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Abstract

In Kyrgyzstan, milk production serves as a crucial financial resource for rural households, providing daily sales and regular income. Despite this, not all cow owners participate in the milk market. This research uses a two-tiered Cragg model to explore the factors influencing both market participation and milk sales volume among 250 households in Chui region. Findings show that cow numbers and access to local pastures significantly affect both market participation and milk sales. Roughage provision and milk prices also have positive impacts, while cropland use and concentrate feed do not significantly influence market participation. The use of milking machinery and legal farm status notably increases milk sales volume, whereas credit constraints and cooperative membership have no significant effect. This research recommends policies to improve pasture access, legal recognition of farms, and market conditions to enhance market integration and sustainability in Kyrgyzstan's dairy sector.

Keywords: Dairy value chains, Kyrgyzstan, milk marketing, Cragg model

JEL codes: Q12; Q13.

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Introduction

In Kyrgyzstan, approximately one quarter of the employed population is involved in crop production and livestock husbandry (World Bank Development Indicators, 2023). However, cash income from these sources is often absent or seasonal in nature (Mogilevskii et al., 2017). Milk has seen strong growth in processing and commercialization, particularly in the Chui and Issyk Kul regions of the country (Yamano et al., 2019). It is a potentially important source of financial liquidity and farmers sell milk daily, allowing for regular payments, often on a weekly basis. However, not all owners of milking cows participate in the milk market. This study aims to identify the factors that facilitate or hinder their entry into the dairy market, focusing on the key dairy-producing region of Chui. Our analysis draws on survey data collected specifically for this study in 2018, covering 250 households engaged in livestock production.

According to the 2019 Life in Kyrgyzstan dataset, 53% of rural households nationwide kept cattle in 2018 and in Chui region this figure is even higher, at 62% (own analysis, Life in Kyrgyzstan, 2025) This high proportion suggests that milk is likely to be a key resource for nutrition and livelihoods; the factors influencing the extent to which it is used to generate cash income are important to understanding the role of cattle in the rural economy.

Against this background, we explore the determinants of small farmers' participation in the Kyrgyz dairy market, asking the following research questions:

1. What are the determinants that explain a farmer's choice to participate in the dairy market in the Chui region of Kyrgyzstan?
2. If a farmer decides to participate in the dairy market, what factors influence the volume of milk sold?

We investigate the factors that drive participation in milk value chains, and which influence the volumes sold, employing a two-tier Cragg model for analysis of our survey data. Compared to a standard Tobit model, the latter allows different determinants to be included in the two model stages (Cragg, 1971).

Nurullaev et al. (2025) analysed market participation of Kyrgyz smallholder dairy producers using pooled Life in Kyrgyzstan data collected in 2012, 2013, 2016 and 2019 and estimating a two-step Heckman model. Their variable selection differs notably from our specification in that they mostly include indicators of household demographics, general household assets and geographical location. Kosimov and Petrick (2024) explore market access of dairy producers in Sughd province of Tajikistan. As discussed below, several other studies examine similar questions for cases in Africa or India.

Our specifically collected survey data allows us to focus on determinants that are likely to affect dairy production in a direct and straightforward way. These include pasture and fodder access, price signals from the milk market, dairy production characteristics such as herd size and dairy-specific mechanization, and the institutional environment of farmers including their formal status and credit access.

The next section gives a snapshot of the dairy sector in Kyrgyzstan followed by a review of the set of determinants investigated in our study. We introduce the data and methods used, present the results, draw conclusions and derive policy implications.

The dairy sector in Kyrgyzstan

Kyrgyzstan experienced the consequences of the Soviet Union's collapse, witnessing a decline in dairy sector indicators due to the reforms that followed its dissolution. As elsewhere, state vertical coordination of value chains collapsed, followed by market liberalization and privatization. The agricultural sector's contribution to GDP has exhibited a steep decline since the country gained independence in 1991 and sectoral labour productivity remains low (Yamano et al., 2019). Nonetheless, agriculture continues to hold significant importance for income generation of the predominantly rural population.

This study was conducted during a period of strong growth in the dairy sector. Over the period 2018–2022 the number of cows grew from 813,000 to 886,000, an average growth rate of about 2% per year. National production of raw milk increased by 9% over the same period reaching 1.7 million tons in 2022, with Chui region leading at 0.45 million tons (National Statistical Committee of the Kyrgyz Republic, 2023, 2024). In that year, around 74% of raw milk production was sold and over 200,000 t exported (ibid.).[1] Milk and milk products are one of the country's most important agricultural exports, sold mostly to Russian and Kazakhstan (Yamano et al., 2019).

Today, cattle holdings are split between registered peasant farms ('farms' from now on), which account for 51% of all cattle, while rural households (holding stock but not registered as farming enterprises) account for approximately 49% (National Statistical Committee of the Kyrgyz Republic, 2023).

1 All processed milk products are included in these figures as raw milk-equivalents; actual tonnes of finished product are much lower. The proportion exported as raw milk is low compared to other products (Dairy News Today, 2024).

Why participate in milk markets? Evidence from global literature

In this section we discuss the main factors which may influence the decision of smallholder farmers to enter the dairy market, and the volume of milk sales. These factors may be categorized into those related to household or farm characteristics, their access to factors of production as well as variables related to the farm's location (Vroegindewey et al., 2021). As we find below, other studies modelling market participation using regression methods similar to those employed in this study focus mainly on Africa (Balagtas et al., 2007; Balirwa & Waholi, 2019; Chamboko et al., 2017; Kuma et al., 2013; Ordofa et al., 2021; Tarekegn & Shitaye, 2022; Tissie et al., 2019; Vroegindewey et al., 2021) and India (Bardhan et al., 2012; Jaiswal & Singh, 2015). We now explore some of these factors, examining their relationship to our outcomes of interest in the literature.

Land

Other than holding sizes in number of dairy cows (which was positively related to market participation and production volume in all reviewed studies), the most important production factor for producers is land. In Kyrgyzstan around 70% of the territory is occupied by pastures (National Statistical Committee of the Kyrgyz Republic, 2023), whilst the Chui valley in particular is also well endowed with arable land. Access to pasture, especially to village pasture located near the farm, allows the farmer to save on fodder purchases, at least in summertime. Likewise, availability of cultivated land permits fodder production. Most reviewed studies focus on cropland or total holdings rather than pastures. Whilst some find positive effects on both participation or volume (Balagtas et al., 2007; Vroegindewey et al., 2021), others find negative effects, particularly on participation, as more land may be associated with additional income activities which reduce the need for milk sales (Bardhan et al., 2012; Jaiswal & Singh, 2015; Kuma et al., 2013). Where this was included in models, access to grazing land specifically has a positive effect (Tissie et al., 2019).

Improved technologies and inputs for intensification

Access to improved breeds, high protein feeds and machinery may enhance productivity, thereby enabling market participation and increased milk sales. Of these, improved breeds is the variable most usually included in published models, and is indeed positively associated with participation, volume or both (Balirwa & Waholi, 2019; Ordofa et al., 2021; Tarekegn & Shitaye, 2022), as is improved feed (Tarekegn & Shitaye, 2022).

A number of determinants influence the likelihood of intensification or uptake of new technology. Farms with larger holdings may be more able to invest than smaller poorer farms (Foster & Rosenzweig, 2010) and access to extension services was positive in many reviewed studies (Balirwa & Waholi, 2019; Chamboko et al., 2017; Muzemil, 2020; Ordofa et al., 2021; Tissie et al., 2019). Education and credit may also play an important role, and these two factors are discussed further below.

Access to credit

Credit would be expected to enable producers to invest in their dairy enterprise, improve productivity as well as avoid de-stocking during difficult times. Few reviewed studies looked directly at this indicator but those that did found it to have a positive effect on both market participation (Muzemil, 2020) or sales volume (Ordofa et al., 2021).

In many developing countries major credit sources include government programs and processors through vertical coordination. Research in selected CIS countries found that 40% of processors offered credit to the farms supplying them, while 36% offered other resources such as inputs (Swinnen & Maertens, 2007). In Kyrgyzstan, such credit supply through vertical coordination is uncommon, but despite the reduced role of the state in agricultural production and marketing, the government continues to participate in agricultural supply chains, for example, by providing subsidized credit to support and develop agriculture at a low interest rate (Ayil Bank, 2023).

According to our own analysis of the 2019 wave of the Life in Kyrgyzstan survey dataset (Life in Kyrgyzstan, 2025), 15% of rural households indicated that they took a credit or a loan in the last 12 months, and the same percentage is shown for Chui region. Kyrgyzstan has some similarities with India regarding access to credit, in India financial institutions are reluctant to provide credit to small dairy farmers (Birthal et al., 2017). These authors argue that restrictions on markets and credit can be mitigated through a value chain approach that includes farmers, aggregators, traders, processors and financial institutions.

Farmer and household characteristics

Numerous studies have examined the role of farmer characteristics in modelling participation and sales volumes, looking most commonly at age, sex and education level of the farm manager, household size and the number of children under six or five years old. These factors present a mixed picture: education is often non-

significant (Vroegindewey et al., 2021), but where there is an association, it tends to be positive (Chamboko et al., 2017; Jaiswal & Singh, 2015). Manager age may be positive (Balagtas et al., 2007), negative (Bardhan et al., 2012) or affect participation and volume differently (Chamboko et al., 2017). Here, the lack of a clear picture may reflect the fact that the effect of manager experience on intensification processes is often U-shaped rather than linear (Robinson & Petrick, 2024). Gender is insignificant in almost all studies reviewed and although Vroegindewey et al. (2021) find higher participation amongst women, this is likely to be affected by very unbalanced sample sizes. On the other hand, large numbers of young children often have negative effect on participation and volume as more milk is used for family consumption (Muzemil, 2020; Tarekegn & Shitaye, 2022); although not all studies found this effect (Balirwa & Waholi, 2019; Vroegindewey et al., 2021). Lastly, overall household size was included in almost all reviewed models, and was insignificant in most; where positive effects were recorded this was attributed to labour availability for milk production (Chamboko et al., 2017; Ordofa et al., 2021).

Geographical location

Geographical factors can significantly influence market participation and sales volume. For example, proximity to a milk processing centre or a populated area can increase a farmer's likelihood of selling milk, as milk collectors have easier access in terms of distance and time. Another influential factor may be altitude; farms located in mountainous regions face accessibility challenges, which can impact market participation.

Various studies have identified distance to markets as the geographical factor most likely to influence market participation, and almost all studies find it to have a negative influence (Bardhan et al., 2012; Muzemil, 2020; Ordofa et al., 2021; Tarekegn & Shitaye, 2022). Other variables such as climate have also been examined, with for example precipitation having a significant positive association with milk market participation or volume (Vroegindewey et al., 2021).

Marketing channel and price

Even during the Soviet era when supply chains were controlled by the state, there existed informal channels for private households to market milk (Gorton et al., 2007). Unlike Eastern Europe, where vertical coordination has emerged (Dries et al., 2009), these informal channels remain the major mode of sale in Kyrgyzstan. According to the 2019 Life in Kyrgyzstan dataset, only 6% of rural households nationally and 3% in the Chui valley reported sell-

ing cow's milk under a contract. India is another country where the milk sector is dominated by smallholders relying on informal channels for milk product distribution, while large farmers have more partnership relationships with milk processors. As a result of these relationships, resource-rich farms involved in cooperative production and supply chains generate higher profits than small farmers. Small farmers have fewer opportunities to grow due to price discrimination from transnational corporations and commercial banks that direct financing towards wealthy farmers (Birthal et al., 2017). However, Birthal's study did not find any evidence that farmers opting for formal channels have greater incentives to enter the milk market. On the contrary, small farmers are more dependent on income from milk sales and, despite price discrimination, continue to supply milk through informal channels without entering into contracts, so we can conclude that informality is not necessarily a barrier to participation. In our dataset, only a tiny proportion of producers sell to formal channels, so we do not explore the impact of formality on market participation (see below) and likewise reviewed studies did not generally include the marketing channel as a variable in the second stage. However, several studies looked at cooperative proximity or membership, which were found to be positive in both stages (Ordofa et al., 2021) or at the second (volume) stage (Tissie et al., 2019). As might be expected, price incentives also tend to have a positive effect on farmers' decisions to participate in the dairy market (Balagtas et al., 2007; Vroegindewey et al., 2021). Nurullaev et al. (2025) find a surprisingly negative relation between milk price and market participation.

In the next section we present our dataset, empirical approach and the set of determinants with associated hypotheses which we have selected for our model of milk market participation and sales volume in Kyrgyzstan. The factors selected will be used to evaluate a two-stage model. The dependent variable for the first stage is the market participation variable transformed into a binary from a continuous variable on the amount of milk sold over the past 12 months. The dependent variable of the second stage is the volume of milk sold in kilolitres over the last 12 months.

Data and methods

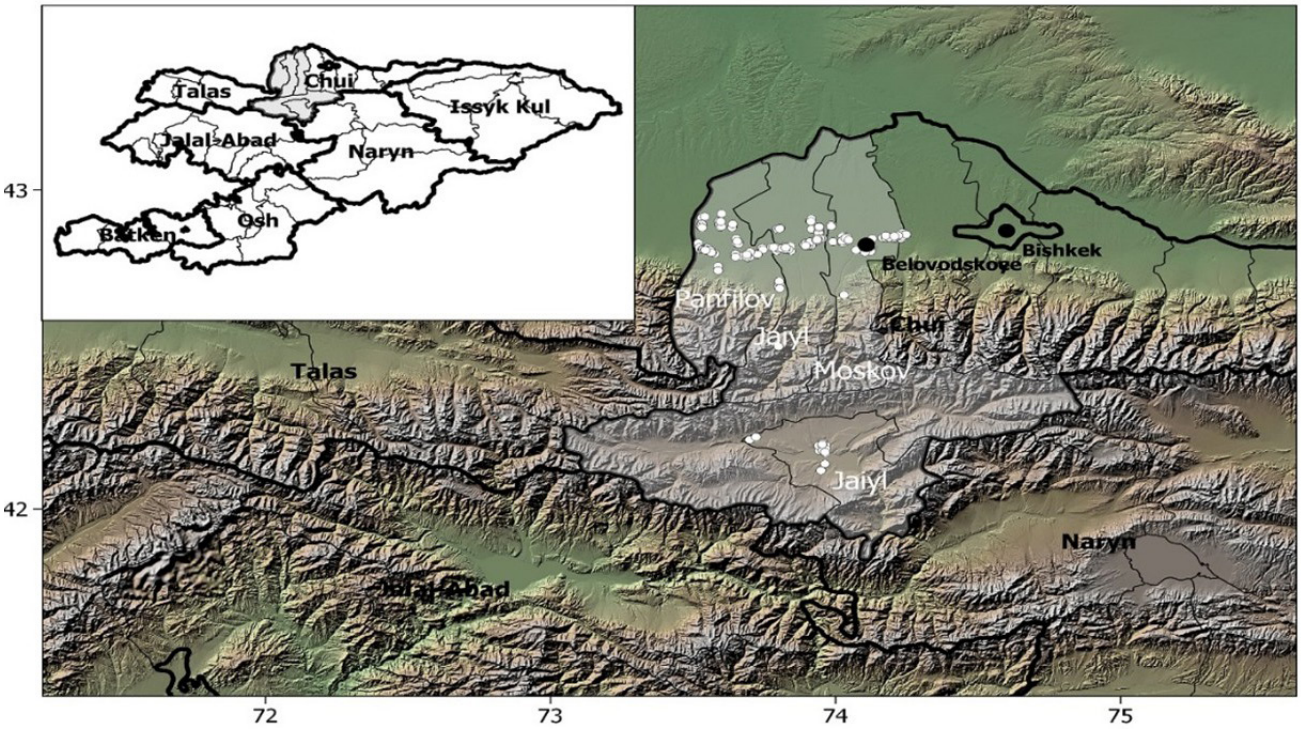
Data sources

To conduct this study, data from the ANICANET project collected in 2018 from 250 households was utilized.[2] The study in Kyrgyzstan concentrated on an important livestock-producing region with a high concentration of cattle, located in the north-western part of Chui valley (Figure 1). The survey covered rural households keeping five or more cattle in three districts of Chui oblast in summer 2018.

2 "Revitalizing animal husbandry in Central Asia: A five-country analysis (ANICANET)" – see Acknowledgements.

Figure 1 Map of sampling

Source: Sarah Robinson



Chui oblast has the third largest stock of cattle and cows in Kyrgyzstan. Moreover, the biggest dairy plants in Kyrgyzstan are located in that area. Three districts, namely, Panfilov, Moscow, and Jayil districts, were chosen as milk production clusters In Chui oblast.

For data accuracy, sampling was stratified by district, so that a similar number of interviews was conducted in each. In each district, the four village communities[3] with the largest number of farmers keeping five or more cattle were selected. Within each district the sample was distributed between village communities proportionally to the size of sampling frame (number of farmers keeping five or more cattle), and selection of respondents was conducted by simple random sampling. The detailed distribution of the sample by village community is presented in Table 1.

3 Village community (ayil aimak)- an administrative-territorial unit, within the boundaries of which the local community exercises local self-government. One ayil aimak may consist of one or more settlements. http://cbd.minjust.gov.kg/act/view/ru-ru/203102/120?-cl=ru-ru

Table 1 Sample by village communities of Chui oblast

#	District	Aiyl aimak	Number of interviews
1	Moscow	Petrovka AA	25
2		Sadovoe AA	23
3		Alexandrovka AA	26
4		Pervoemaya AA	10
Total			**84**
5	Panfilov	Panfilov AA	22
6		Kurpuldok AA	22
7		Voznesenovsk AA	15
8		Kuramaevk AA	24
Total			**83**
9	Jayil	Jayil AA	20
10		Ak-Bashat AA	23
11		Poltavka AA	20
12		Suusamyr AA	20
Total			**83**
Grand total			**250**

Source: authors calculations

The survey questionnaire included questions covering many aspects of livestock production systems including farm structure, land use, production, and marketing, grazing and fodder, as well as access to inputs, loans, labour and information. Additionally, external data on precipitation were obtained from the WorldClim V1 climatic dataset (Hijmans et al., 2005); elevation data were extracted from STRM digital elevation models, the Geosphere R package was used to calculate for distance from processors. Settlement sizes were obtained from national statistics.

Microeconomic household model

To address the research question, we will use a modified version of the agricultural household model proposed by Singh et al. (1986) as the foundation for understanding farmers' behaviour regarding milk sales. Additional variables will be added to the original model to account for market imperfections and the household's market participation behaviour, considering incomplete access to milk markets and necessary resources.

For each household, the decision to participate in the market comprises two parts. The first part involves the household's decision to participate or not in the dairy market, while the second part concerns the volume of sales.

We define a sales volume equation as:

$$Q_i=Q_i\ (M,P,Z,A), \quad (1)$$

where *Q* is the sales volume *(Q=0 if M=0)*; *M* participation in the market (*1* = participation, *0* = non-participation); *P* the selling price of milk; *Z* other characteristics of the household; *A* the household's productive assets.

Since the model consists of two stages, we will divide the independent variables into two parts. One part will relate to the first stage, determining the farmer's behaviour regarding participation in the dairy market, while the second part will pertain to the volume of milk sold.

To econometrically evaluate our model, we will employ a two-tiered (or double-hurdle) model proposed by Cragg (1971). In the first stage, we estimate the probability of farmer participation in the dairy market, while in the second stage, we estimate the volume of milk sales if the farmer decides to participate. The two-tiered Cragg model considers zero values (non-milk-selling households) as observable outcomes and incorporates a set of explanatory variables separately for market participation probability and sales volumes.

The regressions to be evaluated are defined as follows (Burke 2009):

Stage 1: probability of market participation

$$Prob(M_i=1)=Prob(Q_i>0)=\Phi(X_i\ \alpha) \quad (2)$$

Stage 2: expected sales volume conditional on participation

$$E(Q_i\ |Q_i>0,Z_i\ )=Z_i\ \beta+\sigma\times\lambda((Z_i\ \beta)/\sigma), \quad (3)$$

where *Prob* is the probability of participation in the market (*M*); Z_i, *Xi* are two vectors of explanatory variables from the main model; α and β are the coefficients of these vectors of explanatory variables for the first and second stages, and ϕ are Φ the standard normal probability and cumulative distribution functions, $\lambda(c)=(\phi(c))/(\Phi(c))$ is the Inverse Mill's Ratio for any magnitude c, respectively.

The Tobit model is another two-stage model used to address corner solutions when the dependent variable is censored or partially observed. It is applicable when the outcome variable has a lower bound of zero, as in our case where participation and volume of milk sold cannot be negative (Tobin, 1958). The result variable is censored from below, meaning that the model will be a Tobit model

at the lower end. The difference between the Tobit model and the Cragg model is that in the Tobit model, the explanatory variables for both stages are the same, whereas in the Cragg model, different factors are allowed to influence the probability of participation in the market and sales volumes (Burke, 2009). A similar study on the Kenyan dairy market demonstrated that factors for both stages and their directional effects may well be different and our own hypotheses (outlined below) are also separate for the two stages, therefore we estimate effects using the double-hurdle Cragg model (Burke, 2015).

The Heckman model could have been applied if the model treated respondents who do not sell milk as unobservable data (Heckman, 1979). However, in our database, non-dairy market participants are observable; we assigned some missing values of the dependent variable as zero, as cross-checking revealed that missing values indicate non-participation in the market.

Selected determinants of market entry and sales

In this section, we describe the predictor variables selected for our model, and the mechanisms through which we expect them to influence both participation in markets, and volume of milk sold. Not all the variables described here entered the final model, and following this section we describe how some were removed following an examination of multi-collinearity.

Firstly, as was the case for all reviewed examples, we included the number of cows, expected to be a major determinant influencing both engagement in the dairy market and determination of the quantity of milk sold. Another significant factor affecting participation in the dairy market and the subsequent volume of milk sales is the provision of fodder to cattle. This provision is encapsulated by two distinct variables: roughage (comprising hay, crop residue, grass silage, maize silage) and concentrated fodder (comprising grain, root crops, and combined feed) presented in tons over the preceding 12 months. These variables were formulated by amalgamating values from both purchased and domestically cultivated sources. Roughage and concentrate are considered separately because they are indicative of different production systems and feeding strategies (Mottet et al., 2017). In Central Asia in particular, roughage quantities may be important to maintain herd sizes through winter by avoiding mortality whilst concentrate provision indicates a desire to fatten livestock or improve milk production (Robinson & Petrick, 2024; Ur-Rahim et al., 2014).

Furthermore, access to village pastures is deemed a key source of low-cost nutrition for cattle. These pastures are understood as “pastures located in close proximity to populated areas and used

for grazing livestock by rural residents who constantly keep livestock on their homesteads" (Government of the Kyrgyz Republic, 1999). This proximity allows owners to return cows home for milking each evening. In our dataset, this variable is binary, and we expect a positive effect on market participation. In addition, more distant (remote) pastures are also available, however these are less likely to be used for dairy cattle. In our model we expect village pastures to contribute to the probability of holding any cattle, resulting in cost savings on fodder. However, they are not anticipated to significantly impact milk productivity and volumes due to the low energy yield associated with such environments.

It is expected that the area of land cultivated will impact both market participation and volume sold, as the more land is cultivated the more fodder can be produced. In the model, cultivated areas are represented by two continuous variables for cropland and hayfields. These variables may be highly correlated with those for fodder provision, which was checked during our collinearity analysis.

One of the main market incentives both to sell milk and sell in big volumes is price. As there were many missing values in the dataset, and to smooth seasonality the variable of average milk price was converted to median milk prices per settlement (subdistrict). From interviews in the field, it was revealed that all relationships between intermediaries, milk processing companies and farmers supplying milk are based on verbal agreements, and purchasing prices can vary between neighbouring farmers.

Additionally, we included binary dummies for legal farm status and membership in a cooperative or association, since having a specific legal status enables farms to enter contracts for milk supply and access agricultural loans. It is expected that both will have a positive effect on participation and the volume of sold milk.

Mean annual precipitation was initially incorporated into the analysis; elevated precipitation affects agricultural production directly but in our study area it is also indicative of mountainous terrain, thereby implying challenging transportation access and, consequently, augmenting transaction costs. Consequently, we expect that heightened precipitation inversely correlates with the probability of market participation.

Because our survey sample was largely split into producers located in the plains, or at high altitude (Figure 1), an alternative variable representing altitude zone was also considered. This variable is binary in nature, with a value of 1 denoting that the farm is situated at an altitude equal to or exceeding 1500 meters above sea level (MASL), designated as a mountainous region. Like precipitation, it is likely to be associated with a decrease in both the likelihood of

market participation and the volume of milk sold. Similarly, proximity to a processing centre in km is likely to amplify the farmer's motivation to engage in milk sales, particularly in substantial volumes. These three related measures of climate and remoteness were all considered for the final model and explored through correlation matrix analysis.

Additionally, population density may also be a pivotal factor influencing milk sales, as processors exhibit a keen interest in dispatching milk collection vehicles to densely populated locations situated in proximity to primary thoroughfares. This effect was captured by the total population of the village in which the farmer resides.

Factors such as the utilization of milking machines and coolers assume a significant role in the second phase of the process. Milking machines are conventionally employed to facilitate the production of larger quantities of milk. The absence of a cooler may limit the farmer's capacity to store and thus sell substantial volumes of milk.

We expect access to loans to positively influence the volume of milk sales, given that such financial resources may be used for acquiring essential equipment, purchasing seeds for crops, and securing fodder. However, simply recording whether a producer made a successful credit application does not fully capture the different type of credit constraints faced by producers. Thus, following Boucher et al. (2009) and Robinson and Petrick (2024), a binary variable termed "credit constrained" was introduced to encapsulate respondents who applied for credit but did not receive the entire sum, those who applied but were unsuccessful, individuals who refrained from applying for a loan as they felt unsure of their ability to repay (risk rationing) and those who did not apply due to administrative obstacles (transaction cost rationing). Successful borrowers and those who did not apply due to interest rate costs or collateral requirements (price rationing) are not considered to be credit constrained.

A number of factors commonly included in similar literature reviewed above do not appear in our model. These include household characteristics such as age, education and gender of the farm manager, which were often insignificant or ambiguous in reviewed models, whilst our dataset did not include the number of children in the household.

Descriptive statistics for considered variables

Before moving to the econometric estimation, the data was checked for outliers and descriptive statistics are provided in Table 2 for all those variables discussed above which were considered for

the regression analysis. Following cleaning, the dataset included 247 observations for each variable. Concerning the dependent variables, participation in milk markets concerned 77% of the sample whilst those participating sold an average of 10.72 kilolitres per farm per year with a maximum of 80 kilolitres.

Correlation matrix analysis

To assess the feasibility of incorporating variables listed in Table 2 into the regression model, an examination of the correlation matrix is imperative to mitigate potential multicollinearity. The outcomes of the correlation matrix revealed a substantial negative correlation between the median milk price and the distance from the farm to the processing centre, as well as between the median milk price and altitude. Additionally, notable positive correlations were observed between altitude and precipitation, as well as between altitude and the distance from the farm to the processing centre.

Consequently, in constructing the regression model, we opted for including the median milk price as it can be straightforwardly interpreted in the framework of the household model above. Furthermore, precipitation will be excluded from the model as it simply reflecting the relationship between precipitation and distance from markets, and in turn distance is also strongly related to median milk price. Whether each variable was retained or removed is flagged in Table 2.

Table 2 Summary statistics of dairy farming household's sample set

Variable	N of obs.	Mean	Median	Min	Max	Belonging to stage (stage 1-participation, 2-quantity of milk sold)	Non-participants (n = 58)	Participants (n = 189)	Estimated in the final model after checking on multicollinearity
Dependent variables							**Mean**	**Mean**	
Participation	247	0.77	—	0	1	Stage 1	—	—	✓
Volume of milk (kilolitres/year)	247	8.2	4.74	0	80	Stage 2	—	10.72	✓
Household-specific explanatory variables									
Num. dairy cows (head)	247	5.22	4	0	41	Stage 1/Stage 2	1.03	6.51	✓
Milking machinery	247	0.09	—	0	1	Stage 2	0	0.12	✓
Cooler	247	0.87	—	0	1	Stage 2	0.59	0.96	✓
Provision of roughage (tons/year)	247	31.93	15	0	460	Stage 1/Stage 2	16.94	36.53	✓
Provision of concentrate (tons/year)	247	7.8	4.5	0	80	Stage 1/Stage 2	6.66	8.15	✓
Status of farm/household (1=farm)	247	0.48	—	0	1	Stage 2	0.59	0.44	✓
Cooperation membership	247	0.15	—	0	1	Stage 2	0.14	0.15	✓
Access to local pastures	247	0.41	—	0	1	Stage 1	0.12	0.49	✓
Production variables									
Cropland (ha)	247	7.84	3.35	0	97	Stage 1/Stage 2	6.41	8.27	✓
Hayfield (ha)	247	0.83	0	0	30	Stage 1/Stage 2	0.66	0.88	✓
Credit constrained	247	0.44	—	0	1	Stage 1/Stage 2	0.14	0.19	✓
Location-specific explanatory variables									
Median milk price (som/litre)	247	13.8	14	10	15	Stage 1/Stage 2	14.05	13.77	✓
Mean annual precipitation (mm)	247	391	385	341	508	Stage 1	403	387	
Population of village (1000 people)	247	6.62	8.32	0.32	14.6	Stage 1	8.31	6.11	✓
Distance to processing centre (km)	247	14.9	8.85	0.93	64.34	Stage 1/Stage 2	16.33	14.46	
Altitude zone	247	0.08	—	0	1	Stage 1/Stage 2	0.12	0.07	

Results

We present the outcomes of the Cragg double-hurdle model, where the initial hurdle involves a binary form of the dependent variable denoting market participation, taking on a value of one if the farmer engages in the dairy market and zero otherwise. Subsequently, the second stage involves the dependent variable representing the volume of sold milk, conditioned on the farmer's participation in the dairy market.

Table 3 presents parameter estimates for both stages defined by equations (2) and (3) using the "craggit" command in Stata (Burke, 2009). Notably, the number of cows demonstrated a positive and statistically significant influence in both stages. In the second stage, an additional cow predicts an increase of 1,973 litres in the annual volume of milk sold. This figure closely aligns with the average annual milk yield per cow reported by the National Statistics Committee of the Kyrgyz Republic, which stood at approximately 1,985 litres in 2017-2018. However, it is imperative to acknowledge the potential existence of reverse causality. Specifically, the question arises as to whether farmers augment their herd size in response to improved market access. This question necessitates further exploration in subsequent research.

Moreover, within the primary tier, the binary variable designated as "access to local pasture" demonstrated statistical significance at the 1% level and exhibited a positive association with market participation. In contrast, measures of crop and hay land access did not exhibit any discernible impact on market participation. It is posited that, for the minimal production of milk for sale, farmers may not necessarily require extensive land cultivation; at times, the utilization of pastures alone might suffice. But the area of cultivated cropland is significant at the second stage, with an increase of 1 ha increasing the volume of milk sold by 239 litres per year. The increase is not substantial, as farmers may cultivate crops unrelated to livestock production.

Table 3: Determinants of dairy operator's market entry and sales according to Cragg model results

	First stage: market entry (Probit model)			Second stage: sales level (truncated regression)		
	Coef.		*P*-val	Coef.		*P*-val
Number of cows	0.712	***	<0.001	1.973	***	<0.001
Roughage fodder	0.002		0.580	0.053	***	<0.001
Concentrate fodder	0.006		0.684	-0.059		0.508
Local pasture	1.004	***	<0.001			
Cropland area	0.002		0.805	0.239	**	0.014
Hayfield area	-0.074		0.112	-0.234		0.263
Credit constrained	0.314		0.426	-2.095		0.253
Milk price	0.394	***	0.005	2.203	*	0.051
Population	-0.082		0.117			
_cons	-6.557	***	0.001	-44.337	**	0.011
Milking machinery				5.519	**	0.060
Cooler				0.361		0.917
Legal farm status				4.619	**	0.059
Coop member				4.356		0.111
sigma						
_cons	7.816		<0.001			

Dependent variable of the probit model is 1 if operator sold milk and 0 otherwise; Dependent variable of truncated normal model is '000' litres of milk sold'; * (**, ***): significantly different from zero at the 10 (5, 1) % level.

Source: Authors.

Concerning fodder-related variables, concentrate feed provision was found to be non-significant at both stages, which is surprising especially with regard to sales volume. Roughage emerged as significant at the 1% level in the second stage. This implies that a

1-ton increase in roughage is associated with a 53-liter per year augmentation in the volume of sold milk. However, the relatively modest impact of roughage on milk volume could be attributed to its allocation among all cattle, not solely among milking cows.

Regarding market incentives, the median milk price was observed to have a positive effect on market participation. Also at the second stage, the price exhibited a significant effect, with a 1 som per litre increase in the purchasing median milk price per settlement resulting in a 2,203-liter per year upswing in the volume of milk sold.

Among the determinants discerned in the second stage, the utilization of milking machinery manifested statistical significance at the 5% level. Farms using milking machines on average sell 5,519 litres more milk, compared with their counterparts not utilizing such machinery and holding other factors constant. Akin to the concern raised regarding herd size, use of milking machines may be endogenous. Distinguishing whether enhanced market access influenced the acquisition of milking machinery or vice versa poses a challenging aspect that warrants further examination.

Another salient variable demonstrating statistical significance is legal farm status. The estimated outcomes suggest that registered farms sell on average 4,619 litres more milk than their counterparts lacking legal recognition. A positive effect of formal business registration on both milk market participation and sales volumes was also found by Kosimov and Petrick (2024) for Tajikistan. It may be explained by the advantageous opportunities afforded to farms with legal status, including the ability to access agricultural credit and engage in contracts for the supply of milk to processing centres. However, it is noteworthy that such legal entities may choose not to disclose these arrangements, potentially due to concerns related to tax implications. In comparison, other variables such as credit constraint and cooperative membership appear to be insignificant. This may be attributed to the possibility that the activities of the cooperative are not directly related to milk production, processing, and selling, or because the cooperative is not fully functional.

The variable denoting credit constraints was found to be statistically insignificant in both stages of the analysis. In instances where a farmer is categorized as credit-constrained, it is conceivable that alternative channels for financial support, such as borrowing from acquaintances or engaging with informal moneylenders, may be pursued to address funding requirements. In Kyrgyzstan, animals themselves may be considered as financial assets that can be destocked in times of need (Sultakeev & Petrick, 2025). At the same time, dairy farmers may be less dependent on credit access than crop farmers, as the dairy sales generate a constant source of financial liquidity.

Discussion

The analysis reveals several key findings and implications for policy related to pasture access, market participation, and dairy production, set against the broader context of existing literature.

Our study finds that one of the most important determinants of market participation (but not production volume) is access to village pastures. These are not available to all producers, either due to their monopolization by larger producers (Kasymov & Thiel, 2019) or due to the dominance of arable fields in some parts of the Chui valley, leaving little land available for grazing. The importance of grazing land is significant in the small number of other milk marketing studies which examined this factor (Tissie et al., 2019); and has also been found to positively impact the decision to sell beef (Dlamini & Huang, 2019).

Unlike those studies (e.g. Bardhan et al., 2012; Kuma et al., 2013), which found that cropland area negatively affects milk market participation, in our case this variable is insignificant. Therefore, a focus on crop production does not reduce the likelihood of dairy sector participation, whilst the lack of positive effects may arise because small numbers of animals may be stalled and provided with purchased fodder. On the other hand, there is a clear positive association between cropland and volume of sales. This appears intuitive yet is reflected in few of the studies we reviewed, with the exception of Chamboko et al. (2017), who stress the importance of production factors for milk production.

The study also highlights the role of sale prices, not only on market participation (also found by Balagtas et al. (2007) and Vroegindewey et al. (2021)), but also on milk sales volume. Higher sale prices, possibly linked to better access to milk processing centres, can thus drive increased sales. Improving infrastructure to enhance market access could enable farmers to negotiate better prices. Regular monitoring and policy assessments related to milk pricing are essential to understand market dynamics.

The role of price in market participation is of particular importance given the issue of trader cartels, which limit competition through territorial monopolies. Although intermediaries may help small producers to access markets in many region of the world (Abebe et al., 2016; Liverpool-Tasie et al., 2020; Roba et al., 2017), dependence on these actors is often associated with low prices for farmers (Barrett et al., 2022). Cartel formation, common in the Chui Valley, keeps prices down and may discourage market participation. Addressing these anti-competitive practices should be a policy priority to ensure fair market conditions.

Our results concerning the importance of credit are more surprising. However, comparable studies looking at this factor are rare and results mixed. In Ethiopia, credit access enables the purchase of essential dairy production materials (Muzemil, 2020), while in Uganda, it has no significant influence on market participation decisions (Balirwa & Waholi, 2019). These studies use credit uptake rather than the credit constraint variable used in our study.

At our study site, credit uptake was higher amongst farms than households, although farms tended to be more credit constrained. Legal status was an important determinant of milk sales volume, even controlling for herd size in our model. Therefore, educating farmers about the benefits of registering their activities to obtain subsidized credit, as well as reducing registration costs may encourage more producers to formalize their operations, addressing the informal sector's growth and facilitating contractual agreements with milk processors.

Cooperative membership did not have a positive effect on market participation or volume, in contrast to reviewed studies (e.g. Ordofa et al., 2021). However, in Kyrgyzstan as in the broader region, it is known that cooperatives do not function well due to problems of legislation and trust (Lerman & Sedik, 2017). Reliance on informal traders undermines development of cooperatives which in many countries provide technical assistance and milk collection services to members (Yamano et al., 2019).

The study did not differentiate between dairy breeds, as farmers primarily worked with local breeds. As this factor has been associated with value chain participation (e.g. Balirwa & Waholi, 2019; Tarekegn & Shitaye, 2022) it should be included in future studies.

Conclusions and policy implications

This study investigated the factors influencing farmers' decisions to sell milk and the volume sold using econometric methods on the premise that the sale of milk contributes to poverty alleviation by providing daily income for farmers (Birthal et al., 2017). At the same time, the commercialisation and modernisation of agricultural value chains as well as the promotion of export opportunities are explicit policy goals of the Kyrgyz government (Yamano et al., 2019).

The research revealed key findings relevant for policy formulation in these areas. Firstly, access to pastures is a crucial determinant of market participation, with only 41% of operators having access to local pastures. Effective pasture management and fodder provision policies are thus essential to support farmers' market engagement whilst access to cropland supports sales volume. Kyrgyzstan implemented market reforms which support efficient land allocation but could go further, in particular for households which lack access.

Secondly, machinery use and formal registration of producers are associated with higher sales volumes. Educating farmers on the benefits of registering their farming activities and obtaining legal farm status, whilst reducing bureaucratic and tax disincentives to do so could therefore be suitable strategies for promoting sales. Future research should pay attention to the factors that determine machinery adoption in dairy operations.

Lastly, market incentives, such as higher purchasing prices and improved infrastructure, are vital in enhancing milk sales volume. We found that milk prices are held down by both trader cartels and distance from markets. Thus, addressing these cartels, improving ease of travel and facilitating development of cold chains are crucial for integrating small farmers into the market.

This study hence underscores the need for targeted policy interventions to address pasture access, market participation, and dairy production challenges. Ensuring equitable access to pastures, promoting sustainable grazing practices, improving market infrastructure, and addressing anti-competitive practices are crucial. Additionally, encouraging farm registration and supporting breed improvement can enhance market participation and production efficiency. Regular monitoring and tailored policy assessments will be vital in adapting to evolving agricultural dynamics and ensuring sustainable development in the sector.

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References

Abebe, G. K., Bijman, J., & Royer, A. (2016). Are middlemen facilitators or barriers to improve smallholders' welfare in rural economies? Empirical evidence from Ethiopia. Journal of Rural Studies 43, 203-213.

Ayil Bank. (2023). https://ab.kg/bankovskie-uslugi-chastnim-lisam/credits/credity-po-gossprogrammam/54#

Balagtas, J. V., Coulibaly, J. Y., Jabbar, M., & Negassa, A. (2007). Dairy Market Participation with Endogenous Livestock Ownership: Evidence from Cote d'Ivoire American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007,

Balirwa, E. K., & Waholi, E. (2019). Analysis of Market Participation Behavior Among Smallholder Dairy. Journal of Agricultural Science, 11(3).

Bardhan, D., Sharma, M. L., & Saxena, R. (2012). Market Participation Behaviour of Smallholder Dairy Farmers in Uttarakhand: A Disaggregated Analysis. Agricultural Economics Research Review, 25(2), 243-254.

Barrett, C. B., Reardon, T., Swinnen, J., & Zilberman, D. (2022). Agri-food Value Chain Revolutions in Low- and Middle-Income Countries. Journal of Economic Literature, 60(4), 1316-1377. https://doi.org/10.1257/jel.20201539

Birthal, P. S., Chand, R., Joshi, P. K., Saxena, R., Rajkhowa, P., Khan, M. T., Khan, M. A., & Chaudhary, K. R. (2017). Formal versus informal: Efficiency, inclusiveness and financing of dairy value chains in Indian Punjab. Journal of Rural Studies 54 54, 288-303.

Boucher, S. R., Guirkinger, C., & Trivelli, C. (2009). Direct elicitation of credit constraints: conceptual and practical issues with an application to Peruvian agriculture. Economic Development and Cultural Change, 57(4), 609-640. https://doi.org/10.1086/598763.

Burke, W. J. (2009). Fitting and Interpreting Cragg's Tobit Alternative using Stata. Stata Journal, 9(4), 584-592.

Burke, W. J. (2015). A Triple-Hurdle Model of Production and Market Participation in Kenya's Dairy Market. American Journal of Agricultural Economics, 97(4), 1227-1246.

Chamboko, T., Mwakiwa, E., & Mugabe, P. H. (2017). Determinants of Milk Market Participation and Volume of Sales to Milk Collection Centres of the Smallholder Dairy Value Chain in Zimbabwe. Journal of Agricultural Science, 9(10), 1916-9752.

Cragg, J. G. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. Econometrica, 39(5), 829-844.

Dairy News Today. (2024, 22.08.2024). Kyrgyzstan's Dairy Exports Increase by 2,000 Tons in the First 7 Months of the Year. https://dairynews.today/news/kyrgyzstan-s-dairy-exports-increase-by-2-000-tons-in-the-first-7-months-of-the-year.html

Dlamini, S. I., & Huang, W.-C. (2019). A Double Hurdle Estimation of Sales Decisions by Smallholder Beef Cattle Farmers in Eswatini. Sustainability, 11(19), 1-27.

Dries, L., Germenji, E., Noev, N., & Swinnen, J. F. M. (2009). Farmers, vertical coordination, and the restructuring of dairy supply chains in Central and Eastern Europe. World Development, 37, 1742-1758.

Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of Technology Adoption. Annual Review of Economics, 2, 395–424.

Gorton, M., White, J., Dries, L., & Ignat, A. (2007). Dairy farming and milk marketing relationships in the CIS. Eurasian Geography and Economics, 48(6), 733-747.

Government of the Kyrgyz Republic. (1999). On approval of the regulations on the transfer of lease. Retrieved November 29, from https://faolex.fao.org/docs/html/kyr75064.htm

Heckman, J. J. (1979). Sample Selection Bias as a Specification Error. Econometrica, 47(1), 153-161.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology, 25, 1965-1978. https://doi.org/10.1002/joc.1276

Jaiswal, P., & Singh, R. (2015). Economics of milk production and determinants of market participation for small holder dairy farmers in Raipur district of Chhattisgarh. Indian Journal of Dairy Science, 68(6).

Kasymov, U., & Thiel, A. (2019). Understanding the role of power in changes to pastoral institutions in Kyrgyzstan. International Journal of the Commons, 13(2), 931-948.

Kosimov, A., & Petrick, M. (2024). Smallholder dairy producers in transition: dairy market participation and sales in post-Soviet Tajikistan. Paper presented at the Tropentag Conference, Vienna, September 11-13, 2024. Justus Liebig University.

Kuma, B., Baker, D., Getnet, K., & Kassa, B. (2013). Factors Affecting Milk Market Participation and Volume of Supply in Ethiopia. Asian Journal of Rural Development, 4(1), 1-15.

Lerman, Z., & Sedik, D. (2017). Cooperatives in Kyrgyzstan: Findings from a survey of cooperatives and users. In G. W. J. Hendrikse, G. Cliquet, T. Ehrmann, & J. Windsperger (Eds.), Management and Governance of Networks (pp. 233-249). Springer.

Life in Kyrgyzstan. (2025). The 'Life in Kyrgyzstan' Study: A research-based, open access knowledge infrastructure for Central Asia. https://lifeinkyrgyzstan.org/

Liverpool-Tasie, L. S. O., Wineman, A., Young, S., Tambo, J., Vargas, C., Reardon, T., Adjognon, G. S., Porciello, J., Gathoni, N., Bizikova, L., Galiè, A., & Celestin, A. (2020). A scoping review of market links between value chain actors and small-scale producers in developing regions. Nature Sustainability, 3(10), 799-808. https://doi.org/10.1038/s41893-020-00621-2

Mogilevskii, R., Abdrazakova, N., Bolotbekova, A., Chalbasova, S., Dzhumaeva, S., & Tilekeyev, K. (2017). The Outcomes of 25 Years of Agricultural Reforms in Kyrgyzstan (Discussion paper No. 162, Issue. Leibniz Institute of Agricultural Development in Transition Economies.

Mottet, A., Haan, C. d., Falcucci, A., Tempio, G., Opio, C., & Gerber, P. (2017). Livestock: On our plates or eating at our table? A new analysis of the feed/food debate. Global Food Security, 14, 1-8.

Muzemil, A. (2020). Analysis of market participation of small dairy farmers in gubre town, snnpr, Ethiopia. International Journal of Agricultural Science and Food Technology, 6(1), 058-067.

National Statistical Committee of the Kyrgyz Republic. (2023). Agriculture of the Kyrgyz Republic [Сельское хозяйство Кыргызской Республики] http://stat.kg/en/statistics/selskoe-hozyajstvo/

National Statistical Committee of the Kyrgyz Republic. (2024). Statistical Yearbook of the Kyrgyz Republic [Статистический ежегодник кыргызской республики] http://stat.kg/en/statistics/selskoe-hozyajstvo/

Nurullaev, A., Park, E., Ahrendsen, B., Speelman, S., & Connor, L. (2025). Determinants of Market Participation among Milk Producers in Kyrgyzstan. Journal of Agricultural and Applied Economics, 57(1), 1-13. https://doi.org/10.1017/aae.2024.35

Ordofa, G., Zemedu, L., & Tegegne, B. (2021). Determinants of smallholder farmer decision to participate in milk and butter market in Ada'a Berga District, West Shewa Zone, Ethiopia. Journal Of Economic Development, 46(2), 209-227.

Roba, G. M., Lelea, M. A., & Kaufmann, B. (2017). Manoeuvring through difficult terrain: How local traders link pastoralists to markets. Journal of Rural Studies 54, 85-97.

Robinson, S., & Petrick, M. (2024). Land access and feeding strategies in post-Soviet livestock husbandry: Evidence from a rangeland system in Kazakhstan. Agricultural Systems, 219, 104011. https://doi.org/10.1016/j.agsy.2024.104011

Singh, I., Squire, L., & Strauss., J. (1986). Agricultural household models: Extensions, applications, and policy (Vol. 28). Johns Hopkins University Press.

Sultakeev, K., & Petrick, M. (2025). Harsh Winter Shocks and Distress Sales: Consumption and Asset Smoothing Among Livestock Farmers in Kyrgyzstan. Journal of International Development, Article jid.70011. Advance online publication. https://doi.org/10.1002/jid.70011

Swinnen, J. F. M., & Maertens, M. (2007). Globalization, privatization, and vertical coordination in food value chains in developing and transition countries. Agricultural Economics, 37(1), 89-102.

Tarekegn, K., & Shitaye, Y. (2022). Determinants of Market Participation among Dairy Producers in Southwestern Ethiopia. Research on World Agricultural Economy, 3(1), 16-23.

Tissie, M. A., Geda, M. B., & Hamo, T. K. (2019). Factors Affecting Market Participation of Milk Producer Households: The Case of Kofele District, West Arsi Zone, Oromia, Ethiopia. International Journal of Development, 10(2), 33-47.

Tobin, J. (1958). Estimation of Relationships for Limited Dependent Variables. Econometrica, 26(1), 24-36.

Ur-Rahim, I., Maselli, D., Rueff, H., & Bonfoh, B. (2014). Market access and herder's strategies to pass through lean winter periods in Post-Soviet Kyrgyzstan. APCBEE Procedia, 8, 323-328.

Vroegindewey, R., Richardson, R., & Thériault, V. (2021). Key factors for increasing farmer participation in markets: evidence from the Malian dairy sector. Revue d'élevage et de médecine vétérinaire des pays tropicaux, 74(2), 93-103.

World Bank Development Indicators. (2023). Employment in agriculture (based on ILO estimates). https://data.worldbank.org/indicator/

Yamano, T., Samson, J. N., & Tilekeyev, K. (2019). Reinventing the Agriculture Sector. In T. Yamano, H. Hill, E. Ginting, & J. Samson (Eds.), Kyrgyz Republic: Improving Growth Potential. Asian Development Bank.

www.ucentralasia.org