"Leaky Bucket" of Kazakhstan's Power Grid: Losses and Inefficient Distribution of Electric Power

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Abstract: This paper aims to determine and explain the main factors for power losses (the so-called "leaky bucket" effect) in Kazakhstan and the reasons for inefficient energy distribution within the country. Energy efficiency in Kazakhstan is much lower compared to more economically developed countries. The differences between energy efficiency in various regions of Kazakhstan are also significant. This article explores the impact of administrative monopoly tariffs on the regional energy efficiency, based on a national study conducted in Kazakhstan in 2017. The purpose of the study was to identify the administrative barriers and their impact on the sustainability of enterprise development. What hinders the distribution of energy resources among different regions is artificial barriers in the energy market and the administrative tariff monopoly for electric power. This leads to the inefficient distribution of resources throughout the country. In addition, it is difficult to leverage low distribution efficiency in the absence of a market. The authors attempt to prove that the magnitude of administrative barriers directly affects the efficiency and competitiveness of business, as well as the final prices of goods and services for the end consumer.

Keywords: electric power management; Kazakhstan; electric power efficiency; costs

1. Introduction

Kazakhstan's energy-oriented economy is the richest and largest among the countries of Central Asia, with the world's 15th largest proven natural gas and hydrocarbon reserves, and the 9th largest proven oil reserves. These resources account for approx. 60% of export and 18% of the gross domestic product (GDP) (2015) [1]. Kazakhstan is a large country (9th in the world in terms of area) with a significantly diversified climate, infrastructure, economic structure, and regional differences in terms of the possession of resources. The energy intensity of Kazakhstan's economy is very high, more than twice the global average. Among the Organization for Economic Cooperation and Development

(OECD) and USSR countries, the republic ranks 4th in this respect. Studies also demonstrate that Kazakhstan has a significant potential in renewable and non-renewable energy production [2,3]. In 2014, Kazakhstan's energy intensity was 130% higher than that of a European country, e.g., Germany, and 53% higher than the global average. To better understand the causes and drivers of power consumption, it was broken down by sector and region. [4].

Electric power consumption plays an increasingly important role in the structure of Kazakhstan's power industry, as well as the national economic development [5]. The pricing mechanism for coal and electric power reflects the contradiction between the free-market and the administered prices of coal. Electric power prices vary greatly from one region to another. The lowest average regional price is approximately twice as low as the highest price in other regions. Therefore, examining the impact of the administrative pricing monopoly on the regional energy efficiency of enterprises is critical to addressing the energy crisis, reducing emissions, and promoting energy savings [6].

According to the OECD, the Government of Kazakhstan (GoK) fully controls the largest producers, distributors, and suppliers of electric power. The state's interference is even greater than in such energy-oriented economies as Russia and Venezuela. More than 750 operating national and affiliated enterprises create 30%–40% of Gross Domestic Product (GDP). According to some estimates, the quasi-state sector covers 25,000 enterprises and creates approx. 60% of GDP. There are approx. 200 independent power suppliers operating in the country, of which over 40% are natural monopolists. In many regions, such organizations control approx. 100% of the market, and here, the consumer's competitive choice is purely theoretical.

Like many power-oriented countries, Kazakhstan is struggling to recover from the declining external and domestic oil demand due to recent drops in international oil prices. In order to counteract the oil crisis, the GoK has adjusted the currency and monetary policies and introduced significant fiscal changes [7]. Kazakhstan has made commitments to reduce consumption and meet saving objectives, having made energy efficiency a national policy priority in recent years. This has been a timely response to the problems caused by the slowdown in economic growth, which resulted in mitigating the effects of rapid domestic power price increases and the desire to increase the competitiveness of the local industrial enterprises. However, energy efficiency varies widely from region to region in Kazakhstan, which in itself slows down recovery processes. Similarly, other countries have invested in new technologies in order to decrease the loss of power and increase the energy efficiency [8].

Kazakhstan's 2030 Development Strategy states that the country should increase the share of renewable and alternative energy sources and simultaneously improve the infrastructure of the national grid and thermal substations, as well as install power meters, focusing on new, energy-saving technologies [9]. Kazakhstan plans to reduce its energy intensity by 50% by 2050 and to use renewable energy sources to a greater extent.

This study attempts to demonstrate that administrative efforts to create an energy-efficient economy can be unproductive, with results similar to Okun's "leaky bucket" concept. It says that money redistributed from rich to poor is transferred in a "leaky bucket", i.e., a significant amount of money simply disappears along the way [10]. Okun attributed these losses to the administrative costs, i.e., taxes and transferring, as well as the incentive effect.

The literature on energy efficiency research can be divided into two categories. The first discusses regional differences in energy efficiency and its influencing factors in the form of horizontal studies [11,12]. The second category is vertical studies of energy efficiency determinants and major trends [13]. The vertical studies refer to differences in energy efficiency across wide variety of business sectors thanks to digital transformation [14]. Moreover, countries across the globe try to gain technological advancement in the energy sector, as it has sustainable impact on their economies [15]

Also, there is evidence from some studies that there is pressure on the energy sector to implement and roll out environmentally-friendly projects in order to contribute to sustainable energy development [16]. Both of these study groups identify a significant discrepancy in energy efficiency among Kazakhstan's regions and the most significant factors behind them. Contemporary scientists

differ in their views on the reasons behind these discrepancies, depending on their research method and the impacting factors. For example, previous studies suggest different findings, with significant regional differences in energy efficiency [17,18]. Some authors have tried to measure energy saving opportunities, taking into account regional differences in electric power consumption [19], but their analysis lacks an in-depth consideration of the mechanisms for defining differences in energy efficiency. What is more, they were unable to identify the reasons for the mechanism's impact on energy efficiency [20]. Literature on integrating and mapping distributed generation in the renewable power grid provides similar proof with regard to countries that could achieve higher energy efficiency [21]. Previous studies have demonstrated a complex approach in measuring the energy and economic efficiency in residential buildings [22]. We propose an analytical scheme of regional energy efficiency discrepancies based on stochastic boundary production functions and measuring the role of the total factor productivity in regional energy efficiency discrepancies, assuming that the difference in total productivity is the main reason for regional discrepancies. This article is intended to complement the above studies and examine the impact of an administrative pricing monopoly on regional energy efficiency discrepancies.

The paper aims to determine and explain the main factors for power losses in Kazakhstan and the reasons for inefficient energy distribution within the country. First, the impact of an administrative pricing monopoly on regional energy efficiency is investigated. Secondly, the data used in the work to conduct an empirical study are described. Thirdly, the obtained results are discussed, followed by conclusions.

2. Materials and Methods

The paper attempts to demonstrate that the magnitude of administrative barriers directly affects the efficiency and competitiveness of business, as well as the final prices of goods and services for the end consumer. Identification of the presence and size of such administrative barriers, and consequently their impact on the sustainability of enterprise development was the purpose of a national study of production and transaction costs which was conducted in 2017 in Kazakhstan, in which the authors participated personally [23]. The research methodology based on the standard cost model (SCM) [24] using desktop and expert evaluation, secondary grouping, and factor analysis allowed for the analysis of data on the dynamics of costs of enterprises in Kazakhstan.

The research included a sample of 2781 enterprises out of the total number of 1,185,163 operating in Kazakhstan, representing different industries, with different shares in the GDP of Kazakhstan.

The division by size was carried out in accordance with the total share of economic entities in the country. Sectoral quotas considered the sector's share in the country's GDP since costs are part of the final value of the product. Industrial enterprises accounted for 13% of the sample, 24% agriculture, forestry, and fisheries, 12% construction, 26% wholesale and retail, 23% services, and 2% other. By regions, the sample was double quoted. The share of surveyed enterprises in the region corresponds to the region's share in the total GDP of the country. The distribution of respondents in the region by sectors is made in accordance with the sectoral structure of the economy established in each region. Thus, the sample fully reflected the sectoral and regional structure of the economy of Kazakhstan, which allowed to draw reliable conclusions.

Table 1 shows the structure of the surveyed enterprises divided by size. Most of the surveyed enterprises were small businesses.

Taking into account the harsh continental climate, which is typical for all regions of Kazakhstan, both the use of technologically outdated electric power production methods of resources and the underdevelopment of energy-saving technologies, cost optimization of electric power, and heating supply are relevant to the country's business.

Figure 1 shows the share of heating and electric power costs in the total costs of various industries.

Table 1. Sampling structure of a study to estimate production and transaction costs.

№	Business Size	Number of Respondents	Response Rate, %
1	Micro business	203	7%
2	Small business	1556	57%
3	Medium business	787	28%
4	Large business	235	8%
	Total	2781	100%

Source: own elaboration.
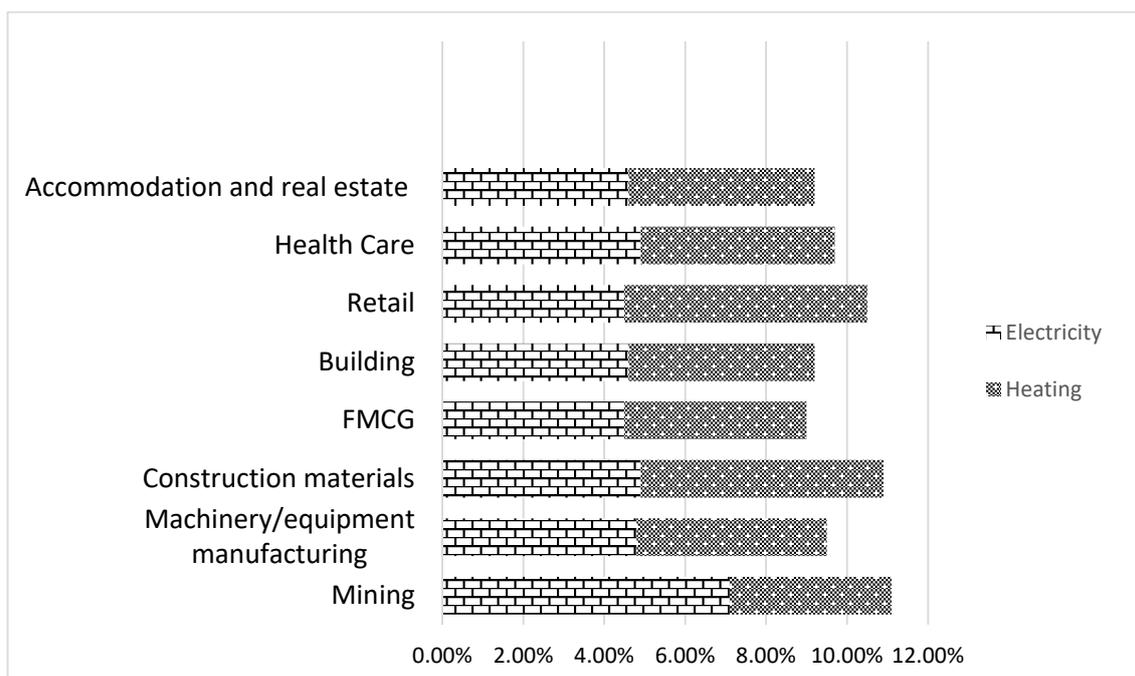
Figure 1. Share of heating and electric power costs in the total costs of selected industries. Source: own elaboration.

The highest energy losses have been identified in the trade and metallurgy sectors, i.e., 10% of the total amount of losses. The paper investigates the energy losses patterns in these two business sectors (Table 2.)

Table 2. Share of electric power and heating costs in the total cost structure, depending on the size of the business.

Share of Item in Total Costs	Micro Business	Small Business	Medium Business	Large Business
Electric power	9.46	7.59	6.86	3.24
Heating	10.14	8.49	4.51	2.20

Source: own elaboration.

As a result, the impact of electric power and heating cost affects business development. When power costs increase, every third enterprise observes a decrease in sustainability, and the critical impact leads to changes in performance indicators. The growth of power costs is particularly critical for small businesses. This study analyzed the data on the cost of growth for enterprises of various sizes, with the prevailing percentage of small businesses (Table 2, Figure 2).
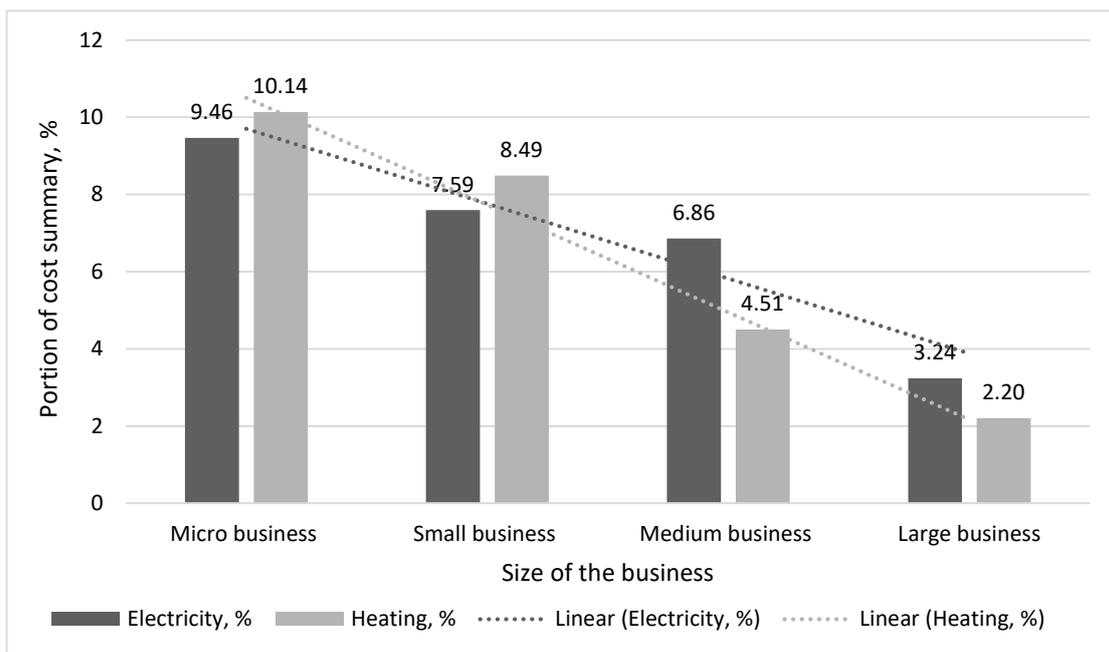
Figure 2. Dependence of electric power and heating costs on the size of the business. Source: own elaboration.

Energy costs have a direct linear dependence on the size of the enterprise as follows:

$$y = bx + a \qquad (1)$$

The energy costs are calculated by using the method of least squares as follows:

$$\begin{aligned} a{\cdot}n + b{\cdot}\sum x &= \sum y \\ a{\cdot}\sum x + b{\cdot}\sum x2 &= \sum y{\cdot}x \end{aligned} \qquad (2)$$

In this case, the equation of the linear dependence of electricity costs (trend) are shown in Figure 2 as follows:

$$y = -1.9393x + 11.638,$$

where the coefficient of determination is $R^2 = 0.9225$ and indicates presence of a strong relationship. The equation of linear dependence of energy heating (trend) is the following:

$$y = -2.7781x + 13.28,$$

where the coefficient of determination is $R^2 = 0.9768$ and shows presence of a strong relationship.

3. Results

3.1. Common National Trends in Business Cost Analysis

The most significant expenses of the enterprise are incurred by the power and heating supply and transaction services of monopolists [23]. The smaller the enterprise, the greater the share of power cost, and the stronger the impact is on business sustainability. In a large enterprise, it is five times lower than in a micro-enterprise. Therefore, for small enterprises, power cost constitutes a survival threshold.

Small forms of business shape out the basis of the entrepreneurial ecosystem of the economy. Thus, it sets the foundation for the growth of new forms of business and it provides an environment for the formation and implementation of entrepreneurial initiative. The more favorable the conditions for the manifestation of the first forms of entrepreneurship, the greater the chances to develop businesses

in the regions, creating new forms of products and services [25]. Small forms of business need state support not so much in the form of direct investment, but in the creation of conditions that do not hinder the manifestation of private initiative [26]. In the conditions of high energy consumption in Kazakhstan, the environment for the development of risky private entrepreneurship is impoverished, especially in industries that need stable conditions in the first years of existence.

The total cost of heating and electric power in the micro-enterprise (sole proprietorship) constitutes up to 20% of production costs, and in small enterprises, 16%. The GoK declares a policy of active support for small businesses, trying not only to increase GDP growth in non-resource-based industries, but also to create a middle class based on small business, as a democratic and financially sustainable fundament of society. However, having decided to create a small business to implement the innovative idea, the Kazakhstani entrepreneur will have to give a fifth of the expenses to pay for heating and electric power generated and supplied by the state and quasi-state monopolists. It is clear, therefore, that the energy policy of the state determines the real conditions for development of private entrepreneurial initiatives.

At the same time, power costs include not only direct costs for the consumed energy, but also from additional transaction fees, to be paid services to quasi-governmental monopoly organizations. These costs include not only services related to direct connection or disconnection of power and heating network to the main lines, but also agency services for obtaining permits and information on the free capacity of power and heating transmission (Table 3). Please note that tariffs for these services differ not only by region in Kazakhstan, but also depending on whether the power transmission and heat conducting organization are natural monopoly holders (NMH).

Table 3. The distribution of the cost of services for the connection to energy infrastructure elements (electric power, heating) (% of the number of answers).

№	Costs	10–40 Thousand KZT	41–100 Thousand KZT	101–700 Thousand KZT
1	Connecting (disconnecting) electrical installations to the power grid for the enterprise	66	20	14
2	Connecting to the heating network of the thermal power plant	48	30	22
3	Connection of electric installations to the power grids of NMH companies, according to requirements stated in NMH specifications	80	10	10
4	Connecting to the heating network of the thermal power plant, according to the technical specifications set by the NMH	37	52	11
5	Permits from the NMH for works related to changes in the energy metering scheme	71	5	24
6	Additional verification of the commercial energy meter prior to connection (in case if the consumer has been disconnected for violation of the terms of the power supply contract);	56	31	13
7	Additional verification of the commercial energy meter prior to connection (in case if the consumer has been disconnected for violation of the terms of the heat supply contract)	86	-	14
8	Costs related to losses caused by obtaining information on the availability of free power generation capacities of the NMH	88	12	-

Source: own elaboration.

If direct production costs for electric power and heat are in a determined dependence on the volume of output, the associated transaction costs have no economic justification. The presented tables show that the formation of costs for energy infrastructure services has a major impact on the amount of fees, which cannot be justified by objective reasons.

Energy costs thus constitute a bottleneck that generates associated costs, exceeding the direct costs and triggering the total cost increase elsewhere in the value chain.

3.2. Regional Patterns of Costs for Electric Power and Heat Supply

Territorial analysis by region shows that there is no direct correlation between the climatic conditions and the duration of the heating season. Also, the analysis demonstrates that there is no direct correlation between the tariff level and the total fee. The transaction costs of energy services differ by region by a factor of six or more (Table 4).

Table 4. The share of heat and electric power costs in the total cost structure, %.

Regions	Akmola	Aktyubinsk	Almaty	Atyrau	West-Kazakhstan	Zhambyl	Karaganda	Kostanay
Electricity	5.7	6.5	5.6	9.7	7.5	2.5	10.1	7.7
Heating	3.4	5.0	2.3	5.7	5.9	1.0	4.8	6.4
Average annual t°	1.8	3.6	6.9	7.7	4.4	9.7	2.3	1.6
Average t° of winter period	−18	−16	−12	−13	−17	−7	−16	−16
Regions	Kyzylorda	Mangistau	South-Kazakhstan	Pavlodar	North-Kazakhstan	East-Kazakhstan	Astana city	Almaty city
Electricity	9.1	8.7	8.0	15.9	4.6	5.7	5.1	2.8
Heating	5.1	6.4	9.6	11.2	10.4	5.3	4.0	2.7
Average annual t°	9	11.1	11.9	1.9	0.5	3	1.40	7.6
Average t° in winter	−8	−4	−5	−17	–	–	−18	−12

Source: own elaboration.

The Pearson correlation coefficient was used to determine the relationship between the two rows of variables. The correlation coefficient is calculated with the formula:

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)\left(Y_i - \overline{Y}\right)}{\sqrt{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2 \sum_{j=1}^{n}\left(Y_j - \overline{Y}\right)^2}}, \tag{3}$$

where $\overline{x}$, $\overline{y}$- are sample averages, defined as follows:

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$
$$\overline{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \tag{4}$$

The coefficient of correlation of average temperature of the winter period in regions with indicators of expenses is −0.11 for heat supply. The correlation of average annual temperature in regions is −0.15 for electric power supply, and −0.18 for heat supply, which is not statistically significant, but indicates a feedback: the higher the average annual temperature in the region, the lower the share of energy in the structure of company expenses.

Figure 3 shows that the lower the average annual temperature and winter temperature, the higher the share of electric power and heat costs in almost all regions across Kazakhstan is. Figure 3 presents exceptions, e.g., Kyzylorda, Mangistau, and South Kazakhstan regions where, at rather high annual average temperatures, the share of costs for electric power and heat supply is quite large. This fact can be explained by two reasons:

1.　The desert climate in summer requires intensive air conditioning and cooling in offices and in public facilities.
2.　These regions have the highest administrative barriers, with widespread bribery on the part of NMHs.

Thus, if the cost of energy consumption is independent of climatic conditions, then it is dependent on other, less obvious and biased factors.

One of the hypotheses in the paper is that there is a correlation between the number of natural monopolies, the number of services they provide (Table 5), and the share of power costs of enterprises.
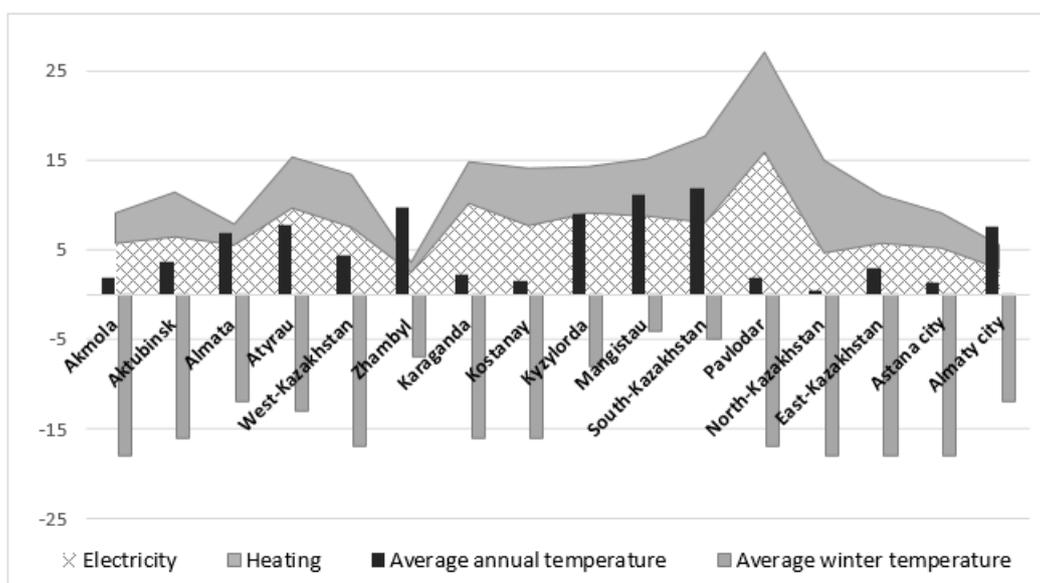
Figure 3. The share of heat and electric power costs in the total cost structure, %. Source: own elaboration.

Table 5. Calculation of the correlation coefficient between the distribution of the number of NMH subsidiaries and the share in the costs of electric power supply in the regions of Kazakhstan.

Regions	Number of NMH	Electric Energy	Deviation from the Mean		Squares of the Deviations		Product of the Deviations
	x	y	dx	dy	dx^2	dy^2	dx dy
Akmola	6	5.7	−1.25	−1.50	1.56	2.25	1.88
Aktyubinsk	3	6.5	−4.25	−0.70	18.06	0.49	2.98
Almaty	17	5.6	9.75	−1.60	95.06	2.56	−15.60
Atyrau	5	9.7	−2.25	2.50	5.06	6.25	−5.63
Zhambyl	1	2.5	−6.25	−4.70	39.06	22.09	29.38
West-Kazakhstan	4	7.5	−3.25	0.30	10.56	0.09	−0.97
Karaganda	7	10.1	−0.25	2.90	0.06	8.41	−0.73
Kostanay	4	7.7	−3.25	0.50	10.56	0.25	−1.63
Kyzylorda	2	9.1	−5.25	1.90	27.56	3.61	−9.98
Kyzylorda	4	8.7	−3.25	1.50	10.56	2.25	−4.88
South-Kazakhstan	3	8.0	−4.25	0.80	18.06	0.64	−3.40
Pavlodar	4	15.9	−3.25	8.70	10.56	75.69	−28.28
North-Kazakhstan	8	4.6	0.75	−2.60	0.56	6.76	−1.95
East-Kazakhstan	6	5.7	−1.25	−1.50	1.56	2.25	1.88
Astana city	20	5.1	12.75	−2.10	162.56	4.41	−26.78
Almaty city	22	2.8	14.75	−4.40	217.56	19.36	−64.90
Amount	116	115.2			629.0	157.4	−128.6
Mean	7.25	7.20					
Correlation coefficient	0.5						

Source: own elaboration.

The calculated correlation coefficient between the number of NMH subsidiaries and the share of costs for electric power supply is 0.5, which points to a stable relationship. The more subsidiaries there are in a region, the greater the share of costs spent on the services of these monopolies. This situation leads to the conclusion that free-market business contains the natural monopoly. This conclusion is also confirmed by the survey of entrepreneurs, which shows that there is a significant corruption component in power costs [23].

Improving energy efficiency is directly related to reducing energy consumption. But in the case of a cold climate and a large territory, it is not possible to reduce the energy consumption of heating. At the same time, finding a balance between the optimal proportions of energy consumption and the development of the region's economy is recommended. Basic social standards are met, first of all, by introducing low-energy production facilities, mastering new energy-efficient equipment, reducing

losses and unproductive expenses of fuel and energy resources. At the same time, it is necessary to set goals for reducing the costs of enterprises for heating and electric power in the overall cost structure of the enterprise.

The authors examined the following comparisons to search for these optimal values regarding the energy intensity of the regions with these specific electric power consumption levels and the share of electric power costs in the total costs of enterprises (Figures 4 and 5)
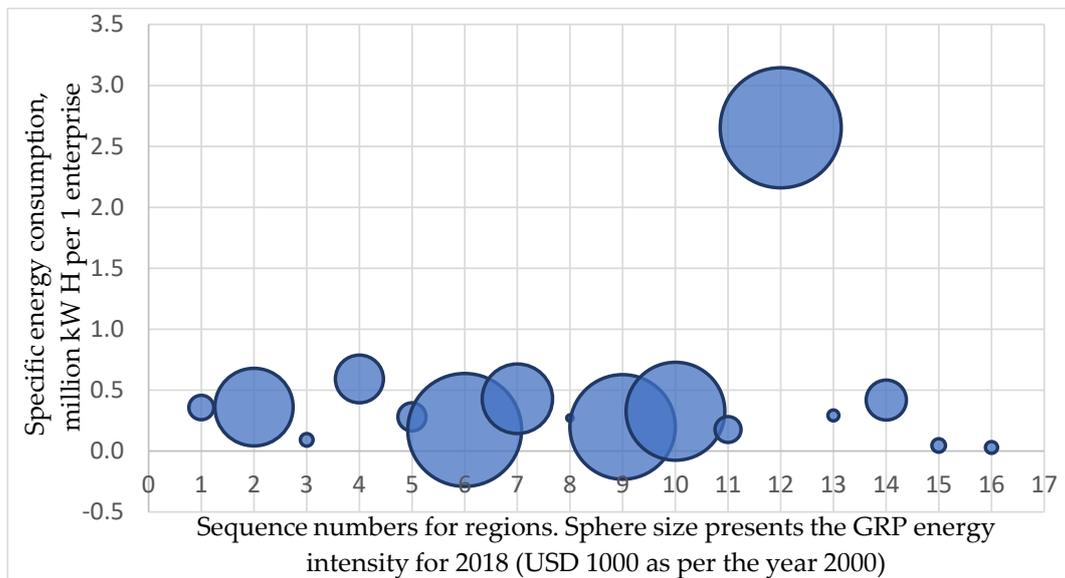
Figure 4. The relationship between electric power consumption and energy intensity of the regions of Kazakhstan in 2018. Source: own elaboration
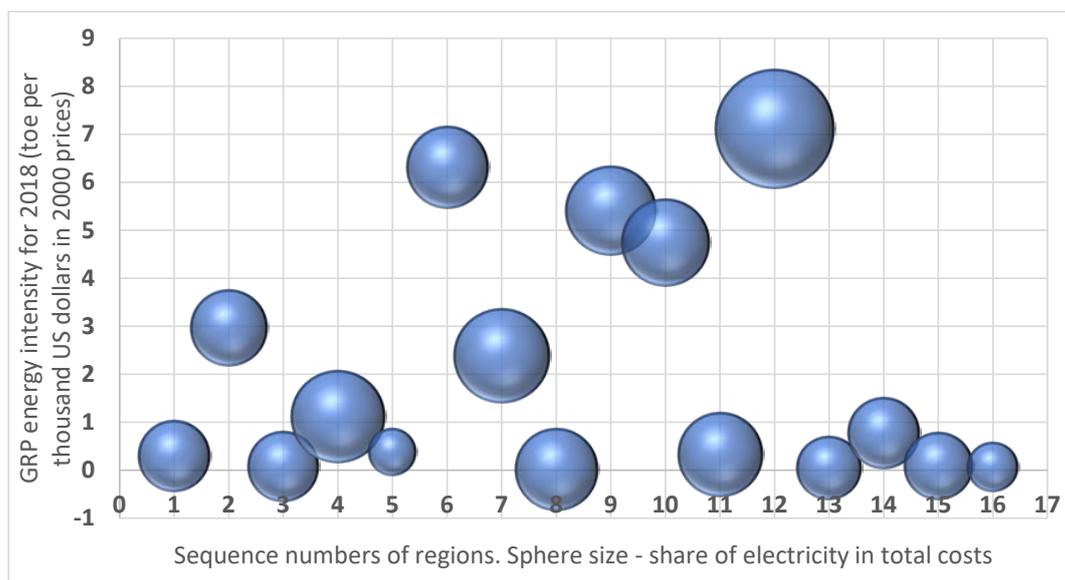
Figure 5. The relationship of energy intensity and the share of electric power in the total costs of enterprises in the regions of Kazakhstan in 2018. Source: own elaboration

The energy intensity of the regions for the year 2018 is presented by Kazakhstan's national statistics providers, which were calculated as the ratio of the gross consumption of fuel and energy resources for all production and non-production needs in tons of oil equivalent to the value of the gross regional product (GRP) (USD 1000 as per the year 2000).

The horizontal axis of Figure 4 shows the regions of Kazakhstan in the order previously shown in Table 5. The vertical axis shows the value of electric power consumption, attributed to an average of 1 enterprise in the region (specific energy consumption). As observed in Figure 3, the largest specific energy consumption in region 12, i.e., Pavlodar, is 2.65 million kWh for one enterprise and significantly differs from other regions. The average value of specific energy consumption for Kazakhstan is equal to 0.42 million kWh. Also, Pavlodar has the highest energy intensity (as observed by the size of the sphere corresponding to this region). In addition to the Pavlodar region, no. 6 (West Kazakhstan region), no. 9 (Kyzylorda region), and no. 10 (Mangistau region) are characterized by high energy intensity, the value of which is 2–3 times higher than the average value in Kazakhstan.

The high energy consumption and energy intensity of the Pavlodar region can be explained by both climate (the temperature in winter can drop to −40 °C) and industrialization of the region (it is a location for a number of energy-intensive non-ferrous metal works).

As regions with low energy consumption, West Kazakhstan, Kyzylorda, and Mangistau are highly energy intensive. Considering that the main industrial profile of these regions is oil production (without oil refining), a high energy intensity indicator may indicate insufficient energy efficiency of the technology and equipment used, including losses due to the inefficient operation of electric power suppliers.

The upper third quarter (horizontal) of Figure 4 presents regions with high energy intensity: West Kazakhstan, Kyzylorda, Mangystau and Pavlodar. As observed in Figure 5, the size of the sphere corresponding to the Pavlodar region, which presents the share of electric power costs in the total costs of the region's enterprises, is the largest among all of the regions and 2.2 times higher than the average value in Kazakhstan. These areas represent the group of the least energy efficient regions of Kazakhstan.

The central part (horizontal) of Figure 5 presents regions with an average energy intensity, namely Aktobe and Karaganda. The share of electric power costs in Aktyubinsk is equal to the average value, and in the Karaganda region, it is 1.5 times higher than the average value in Kazakhstan. Both areas are industrialized.

The lower third (horizontal) of Figure 5 presents the most efficient regions, in terms of both energy intensity and power costs.

Based on the diagrams considered, the authors propose that the low electric power efficiency of the regions is not so much due to energy-intensive products manufactured in the region, but by inefficient (outdated) technologies and equipment located in such regions.

To test this hypothesis, this analysis applies a mathematical clustering of regions according to three previously applied variables: electric power consumption, energy intensity, and the share of electric power cost in the total costs of enterprises.

Using the Ward method and the principle of Euclidean distances, the authors developed a dendrogram of the distribution of regions (Figure 6).

In Table 6, at a confidence level of 10, four clusters of regions can be visually identified. Furthermore, the authors used the k-means method for clustering 16 regions of Kazakhstan, and developed a graph of the distribution of average values shown in Figure 7.

Table 6. Average values of indicators for clusters.

Indicator	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Electric energy consumption	0.366858	0.216713	2.65252	0.264953
GRP energy intensity	0.970000	0.254286	7.12000	4.867500
Electric power costs	8.875000	4.571429	15.90000	7.950000

Source: own elaboration.
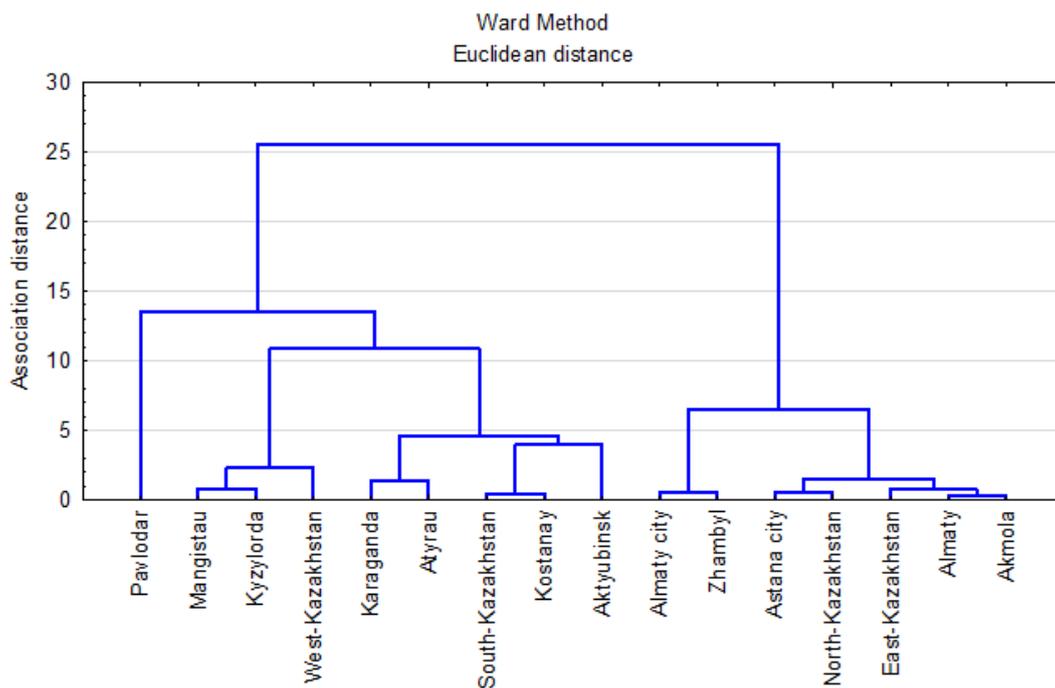
Figure 6. A dendrogram of the distribution of regions. Source: own elaboration
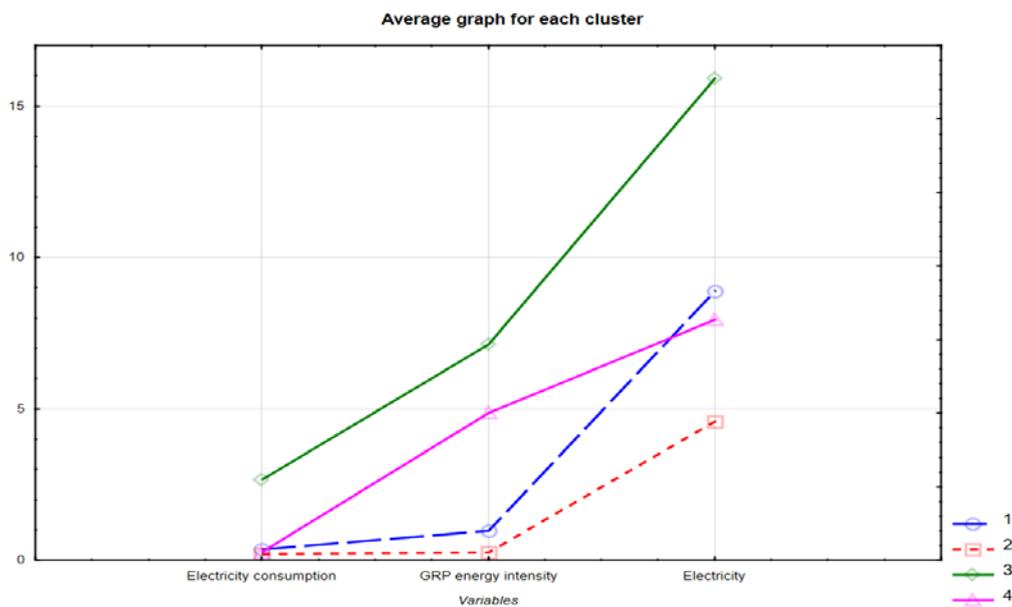
Figure 7. Graph of average indicator values for selected clusters. Source: own elaboration.

Table 6 presents details of the values of indicators per cluster.

Cluster 1 includes Atyrau, Karaganda, Kostanai, and South Kazakhstan regions and it is characterized by small values of specific electric power consumption and energy intensity. Its average power cost index is also slightly higher.

Cluster 2 is characterized by maximum energy efficiency. This is the biggest cluster in Kazakhstan, and it includes Aktobe, Almaty, Zhambyl, North Kazakhstan, and East Kazakhstan regions, as well as the cities of Astana and Almaty.

Cluster 3 represents the Pavlodar region and is characterized by minimal energy efficiency. The indicators under consideration are the highest, as observed above in Figures 4 and 5.

Cluster 4 is characterized by a low specific energy consumption, but a high energy intensity (nearly maximum) and an average indicator of power costs. The cluster is represented by four regions: Aktobe, Kyzylorda, Mangistau, and West Kazakhstan.

Thus, almost half of the regions of Kazakhstan (Cluster 2) are represented by energy-efficient enterprises, which are characterized by a minimal share of power costs in their total costs, which confirms the presented hypothesis.

The energy efficiency policy of Cluster 3, represented by Pavlodar region, needs to be reviewed in terms of all aspects that comprise the process of rational use of electric power.

In addition, the regions that comprise Cluster 4 need to consider ways to reduce their energy intensity, which brings this cluster closer to the level of inefficiency.

3.3. The Price of Energy Barrier for Business

As mentioned above, apart from direct costs for electric power and heating, business also bears the related transaction costs. Table 7 demonstrates that a quarter of the surveyed entrepreneurs face transaction costs for obtaining permits (including those from the NMH subsidiaries) and practically every tenth of them bears the costs of bribes for the representative of the NMH subsidiary. These high transaction costs of business indicate that the GoK lacks a consistent support policy for the energy sector and small business.

Table 7. Transaction costs of enterprises in the service sector.

№	Transaction Costs	Response Rate, %
1	Fines	32%
2	Permits from the state monopolists and quasi-state sector, as well as regular controls	25%
3	Access to BVI loans	24%
4	Legal costs	23%
5	Bribes for public officers	16%
6	Bribes for second-tier bank representatives	13%
7	Bribes for the representatives of the natural monopolists (NMH)	9%

Source: own elaboration.

The above structure of business and industry costs allow for the determination of the amount of financial resources that can be released into the economy by reducing the non-productive administrative barriers (Table 8).

Table 8. Calculation of costs related to connecting to the power grid by the NMH.

№	Transaction Costs for Heat and Electric Power	Share in Cost Structure, %	Recommendations	Volume of Costs Reduced, mln KZT
1	Connection (disconnection) of electrical installations to the power grid	5.55	Cut back by 50%	40,921.7
2	Connection to the heating networks of the energy supplier (power producer);	8.0	Cut back by 50%	25,450.5
3	Permits from the NMH for changing the energy metering scheme;	6.26	Cancel	123,903.8
4	Additional verification of the device of commercial metering of electric power prior to connection (if the consumer has been disconnected for violation of the power supply contract);	8.3	Cut back by 50%	25,450.5
9	Additional verification of the unit of commercial heating meters prior to connection (in case if the consumer has been disconnected for violation of the terms of the heating supply contract);	5.58	Cut back by 50%	30,317.4
10	Obtaining information on the free capacities of NMH (information costs on electric power and heating supply)	5.9	Cancel	8930.0

Source: own elaboration based on a study group report.

Such proposals were made by the working group based on the results of the analysis of frontal costs in 201. It was assumed that, by 2020, the level of total costs hampering business development will gradually decrease. The total amount of potential cost savings for the business could be KZT 254,973.9 million or USD 814.6 million at the current exchange rate during the study period. These funds could be used both to support business operations and to invest in the development of new production facilities. Back in 2017, the GoK was concerned about the high level of business costs incurred by the domestic enterprises and the proposed changes could make Kazakh business more resistant to adverse external influences. However, by 2020, the proposed measures have not been implemented as planned.

Previous studies have shown that a significant cost share of accounts for energy use costs regulated by quasi-state structures [24]. At that time, reducing even some of the administrative barriers could save business considerable funds and lead the country's energy policy into a new model of efficient consumption.

The impact of increasing power costs and the associated service and trade costs is particularly critical. With the first deterioration of external conditions, the services sector in general and trade in particular are unable to cross the critical threshold of costs of rent, utilities, and contributions to monopolists for the use of resources.

In the structure of expenses of trading enterprises, total expenses for heating and the electric energy constitute 10.5% and is the largest cluster of operational costs related to location (see Figure 8).
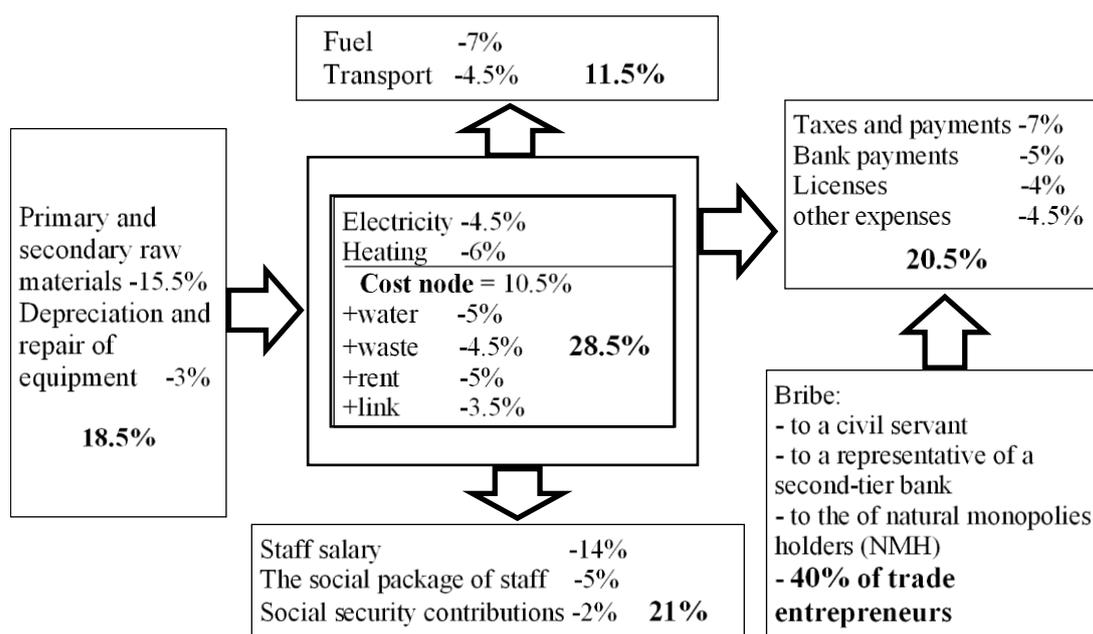
Figure 8. Structure of localization costs of service enterprises. Source: own elaboration.

Trading in Kazakhstan has industry-specific and region-specific patterns that affect the cost structure the enterprise. In trade, typical factors depend on the size of the rented space and a high share of overhead costs, the country's characteristics, i.e., large open areas, low population density, and the total small market capacity, as well as significantly varying climatic conditions. Those factors (rent, waybills), which are part of the overall management process, became a prerequisite for business survival in Kazakhstan. The increase of rent and overhead costs in global trade is usually regulated by changes in the pricing policy and the optimization of the entire production process, but in Kazakhstan, low market capacity does not allow for enough turnover and the compensation of costs. In addition, indirect fees for monopolists for services related to energy transmission, as well as bribes, account for a significant share of trade business costs. Practice shows that, as the economic situation deteriorates,

the size of these costs doesn't decrease and their share in total costs is even higher. According to the survey results, 40% of entrepreneurs in the trade sector had faced this problem.

Thus, the associated costs are clustered around the increasing electric power and heating consumption in trade, resulting in up to one-third of total costs and exceeding other cost groups. These costs can be called "knots" not only because they combine 6–10 types of costs related to their localization, but also because the increase of these costs creates risks for the entire organization. It is the increase in rent and utility charges that is a critical threshold, which trade enterprises cannot overcome in the case of unfavorable conditions, even in a short period of time.

By early 2020, the share of small and medium-sized enterprises (SMEs) in Kazakhstan's GDP increased to 29.5% and the number of its employees reached 3.3 million. The structure of SMEs in Kazakhstan is still dominated by service companies, especially traders. The growth in the number of trading companies over the last seven years has had almost no impact on the stability of business, and the service sector remains volatile. Given the favorable market conditions in the past years, the number of new arrivals and shutdowns in trade has almost equaled.

Trade is attractive for SMEs, and is the leading sector in terms of new enterprises, with approx. 16,000 enterprises registered annually. However, trade enterprises are fragile, as they can go bankrupt just as quickly (see Figure 9). Over 60% of small enterprises in liquidation are wholesalers and retailers (2700) [23]. The largest number of SMEs that have suspended their activities is also in the trade sector, i.e., 29,800.
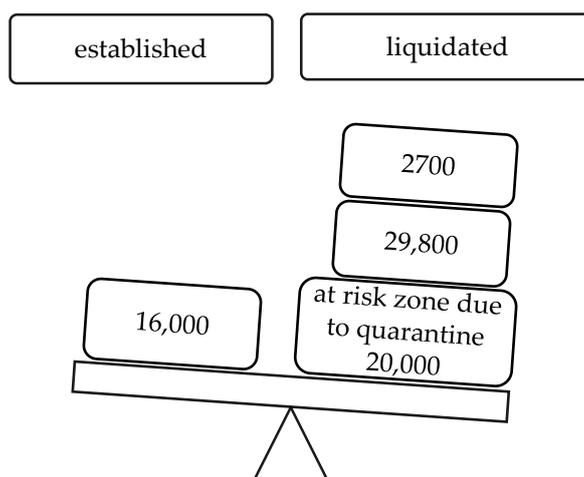
Figure 9. The balance between established and liquidated trade companies in Kazakhstan. Source: own elaboration.

Figure 10 shows the factors that have put additional strain on the business and created bankruptcy risk. The inability to pay for rent and utilities is the main threat for half of the SMEs and almost all forms of off-line trade.

Based on the observation of the market situation in Kazakhstan, it can be concluded that service companies (see Figure 11), especially in the trade sector, incur huge losses and may go into bankruptcy soon. Entrepreneurship in Kazakhstan has not yet become a stable part of the economy, and with the loss of income from domestic businesses, small entrepreneurs will join the ranks of the unemployed if the income from their businesses is lost.

Research shows that the enterprises of the service sphere, especially trade, bear huge losses and will go bankrupt in the near future.
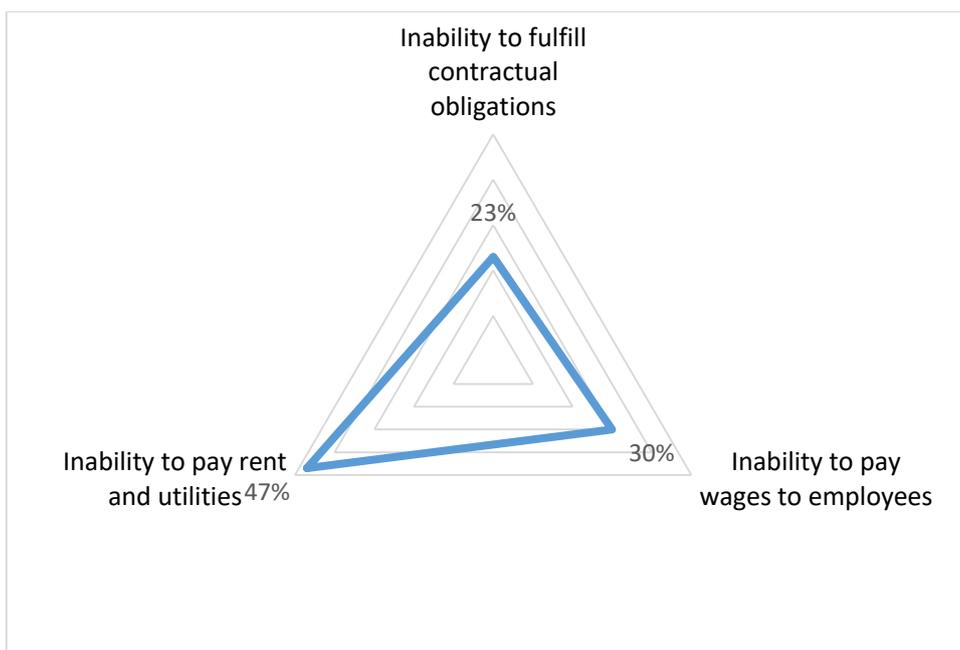
Figure 10. Causes for possible bankruptcy of SMEs. Source: own elaboration
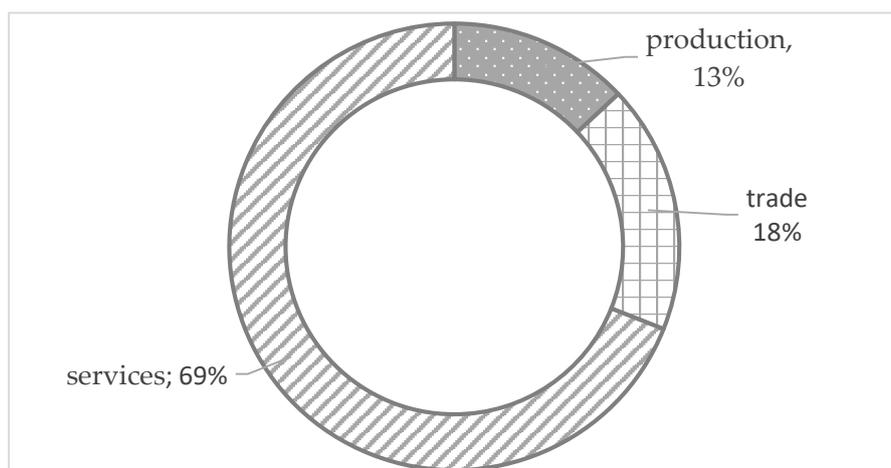
Figure 11. Which type of business is most concerned about the situation? Source: own elaboration

4. Discussion

In recent years, interest in regional energy efficiency research has been observed in a number of countries. For example, in China, a spatial analysis of factors affecting regional energy efficiency allowed the authors to draw conclusions about the need to [25]:

- Improve the quality of electric power and optimize the structure of the regional economy.
- Promote energy saving and enhance the technical level of local enterprises.
- Promote the general development and strengthening regional coordination.

Based on a regional approach to improving energy efficiency in Finland [26], it has been argued that "increasing the energy efficiency is one of the key elements when transferring energy systems towards sustainability, and procedures and solutions towards lower emissions, and also increased energy security and improved competitiveness, are often executed at the regional level".

Modelling the methodology for regional energy efficiency assessment and forecasting [27] allows the Chinese authorities to recommend different energy policies for different regions. For regions with

low energy efficiency, it is crucial to control the distribution of energy resources. A more extensive use of resources should no longer be allowed. In addition, the local government should create an incentive to improve "clean" energy technologies and reduce energy losses. In regions with moderate energy efficiency, it is important to focus on the technological improvement of the production process. The use of energy-saving, pro-environmental technologies should be encouraged and supported financially. For regions with high energy efficiency, it is necessary to focus on controlling the scale of energy supply from other regions.

Kazakhstan's energy sector faces a number of systemic problems, which have been exacerbated by the decrease in global energy prices, a reduction in industrial production in the context of the pandemic and a drop in demand for electric power. The World Bank's report "Stuck in transition: reform experiences and challenges ahead in the Kazakhstan power sector" [28] focuses on the risk of security of supply, significant investment needs, and the need for effective regulation and continuous reforms.

Based on the results of the study of frontal costs [29], the GoK proposed and discussed measures to reduce administrative barriers, providing business with a total cost reduction of KZT 580.6 billion, which as of 2017 is equal to USD 1.85 billion. Only a partial reduction of regulations on fees for energy infrastructure monopolists could provide savings of as much as KZT 255 billion.

In addition, the GoK plans to spend KZT 300 billion on the "Employment Roadmap". This will allow creating 250,000 jobs and implementing not only local, but also several national facilities, including construction of water reservoirs or dams. However, it has already been predicted in the worst-case scenario that the crisis will affect at least 2,000,000 workers in the SME sector and potentially up to 500,000 could be unemployed (Figure 12).
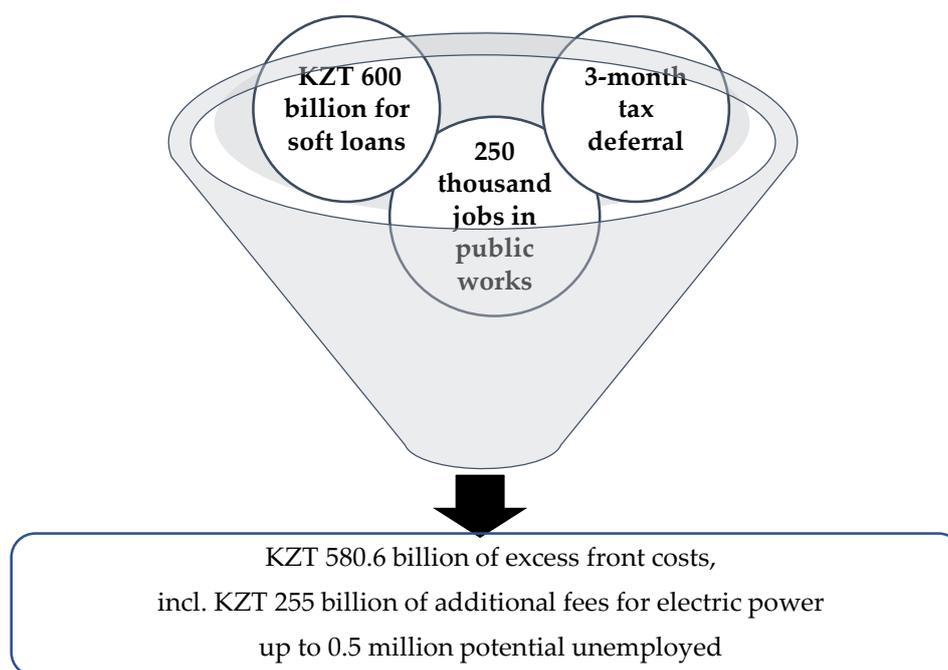
Figure 12. Kazakhstan's leaky bucket of business support. Source: own elaboration.

Small businesses can't use tax holidays and direct incentives they have been granted by the GoK, since the savings are spent on power fees and related costs. Enterprises are unable to change their energy consumption regime and thus reduce costs, and government assistance is ineffective. As a result, SMEs go bankrupt and become a social burden for the state. Thus, a country with rich natural resources may find itself in a catastrophic economic and social situation amidst dropping oil prices and a forced stagnation due to a global pandemic.

It was decided to provide another KZT 600 billion for crediting the operational capital of SMEs at 8% per annum. The income tax exemption should allow businesses to save more than KZT 380 billion

in three years, and to allocate the released funds for development. The campaign will cover 1.2 million SMEs [30].

Attracting foreign investors to Kazakhstan is hindered by significant state interference in key markets, including the energy market. To increase global competitiveness, the country's free-market institutions should work transparently, fairly, and efficiently [31].

In Kazakhstan, there is no competition in power supply to retail customers and no freedom of choice with respect to electric power suppliers [28]. This is exemplified by the lack of information about the free capacities of electric power suppliers. Subsidiaries of NMHs do not provide reliable information on the free capacities of nearby transmission substations, and entrepreneurs are told to connect to other substations, which in turn increases their cost of connecting to the power grid.

Significant fragmentation, a non-transparent ownership structure, the strong influence of politics on tariff pricing, a lack of funds for the modernization of power production infrastructure, and inefficient operation make energy distribution the weakest link in Kazakhstan's energy sector [32].

Another disadvantage of the retail market is that several suppliers are closely linked to energy producers as subsidiaries, and therefore are not interested in finding the cheapest power supplier in the national market, which hinders competition [33].

The tariff system is based on the traditional "cost-plus" principle, which reduces incentives for regulated companies to minimize costs and improve service quality. This disadvantage is observed in Kazakhstan along the entire value-added chain of electric power supply. The greatest potential for operational cost reduction is in the supply chain, which accounts for about 50% of the total energy saving potential [34].

Decreasing state interference in the economy and developing competitive, private sector-friendly markets is obligatory. The country recognizes the need to develop national business and runs a number of support programs in this respect. However, these efforts are actually undermined by the macroeconomic environment that does not support the private sector. The financial sector does not provide businesses with accessible resources, local governments create unequal conditions and administrative barriers, and the quasi-state sector crowds out innovative entrepreneurship, including in the energy sector [35].

In the modern economy, electric power turns out to be not only an economic factor, but also a political one. Energy policy forms the model of economic and business development as in the other countries across the globe [36]. In the value chain, power consumption triggers business costs, and as a result, the final cost of a product. Only with a transition to new energy models can the traps of a raw material economy be avoided.

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