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RESEARCH ARTICLE

Agricultural Policies and Technical Efficiency of Wheat Production in Kazakhstan and Russia: Evidence from a Stochastic Frontier Approach

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Abstract

We utilize a unique primary data set of farms in Russia and Kazakhstan to investigate the link between policy reforms and technical efficiency. These countries have heavily subsidized their domestic agricultural production over the last decade, with a total of around USD 76 billion USD and USD 11.5 billion USD in government funding directed towards the agricultural sectors in Russia and Kazakhstan, respectively. Results of a stochastic frontier analysis make evident that variable inputs, such as fertilizer, have a relatively large influence on wheat production compared to land. Nearly every fifth farm has a technical efficiency level lower than 60%, suggesting significant unrealized production potential. While our analysis shows a negative relation between subsidies and efficiency, other factors, such as farmer's education, cooperative and agroholding membership, and participation in insurance programs, are positively related to farm efficiency. The results imply that the governments and policymakers could mobilize the unutilized wheat production potential by improving the farmer education system, fostering cooperation among farms, and developing functioning farm insurance schemes.

Keywords: Food security; KRU countries; stochastic frontier analysis; subsidies; technical efficiency

JEL classifications: Q12; Q14; Q18

1. Introduction

An increasing global population and reduced poverty levels are leading to considerable growth in worldwide demand for food. By 2050, the world population is projected to exceed 9 billion people, requiring an estimated 60% increase in global agricultural production (FAO, 2013). Russia and Kazakhstan are among the world's largest producers and exporters of wheat, thus, these two countries have a significant impact on global food security. Russia has become the largest wheat exporter in the world, accounting for 20% of wheat exports worldwide (2018/19), with wheat exports primarily directed to North Africa and the Near East (especially Egypt and Turkey) (Svanidze and Götz, 2019; Uhl, Perekhozhuk, and Glauben, 2019). Kazakhstan accounts for about 5% of world exports. It is the primary wheat supplier to its neighboring countries in Central Asia (Kyrgyzstan, Tajikistan, and Uzbekistan) as well as the South Caucasus (Armenia, Azerbaijan, and Georgia) (Bobojonov, Duric, and Glauben, 2020; Svanidze et al., 2019).

Though still low compared to European countries, the USA and Canada, Russia, and Kazakhstan have increased wheat yields over the last decade (Rylko, 2018). In 2016, wheat yields in Kazakhstan and Russia amounted to 1.33 and 2.95 tons per ha, respectively, compared to 3.90, 3.63, and 5.85 tons per ha in the USA, Canada, and France, respectively (FAOSTAT, 2018). In light of this, within the existing literature, there are discussions regarding Russia's and Kazakhstan's considerable potential to boost their wheat production by improving production efficiency and increasing the area of cropland (Bokusheva and Hockmann, 2006; Liefert and Liefert, 2015; Swinnen et al., 2017). According to estimates by Swinnen et al. (2017), Russia, Kazakhstan, and Ukraine have the potential to collectively increase their wheat production from their current levels by around 40–110 million tons per year. By increasing the production and export of wheat, Kazakhstan and Russia could contribute to meeting the growing global demand for food and play a prominent role in future global food security. Because of the high costs of re-cultivating abandoned lands, improving the efficiency of wheat production could be a viable option for boosting production (Fehér et al., 2017; Liefert et al., 2010; Lioubimtseva and Henebry, 2012; Petrick et al., 2014; Schierhorn et al., 2014).

The governments of Russia and Kazakhstan have implemented several agricultural reform programs to mobilize additional agricultural production potential to achieve self-sufficiency. Russia even aspires to become one of the largest food exporters in the world (Wegren, 2020), with these aspirations typically and primarily being reached through the subsidization of domestic agricultural production (Petrick and Pomfret, 2016; USDA, 2012; Uzun, Shagaida, and Lerman, 2019). Under Russia's "Agricultural Development Program of 2013-2020", for instance, a total of 2.28 trillion Rubles (USD 76 billion) were allocated from the federal as well as provincial budgets (USDA, 2012). Most of these financial supports are directed towards agricultural producers in the form of direct subsidies for fertilizers, fuel, lubricants, and soil nutrients and subsidized interest rates for agricultural loans. In 2013, the Kazakhstani government introduced a new program, "Agribusiness 2020", which aims to stimulate competitiveness in the agri-food sector. A total of 3.1 trillion Kazakhstani Tenge (approximately 11.5 billion USD) was allocated to this program from the state budget (Petrick and Pomfret, 2016).

Another important policy reform in Russia and Kazakhstan to support agricultural production is subsidizing its insurance sector. In Russia, the government subsidizes multi-peril crop insurance, where 50% of premiums are covered by the state (Bobojonov, Goetz, and Glauben, 2014). Similarly, agricultural insurance also plays an important role in Kazakhstan. The government fosters the development of this sector with subsidies amounting to 50% of insurance company costs associated with indemnity payments (Mahul and Stutley, 2010).

Developing supply chain infrastructure and market access is another important policy priority in both Russia and Kazakhstan, although reforms of this kind are more common in Kazakhstan than in Russia. Under the "On Grain" law of the Republic of Kazakhstan, the government buys grain from farmers at pre-stated prices through its "KazAgro" holding. One of the key goals of the holding is to maintain food security in the country and stabilize grain prices on the domestic market.

In addition, Russia and Kazakhstan have implemented several agricultural programs to improve the knowledge and skills of farmers. Similar to the supply chain support policies, Kazakhstan has implemented more reforms related to educational activities. For example, the government of Kazakhstan has attempted to provide free education to all farmers, allocating 1 billion Kazakhstani Tenge (KZT; USD 3.05 million) from the republican budget for this purpose. Free seminars on agricultural topics are reportedly held by the National Chamber of Entrepreneurs of the Republic of Kazakhstan (the "Atameken") (Rahimbekov, 2016).

Another characteristic of agricultural development in Russia and Kazakhstan is the critical role of agroholdings. These large-scale production units emerged as farms were vertically and horizontally integrated to overcome risks and constraints associated with the demolished infrastructure during the early years of the Soviet Union's collapse (Visser, Mamonova, and Spoor, 2012).

This study investigates the technical efficiency of wheat-producing farms in Russia and Kazakhstan and its relation to various technical efficiency factors. These factors include the amount of farm subsidies paid by the government to farmers, access to supply chains,

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participation in insurance programs, and cooperative and agroholding membership. Several studies have investigated the development of technical efficiency in Russian agriculture during the transition years (Belyaeva and Hockmann, 2015; Bokusheva and Hockmann, 2006; Hahlbrock and Hockmann, 2011; Rada, Liefert, and Liefert, 2017; Sotnikov, 1998; Sedik, Trueblood, and Arnade, 1999; Voigt and Uvarovsky, 2001; Osborne and Trueblood, 2006); however, the relation between specific policy reforms and technical efficiency has not yet been assessed quantitatively before. We are especially not aware of any other study investigating the farm-level effects of subsidies in these two countries. In general, there is no consensus among the researchers about the relation between government subsidies and farm efficiency. While one stream of researchers observes a positive impact of subsidies on farm efficiency (Young and Westcott, 2000; Latruffe et al., 2016), others reveal quite the opposite (Minviel and Latruffe, 2017; Zhu and Lansink, 2010; Staniszewski and Borychowski, 2020), and yet others find no statistically significant connection between the two variables (Alem et al., 2019; Minviel and Latruffe, 2017).

Following a stochastic frontier approach, we, therefore, aim to fill this research gap by providing a pioneering empirical analysis investigating the technical efficiency of wheat-producing farms in Russia and Kazakhstan. This study utilizes a unique primary dataset of 270 wheat-producing farms in Russia and Kazakhstan, which was collected via a farm survey in 2015.

The remainder of the text is organized as follows: The main literature on the topic of this study is reviewed in Section 2, while the methodology and data are described in Section 3. The results of the analysis and discussion are provided in Section 4. Lastly, Section 5 presents the concluding remarks.

2. Literature Review

The factors influencing technical efficiency in developing and developed countries have been intensively investigated within the existing literature. Subsidies may increase the technical efficiency of farms, especially those that are financially constrained. Theoretically, by providing financial support to farmers, subsidies may enable farmers to invest in more advanced technologies and production/organizational techniques (Young and Westcott, 2000; Latruffe et al., 2016). However, the so-called income effect of subsidies might imply that subsidies could also negatively affect farm efficiency: Since a certain share of the farmers' income is guaranteed by subsidies, farmers are thus less motivated to adopt more efficient production methods (Minviel and Latruffe, 2017; Zhu and Lansink, 2010; Staniszewski and Borychowski, 2020). On the other hand, since strengthening efficiency is generally not at the center of subsidization programs, a significant influence of subsidies on farm efficiency might not even be identified (Alem et al., 2019; Minviel and Latruffe, 2017). Thus, economic theory, as well as the empirical evidence from the existing literature, is inconclusive, observing that subsidies may either increase or decrease farm efficiency or may not have any influence at all.

Empirical studies bring up rather mixed results due to differences in the study contexts (e.g., country, period, types of farms), databases (e.g., number of farms, cross-sectional or panel data) and estimation methodologies (e.g., parametric or nonparametric approaches) (Minviel and Latruffe, 2017). A recent meta-analysis by Minviel and Latruffe (2017) states that in 76% of the empirical studies, government subsidies have either negative or no significant effect on farm efficiency.

This again raises the question of whether the Russian and Kazakhstani governments' subsidy programs are effective instruments for boosting production potential. Several studies have addressed efficiency in agricultural production in Russia. Sotnikov (1998), for example, observes a negative impact of subsidies on technical efficiency at the regional level. He estimates technical

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efficiency at the regional level using data from 75 regions of Russia, revealing that regions that subsidize agricultural production experience an increase in technical inefficiency. Results provided by Petrick and Götz (2019) do not find a significant influence of farm subsidies on the herd growth of dairy farms in Russia and Kazakhstan.

Another important factor discussed in the literature also relevant to the policy priorities of Russia and Kazakhstan is the education of farm managers, which is found to have a strong positive impact on production efficiency (Danso-Abbeam and Baiyegunhi, 2019; Vitale, Vitale, and Epplin, 2019). Furthermore, through close cooperation with other farms, farmers can share machinery and equipment with each other, thus ensuring access to a broader range of capital assets (Dong, Mu, and Abler, 2019). Schmitt (1993) also supports this statement, proposing that hierarchically organized farms like agroholdings are more efficient compared to other forms of governance. A recent study by Golovina et al. (2019) also reveals a significant link between the financial success of a number of Russian private farms and their collaborative arrangements.

Likewise, improving access to markets allows farmers to supply their products directly to larger buyers, like procurement and agro-processing enterprises. This decreases the transaction costs of farmers and has a significant positive effect on their production efficiency. The findings of Burki and Khan (2011) indicate a strong positive impact of formal participation in supply chains on technical efficiency.

A positive relationship between farm risk management and efficiency has been observed by many scholars worldwide (Di Falco and Chavas, 2006; Hennessy, Babcock, and Hayes, 1997). Farmers can use various insurance schemes to reduce their level of risk regarding uncertain production and profit levels. By insuring themselves against those uncertainties, farmers can use their inputs with more confidence, thereby positively influencing the efficiency level. Insurance could be considered an effective way of delivering support, although it's one that is typically provided only when urgently needed (Hennessy, Babcock, and Hayes, 1997). Thus, better functioning farm insurance systems may positively affect technical efficiency.

To the best of our knowledge, however, we are not aware of any study that investigates the relation between policy factors (e.g., subsidies, access to insurance) and farm efficiency in Russia and Kazakhstan specifically. Therefore, this paper contributes to the efficiency literature by providing empirical evidence on the relation between government subsidies and farm efficiency in these countries.

3. Methodology and Data

3.1. Methodology

The existing literature suggests two main methods for estimating technical efficiency that are widely used among scholars: Stochastic Frontier Analysis (SFA) (parametric method) and Data Envelopment Analysis (DEA) (nonparametric method). Nevertheless, some researchers argue against the applicability of the DEA method in agricultural studies, since the approach does not consider stochastic errors and hence is sensitive to outliers (e.g., Ma et al., 2018). The SFA approach also has certain limitations, like reliance on a pre-defined functional form of the production function. However, given the nature of our data and the possibility for potential outliers, the shortcomings of the DEA model outweigh that of the SFA approach. Hence, following Brümmer (2001), Karimov (2014) and Latruffe et al. (2016), we employ a SFA model to analyze the relation between different policy variables and technical efficiency.

A stochastic frontier production function can be generally specified as

$$y_i = f(x_i; \beta) \exp\ (v_i - u_i) \tag{1}$$

where y_i is the actual output quantity for the i^{th} farm, x_i and β are the vector of input variables and their corresponding parameters, respectively. While $f(*)$ stands for the functional form of the

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model, v_i is a random error with a mean level of zero and u_i is a non-negative error term that captures production inefficiency. We use a translog functional form[1] to specify the stochastic frontier production function, which is expressed as follows:

$$ln\ y_i = ln\ y_i^* - u_i,\ \ u_i \geq 0, \tag{2}$$

$$\ln y_i^* = \beta_0 + \sum_{n=1}^{N} \beta_n lnx_{ni} + \frac{1}{2}\sum_{n=1}^{N}\sum_{m=1}^{N} \beta_{nm}\, lnx_{ni}\, lnx_{mi} + v_i - u_i \tag{3}$$

$$u_i \sim i.i.d.N^+\left(0, \sigma_u^2\right),$$

$$v_i \sim i.i.d.N\left(0, \sigma_v^2\right),$$

where n represents the number of inputs considered in the model (land, labor, variable inputs, and capital). Equation(3) defines the translog production function, with $y_i{}^*$ representing the maximum possible level of output. The translog production function considers farm revenue to be dependent on labor, land, variable inputs, and capital.

The variable v_i is the stochastic random error term and u_i is the non-negative error term, which are both identical and distributed independently from each other (Kumbhakar, Wang, and Horncastle, 2015). The observed output y_i is always lower than the frontier output $y_i{}^*$.

The term u_i (2) is equal to the log difference between the maximum possible level of output and the actual output. Hence, the termu_i shows the portion of output that is lost because of inefficiency. Thus, if we find that the estimated value of u_i is close to one, the farm is operating at a level close to full efficiency. Rearranging equation(2) results in:

$$\exp(-u_i) = \frac{y_i}{y_i^*} = TE_i, \tag{4}$$

where $exp\ (-u_i)$ is the ratio of actual output to the maximum possible output, and can be interpreted as the technical efficiency of the i^{th} farm. The value of $exp\ (-u_i)$ lies between 0 and 1, with 1 indicating full technical efficiency and 0 corresponding to full technical inefficiency (Kumbhakar, Wang, and Horncastle, 2015). Full technical efficiency means that farms are obtaining the maximum possible output using the set of resource inputs (Palmer and Torgerson, 1999).

The inefficiency effect model is specified as follows:

$$TE_i = \delta_0 + \sum_j \delta_j z_{i,j}, \tag{5}$$

where TE_i represents the estimated technical efficiency of the i^{th} farm and the $z_{i,j}s$ corresponds to are the factors affecting technical efficiency. The factors considered include farm size, storage capacity, quantity of machinery, subsidies, education of farm manager, cooperative or agroholding membership, direct access to procurement, or processing enterprises and insurance. The parameters δ_0 and δ_j's are to be estimated.

For the translog production function, output elasticities of n^{th} input, e_n, estimated at the mean values of respected data points, may be specified as (Abdulai and Eberlin, 2001):

$$e_{ni} = \frac{\partial\, ln\, y_i}{\partial\, ln\, x_{ni}} = \beta_n + \sum_{m=1}^{N} \beta_{nm}\, ln\, x_{mi}. \tag{6}$$

The elasticity of output concerning the n^{th} input measures the responsiveness of output to the percentage change in a respective input.

[1]In this study, we employ a translog functional form since the results of the likelihood ratio test suggests better suitability of the translog functional form over Cobb Douglas.

3.2. Data

Farm-level production data is typically not available at statistical agency offices, which results in researchers having to conduct their own primary data collection (Petrick, 2017). This study is based on such primary data: a survey of 600 farms in Russia and 200 farms in Kazakhstan gathered in 2015 covering the Akmola region of Kazakhstan and the Russian provinces of Novosibirsk, Altai Krai, Stavropol, Belgorod, and Ryazan. The six provinces included in the survey are among the largest wheat-producing regions in Russia and Kazakhstan and have similar production structures (e.g., technology, climate) (Appendixes 1 and 2). Using the multistage sampling technique, a sample of 800 farms from 104 villages in six regions of Russia and Kazakhstan were surveyed. The sample was selected based on two stages: In the first stage, representative districts (rayons) were selected in each of the six regions, and then a representative number of farmers were randomly chosen in those districts. The survey was conducted via face-to-face interviews with farm managers. Farms that did not grow wheat as their primary source of income in 2014 and that did not provide full financial information were not considered in the analysis. Therefore, altogether, this study is based on data from 270 farms (137 Russian and 133 Kazakh farms) from all six districts mentioned above. The bulk share of the sample consists of small farms (58%), individual entrepreneurs (20%), and limited liability partnerships (15%).

Table 1 describes the summary statistics of the main variables used in the analysis. The production function model includes total output, measured in terms of agricultural revenue, as the dependent variable, with a mean value of USD 443.4 thousand. The average per hectare revenue is USD 823, which ranges between USD 100 and USD 1,000 for 72% of the farms. Farm revenue of 14% of the farms was less than USD 100, while the remaining 14% of the farms reported more than USD 1,000 per hectare in annual farm revenue.

Furthermore, the model framework considers the input variables of labor (total man-days per year); land (total cultivated area in hectares); variable inputs (total costs of raw materials, seeds, fertilizers, pesticides); and capital (total costs of machinery, veterinary services, advisory services from outside suppliers and depreciation). On average, the farms used around 9,000 man-days of labor in the surveyed year and cultivated more than 2,000 hectares of land for wheat production. Around 23% of the sample cultivated less than 100 hectares of land, nearly half of the sample cultivated between 100 and 1,000 hectares of land and approximately 24% of the sample cultivated between 1,000 and 10,000 hectares of land. Farms with more than 10,000 hectares of land accounted for around 5% of the sample. In total, the average farm spending on variable inputs was USD 110,000 and capital costs, amounting to USD 12,600 per farm.

The main explanatory variable in our efficiency model is subsidies *(subsidies)*, which represents the amount of government support. Farmers received an average of USD 25.7 as subsidy (about 8 USD cents per hectare) payments during the surveyed year, with the maximum amounting to 594 USD.

Figure 1 illustrates the types of subsidies received by the farmers. The vast majority of farmers (84.5%) received subsidies for crop production, followed by subsidies for livestock (6.1%), insurance subsidies for agricultural activities (5.5%), and interest subsidies on agricultural loans (3.9%). Subsidies for crop production in Kazakhstan and Russia included direct payments per hectare of cultivated farmland to purchase inputs like fertilizers, fuels, lubricants, and soil nutrients (Petrick and Pomfret, 2016; USDA, 2012).

In addition, a range of different factors determining the level of technical efficiency were considered in the model set-up (Table 1). The quality variable *education* is included as a dummy variable and is equal to one if a farm manager has at least a college level education. In the u nderlying farm sample, more than 80% of all managers have at least a college level education. The access to capital assets variable *capital_access* is equal to 1 if a farm is either a member of a cooperative or an agroholding. We assume that farms that are part of a cooperative can share machinery, equipment, and tools and, therefore, have better access to capital assets in general.

Table 1. Descriptive statistics of the variables

		Mean	Std. Dev.	Min	Max
Variables included in the production function					
Output					
Revenue	USD ('000)	443.4	930.1	4.0	7,657
Inputs					
Labor	man-days	4,757	9,046	2	62,256
Land	hectares	2,182	5,801	1.5	62,000
Variable inputs	USD ('000)	110	260.8	0.178	2,300
Capital	USD ('000)	12.6	63.1	0.0078	948.8
Determinants of technical inefficiency (included in the technical inefficiency function)					
Farm characteristics variables					
Farm size[a] (total land owned by the farm)	hectares	2,920	7,258	5	62,000
Storage capacity[a]					
(total grain storage capacity of the farm)	tons	627	2,886	0	40,000
Quantity of machinery[a] (total number of agricultural machinery owned by the farm)	quantity	10	12	0	79
Government support variable					
Subsidies[a] (Amount of subsidy payments received by the farm in 2014)	USD/year	25.7	81.3	0	594
Quality variable					
Education (If a farm manager has at least college level education)	dummy	0.83	0.38	0	1
Capital assets access variable					
Capital access (If farm is a member of a cooperative or an agroholding)	dummy	0.20	0.39	0	1
Market Access variable					
Supply chain (If farm directly supplies to procurement or processing enterprise)	dummy	0.53	0.50	0	1
Risk management variable					
Insurance (If farm uses crop insurance)	dummy	0.23	0.42	0	1

[a]Natural logarithms of these variables are used in the technical inefficiency function.
Source: Authors' estimations.

Likewise, as a member of an agroholding, farms have access to an extensive range of capital assets owned by the parental organization. On average, 20% of the surveyed farms are either members of a cooperative or belong to an agroholding. The dummy variable *supplychain* characterizes market access and is equal to one if a farm supplies its products directly to procurement or agro-processing enterprises. Often, small farms in Russia and Kazakhstan do not have the opportunity to bring their products directly to processing companies for several reasons. For example, many large mills won't accept grains from farmers in smaller quantities, meaning these small farmers are

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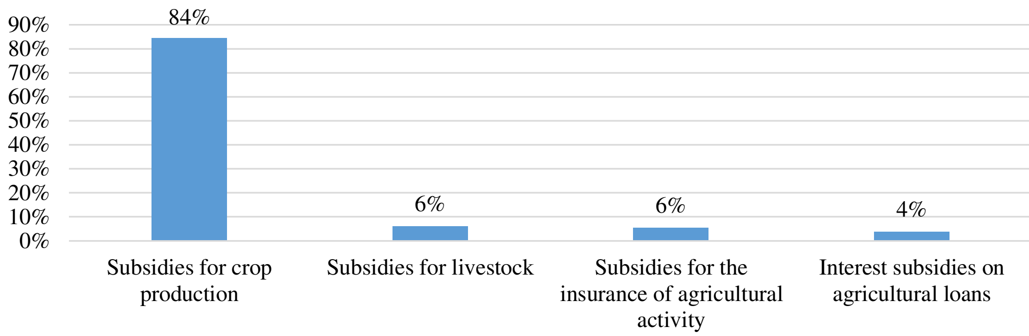

Figure 1. Types of subsidies received by farmers. Source: Authors' estimations.

often forced to sell their grains to the middlemen at rather low prices. Farmers have indicated that wheat prices paid by middlemen sometimes amount to only around 50% of the price paid directly by mills. Apart from lower prices paid, middlemen do not guarantee the purchase of a certain and stable amount of wheat from the farmers, which creates uncertainty for farmers if they are able to sell their wheat on the market. This might lead farmers to cautiously use costly inputs like fertilizers, which is negatively associated with production efficiency. According to our survey data, 53% of the respondents have direct access to the mentioned supply channels, and 47% are forced to sell their grains via middlemen.

Nearly one-fourth of the respondents surveyed use crop insurance to secure their crops. The variable *insurance* represents the risk management practices of farmers. By insuring themselves against uncertainty of yields and revenue, farmers use their inputs more optimally according to technical norms instead of in response to risk-averse behavior. Thus, higher yields may be achieved on average. Therefore, better functioning farm insurance systems may positively affect technical efficiency. Risk-averse farms may be characterized by low input use when insurance options do not exist. Thus, land and capital may be underutilized without proper risk management tools. Due to mandatory insurance programs in Kazakhstan, crops in Kazakhstan are covered by insurance to a higher degree (38%), while the share in Russia is significantly lower, amounting to only 8%.

Concerning the farm characteristics variables, the average farm of the sample has over 2,920 hectares of land *(size)*, has a grain storage capacity of 627 tons *(capacity),* and owns 10 pieces of agricultural machinery *(machines),* including tractors, combines, farm trucks, and bulldozers.

4. Empirical Results and Discussion

Table 2 reports the estimates of output elasticities defined by equation(6). We find the elasticities of the three input variables (land, variable inputs, and capital) of the production function to be positive and statistically significant, reflecting a positive relation of inputs at the output level. The link between labor and output level is also positive; this relationship, however is not statistically significant. Although this might seem surprising at first glance, a closer look might reveal such a relationship to be quite sensible, since wheat production in both countries is not very labor-intensive and is instead more dependent on agricultural machinery and equipment.

The highest level of elasticity estimates is observed for the variable inputs (0.73), followed by land (0.47), capital (0.29), and labor (0.20) (Table 2). Therefore, production increases by 0.73% if variable inputs (e.g., fertilizer, crop protection chemicals) are increased by 1% compared to a 0.47% increase if 1% more land is used in agricultural production. This corresponds with the existing literature indicating that an increase in variable inputs (e.g., seeds, fertilizers) is of much

Table 2. Output elasticities

Input variable	Elasticity
Labor	0.201
Land	0.475***
Variable inputs	0.735***
Capital	0.297***

Notes: ***significant at 1% level; **significant at 5% level; *significant at 10% level.

Table 3. Frequency distribution and summary statistics of the technical efficiency estimates

Technical efficiency (%)	Number of farms	Percent of farms
$\geq$80	122	45%
$70 \leq x < 80$	70	26%
$60 \leq x < 70$	32	12%
$50 \leq x < 60$	22	8%
<50	24	9%
Mean		0.74
Min		0.07
Max		0.97

Source: Authors' estimations.

higher importance for increasing agricultural production in Russia compared to re-cultivating abandoned land (e.g., Lioubimtseva and Henebry, 2012; Schierhorn et al., 2014).

While the mean of the estimated technical efficiency amounts to 74%, the maximum and minimum technical efficiencies are equal to 97 and 7%, respectively (Table 3). Around 45% of all farms utilize more than 80% of their full technical potential. While about 38% of the farms use between 60 and 80% of their total production capacity, nearly every fifth farm has a technical efficiency level lower than 60%; thus, there is still vast potential to increase production efficiency and increase wheat production in Russia and Kazakhstan.

It becomes evident (Figure 2) that the Akmolinskaya region in Kazakhstan has the highest technical efficiency (82%) compared to all other regions included in the analysis, followed by the Russian regions of Ryazan (73%) and Belgorod (72%). The Novosibirsk region shows the lowest performance with a technical efficiency of around 60%.

Coming to the technical inefficiency function, the estimated parameters of all variables except *size* and *supplychain* have a statistically significant association with technical efficiency (Table 4).

Our results suggest that government support in the form of direct subsidy payments, represented here by the variable *subsidies,* has a statistically significant negative association with farms' technical efficiency (Table 4). This indicates that subsidies are negatively associated with technical efficiency. Thus, the results of this farm-level analysis do not support Rylko (2018), who traces back the increase in average wheat yields in Russia observed over the last years to a "good" agricultural policy. As a certain share of the farmers' income is guaranteed by subsidies, they have less motivation to implement more efficient production and organizational techniques. This finding supports the study by Sotnikov (1998), who suggests that regions in Russia with agricultural production subsidization are characterized by increasing technical inefficiencies. Another

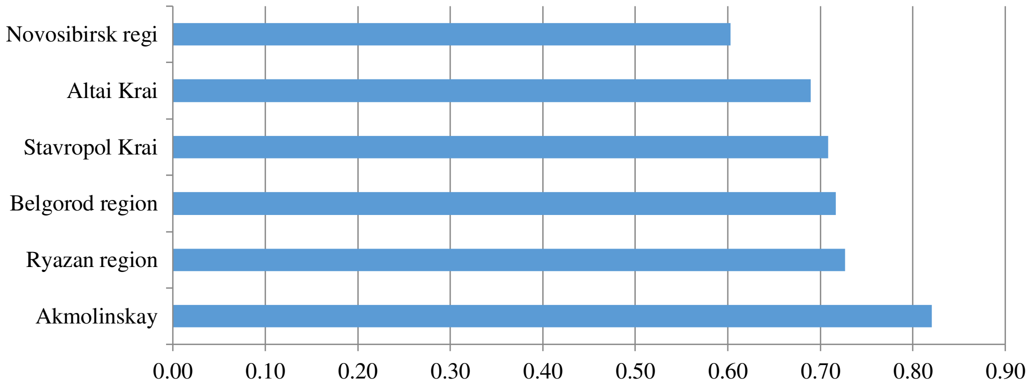

Figure 2. Technical efficiency of farms by region. Source: Authors' estimations.

study by Petrick and Götz (2019) does not reveal any significant link between subsidies and livestock production efficiency in Russia.

Nevertheless, the interpretation of the results should take into account that larger farms usually receive higher amounts of subsidies compared to smaller farms. For example, Uzun et al., (2019) indicate that 1.2% of large enterprises in Russia received 40.9% of the subsidies in 2015. Small farms usually receive very limited subsidy amounts, as seen in our sample of 8 USD cents per hectare on average, which is relatively small compared to the transfers received by European farmers. In Russia, the large agroholdings usually receive most of the subsidies (Uzun, Shagaida, and Lerman, 2019), which were not included in the sample surveyed in this study. Therefore, the results of this study do not apply to large agroholdings in Russia, which enjoy larger budget transfers from the government (Uzun, Shagaida, and Lerman, 2019).

There is also a statistically significant positive association between farm manager's education *(education)*, which improves the quality of labor force used during production, and technical efficiency (Table 4). Farms with better-educated managers are, on average, more efficient compared to farm managers with a lower level of education. This concept is largely accepted by most scholars in the literature (Battese and Coelli, 1995; Danso-Abbeam and Baiyegunhi, 2019). Epshtein (2005) also observes the importance of management quality in the case of corporate farms in Russia's Leningrad region. He reveals that management quality can explain around 50% of the variability in the financial health of the farms in the Leningrad region.

Likewise, the variable *capital_access,* representing better access to capital assets, shows a significant positive influence on technical efficiency (Table 4). Cooperative farms can share capital assets amongst each other and thus access a higher quantity of resources. Similarly, agroholding members can access the machinery, equipment, etc., of the parental organization, ensuring higher quantities of available resources. Our findings confirm the results of Hahlbrock and Hockmann (2011), wherein farms that are members of agroholdings perform better in terms of production efficiency compared to nonmember farms in the Belgorod region of Russia. Furthermore, another study by Tleubayev et al. (2021) observes a positive link between agroholding affiliation and financial performance among Russian agri-food enterprises.

This study supports the findings of existing research confirming a significant positive relationship between risk management and farm efficiency (e.g., Breker, 2017; Di Falco and Chavas, 2006) (Table 4). Agricultural production risk might be particularly high in Russia and Kazakhstan, which have experienced repeated droughts with widespread harvest shortfalls, such as in 2010/11, when up to 60% was lost in Russia's Volga region. Although the functioning of agricultural insurance systems in Russia is highly questionable (Bobojonov, Goetz, and Glauben, 2014), our analysis finds positive and statistically significant parameters of the variable *insurance,* indicating that insurance contributes to higher technical efficiency. This could also be traced back to the role

Table 4. Parameter estimates of the stochastic frontier (Translog) model

Variables	Parameter	Coefficient	Standard error
Stochastic production function			
Constant	B_0	4.6873***	0.6391
Labor	B_1	0.0355	0.0466
Land	B_2	0.2756***	0.0476
Variable inputs	B_3	0.4796***	0.0444
Capital	B_4	0.2218***	0.0424
0.5 labor × labor	B_{11}	−0.0850**	0.0334
0.5 × land × land	B_{22}	0.1451***	0.0368
0.5 × variable input × variable input	B_{33}	0.0029	0.0294
0.5 × capital capital	B_{44}	0.0207	0.0271
Labor × cand	B_{12}	−0.0146	0.0322
Labor × variable input	B_{13}	0.0425	0.0356
Labor × capital	B_{14}	−0.0194	0.0342
Land × variable input	B_{23}	−0.0456	0.0293
Land × capital	B_{24}	0.0364	0.0313
Variable input × capital	B_{34}	−0.0435*	0.0248
Technical inefficiency function			
Constant	δ_0	0.2236	1.1574
Farm size *(size)*	δ_1	0.3349	0.2076
Farm storage capacity *(storage)*	δ_2	−0.2813**	0.1244
Quantity of machinery *(machines)*	δ_3	−0.8471*	0.4569
Government support *(subsidies)*	δ_4	0.2109*	0.1128
Education of farm manager *(education)*	δ_5	−1.3051**	0.5568
Capital access *(capital_access)*	δ_6	−1.3694*	0.8385
Supply chain access *(supplychain)*	δ_7	−0.4893	0.4801
Risk management *(insurance)*	δ_8	−1.6314**	0.8363
Log-Likelihood		−299,51	
Wald Chi2		690,78	
Prob. Chi2		0.000	
Mean fficiency		74.39%	
N		270	

Notes: ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.
Source: Authors' estimations.

of agricultural insurance as collateral for credits to finance the purchase of inputs, as well as machinery. Thus, farmers with insurance may have better chances at obtaining short-term credits.

Finally, access to markets via direct supply to procurement and agro-processing enterprises (*supplychain*) has a positive, but not statistically significant, association with farm efficiency (Table 4).

5. Conclusions

This study has made use of primary farm data gathered via a 2015 farm survey of wheat farms in Kazakhstan and Russia. The results of a production function model show that variable inputs, such as fertilizer, have relatively high importance in wheat production compared to land. Therefore, in order to mobilize the unutilized grain production potential, increases in the usage of variable inputs should be fostered, whereas the re-cultivation of abandoned agricultural land, which would also most likely come with high costs, plays a smaller role. Moreover, we find relatively low levels of technical efficiency on average, which can be interpreted as a clear sign that the potential to increase crop production further is high. This corresponds with the currently observed wheat yields in Russia and Kazakhstan that are rather low in comparison with the EU, for example.

Furthermore, the results of the econometric analysis of the determinants of technical farm efficiency show that agricultural subsidies granted to farms in Kazakhstan and Russia are negatively related with the efficiency levels of the farms. This can be explained by the income effect: Since subsidies partially guarantee farm income, the motivations of farm managers to implement measures that raise technical efficiency in order to achieve a higher income decrease. This brings into question the relevance of subsidy programs implemented by the Russian and Kazakhstani governments to boost their wheat production potential. While our analysis suggests a negative link between subsidies and efficiency, other factors, such as better education, cooperative and agroholding membership, and participation in insurance programs are positively associated with farm efficiency. Government investments for improving the farm education system, fostering agricultural cooperatives, and developing a functioning farm insurance system are therefore viewed as promising ways for mobilizing the unutilized grain production potential in both countries.

In spite of the above-mentioned contributions, this study has certain limitations that should be considered by forthcoming research. Firstly, the sample of wheat farms included in the final analysis is relatively small. Secondly, the cross-sectional nature of the data used in this study did not allow for dynamic effects to be captured. Thirdly, since our analysis is based on a sample of farms from six provinces of Russia and Kazakhstan, our results and recommendations should be interpreted with caution and may not be readily generalized to the whole country. Therefore, to overcome these limitations and to better understand the subsidy-efficiency nexus in these countries, further research capturing a larger sample of farms that includes panel data should be considered.

Data Availability Statement. The data that support the findings of this study are available from the corresponding author, [Alisher Tleubayev], upon reasonable request.

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Competing Interests. None.

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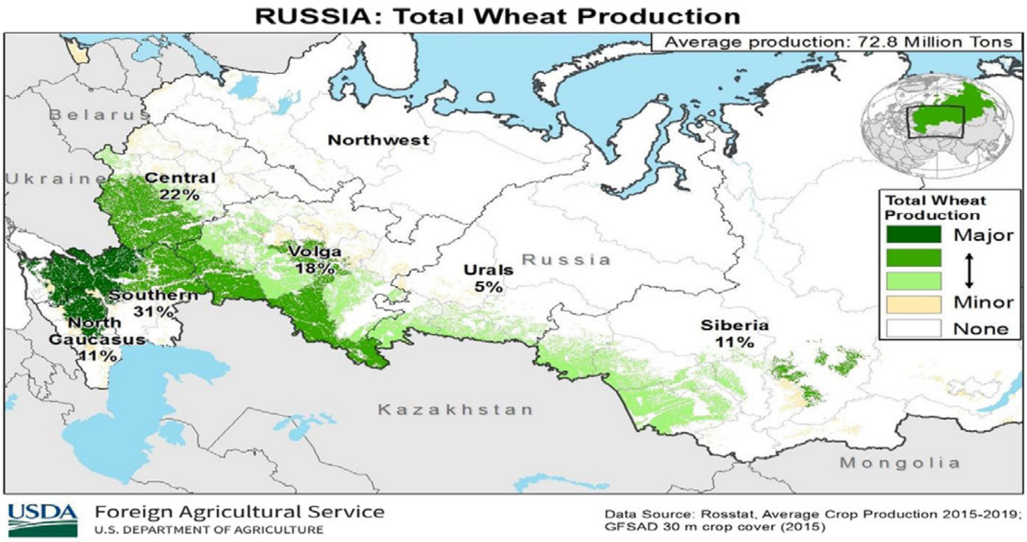
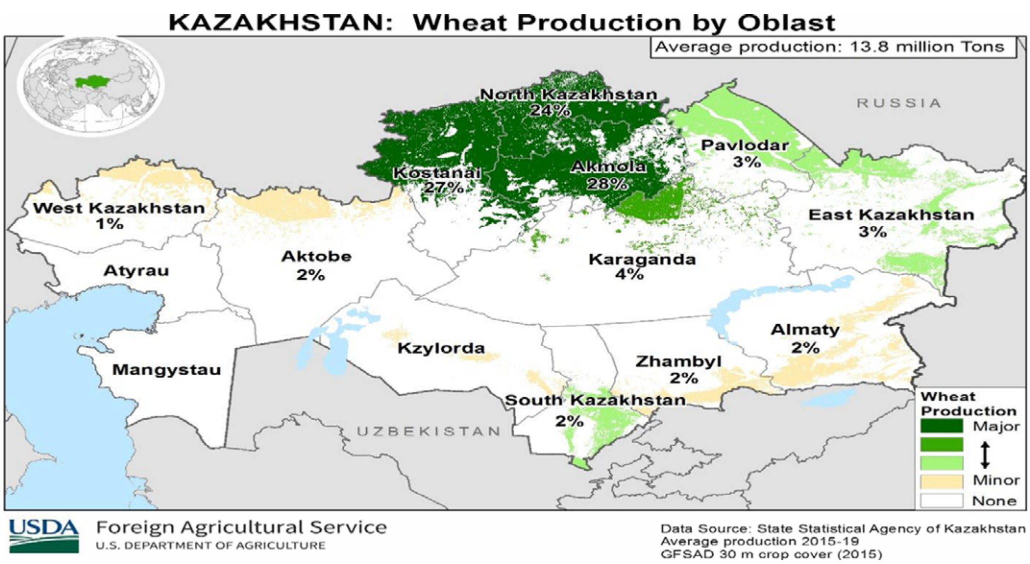
Appendices



Appendix 1. Total wheat production map of Russia.
USDA 2021, Russia Crop Production Maps – Total Wheat.



Appendix 2. Total wheat production map of Kazakhstan.
USDA 2021, Kazakhstan Crop Production Maps – Total Wheat.

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