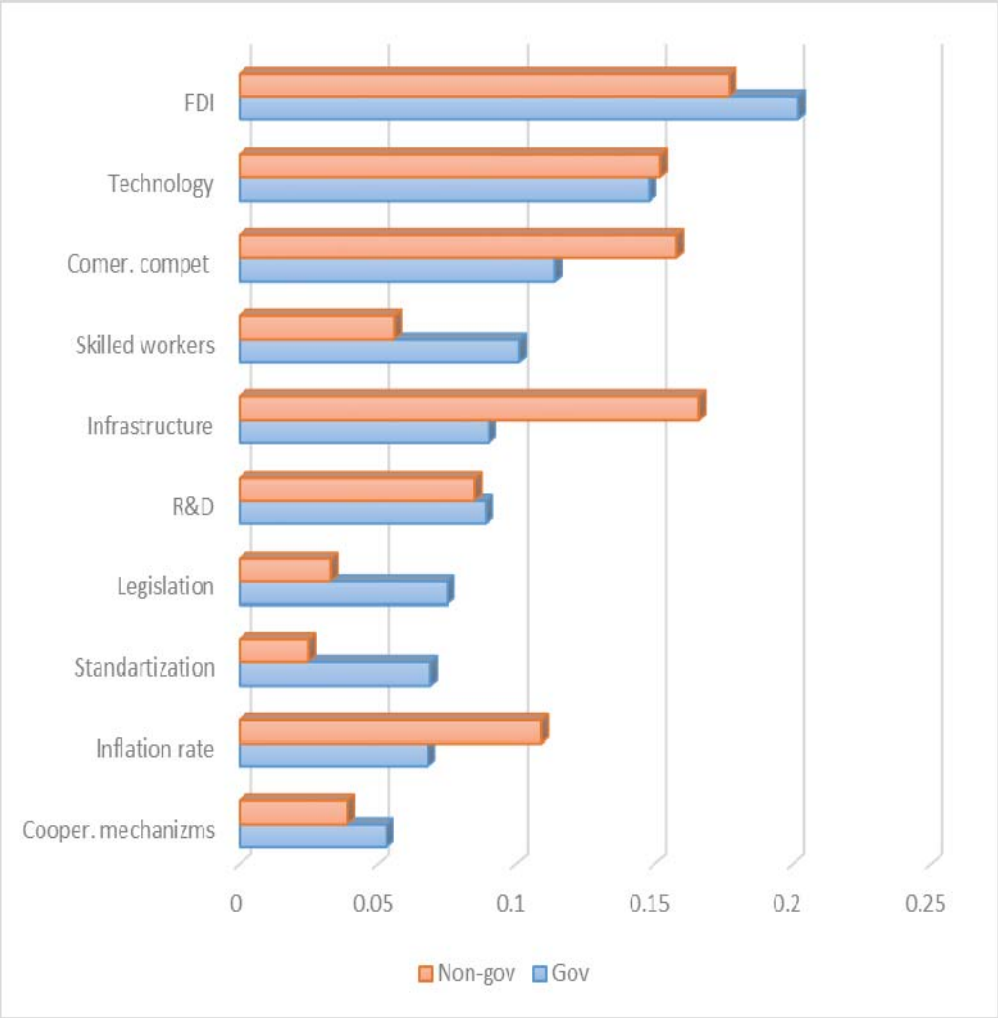


Figure 13 below represents the graphical results of overall ranking of sub-criteria according to both government and non-government respondents.

Figure 13. Comparison of overall ranking of sub-criteria



The order of sub-criteria in Figure 13 is made according to the respondents' priority from the government sector.

4.1.5 Results on survey regarding COVID-19 pandemic

All the respondents additionally were asked if they would change their answers in pair-wise comparison questionnaire, considering the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years). In brief, if they would change the priority that they gave to criteria and sub-criteria.

The answers of the respondents are introduced in Table 21 below.

Table 21. Results on survey regarding COVID-19 pandemic

Question	**Group 1: Government respondents (15)**	**Group 2: Non-government respondents (10)**
Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you change your priority of choice?	No	No

Thus, considering the possible impact of the COVID-19 pandemic none of the respondents decided to change their opinions.

4.2 Discussion of the Results

In this research two groups of respondents were asked for their opinion on the key factors for petrochemical industry development. While the first group consisted from the experts of the Ministry of energy, the second one was represented by non-government organizations in the oil and gas sector of the Republic such as the national company, national welfare fund, and SEZ. Thus, the study summarizes the opinions of both groups of experts, compares them with each other, and identifies the most important criteria.

According to the results, among the main criteria – economic criteria were ranked as the most significant factor for the industry development then followed by technical and regulatory criteria. It should be noted, that this trend is equal for both groups of respondents, but with different weights. Moreover, the trend regarding sub-criteria under Economic criteria is similar for both groups of respondents as well. However, the sub-criteria got different weights as well. Thus, foreign direct investments are considered as the most important factor for the Economic criteria, followed by commercial competitiveness and inflation rate. As was discussed in the literature review one of the examples of successful experience in the industry development is foreign participation and investments with the advent of state-owned corporations. For instance, Sinopec company in China, which facilitated relations between China and foreign companies in

the field of exchange of experience and technology at the highest level (Halova & Osmanova, 2015). As regards commercial competitiveness, this factor covers the basic components which allow the creation of globally competitive industries in the country such as market, conditions, related, and supporting industries and strategies (Amantay, 2020). In addition, proximity to demand markets, access to raw materials, access to technology, and government incentives are among the main factors contributing to the development of the petrochemical industry according to Halova & Osmanova (2015). At the same time, as has been discussed in the literature review such practices as cluster creation and development may play a crucial role in the creation of competitive conditions. Thus, the cluster model of inter-economic relations can be considered as a factor contributing to technological integration and accelerated innovative development (Kuznetsov et al., 2019). On the other hand, external factors of strategic development of a petrochemical enterprise include factors of the industry development such as the impact of inflation (Gayfullina & Nizamova, 2018). Although the sub-criteria was not chosen as a first priority, it is also an important factor as it can have an impact on the costs and investments. Thus, such macroeconomic instability makes it difficult to diversify exports and may lower incentives for risk-averse investors in non-commodity trading sectors (Gelb, 2010). Nevertheless, in the global ranking inflation rate got quite a high rank from non-government respondents, while was chosen as almost less important criteria by the first group.

Among Technical criteria, experts had different points of view. In general, both groups of respondents consider technology transfer to be an important factor for the industry development. Thus, this criterion received almost the same weights from both groups, however, it was the most important factor for respondents from the government sector. Thus, the experts considered technology transfer and development as a key factor in the development of the industry. Nevertheless, while qualified personnel appeared to be the second important factor for government experts, it was the least important criterion for the second group of respondents. On the other hand, infrastructure development was considered the most important criteria for non-government experts. This is the most obvious difference in the responses between both groups, which probably may be due to experts' different backgrounds, work experiences, etc. For example, experts from the government sector may consider the existence of skilled workers is needed firstly in order to build and develop the infrastructure (the State program on the industrial development of Kazakhstan; OECD). On the other hand, non-government experts may consider the existence of infrastructure as the first priority factor for investment attraction. For instance, on the territory of the special economic zone (SEZs), where external, internal, and industrial infrastructure is being carried out, this issue is of particular consideration. In general, referring to literature many researchers has a different point of view regarding this issue as well. For example, according to Kim (2005) development of physical infrastructure has always been on top of the development agenda. On the other hand, OECD (2015) research considered major skill gaps and underqualified staff as an

important obstacle for petrochemical industry development. Thus, there were contradicting differences in the views of respondents which may be due to their background and the responsibilities of the two different decision-making groups. In general, the overall trend of innovation development (R&D) for both groups was similar. However, this criteria was the last important for government experts. The reason for that choice may be due to prioritization of already existing technologies and focusing on their transfer rather than on looking for innovation.

Finally, regarding Regulatory criteria results of weight calculation showed that the level of the legislative and regulatory framework, as well as technical regulation and standardization, appeared as a priority for the first group. These opinions may be due to the particular involvement of government experts in legislative and regulatory framework development, as well as technical regulation and standardization issues. Thus, for example, technical regulation system and standardization are of the strategical importance for industrial development according to the State program on the industrial development of Kazakhstan. Moreover, the issue of adoption of international norms is widely considered in terms of industry support, as this may cause difficulties for technology transfer, etc.

On the other hand, cooperation mechanisms development was considered more important for the second group. Referring to literature, international practices show that at the stage of fundamental transformations of the entire economy, state-owned enterprises and institutions, as well as the business sector, benefit from a public-private partnerships.

Moreover, states whose economies are most remote from the technological border especially need such institutions (Morozova & Nesterenko, 2011; Halova et al., 2015).

Naturally, the respondents' opinions in this study could be biased, and differences and contradictions in answers between both groups may also be explained due to experts' different backgrounds, work experiences, etc.

In addition, all the respondents regarding the question about the possible impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), did not change their opinion.

Thus, the research tried to check some hypotheses (refer to section 3.5 of Chapter 3). In this regard, hypotheses 1 and 5 were confirmed. In particular, Economic criteria related factors appeared to be the most important for the development of the petrochemical industry in Kazakhstan. Moreover, the COVID-19 pandemic outcomes will have no influence on the priority choice of factors for the petrochemical industry development.

Overall, foreign direct investments, commercial competitiveness, and technology transfer are among the most important criteria in government experts' opinion. On the other hand, foreign direct investments, commercial competitiveness, and infrastructure development are considered the most important factors in non-government experts' points of view.

Based on the analysis of key criteria for the development of the petrochemical industry, I propose to develop a step-by-step strategy (roadmap) and a list of measures for

its implementation aimed at fulfilling its key tasks by developing a number of state support measures:

- to enhance the investment attractiveness of the industry through tax and financial incentives;

- to enhance mechanisms for cluster development and public-private partnership in the construction and modernization of infrastructure and technology transfer;

- development of export potential and import substitution in the domestic market;

- qualified personnel support (elaboration and establishment of occupational standards for the industry might be the initial measure).

There are a number of studies regarding the development of the petrochemical industry, as well as other sectors, in the context of different countries and economies. Thus, different factors contributing to the development of the industry were discussed. In this way, this research also tried to compare obtained results with existing literature.

The construction of petrochemical enterprises is quite capital-intensive, in this way foreign investments appeared to be an important factor. Thus, Halova et al. (2015) in their study considered foreign participation and investments in China's petrochemical sector as one of the most important factors contributing to its active development. The main part of foreign investment was directed to technical advice for projects. With the advent of state-owned corporations, relations between China and foreign companies have intensified in the field of exchange of experience at the highest level, and further modernization of the industry has increased. Galeyeva (2012) also suggests that special

attention should be paid to expanding the attraction of foreign direct investment and foreign venture.

According to Enos (1984) government participation and foreign technology transfer were the key factors for success in the case of petrochemical industry development in South Korea.

Regarding other sectors, Amantay (2020) identified factors for renewable energy development in the context of Kazakhstan. In this study, author applied AHP methodology to compare the opinions of different groups of respondents as well. Thus, for government experts - economic barriers (low levels of investment) were the most important, whereas for private experts - technical barriers (lack of infrastructure and transmission system) appeared to be the most important.

The importance of foreign direct investment (FDI) for the development of industries, especially at an initial stage, is highly empathized in many pieces of literature. Keeley & Matsumoto (2018) in their research analyzed the importance of foreign direct investment for the development of renewable energy in developing countries. Thus, the importance of FDI has been increasingly admitted. Many countries have developed various measures to attract FDI in the sector.

Overall, investments and technology transfer are considered as the most important factor for the industry development in many different studies. In addition, infrastructure, a partnership between the state and the private sector are also have important influence (Ren, 2009; Galeyeva, 2012; Enos, 1984; Gayfullina, 2018,

Prokopenkov, 2007; Gelb, 2010). Thus, the results of this study generally have a similar trend.

Despite the fact that all the criteria are quite important as themselves, through analyzing and prioritizing the factors among the identified list, the decision-makers can focus on issues that are more important. Without prioritizing when changes occur, we have much less leeway on how we will proceed and may have to abandon some of our previous “must-have” requirements. In this way, prioritizing helps us manage our requirements and resources, which include people, time, and budget.

Chapter 5. Conclusion

This chapter of the thesis research covers a summary of the study, overall conclusion, academic contribution, policy implication, and study limitation.

5.1 Summary

Kazakhstan has rich energy potential. Thus, the main value of the Kazakhstan economy is its oil and gas production. According to the Statistics committee of the Ministry of national economy of the Republic of Kazakhstan at the end of 2016, the share of the oil and gas industry in GDP amounted to 10.4 % (Yakubovskaya, 2010). However, diversification of the economy is very important in order to build sustainable economic growth (Hvidt, 2013).

In this way, Kazakhstan announced the petrochemical industry as high potential and one of the five key areas of development within the framework of the State Program of Industrial and Innovative Development.

This research analyzed the factors, which define the essential criteria for the industry development. Thus, ten key specific criteria were identified based on extensive literature review, various reports, policy programs, as well as through communicating with experts in the energy sector. The mentioned ten criteria were then classified into three main criteria: economic, technical and regulatory criteria. For the purpose of this research Analytical Hierarchy Process (AHP) model was applied. In this way, two groups

of respondents (government and non-government) were asked for their opinion on the importance of these key criteria for petrochemical industry development. Then, the criteria were weighted and prioritized using the AHP model. The comparison between the opinions of both groups of respondents was made.

In addition, the respondents were asked if they would change their opinion taking into account possible impact of the COVID-19 pandemic in the next 5-10 years.

Responses for the criteria were weighted and prioritized using AHP model, and answers from two groups were compared.

Overall, foreign direct investments, commercial competitiveness, technology transfer, and infrastructure development are found to be the top factors for petrochemical industry development in the context of Kazakhstan. While government officials gave weights more on economic factors, non-government experts gave more weights on technical factors. However, both groups agree that the foreign direct investments to be the most important factor. Moreover, all the respondents did not change their opinions regarding the question about possible influence of the COVID-19 pandemic on the future industry development.

5.2 Overall conclusion and study limitation

Development of the petrochemical industry is among the key priorities for Kazakhstan in the way of its economic diversification and sustainability. Nevertheless, there are important factors for this sector development that need to be considered.

According to the results, economic issues are the highest ranked category of factors that are the most important for the industry development, and then followed by technical and regulatory issues.

Thus, foreign direct investments, technology transfer, and commercial competitiveness are among the most important criteria from government experts' point of view. On the other hand, foreign direct investments, infrastructure development, and commercial competitiveness are considered the most important factors in non-government experts' points of view. Nevertheless, technology transfer also appeared to be important for non-government experts, however, this factor got slightly fewer weight comparing to infrastructure development. In addition, skilled workers also were considered an important factor for government experts, however, it was the last important criterion for non-government respondents. There were contradicting differences in the views of respondents which may be due to their background and the responsibilities of the two different decision-making groups. Naturally, the respondents' opinions in this study could be biased. The difference between the two groups' responses and possible reasons were widely discussed in the previous chapter (section 4.2).

In this way, the above mentioned factors should be considered and given first priority in the decision-making process for petrochemical industry development in the context of Kazakhstan.

However, this study has some limitations. Thus, the identified criteria and sub-criteria of the research are not the only factors that needed appropriate attention, additional factors can be identified in future researches. Nevertheless, discussion with the stakeholders might be needed. In addition, in this research, respondents from government and non-government sectors were participating. However, stakeholders from other fields, such as private, as well as academic could also take a part in future researches.

5.3 Academic contribution and policy implication

This research is the first work that has been done on analyzing and prioritizing the factors for petrochemical industry development in the context of Kazakhstan. There is no other analogous research has be en done yet. Thus, the study has an important academic contribution by filling the research gap in this field through developing and analyzing the main criteria and sub-criteria for the industry development. Moreover, the study may also be implemented in the case of other developing countries with a similar economy.

This research may assist the decision-makers in better understanding the difference between these two important groups of stakeholders in the industry. Thus, such major factors as foreign investments, technology transfer, and infrastructure development

should be given particular attention in order to maintain the industry development. Accordingly, the main results obtained from this research can be used for the strategy development in the petrochemical sector, as well as another policy instrument design.

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Appendix

Survey on criteria for the development of petrochemical industry

1. Introduction about research

Dear respondents:

Thank you for participating in this survey, which is conducted in order to get a master degree in the Technology Management Economics Policy Program (TEMEP) at Seoul National University. The title of thesis research is “Analysis on the decision-making process for petrochemical industry development in the case of Kazakhstan”, and this study is conducted by Khazhina Zulfiya, under the guidance of Professor Eunnyeong Heo.

This questionnaire is introduced to collect the experts’ opinion on the key factors for petrochemical industry development. In this regard, 3 main criteria and 10 sub-criteria were identified, and the Analytical Hierarchy Process model has been employed to prioritize them. Therefore, the experts have been asked to answer the pair-wise questions to compare relative importance of the main and sub-criteria. The hierarchical structure of the criteria is shown in Figure 1, and the description of the sub-criteria is shown in the Table 1. As illustrated in Figure 1, the first level of the AHP method starts with the final goal of the research. The main criteria and sub-criteria that should be evaluated are placed in the second and third levels, respectively.

Figure 1. Hierarchical structure of criteria for the development of the petrochemical industry and description of sub-criteria

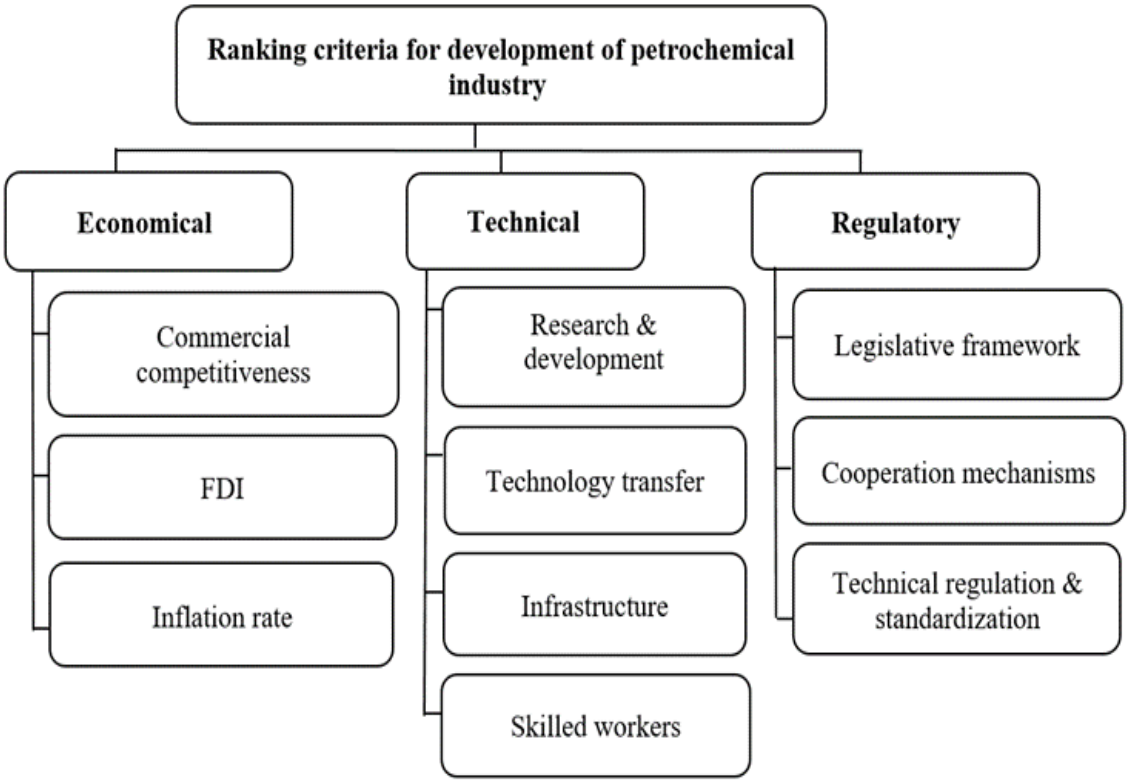


Table 1. Description of criteria and sub-criteria

Main criteria	Sub-criteria	Description
Economic (E)	Commercial competitiveness	Conditions, market, related and supporting industries
	FDI	Foreign direct investment
	Inflation rate	Impact of inflation rate on the industry development
Technical (T)	Research & development	Level of innovation in the petrochemical industry and research activities
	Technology transfer	Incentives for the transfer of advanced technologies
	Infrastructure	Development of transport, logistics, energy and other infrastructure
	Skilled workers	Level of qualified local personnel in the industry, both at the construction and operation stages
Regulatory (R)	Legislative framework	Level of legislative and regulatory framework
	Cooperation mechanisms	Level of development of the public-private partnership mechanism and centralized state corporation
	Technical regulation & standardization	Level of harmonization of state standards with international requirements

2. Guideline to fill the questionnaire up

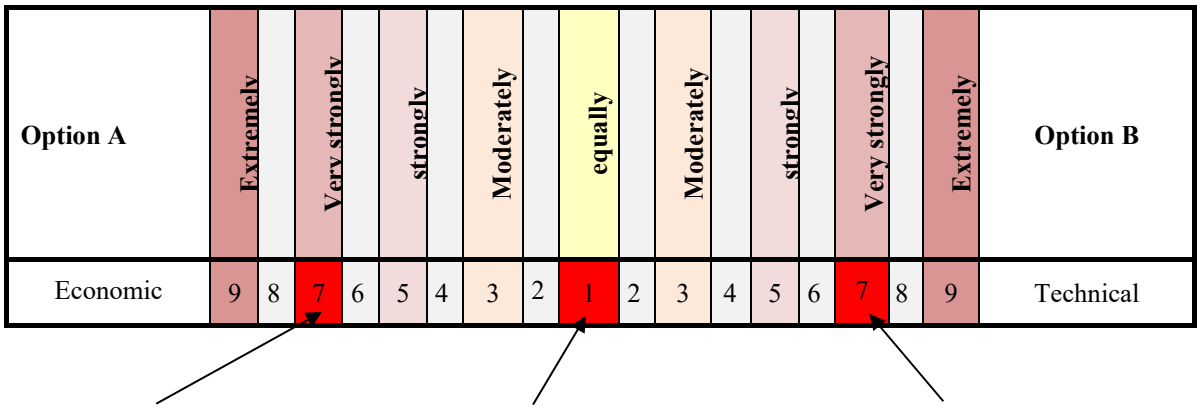
You will be offered four multi-part questions presented in the form of a 9-point scale of pair-wise comparison of criteria A and B. You will need to select a numeric scale value based on the importance of one criterion in relation to another (Table 2).

Table 2. Scale for pair-wise comparison of criteria (A and B)

Judgments	**Numeric scale**
If option A and B have the **same** importance	1
If option A is **moderately** more important than option B	3
If option A is **strongly** more important than option B	5
If option A is **very strongly** more important than option B	7
If option A is **extremely** more important than option	9
You can also choose even numbers for the intermediate score	2, 4, 6, 8

Below is an example of the response on this scale. You need to choose one of the numeric values of the scale according to your opinion. To avoid printing the questionnaire, you can highlight the number in red directly in this Word document (Table 3).

Table 3. Empirical example to do pair-wise comparison



This means that:

Criterion A (Economic) is a very strongly significant criterion compared to criterion B (Technical)

This means that:

Criterion A (Economic) and criterion B (Technical) are equally important

This means that:

Criterion B (Technical) is a very strongly significant criterion compared to criterion A (Economic)

3. Survey

Question 1

Please arrange the main criteria in order of importance from 1 (most important) to 3 (least important).

Table 4. Main criteria

Criteria	Rank
Economic (E)	( )
Technical (T)	( )
Regulatory (R)	( )

In accordance with the mentioned criteria and using a scale from 1 to 9, please select the degree of importance of Criterion A (left column) in relation to criterion B (right column).

Option A	Extremely		Very strongly		strongly		Moderately		equally		Moderately		strongly		Very strongly		Extremely	Option B
E	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	T
E	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	R
T	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	R

Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you change your priority of choice? (you can highlight the answer in red directly in this Word document).

Yes ☐ ☐ No

If you answered “Yes”, please indicate your answers below. Thank you.

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
E	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	T
E	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	R
T	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	R

Question 2

Please arrange the Economic sub-criteria in order of importance from 1 (most important) to 3 (least important).

Table 5. Economic sub-criteria

Sub-criteria	Rank
Commercial competitiveness (CC)	( )
Foreign direct investment (FDI)	( )
Inflation rate (IR)	( )

In accordance with the mentioned criteria and using a scale from 1 to 9, please select the degree of importance of criterion A (left column) in relation to criterion B (right column).

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
CC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	FDI
CC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IR
FDI	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IR

Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you

change your priority of choice? (you can highlight the answer in red directly in this Word document).

Yes ☐ ☐ No

If you answered “Yes”, please indicate your answers below. Thank you.

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
CC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	FDI
CC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IR
FDI	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IR

Question 3

Please arrange the Technical sub-criteria in order of importance from 1 (most important) to 4 (least important).

Table 6. Technical sub-criteria

Sub-criteria	Rank
Research & development (R&D)	( )
Technology transfer (T)	( )
Infrastructure (I)	( )
Skilled workers (W)	( )

In accordance with the mentioned criteria and using a scale from 1 to 9, please select the degree of importance of criterion A (left column) in relation to criterion B (right column).

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
R&D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	T
R&D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	I
R&D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	W
T	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	I
T	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	W
I	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	W

Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you change your priority of choice? (you can highlight the answer in red directly in this Word document).

Yes ☐ ☐ No

If you answered "Yes", please indicate your answers below. Thank you.

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
R&D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	T
R&D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	I
R&D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	W
T	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	I
T	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	W
I	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	W

Question 4

Please arrange the Regulatory sub-criteria in order of importance from 1 (most important) to 3 (least important).

Table 7. Regulatory sub-criteria

Sub-criteria	Rank
Legislative framework (Legisl.)	( )
Cooperation mechanisms (Cooper.)	( )
Technical regulation & standardization (Stand.)	( )

In accordance with the mentioned criteria and using a scale from 1 to 9, please select the degree of importance of criterion A (left column) in relation to criterion B (right column).

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
Legisl.	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cooper.
Legisl.	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Stand.
Cooper.	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Stand.

Suppose we were to consider the impact of the COVID-19 pandemic on the future development of the petrochemical industry (the next 5-10 years), would you change your priority of choice? (you can highlight the answer in red directly in this Word document).

Yes ☐ ☐ No

If you answered "Yes", please indicate your answers below. Thank you.

Option A	**Extremely**		**Very strongly**		**strongly**		**Moderately**		**equally**		**Moderately**		**strongly**		**Very strongly**		**Extremely**	**Option B**
Legisl.	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cooper.
Legisl.	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Stand.
Cooper.	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Stand.

3. Demographic and general information of the respondent

Age: ……year

Gender: ……..…….

Workplace: ……...……...

Job position: …….....

Work experience: ……year

Information provided by respondents is confidential and will not be disclosed. The answers provided will only be used for academic purposes.

Thank you for your time and participating!

List of Acronyms

AHP	Analytical hierarchy process
CI	Consistency index
COVID	COronaVIrus Disease
CR	Consistency ratio
FDI	Foreign direct investment
GDP	Gross Domestic Product
IEA	International Energy Agency
LLP	Limited liability partnership
MCDM	Multi Criteria Decision Making
NIPT	National Industrial Petrochemical Techno park
OECD	Organization for Economic Cooperation and Development
PCM	Pair-wise comparison matrix
PPP	Public-private partnership
RI	Random index
SEZ	Special economic zone

국문 요약 (Abstract)

카자흐스탄 석유화학산업의 개발에 대한 의사결정구조 연구

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카자흐스탄의 경제에서 부존 석유가스자원 및 석유가스 생산업의 중요성은 매우 크다. 2016년 카자흐스탄 석유가스산업은 GDP의 10.4 % 를 차지하고 있다. 그러나 엄청난 부존자원에도 불구하고 자국내 정유 및 석유화학산업시설의 부족으로 석유화학제품 수요의 94%는 수입에 의존하고 있다 (Yakubovskaya, 2010). 이에 카자흐스탄 정부는 경제다양화를 위한 산업혁신개발프로그램(State Program of Industrial and Innovative Development)의 일환으로 국내 석유화학산업의 개발 계획을 발표한 바 있다.

본 연구에서는 Analytical Hierarchy Process (AHP) 기법을 활용하여 카자흐스탄 국내 석유화학산업의 효과적이고 효율적인 개발을 위한 의사결정구조를 연구하여 카자흐스탄 정부의 석유화학산업 개발과정에 기초자료를 제공하고자 한다. 연구에서는 먼저 문헌조사 및 전문가 자문을 통하여 10개의 주요요인을 도출한 후 이를 다시 경제, 기술 및 규제 등 3개 분류로 나누었다.

설문 대상은 카자흐스탄 정부 내 석유가스산업 관계공무원과 산업계의 산업개발 전문가 등 2개 그룹으로 나누어 설문을 진행하여 두 그룹간의 의사결정구조를 비교하였다. 또한 COVID-19로 인하여 의사결정에 변화가 있을지에 대한 추가 설문도 진행하였다.

설문결과 foreign direct investments, commercial competitiveness, technology transfer, and infrastructure development 등이 가장 중요한 요소로 선정되었다. 그룹별로는 정부 공무원은 경제 분야의 요소를 강조한 반면, 산업계 전문가들은 기술적 요소들을 강조하였다. 그러나 두 그룹 모두 투자 (foreign direct investments) 요소를 가장 중요하게 평가하였다. 한편 COVID-19 사태로 인한 의사결정 변화는 없는 것으로 분석되었다.

주요어 : (경제다양화, 석유화학산업, AHP, 의사결정구조, 카자흐스탄)

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