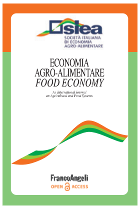
Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 1, pp. 1-20 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12752



Productive efficiency and trade opportunities for Kazakhstan dairy farms

Sang Woo Han[a], **Song Soo Lim**[*,b], **Aida Balkibayeva**[c]

[a] Korea Productivity Center, Korea
[b] Korea University, Korea
[c] S. Seifullin Kazakh Agro Technical University, Kazakhstan

Abstract

This study analyses the productive efficiency of dairy farms in Kazakhstan and suggests export implications by the expansion of trade networks and the participation of global value chains. As the world's largest landlocked country and ninth largest area in the world, Kazakhstan has often been considered to have vast potential to produce and export dairy products. The greater openness of markets and improved geostrategic circumstances with the latest rail link between China and Europe are expected to strengthen Kazakhstan's trade opportunities with the rest of the world. Despite these positive prospects, few empirical studies have examined the export potential of the country's dairy products. To bridge this gap, this study surveys 23 dairy farms across nine oblasts in Kazakhstan and performs a data envelopment analysis with milk production as the output variable and feed, labour, and capital as the input variables. The estimation results indicate that Kazakh dairy farms could reduce input use by up to 70% under the most efficient system. A dichotomy of productive efficiency among large and capital-intensive versus small-scale family farms suggests that the country should promote inclusiveness through sharing knowledge and best practices within the industry.

Article info

Type:
Article
Submitted:
14/07/2020
Accepted:
22/07/2021
Available online:
03/12/2021

JEL codes:
O13, Q16, Q18

Keywords:
Data envelopment analysis
Production efficiency
Kazakhstan dairy industry
Belt and Road Initiative

Managing Editor:
Valeria Borsellino

* *Corresponding author*: Song Soo Lim - Professor - Korea University - Department of Food and Resource Economics - 145 Anam-ro, Sungbuk-gu - 02841 Seoul, Korea. E-mail: songsoo@korea.ac.kr.

Introduction

Kazakhstan is considered to have vast agricultural potential on several grounds. First of all, the country has abundant land resources, as it the world's largest of 43 landlocked countries and the ninth largest area in the world. In addition, it owns large reserves of energy and mineral resources such that exports of oil, gas, ore, and metals are its primary source of earning foreign reserves (USEIA, 2017). Despite these advantages, high energy export dependence can be a double-edged sword. For example, the commodity boom in the 2000s triggered significant economic growth, while the global financial crisis in 2009 and commodity price collapse of 2014-16 held back the Kazakh economy.

Indeed, Akhmetov (2017) found that real agricultural output has decreased more than four times since 1990 because of the effects of the Dutch disease. Nurmakhanova (2016) also suggested that the impact of the increase in oil prices could be balanced by the appreciation of the real exchange rate. Kazakhstan now has vast tracts of land falling into neglect, and the combination of better yields, more efficient breeds, and technological advances would increase agricultural production greatly. However, Kraemer *et al*. (2015) countered that the production potential of uncultivated agricultural land is much lower than widely thought.

Besides, economic and policy reforms have been tuned for sustained growth. After the collapse of the USSR, Kazakhstan was the last to declare independence in 1991. Thereafter, the young and independent Kazakhstan rapidly transformed its economic system into a market economy and attracted considerable foreign direct investment (Cohen, 2008; OECD, 2017). In 1997, the "Kazakhstan 2030" program outlined long-term strategic priorities in the areas of national security, internal stability and the consolidation of the people, an open market economy, the healthcare system and environment, energy resources utilization, transport infrastructure, and an efficient public administration (Pomfret, 2014). The subsequent "Strategy 2050" initiative announced in 2012 furthered the country's plans for economic diversification and the privatization of domestic and export sectors to achieve its goal of becoming one of the top 30 developed countries (Borghijs, 2017).

Kazakhstan has made significant progress in regional and global integration. It is worth considering three aspects. One is the formulation of a treaty on the Eurasian Economic Union (EEU) in 2015. Although political motives played a key role in the regional commitments, EEU members agreed to have not only a free trade and customs union, but also the free movement of capital and labour and eventually a common economic policy (OECD, 2016). Kazakhstan's accession to the WTO in 2015, which took nearly 20 years, is another trade initiator, fitting into the country's vision of economic development and international standing.

Finally, the Belt and Road Initiative (BRI), announced in 2003 that connects China through Central Asia and the Middle East to Europe by land and to southeast Asia and east Africa by sea combines investment, development and trade objectives (Chatzky and McBride, 2020). As of 2020, 140 countries have signed a cooperation agreement with China for the BRI of which only 57 countries including Kazakhstan are located in the corridor from China to Europe (Birch, 2021). If the $1.2~1.3 trillion projects by 2027 are proven to be successful, Kazakhstan can be not only a bridge between large markets but also a competitive exporter of agricultural and oil and gas products.

Against this backdrop the country has its eye on fulfilling the export potential in the dairy industry as well. Despite its positive prospects, few empirical studies have examined the country's trade opportunities of dairy products. To bridge this gap, this study examines milk production efficiency based on a survey of dairy farms. These empirical findings are expected to shed light on the development goals of Kazakhstan's dairy sector in that it provides high quality products and is exploring the potential for exports.

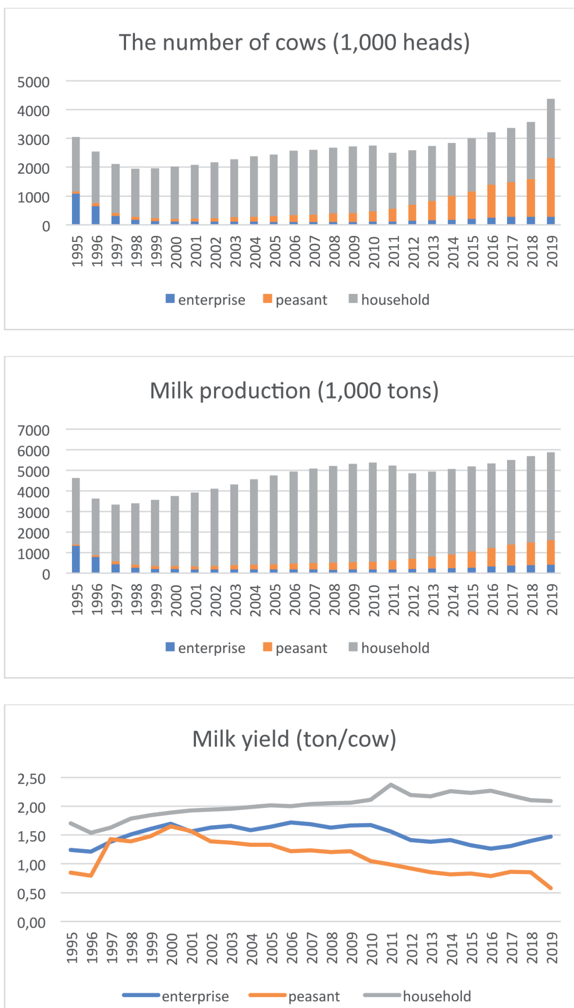
1. Development of the dairy sector

Dairy is the second largest agricultural subsector in the country. It accounted for 29% of agricultural GDP, or $31 billion, in 2014 (Business Sweden, 2016). Against the backdrop of these favourable macroeconomic and institutional changes, this study explores Kazakhstan's export potential in the dairy sector. Few empirical studies have thus far investigated the export potential of the country's dairy products. To bridge this gap, this study examines the productive efficiency of surveyed dairy farms regionally by employing the data envelopment analysis (DEA) method. The milk production efficiencies of Kazakhstan farms are also compared with their counterparts in European countries to shed light on the country's export potential in this sector.

Kazakhstan was the home of nomadic herders with migratory grazing for centuries. During the Soviet era, collective livestock farms, or "kolkhozes", were forcedly created and operated under state intervention (FAO, 2011). After the demise of the Soviet Union, large-scale kolkhozes were dismantled and their livestock distributed to kolkhoz workers. As a result, many newly created small-scale farmers began to account for a considerable share of overall production, even despite losing their access to land, government services, and marketing.

Kazakhstan farms are officially divided into three groups by the Committee on Statistics depending on their size and commercial activities. Firstly, "agricultural enterprises" are legal entities or their subdivisions that are strictly engaged in the commercial production, storage, and processing agricultural products. As of January, 2020, there are 17,403 agricultural enterprises in the country. These tend to be large-scale operations similar to the collective farms of the Soviet era (average size over 8 000 hectares) and each enterprise hires more than 250 employees (OECD, 2013). They focus on grain production, with only small shares in terms of the number of farms (0.9%), the number of cows (6.4%), and milk production (7.1%) (Figure 1).

Figure 1 - Dairy production and productivity by farm category



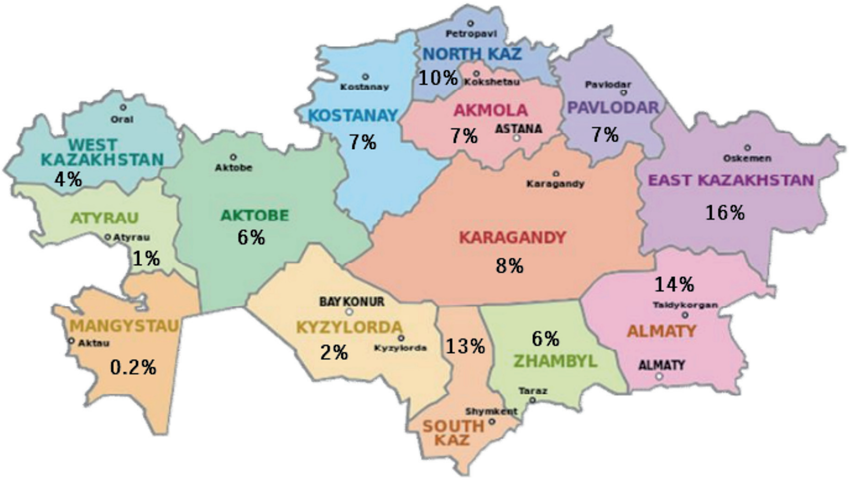
Source: The Committee on Statistics (www.stat.gov.kz).

Secondly, "peasant farms" are family-oriented individual and private farms. The country's 219,449 peasant farms are substantially smaller than agricultural enterprises with an average land size of 270 hectares and they record a middle position for the number of farms (11.7%), the number of cows (46.8%), and milk production (20.2%).

Finally, "household farms" are personal subsidiary farms. Since households are not regarded as legal entities, they neither pay business taxes nor receive production subsidies from the government. About 1.6 million household farms with an average land size of 0.13 hectares farm various plots including collective gardens, vegetable gardens, and country plots. As the dominant agricultural units (87.4%) with between one and five cows, household farms accounted for 46.8% of the number of cows and 72.8% of milk production in 2019.

Reached its peak of about 5.9 million tons in 2019, milk production has grown at 1.2% per year over the 1995-2019 period. As of 2019, household farms are the largest producer group that accounts for 73% of total milk production followed by peasant farms with 20%. However, peasant farms have shown an upward trend in the production share while household farms' share has slipped over years. Cow productivity for household farms in 2019 is 2.1 tons per cow, which is far greater than 0.6 and 1.5 tons per cow for peasant farms and agricultural enterprises, respectively. The increase in milk production observed since 2012 is related mainly to the increase in cow population because cow productivity remains low and in fact is on the decrease.

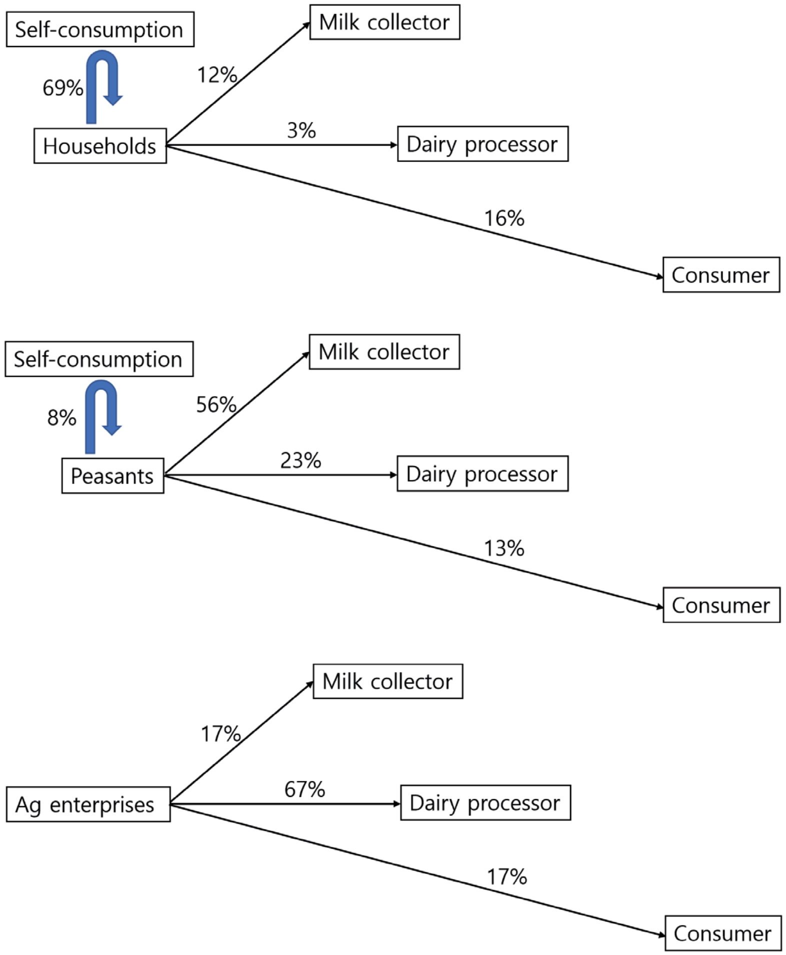
Figure 2 - Geographical distribution of milk production shares in 2019



Note: South Kazakhstan was renamed as Turkestan in 2018.
Source: The Committee on Statistics (www.stat.gov.kz)

Figure 2 shows the regional structure of milk production in 2019. Judged by production shares, the leading provinces are East Kazakhstan 16%, Almaty 14%, South Kazakhstan 13% (it was renamed as Turkestan in 2018), and North Kazakhstan 10%. Agricultural enterprises in the northern provinces, including North Kazakhstan, Akmola, and Kostanay account for relatively larger shares in production while peasant farms play an important role in the central and eastern provinces, including East Kazakhstan, Almaty, and Karagandy. Household farms are concentrated in South and East Kazakhstan and Almaty.

Figure 3 - Aggregation, processing and distribution of milk by farm category in 2011



Source: Netherlands Worldwide (2019).

Milk commercialization and processing are quite limited in the country due to production structure and sparse collection centers across the expansive country. Since small-scale household farms that own fewer than 5 cows, accounting for about 80% of all farms produce milk for self-consumption, only a third of produced milk go to processing or directly to consumers (Figure 3). By contrast, agricultural enterprises forward about 67% of their production to dairy processors.

The low level of commercialization and processing is attributable to the long distance between raw milk producers and milk collectors, which can be more than 600 km, inaccurate temperature conditions during raw milk storage and transport, and high seasonality of raw milk production due to the dominance of pasture breeding.

According to Punda (2016), milk producers sell about 50% of milk unprocessed. Even with a network of milk collecting stations to collect milk from households and peasant farms, processors face increasing raw material costs and experience difficulty in controlling the quality of raw milk. The FAO-developed mobile app, the so-called "Collect Mobile" has been introduced to provide processors with accurate information regarding optimal collection routes, the required capacity for mobilizing cooling tanks and refrigeration transport, and the sources of raw milk across scattered farms (FAO, 2021).

Kazakhstan is a net importer of dairy products (Table 1). Import volumes totalled 5.8 million tons, or about 11.2% of national production in 2019. Key dairy products imported are milk and cream, including concentrated, kephir and yogurt, butter, and cheese. They are largely from the Siberian Federal District of Russia, whose borders are connected with logistics, rendering more efficient exploitation of regional comparative advantages. Ukraine, Belarus and the Netherlands are also important exporters to Kazakhstan. As stated above, imports are largely attributable to the limited and uneven supply of domestic milk, partly caused by sizable seasonable fluctuations and the problem of collecting milk from many scattered household farms.

When carry-over stocks from the beginning of the year are included, the country has about 6.7 million tons of milk available in the same year. Some 6.3 million tons of milk were consumed in 2019, of which 4.3 million tons were food uses and 1.9 million tons were processing uses. Thus, per capita consumption or availability of milk is calculated at 363.1kg.

Table 1 - Milk supply and demand (in 1,000 tons)

	2012	2013	2014	2015	2016	2017	2018	2019
I. Supply								
Opening stock	620	585	511	531	402	371	306	310
Production	4,852	4,930	5,068	5,182	5,342	5,503	5,686	5,865
Imports	620	646	685	569	592	574	541	546
Total	6,092	6,161	6,264	6,282	6,336	6,448	6,533	6,721
II. Demand								
Processing use	1,483	1,507	1,576	1,593	1,634	1,705	1,826	1,903
Other use	1	1	1	1	1	1	1	1
Loss	31	31	31	31	32	32	33	34
Exports	11	33	40	97	47	55	105	154
Food use	3,981	4,078	4,084	4,158	4,252	4,351	4,259	4,311
Closing stock	585	511	531	402	371	306	310	318
Total	6,092	6,161	6,263	6,282	6,337	6,450	6,534	6,721

Note: The total figures for supply and demand may not coincide each other due to rounding error.
Source: The Committee on Statistics (www.stat.gov.kz).

2. Review of literature

There is a paucity of studies of the economic potential or trade opportunities of Kazakhstan's dairy sector. Existing work mainly addresses industry situations and policy development (Kazkenova *et al.*, 2015; Lim, 2016; Nazhmidenov, 2010; Petrick and Promfret, 2016; Van Engelen, 2011). Petrick *et al.* (2014) pointed out that the value chain of dairy products in Kazakhstan is bifurcated into urban and rural consumers. Urban consumers largely depend on processed dairy products under an import-dependent chain, while rural consumers are served from a local value chain of raw, unprocessed products.

This study also highlighted room for improvement to ensure industry competitiveness, such as enhancing food quality standards with the appropriate cooling and sanitary conditions, ensuring better access to grazing land, resolving the overstocking and intermixing of livestock, increasing fodder supply in winter, and developing domestic and global value chains. On this matter, Lashkareva *et al.* (2016) suggested that an additional state subsidy may be required to support the development of areas unfavourable for agriculture.

As for the export aspects of Kazakhstan's dairy products, Pomfret (2014) claimed that Kazakhstan should expand its trade connectivity along the East-West corridor under China's new silk road. In particular, the government should improve transportation and marketing infrastructure to realize niche markets and products. Temyrbekova *et al.* (2015) found that Belarus and Russia have a comparative advantage in trade in relation to Kazakhstan. In particular, the average milk yield per cow in Kazakhstan is far lower than that in Russia and Belarus. Indeed, milk yields of Kazakhstan farms are low by international standards (Petrick *et al.*, 2014). However, a limitation of this study was its use of net exports as a key indicator of competitiveness.

Table 2 summarizes selected DEA studies, noting that no study has thus far attempted to analyse the efficiency of Kazakhstan's dairy production by using a DEA approach. Previous studies indicate that common output variables in DEA modelling are sales receipts and milk production, while input variables include the various production costs and volumes of inputs such as labor, capital, feed, and land. Based on the literature, this study therefore adopts milk production as an output variable and labour, feed, and capital costs as input variables.

Table 2 - Summary of the literature on DEA for dairy products

Study	**Subject**	**Output variables**	**Input variables**
Youn *et al.* (1999)	95 farms in Japan	• Milk sales receipts • Livestock sales receipts • Other receipts	• Variable costs • Depreciation costs • Labor costs • Land size
Cho and Kim (2001)	97-127 farms in Korea	• Milk sales receipts	• Concentrate costs • Fodder costs • Operating expenses • Land size • Own labor hours
Park *et al.* (2006)	146 farms in Korea	• Milk production • By-product receipts	• Concentrate costs • Fodder costs • Operating expenses • Land size • Own labor hours
Lee and Park (2011)	19 farms in Korea	• Gross receipts • Milk sales receipts • Calf's sales receipts • Other receipts	• Concentrate costs • Fodder costs • Own labor costs • Other costs
Cloutier and Rowley (1993)	187 farms in Canada	• Milk production • Milk sales receipts • Gross receipts	• Feed costs • Livestock numbers • Labor hours • Land size

Table 2 - continued

Study	Subject	Output variables	Input variables
Jaforullah and Whiteman (1999)	264 farms in New Zealand	• Milk fat production • Milk solids production • Lacto-protein production	• Feed costs • Livestock numbers • Feed costs • Fertilizer costs • Sanitary expenses • Capital costs • Land size
Stokes *et al.* (2007)	34 farms in the United States	• Milk production per cow • Milk fat production per cow	• Livestock numbers • Labor hours • Land size
Theodoridis and Psychoudakis (2008)	165 farms in Greece	• Gross production	• Labor hours • Fixed costs • Variable costs
Switlyk (2020)	11,055 farms in Poland	• Sales values including subsidies	• Livestock numbers • Land size • Seed costs • Feed costs • Machinery costs • Energy costs • Depreciation costs • Other costs
Luik *et al.* (2014)	147 farms in Estonia	• Sales revenue of milk and dairy products • Sales revenue of animals and other agricultural products	• Livestock numbers • Land size • Labor hours • Feed costs • Capital costs • Other costs
Wilczynski *et al.* (2020)	869~1,308 farms in Poland	• Sales and subsidies	• Livestock numbers • Land size • Forage and concentrates costs • Machinery costs • Energy costs • Depreciation costs • Other costs

3. Materials and methods

First introduced by Charnes *et al.* (1978), DEA has become established as a framework for measuring the efficiency of various inputs and outputs. The DEA approach can assume either constant returns to scale (CRS) or variable returns to scale (VRS) technology (Cooper *et al.*, 2000). Following Asmild *et al.* (2006), this study adopts a standard DEA as follows.

Assume a set of n production units, also called decision-making units (DMUs), and that m inputs are used to produce s outputs. The input and output vectors for DMU_j, j=1,...,n, are expressed as $x_j = (x_{1j},\ldots,x_{mj})^T$ and $y_j = (y_{1j},\ldots,y_{sj})^T$, respectively. Let X be the (m x n) matrix of inputs and Y be the (s x n) matrix of outputs.

The production possibility set T is given as:

(1) $$T = \{(x, y) | x \text{ can produce } y\}$$

Given the observed sets of inputs and outputs, $(x_j, y_j), j = 1, \ldots, n$, the production possibility set under VRS technology, which is also known as a CCR model (Charnes *et al.*, 1978), is expressed as follows:

(2) $$T' = \left\{(\acute{x}, \acute{y}) \middle| x \geq \sum_{j=1}^{\acute{n}} x_j \lambda_j ,\ y' \leq \sum_{j=1}^{n} y_j \lambda_j ,\ \acute{\lambda}_j \geq 0,\ \sum_{j=1}^{n} \lambda_j = 1\right\}$$

The input-oriented technical efficiency of is given by

(3) $$\min_{\theta} \theta \quad \text{subject to} \quad (\theta x_0, y_0) \in T$$

Equation (3) is equivalently expressed as:

(4) $$\begin{aligned} &\min_{\theta,\lambda} \theta \\ &\text{subject to} \\ &\theta x_0 \geq X\lambda \\ &y_0 \leq Y\lambda \\ &1^T\lambda = 1 \\ &\lambda \geq 0 \end{aligned}$$

The solution to Equation (4) provides the efficiency score for DMU_0 under VRS technology. If the convexity constraint $1^T\lambda = 1$ is excluded from Equation (4), it expresses CRS technology, which is also called a BBC model (Banker *et al.*, 1984). The optimal θ indicates how efficiently inputs have been used to produce y_0. If $\theta<1$, DMU_0 is not efficient such that it can proportionally reduce inputs by (1-θ), maintaining the same level of output, y_0.

DEA efficiency can be decomposed into pure technical efficiency (PTE) and scale efficiency (SE). The PTE obtained by solving the BBC model describes inefficiencies due to only managerial underperformance, while SE refers to an inappropriate choice of scale. So-called overall technical efficiency (OTE) corresponds to the CCR model and measures the inefficiencies arising from the input-output representation and size of production. The relationship $SE=\frac{OTE}{PTE}$ provides a measure of SE. If SE<1, DMU_0 is under increasing returns to scale (irs) technology and can improve SE by adding more inputs.

This study identifies the problems linked with data availability and quality, necessary for the DEA analysis. Unlike most European studies that used public database of the farm accountancy data network (FADN), dairy farm-based microeconomic data in Kazakhstan are quite rare and thus they should be mostly obtained by a targeted survey (Kaliyeva *et al.*, 2020). Designing and conducting a survey is also confronted with a couple of common challenges. One has to do with poor bookkeeping by many peasant and household farms such that they often lack clear records of income, expenses, production and other documents. The other arises from the fact that dairy farms scatter all around the vast country, which makes conducting a personal interview survey and striking a balance in geographical regions quite difficult.

Against a backdrop of these limitations, a survey was designed and carried out from February to April in 2017. Participants in the survey were recruited by a university in Nur-Sultan, the capital of Kazakhstan through the Diary Committee meetings (10 samples). A recruitment email was also sent to members of various farm associations inviting them to participate in the survey (11 samples). Additional two questionnaires were secured from personal visits. Survey participation was voluntary without compensation. Participants totalled 23, covering nine out of the 14 oblasts in the country.

Table 3 provides the summary statistics for the output and input variables in 2015. The only output variable is milk production, while the input variables consist of labour hours, feed costs, and capital costs.

The relatively high standard deviation of the output and input variables for these Kazakhstan dairy farms reflects the heterogeneous farming conditions they face. Owing to the vast area of the country, the climatic and soil conditions are diverse; hence, the availability, accessibility, acceptability, and quality of feed and other input resources depend on farm-specific circumstances.

Table 3 - Summary statistics for input and output variables of sample farms

	Milk production (ton)	Labor hours	Feed costs (1,000 tenge)	Capital costs (1,000 tenge)	Milk production per cow (kg)
Average	43,687	266,235	60,750	53,137	4,317
Maximum	636,108	1,460,000	242,399	600,000	7,000
Minimum	305	360	1,000	0	1,969
Standard deviation	131,849	366,449	78,763	142,699	1,383

4. Results and discussion

Table 4 presents the efficiency scores for Kazakhstan dairy farms. The farms on the efficiency frontier show an efficiency score of one. Those with an efficiency score below one are defined as having inefficient production. According to the CCR model, DMU5, DMU6, and DMU13 are identified as having efficient production. In addition to these DMUs, the BCC model adds DMU13, DMU14, DMU15, DMU16, DMU17, and DMU21 as efficient farm units. The average OTE score of 0.188 for all sample farms indicates that they would have reduced the use of inefficient inputs by about 81% in their production. The average PTE score of 0.464 suggests that farms could have achieved the same level of milk production with a reduction in inefficient input use of about 54%. The average SE score of 0.296 implies that if inefficient farms change their scales in the most efficient way, they could cut the use of inputs by about 70%. In production technology, farms other than those on the efficiency frontier are subject to IRS.

As expected, the most efficient farms recorded greater average milk production with far lower labour hours and feed costs compared with inefficient farms. However, the higher capital costs incurred by efficient farms imply that they have relatively capital-intensive production systems (Table 5).

Unlike the promising DEA results, most Kazakhstan dairy farms suffer from unfavourable farming and market conditions as well as physical infrastructure constraints. Household dairy farms make the greatest contribution to overall production and their milk production costs are far lower than those of larger and modern dairy farms, each having 500 to 2,000 head of dairy cattle (FAO, 2011).

However, the existing gap in the production structure between households and agricultural enterprises causes a variety of problems. A chronic problem is that household farms lack access to industrial milk processing, mainly

Table 4 - Efficiency scores for Kazakhstan dairy farms

DMU	Region	OTE	PTE	SE	Returns to scale
1	Akmola	0.006	0.062	0.100	IRS
2	Akmola	0.062	0.237	0.261	IRS
3	Akmola	0.002	0.552	0.004	IRS
4	Akmola	0.048	0.106	0.451	IRS
5	Aktobe	1.000	1.000	1.000	CRS
6	Almaty	1.000	1.000	1.000	CRS
7	Almaty	0.168	0.438	0.383	IRS
8	East Kazakhstan	0.009	0.022	0.421	IRS
9	East Kazakhstan	0.002	0.045	0.033	IRS
10	East Kazakhstan	0.006	0.102	0.063	IRS
11	East Kazakhstan	0.004	0.042	0.097	IRS
12	East Kazakhstan	0.006	0.063	0.095	IRS
13	East Kazakhstan	1.000	1.000	1.000	CRS
14	East Kazakhstan	0.034	1.000	0.034	IRS
15	Karagandy	0.012	1.000	0.012	IRS
16	Karagandy	0.541	1.000	0.541	IRS
17	Karagandy	0.029	1.000	0.029	IRS
18	Kostanay	0.011	0.058	0.191	IRS
19	Pavlodar	0.012	0.034	0.359	IRS
20	Pavlodar	0.323	0.500	0.647	IRS
21	South Kazakhstan	0.042	1.000	0.042	IRS
22	Zhambyl	0.004	0.125	0.031	IRS
23	Zhambyl	0.005	0.278	0.018	IRS
Average	–	0.188	0.464	0.296	–

Note: CRS is constant returns to scale and IRS is increasing returns to scale.

because of their remote location and poor infrastructure for collecting, storing, and transporting fresh milk. Efficient aggregation and storing the small volumes of milk from widely dispersed household farms are a common challenge in many developing countries as well (FAO, 2014). Different food safety practices and qualities of raw milk across individual households create standardization and quality problems. GIS-based digital transformation and innovations can be a practical solution to overcome these inherent constraints.

Table 5 - Summary statistics of efficient and inefficient farms

	All (23 farms)		Efficient farms (3)		Inefficient farms (20)	
	Average	**Std. dev**	**Average**	**Std. dev**	**Average**	**Std. dev**
Milk production (ton)	43,687	131,849	299,304	240,408	5,345	7,165
Feed costs (1,000 tenge)	60,750	78,763	27,767	22,208	65,697	82,901
Labor hours	266,235	366,449	93,440	51,301	292,154	385,853
Capital costs (1,000 tenge)	36,965	121,504	203,757	280,224	11,946	20,003

Besides, the unstable feed supply between summer and winter and variable feed quality regionally are other difficulties faced by the dairy sector. As a result, feed is expensive and it's hard to get high-quality, compound feed. These unfavourable feed conditions correspond to the limited production capacity of premium dairy products. The industry needs to upgrade its supply chains and seek a holistic approach by facilitating bulk feed purchase by farmer groups, contract farming linking farmers to input and output markets, and improved institutional protocols. On the contrary, the fact that cows can be fed with natural feeds out of the country's rich plant diversities can create new opportunities in export markets.

According to the FAOSTAT, Kazakhstan is the 9th milk consumer in the world. The country's milk consumption per capita is 288kg in 2013. Despite its growth in exports over 2018-19, the country maintains a trade deficit in dairy products. Especially, finished dairy products are being imported because of the relatively high domestic milk price coupled with relatively low domestic milk quality compared with its neighbouring countries and European counterparts (Kazkenova *et al.*, 2015; OECD, 2013). Import demand for milk powder is also growing as the consumption of ultra-heat treated (UHT) milk is overtaking that of pasteurized milk. Since domestic milk quality is unsuitable for UHT milk, commercial processors increasingly use imported reconstituted milk powder to produce extended shelf-life milk.

Despite these limitations and difficulties, the Kazakhstan government is striving to modernize and develop the dairy sector. Under its masterplan for the 2013-20 period, the country aimed to construct 2,000 new dairy farms with stocks of 24-200 cows per farm (The Republic of Kazakhstan, 2013). These farms are expected to produce an extra 689,000 tons of milk annually with 187,000 milk cows by 2020. The government also signed a roadmap that is intended to align the country's dairy safety standards with the Eurasian Economic Union (EAEU), the EU and China and to materialize export potentials for Kazakh producers (Cornall, 2019). Supported by the European Bank for Reconstruction and Development (EBRD) and the Food and Agriculture Organization (FAO), the move includes enhancing milk yields that are equivalent to its neighbouring countries, securing year-round availability and escalating milk safety parameters.

The development of "the Belt and Road Initiative (BRI)" can pave the way for the export potential of agricultural goods, including dairy products. By connecting China, Europe, Africa, and southeast Asia, the initiative is expected to increase transit volumes via Kazakhstan from 47,400 twenty-foot equivalent units (TEUs) in 2015 to 1.7 million TEUs in 2020, about 10% of the total EU-Asia transport volume (Samruk-Kazyna, 2017). In addition, Kazakhstan has several competitive advantages in terms of providing a one-country link between China and the Caspian Sea, furthering the bilateral partnership and cooperation with the EU, and improving the business-enabling environment for trade and investment.

Conclusions

Consistent with expectations, the DEA results suggest a dichotomy of productive efficiency among Kazakhstan dairy farms. Despite the existence of several efficient farms, which have relatively large production and capital-intensive technology, the production of many of the other farms surveyed lag far behind the efficiency frontier. This finding shed light on the importance of promoting inclusiveness through sharing knowledge and best practices within the industry. To bridge the gap between traditional safety practices and the global standards, the country needs to strengthen its commitment to improving the safety of raw milk and dairy products, developing the national monitoring system for animal health and production, and creating the regional dairy value chain, which would enhance the economic sustainability of many small-scale household farms.

Digital transformation and innovations at farms and supply chains, as illustrated by the case of the "Collect Mobile" app could help pave the way for optimizing core functions and links ranging from production to aggregation, processing, and distribution. Ultimately, the dairy industry needs a governance structure that manages the linkages across actors at each stage in the chain and creates enabling environments within the overall chain to be competitive in trade.

A favourable development in external environments including its accession to the WTO and EAEU is likely to expand trade networks and global value chains for the dairy industry. Of particular importance for Kazakhstan is the creation of transport corridors that connects the country to China, Russia, Western Asia and Western Europe within the BRI. This could serve as a stepping stone to revamp the existing trade structure that depends on Russia and its neighbours.

This study has limitations that attempt to derive trade implications only through production efficiency at the farm level and related elements. Needless to say, many other factors, including product quality, brand and reputations, production and processing methods, and logistics are important determinants of trade. Caution is needed to interpret the empirical analysis since due to practice constraints, surveyed farms were not selected as randomized.

Research should continue in discovering the competitive potential of Kazakhstan's dairy products in a comprehensive manner, but this study is an important first step. Future research could analyse if Kazakhstan dairy farms are efficient in production relative to neighbouring economies, which can serve as a bridge to explore new trade avenues.

References

Akhmetov, A. (2017). Testing the presence of the Dutch disease in Kazakhstan. MPRA Paper No. 77936.

Asmild, M., Paradi, J., Reese, D. & Tam F. (2006). Measuring overall efficiency and effectiveness using DEA. *European Journal of Operational Research*, *178*: 305-321.

Banker, D., Charnes, W. & Cooper, W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*, *30*: 1078-1092.

Birch, K. (2021). China's Belt and Road Initiative gets Silk Road Expo boost. Business Chief, May 17, 2021.

Borghijs, A. (2017). Kazakhstan aiming for the top 30. Japan Institute for Overseas Investment. Mar 23, 2017.

Business Sweden (2016). Opportunities within the Agricultural Sector: Kazakhstan. Business Sweden, Kazakhstan.

Chatzky, A. & McBride, J. (2020). China's massive Belt and Road Initiative. Council on Foreign Relations, January 28, 2020.

Charnes, A., Cooper, W. & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, *2*: 429-444.

Cho, S., & Kim, C. (2001). An analysis of dairy farm efficiency. *Korean Journal of Agricultural Management and Policy*, *28*: 1-16.

Cloutier, L. & Rowley, R. (1993). Relative technical efficiency: Data envelopment analysis and Quebec's dairy farms. *Canadian Journal of Agricultural Economics*, *41*: 169-176.

Cohen, A. (2008). Kazakhstan: The Road to Independence: Energy Policy and the Birth of a Nation. Sweden: Central Asia Caucasus Institute.

Cooper, W., Seiford, L., & Tone, K. (2000). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. London: Kluwer Academic Publishers.

Cornall, J. (2019). Kazakhstan pushing ahead with dairy roadmap. Dairy reporter. com, August 14, 2019.

Food and Agriculture Organization (2021). Apps and animations improve traditional dairy production in Kazakhstan. FAO Stories, June 1, 2021.

– (2014). Developing sustainable food value chains: Guiding principles. Rome.

– (2011). Dairy Development in Kazakhstan. Rome.

Jaforullah, M. & Whiteman, J. (1999). Scale efficiency in the New Zealand dairy industry: A non-parametric approach. *Australian Journal of Agricultural and Resource Economics*, *43*: 523-541.

Kaliyeva, S., Areal, F & Gadankis, Y. (2020). Attitudes of Kazakh rural households towards joining and creating cooperatives. *Agriculture*, *10*: 568.

Kazkenova, A., Ainakanova, B., Kuzmenko, S., Yerdenbekova, B. & Kassenova, A. (2015). Analysis of dairy and meat products in the Republic of Kazakhstan. *Asian Social Science*, *11*: 90-97.

Kraemer, R., Prishchepov, A., Dara, A., Kuemmerle, T., Müller, D., Radeloff, V., Terekhov, A. & Frühauf, M. (2015). Long-term agricultural land-cover change reveals limited potential for cropland expansion in the former Virgin Lands area of Kazakhstan. *Environmental Research Letters*, *10*: 054012.

Lashkareva, O., Abetova, S., Kozhakhmetova, G., Moldashov, N. & Auelbekova, A. (2016). Development of a classification system for agricultural lands in Kazakhstan. *Outlook on Agriculture*, *45*: 78-86.

Lee, Y. & Park J. (2011). A study on the management capacity and management efficiency of dairy farms. *Korean Journal of Agricultural Management and Policy*, *38*: 381-402.

Lim, S. (2016). Trends and changes in Kazakhstan's grain and farm policies. *World Grain Market*, *5*: 129-150.

Luik, H., Ants-Hannes, V. & Rando, V. (2014). "Using the information about dairy herd's genetic level and milk quality in explaining the technical efficiency of Estonian dairy farms: a two-stage (DEA and Tobit) approach". 2014 International Congress, August 26-29, 2014, Ljubljana, Slovenia 182650, European Association of Agricultural Economists.

Nazhmidenov, K. (2010). The dairy sub-sector. Investment Centre Division, FAO, Rome.

Netherlands Worldwide (2019). Dairy sector in the Russian Federation and Kazakhstan. Market Research, October 2017.

Nurmakhanova, M. (2016). Oil and growth challenge in Kazakhstan. Economic Education and Research Consortium Working Paper No. E16/06.

OECD (2013). OECD review of agricultural policies: Kazakhstan. Paris: OECD Publishing.

OECD (2016). Agricultural policy monitoring and evaluation 2016. Paris: OECD Publishing.

OECD (2017). OECD reviews of innovation policy: Kazakhstan 2017. Paris: OECD Publishing.

Park, J., Kim, N. & Youn, G. (2006). A productive efficiency analysis of dairy farm management using nonparametric approach. *Korean Journal of Agricultural. Management and Policy*, *33*: 58-69.

Petrick, M., Oshakbaev, D. & Wandel, J. (2014). Kazakhstan's wheat, beef and dairy sectors: An assessment of their development constraints and recent policy responses. Paper presented at the symposium, Kazakhstan's economic strategy: Halfway to 2030, the Association for Comparative Economic Studies, Philadelphia, Jan 4, 2014.

Petrick, M. & Pomfret, R. (2016). Agricultural policies in Kazakhstan, Discussion Paper, Leibniz Institute of Agricultural Development in Transition Economies No. 155.

Pomfret, R. (2014). Kazakhstan's 2030 Strategy: Goals, instruments and performance. Paper presented at the symposium, Kazakhstan's economic strategy: Halfway to 2030, the Association for Comparative Economic Studies, Philadelphia, Jan 4, 2014.

Punda, I. (2016). The problem of raw milk collection in Kazakhstan: FAO assessment and solution algorithm. FAO Investment Centre, September 5, 2016, Astana.

Samruk-Kazyna (2017). Railway infrastructure: Upside transit potential. *Research and Knowledge Management*, Jan 20, 2017.

Stokes J., Tozer P., Hyde J. (2007). Identifying efficient dairy producers using data envelopment analysis. *Journal of Dairy Science*, *90*: 2555-2562.

Switlyk, M. (2020). Technical efficiency of dairy farms in 2008-2017. Research Papers of Wroclaw University of Economics and Business 2020, Vol. 64, No. 2.

Temyrbekova, A., Temyrbek, E., Tastandieva, N., Jandosov, K. & Aldabergenov, N. (2015). Impact of Kazakhstan's integration into the Eurasian Economic Community on the competitiveness of the country's agriculture. *Review of European Studies*, *7*: 173-186.

The Republic of Kazakhstan (2013). Masterplan: Development of the dairy industry in the Republic of Kazakhstan until 2020. The Ministry of Agriculture, Department of Animal Husbandry, Sep 18, 2013.

Theodoridis, A. & Psychoudakis, A. (2008). Efficiency measurement in Greek dairy farms: Stochastic frontier vs. data envelopment analysis. *International Journal of Business and Economic Sciences Applied Research*, *1*: 53-67.

U.S. Energy Information Administration (USEIA) (2017). Country analysis brief: Kazakhstan. May 10, 2017.

Van Engelen, A. (2011). Dairy Development in Kazakhstan. Rome: FAO.

Youn, G., Shin, Y. & Kwak, Y. (1999). A study on the productive efficiency between individual farms: An application of DEA method and cluster analysis. *Korean Journal of Livestock Production and Management*, 15: 306-323.

Wilczynski, A., Koloszycz, E. & Switlyk, M. (2020). Technical efficiency of dairy farms: An empirical study of producers in Poland. *European Research Studies Journal*, 23(1): 117-127.

Sang Woo Han
ESG Policy Advisory Center - Korea Productivity Center (KPC), Korea
Jeokseon-dong 32, Saemuan-ro 5Ga-gil, Jongno-gu - 03170 Seoul, Korea
E-mail: swhan@kpc.or.kr
He holds a Master of Food and Resource Economics from Korea University. Researcher at Korea Productivity Center. Current research interests are related to the design of Korea ESG guidance and the establishment of ESG strategy for food companies.

Song Soo Lim
Department of Food and Resource Economics - Korea University, South Korea
145 Anam-ro, Sungbuk-gu - 02841 Seoul, South Korea
Tel: +82 2 3290 3033
E-mail: songsoo@korea.ac.kr
Ph.D. in Agricultural Economics from Texas A&M University in 1995 and Professor of agri-food trade since 2008. On-going research topics include the economic effects of trade liberalization, the WTO trade disputes, and agricultural development and cooperation.

Aida Balkibayeva
Department of Economics, S. Seifullin Kazakh AgroTechnical University - Nur-Sultan, Kazakhstan
Zhenys prospect, 62 - Nur-Sultan, Kazakhstan
E-mail: ambal1974@mail.ru
She holds a Candidate in Economic Sciences degree since 2005 and an Associate Professor title and position since 2008. Her research interests relate to Agricultural Economics and Management, particularly Agrobusiness Organization, Cooperation, Rural Development.