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Market Distance and Household Income: Quasi-experimental Evidence from Mongolia

Tseveenjav Lkhanaa
Bank of Mongolia

Chemin Eugène-Rigot 2
P.O. Box 136
CH - 1211 Geneva 21
Switzerland

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Tseveenjav Lkhanaa[1]
Bank of Mongolia

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Abstract

This paper examines the impact of access to markets on livestock-related income of herder households in Mongolia. The empirical findings show that reducing the distance to markets by ten kilometers increases household income by 1.0 percent on average.

Keywords: access to markets, market distance, rural poverty, rural household income, herder household income, household location

JEL: I30, O12, O18, Q12, R3.

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[1] Senior Economist, Bank of Mongolia. Email: tseveenjav.l@mongolbank.mn, Baga toiruu-3, 15160, Ulaanbaatar 46, Mongolia. Phone: 976-11-323560.
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1 Introduction

Worldwide, 2.1 billion people live under the poverty line; most of them are in rural areas (Food and Agriculture Organization of the United Nations, 2017). Numerous scholars have analysed factors influencing poverty reduction in rural regions, including the role of road infrastructure (Minten and Kyle, 1999; Gibson and Rozelle, 2003; Lokshin and Yemtsov, 2005; Atack et al., 2010; Faber, 2014 and Liu and Lan, 2015). Rural households, especially those reliant on the agricultural sector, are significantly affected by the conditions of road networks (Gollin and Rogerson, 2010). However, despite this attention, there is still a lack of understanding regarding the specific impact of road infrastructure on household income.

Empirical studies in the development literature have extensively examined the effects of rural roads on various outcomes, including regional economic growth and agricultural productivity (Zhang and Fan, 2004; Mu and Van de Walle, 2011; Aggarwal, 2018; Asher and Novosad, 2020; Banerjee et al., 2020). Some scholars argue that rural roads have a significant impact on market access and can therefore influence household consumption and income. For instance, Emran and Hou (2013) found a positive effect of access to domestic and international markets on households' per capita consumption in rural China, and Emran and Hou (2008) on income in the same setting.

While studies have been conducted in other Asian countries, no research has considered the effect of market distance on rural household income in Mongolia. This is my main research question: How does the distance to the local market impact the income of herder households in Mongolia? This study hypothesizes that if a herder household is closer to local markets, it will increase its livestock-related income.

Estimating the effect of market access is not obvious due to several potential biases: the endogenous selection of the household's winter location, the development of markets within a geographic area, and the non-random placement of transport infrastructure by the government. Hence, I calculated a two-stage least squares (2SLS) estimation. The results show that local market distance negatively affects herder household livestock-related income. Generally, when the market distance decreases by ten kilometres, a herder household's livestock-related income increases by one percent.

I employed several independent datasets. Furthermore, the data source for livestock-related income of herder households is the Socio-Economic Survey from 2018. For household location and control variables, I utilised the Livestock Census from 2018 as well. I sourced distance data from the Ministry of Roads and Transport Development, and I collected environmental data from Google Earth Engine in 2018.

My paper makes three contributions to the literature. First, it contributes to the literature in terms of the impact of market distance. My results align with those of Emran and Hou (2008) and Emran and Hou (2013), who demonstrated the effect of market access on rural household income and consumption. Second, to the best of my knowledge, no other study has focused on the impact of local market distance on household income in Mongolia. Third, there is limited research on nomadic herders. Hence, I seek to address this gap by being one of the first to investigate market access for this population.

The rest of the paper is organised as follows. I first discuss the context in Section 2. Then, in Section 3, I outline the data sources, descriptions of the dependent and independent variables, summary statistics, and the empirical strategy. In Section 4, I present the findings from the empirical analysis, including the OLS and 2SLS estimations. Finally, in Section 5, I provide the discussion, conclusion, policy recommendations, point out the limitations of the study, and suggest directions for future research.

2 Context

I discuss the herder population in Section 2.1 and policies related to herders in Section 2.2.

2.1 Nomadic herders in Mongolia

The Constitution of Mongolia declares that 'Livestock is a national treasure and remains under the protection of the state', highlighting the significant role of the livestock sector in the country. Moreover, data from the National Statistics Office, as shown in Table 1, reveals that in 2018, the livestock sector contributed 15.5 percent to GDP and accounted for 23.7 percent of Mongolia's total employment. Additionally, the contribution of livestock income to total exports reached 9.2 percent in 2018. Roughly 26 percent of Mongolian households, or 290,000 nomadic people, continue the tradition of nomadic herding, residing in tents known as gers (i.e. yurts) across the vast and rugged steppes, which have served as their ancestral homelands for millennia. As of 2018, 66.5 million heads of livestock were counted in Mongolia, which ranks 4th in the world in the number of horses, 10th in the number of goats, 12th in the number of sheep, 12th in the number of camels, and 58th in the number of cattle (FAO, 2019).

Table 1: Herder statistics of Mongolia, 2012-2018

Year	Number of herders	Number of herder households	Number of livestock (in millions)	Share of herders in total population	Share of herder households in total households	Share of livestock sector in total employment	Share of livestock sector in total GDP (at 2010 constant prices)
2012	289,414	207,824	40.9	10.1%	27.1%	30.2%	12.6%
2013	285,691	209,933	45.1	9.7%	26.4%	27.0%	14.1%
2014	293,620	213,363	52.0	9.8%	25.9%	25.7%	14.9%
2015	297,828	216,734	56.0	9.7%	25.2%	26.4%	16.8%
2016	311,373	223,761	61.5	10.0%	25.7%	28.2%	16.3%
2017	303,590	228,950	66.2	9.6%	25.9%	26.1%	16.3%
2018	288,700	230,854	66.5	8.9%	25.8%	23.7%	15.5%

Source: National Statistics Office of Mongolia

Despite the growing number of livestock and the rising prices of livestock products (Tseveenjav et al., 2018), the income levels of herder households have either stagnated or declined compared to previous years (The National Statistics Office of Mongolia, 2018). The poverty[1] level among herders in Mongolia is notably high (The National Statistics Office of Mongolia, 2018). Figure 1 presents the average poverty rates for both the national population and herder households between 2010 and 2018. While there was a declining trend over this period, in 2018, the national poverty rate was 28.4 percent. However, the poverty rate among herder households remained markedly higher than the national average, reaching 33.2 percent in 2018.

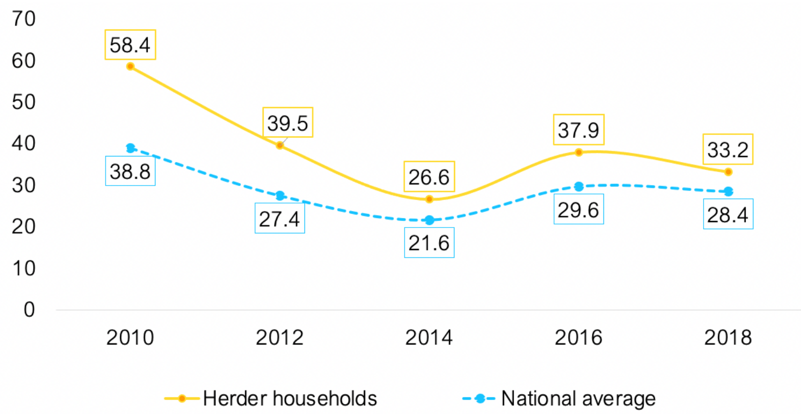

Figure 1: The percentage of poverty within households headed by herders, 2010-2018
Source: National Statistics Office of Mongolia

Where nomadic herders in Mongolia choose to situate their household depends heavily on whether they find water and good grazing areas to sustain their animals throughout the year. They adapt their movements based on the changing weather and seasons. During the warmer months, such as spring and summer, they migrate to higher elevations where there is ample grass and access to water from rivers and streams. However, as temperatures drop during colder seasons, they move to lower areas or sheltered valleys to avoid harsh winter conditions. During the winter, when there is not much grass, nomadic herders provide their livestock with extra prepared feed and hay and keep them fenced in shelters. This ensures the livestock's well-being during harsh weather. As such, herders return to the same location each winter.

Although the number of livestock in Mongolia is growing year by year, about one-third of herders still face poverty, thus motivating this study. I assumed that the geographic remoteness

[1] In Mongolia, the poverty line is determined using the cost of basic needs approach. If a person does not meet the minimum standard of living, he/she is considered poor. The poverty line was at 166,580 MNT in 2018 in Mongolia (The National Statistics Office of Mongolia, 2018).

of herders from markets (where they raise their livestock) would impact their livelihoods, poverty level, and income derived from livestock.

Mongolia, ranked as the eighteenth largest country globally in terms of land area, presents challenges for herder households residing in remote and dispersed locations. Compounding this issue is the scarcity of nearby markets where these herders can easily sell their products. As such, I hypothesised that a major factor contributing to their poverty would be the lack of market accessibility. Hence, I aimed to investigate the impact of market distance on the livestock-related income of nomadic herder households in Mongolia.

2.2 Policies regarding herders

The Government of Mongolia has approved two policies related to its income-raising programme: (1) the Policy on the Herders of Mongolia and (2) the Mongolia Sustainable Development Vision 2030. These two policies aim to increase herder households' income, expand local market accessibility, and reduce poverty.

The Parliament of Mongolia (2009) approved the policy on herders. One of the policy's main goals is to raise the incomes of herder households by improving market accessibility. Moreover, The Parliament of Mongolia (2016) also approved the SDGs of Mongolia. The first goal of the policy is to eliminate poverty in the country by 2030. The second goal is to improve livestock production, market accessibility, and transportation networks for herder households. The third goal is to increase the length of paved roads by 800 kilometres to help the agriculture, industry and mining sectors, which would support economic growth.

3 Empirical strategy and data

In this section, I first discuss the empirical strategy before explaining the data sources and sample selection.

3.1 Empirical strategy

The impact of market distance on herder households' livestock income is my central focus. I assumed that a greater distance from a household to its provincial market would have a negative effect on herder households' livestock-related income. First, I applied the following OLS model to examine the relationship:

$$log(income_{icp}) = \alpha_0 + \alpha_1 distance_c^p + X_i'\theta_i + X_c'\theta_c + X_p'\theta_p + \epsilon_{icp} \tag{1}$$

Where $log(income_{icp})$ is the outcome variable representing the livestock-related income of herder households i, located in county c in province p in 2018, winsorised at the 99% level and measured in logs. $distance_c^p$ indicates the distance from the county where herder households are located to the nearest province where the local market is held. X_i encompasses controls for herder households, including the characteristics of the household head and household assets. X_c represents county-level control variables, such as county population and mean slope, and weather-related variables, such as temperature, wind speed, and snow depth. X_p denotes province-level control variables, such as gross domestic product (GDP), the provincial population, and the number of shops. The standard errors, ϵ_{icp}, are robust to heteroskedasticity. Table 6 in the Appendix describes all the variables.

When studying the impact of local market distance on households, it is important to consider three potential biases: the endogenous selection of household location, market development within a geographic area influenced by the inherent attributes of nearby provinces, and the non-random placement of transport infrastructure by the government. I now discuss these in more detail.

In Mongolia, nomadic herder families typically move seasonally, journeying during the spring, summer, and autumn but settling in one place during the harsh winter months. For instance, prior to November, herders start moving towards their winter locations, where they remain until March. Winter in Mongolia is characterised by extreme cold, with temperatures dropping to an average of -35 to -45°C in some areas, and sometimes even plummeting as low as -60°C. Additionally, snowfall is common throughout the country, and the cold winds can be harsh. Consequently, herders take extensive precautions, including building sheds, fences, and shelters for their livestock. Each winter, herder households return to the same place where they have prepared winter shelters for their livestock.

Another challenge in assessing the impact of market distance on household income from livestock production is determining whether the area is surrounded by economically prosperous regions. It is crucial to account for varying economic conditions across different counties. In my analysis, I include the province's GDP, the number of shops, and the population size. Additionally, I include indicators that encompass geographic and agroclimatic factors such as the mean slope, average temperature, wind speed, and average annual snow depth. These factors are essential for a geography-based identification approach. Without controlling for the geography and topography of a household's county of residence, the instruments based on other counties' geographies and topographies may not fully satisfy the exclusion restrictions.

Finally, the placement of roads may be endogenous. Indeed, public infrastructure may be strategically placed to connect major cities.

To deal with these issues, I used an empirical strategy similar to that employed by Emran and Hou (2013), Banerjee and Duflo (2013), Faber (2014) and Aguirre et al. (2018). These scholars employed an instrumental variable (IV) estimator to create exogenous Euclidean straight lines, theoretically connecting spaces as if the terrain were entirely flat. If the topography is flat and there are no other restrictions along the route, the shortest road path between two points is a straight line. Factors like terrain and soil conditions may affect infrastructure feasibility, however. The topography could influence the selection of transportation routes, as highlighted in the literature on transport engineering. For instance, Armstrong (1998), American Railway Engineering Association (2013) and Donaldson (2018) analysed the significance of topography in determining railway routes. Additionally, Duflo and Pande (2007) used topographical features as identifying instruments for the placement of dams. I derived the location of each household, county, and province by longitude and latitude, from which I determined their elevations using ArcGIS. Then I connected straight-line distances from each household to the nearest province and calculated topographical features. Emran and Hou (2013) employed the following IVs for market distance: the weighted mean, the maximum, the minimum, the range of elevation and slope, and the straight-line distance from the county to the local market. The approach followed in this paper is similar. I used the straight-line distance and the weighted minimum slope. The IV model, expressed as a two-stage model, is the following:

The first stage is as follows:

$$distance_c^p = \beta_0 + \beta_i Z_i^p + X_i'\gamma_i + X_c'\gamma_c + X_p'\gamma_p + X_w'\gamma_w + u_{icpw} \tag{2}$$

The second stage is as follows:

$$\log(\text{income}_{icp}) = \alpha_0 + \alpha_1 \hat{distance}_c^p + X_i'\theta_i + X_c'\theta_c + X_p'\theta_p + X_w'\theta_w + \epsilon_{icpw} \tag{3}$$

Z_i^p now represents the IVs. Table 6 in the Appendix provides a detailed description of all variables. To test the relevance of the IVs, I used the F-test.

3.2 Data

My analysis is based on several data sources, which are outlined in Table 2. I linked the different datasets using the household identification number, province, and county name. This section describes the data sources and key variables. I describe the data construction and merging in greater detail in Appendix A.

Table 2: Overview of the data sources

Variable	Source	Year
Livestock-related income	Household Socio-Economic Survey of Mongolia, National Statistics Office of Mongolia	2018
Distance	The Ministry of Roads and Transport Development of Mongolia	2018
Household location and household controls	Livestock Census of Mongolia, National Statistics Office of Mongolia	2018
County and province controls	National Statistics Office of Mongolia	2018
Environmental controls	Google Earth Engine (GEE)	2018

Livestock-related income: The National Statistics Office of Mongolia conducted the Household Socio-Economic Survey in 2018, representing a national cross-section of the population. The sample in this survey was chosen randomly from across all provinces. The survey covered 16,454 households and 59,820 individuals. This survey is administered every two years; it aims to estimate people's welfare, determine living standards, and gauge the poverty level; it covers a broad range of questions concerning demographic and socio-economic indicators such as education level, health status, employment, livestock and crops, livestock production, trade, services, income, savings, loans, and aspects of household consumption (e.g. energy, goods, non-food costs).

Distance: I obtained information on distance lengths from the Ministry of Roads and Transport Development of Mongolia. The ministry provides actual road distance from the county to the province levels. Local markets are situated in the centre of each province. Hence, I utilised the longitude and latitude coordinates of the provincial centre to determine the location of the local market. Appendix A provides a more detailed explanation of how the distance to the nearest market is calculated.

Household location and household controls: Data from the annual nationwide Livestock Census of Mongolia, carried out in December 2018, cover 169,711 households and 288,700 herders. The data include not only livestock statistics but also information on herders (such as health insurance, social insurance, loans, household assets, and household location by longitude and latitude).

County and provincial data: I obtained data on county and provincial characteristics from the Business Register database and the National Statistics Office of Mongolia.

Environmental data: I collected environmental data from Google Earth Engine (GEE), a cloud platform for geospatial analysis. GEE provides access to climate data, including temperature, precipitation, humidity, and other meteorological parameters. I used hourly data on temperature, snow depth, and wind for each county in Mongolia in 2018.

3.3 Sample selection and summary statistics

The final dataset includes 1,345 herder households from all provinces in Mongolia.

Table 3 presents summary statistics for the key variables (please see Table 7 in the Appendix for details on the other variables). The average livestock-related income of herder households in the last 12 months was 567,120 MNT[2], with a standard deviation of 582,679 MNT. The average distance from county to province was 141 kilometres, ranging from 5 to 430 kilometres.

Table 3: Summary statistics

Variables	Mean	Std. dev.	Min	Max	N
Livestock-related income (MNT)	567,120	582,679	5,792	3,221,667	1,345
Distance (kilometres)	141	84	5	430	1,345

4 Results

4.1 Main results

Table 4 shows the results of the impact of market distance on herder households' income. Columns (1) and (2) present the findings using OLS, and columns (3) and (4) using 2SLS. The even columns include additional control variables.[3]

The OLS outcomes indicate that the local market distance has a statistically significant and negative effect on the livestock-related income of herder households in rural Mongolia. In Column (1), we can see that if the market distance increases by 10 kilometres, the livestock-related income of herder households declines by 1.8 percent, which is statistically significant at the one percent level. In Column (2), household, county, province, and weather controls are included. The findings imply that if the market distance increases by 10 kilometres, the livestock-related income of herder households falls by 0.9 percent, which is statistically significant at the five percent level.

OLS estimates do not correct for potential endogeneity in local market distance due to geographic and topographical features, which can influence transport infrastructure. Consequently, the OLS estimates may be biased. Therefore, I used the IV strategy outlined in Section 3. The results are presented in columns (3) and (4) of Table 4. The coefficient estimates on market distance from the IV regressions are negative and statistically significant,

[2]The average exchange rate was 1 USD = 2,472.67 MNT in 2018 according to the Bank of Mongolia.
[3]The corresponding first-stage regressions are displayed in Table 8.

ranging from -0.0016 to -0.0010. Column (4) indicates that if the market distance increases by 10 kilometres, the livestock-related income of herder households shrinks by one percent; this outcome is statistically significant at the five percent level.

Table 4: The impact of local market distance on the livestock-related income of herder households

Variables	Dependent variable: Log(Livestock-related income)			
	OLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
Distance	-0.0018***	-0.0009**	-0.0016***	-0.0010**
	(0.000)	(0.000)	(0.001)	(0.000)
Diagnostic tests				
Underidentification test:				
Kleibergen-Paap rk LM statistic:	-	-	327.0	336.6
			[p-value =0.00]	[p-value =0.00]
Weak identification test:				
Cragg-Donald Wald F statistic	-	-	1,186.2	1,155.6
Kleibergen-Paap rk Wald F statistic:	-	-	900.9	1,119.4
Stock-Yogo weak ID test critical values:				
5% maximal IV relative bias	-	-	19.9	19.9
Overidentification test of all instruments:				
Hansen's J-statistic	-	-	1.6	0.7
			[p-value = 0.20]	[p-value =0.40]
Controls	No	Yes	No	Yes
Observations	1,345	1,336	1,345	1,336
R^2	0.075	0.500	0.075	0.500

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To assess the strength of the instruments, I used the F-statistic. The first stage F-statistic ranges from 900.9 to 1,119.4, indicating a strong correlation between the instruments and the endogenous variable. I also conducted an overidentification test. The Hansen's J-statistic values were 1.6 (p=0.20) without control variables and 0.7 (p=0.40) with control variables. As such, the models passed the test of overidentifying restrictions.

4.2 Robustness checks

To ensure the robustness of the results obtained from the topography-based IV approach, Emran and Hou (2013) performed a robustness check by including public goods (such as schools and health clinics provided by the government to a province) in the set of regressors.

They also integrated controls for employment in public health as indicators of the scale of the public sector. Likewise, I carried out robustness checks, adding controls for public goods provided by the government. Specifically, I included variables representing the presence of schools, the capacity of health clinics, and employment in public health. These public goods are critical to consider for several reasons. Firstly, public goods, like schools and health clinics, directly impact household welfare and income by providing essential services that improve health, education, and overall quality of life. Improved health and education can boost productivity and income-generating capacity. By controlling for these public goods, I was able to better isolate the specific impact of market distance on livestock-related income. Second, the distribution of public goods is often geographically targeted, potentially confounding the relationship between market distance and income. Including these variables helps to control for this targeting and ensures that the observed effects are attributable to market distance rather than the availability of public services.

Table 5: Robustness checks: Different specifications

Variable	Dependent variable: Log(Livestock-related income)				
	Main result				Robustness Checks
	OLS		2SLS		2SLS
	(1)	(2)	(3)	(4)	(5)
Distance	-0.0018***	-0.0009**	-0.0016***	-0.0010**	-0.0010**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Controls	No	Yes	No	Yes	Yes
Observations	1,345	1,336	1,345	1,336	1,329
R^2	0.075	0.500	0.075	0.500	0.502
F-stat on IVs	-	-	900.9	1,119.4	1,114.3
Hansen's J-statistic	-	-	1.6	0.7	0.8
			[p-value = 0.20]	[p-value =0.40]	[p-value =0.38]

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Columns (1) through (4) of Table 5 present my main findings, while Column (5) provides additional analyses to ensure the robustness of the results by integrating public goods provided by the government. The estimated coefficients are similar to the main results. An increase in market distance by 10 kilometres results in a one percent decline in the livestock-related income of herder households, which is statistically significant at the five percent level.

5 Discussion and conclusion

I investigated the impact of market distance on the livestock-related income of herder households in rural Mongolia. I found a significant, negative relationship between market distance and livestock-related income.

My findings align with Emran and Hou (2008), highlighting the positive impact of market accessibility on the livestock-related income of herder households. Generally, if the market distance shrinks by 10 kilometres, a herder household's livestock-related income grows by one percent; this result is statistically significant at the five percent level.

The government of Mongolia aims to increase herder households' income by 80 percent through initiatives such as the "Policy on the Herders of Mongolia" and "the Mongolia Sustainable Development Vision 2030". This study provides empirical evidence supporting the positive effects of improved market access on herder households' income. The results suggest that enhancing market accessibility or opening new markets closer to herder households could substantially increase their revenue.

One limitation of this study is that I utilised official road data from the Ministry of Roads and Transport Development, which did not differentiate between paved or dirt roads due to the quality of the road data. It could be argued that the adverse effects of distance on household income could be less on those closer to paved roads. Hence, future studies should explore how the distances of paved or dirt roads impact household income. Geographic software, such as ArcGIS, should be used to calculate distances for paved and dirt roads using satellite imaging. Another limitation is that, due to data constraints, I did not consider communal activities such as herder unions and cooperatives that collectively sell livestock, or intermediaries who buy livestock products directly from herders.

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Appendix

First, I combined the datasets from the Livestock Census 2018 and the Household Socio-Economic Survey in 2018 using household identification numbers. Subsequently, I integrated these two datasets to gather information on 3,445 households utilised in this study. The Livestock Census is conducted annually from the 7th to the 17th of December. Thus, the geographic locations of herder households represent their winter settings, and I employed each household's location throughout the winter season. Mongolian herder households remain in an exact location from October to March to take shelter from the cold months. Hence, I utilised data from herder households covering October to March 2018. Additionally, I excluded households meeting specific criteria, such as those without livestock, those situated in urban areas, and those identified as outliers in terms of livestock-related income. Consequently, the final dataset included 1,345 herder households from all provinces of Mongolia.

Second, I found the longitude and latitude information for each household and province from the 2018 Mongolian Livestock Census. To measure the distance from the market, I estimated the nearest local market from each household using a 100-kilometre, 50-kilometre, 30-kilometre, and 20-kilometre radius.

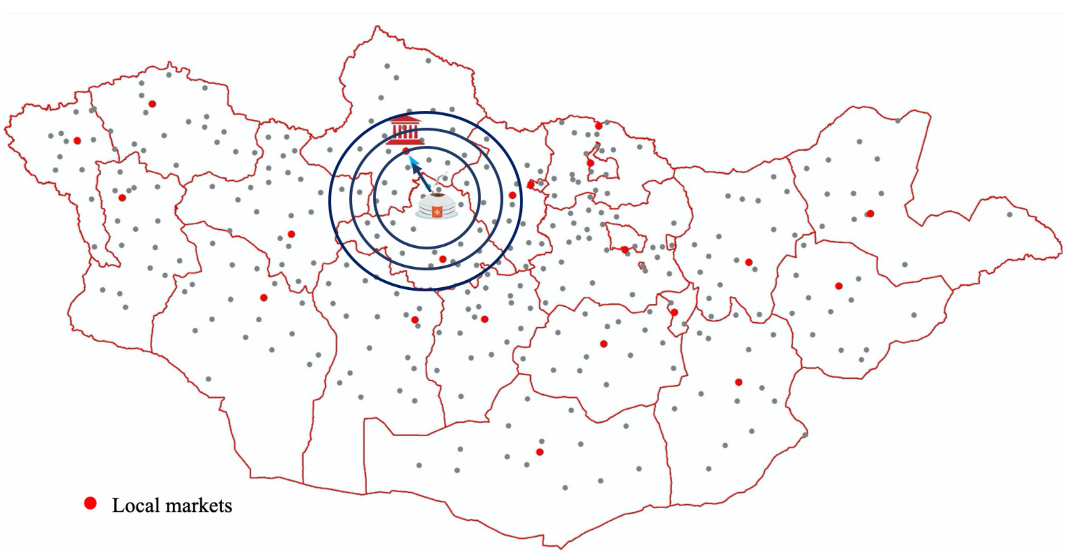

Figure 2: Identifying the nearest market using ArcGIS software

For example, if there were four local markets within 100 kilometres, I used a 50-kilometre radius to find two local markets and a 30-kilometre radius to find one regional market. Hence, I estimated the distance from each household to the market using the smallest possible radius from the household. Moreover, as IVs, I estimated travel straight-line distances from each household to the nearest local market using ArcGIS software, which allowed me to calculate the elevation of each household and each province's local market.

Table 6: Description of the variables used in the analysis

Variables	Description
Dependent variables	
Livestock-related income (MNT)	Herder households' livestock-related income in 2018, MNT
Variable of interest	
Distance (kilometres)	Distance from county to the nearest province, where the market is located, by kilometres
County controls	
County population	The population of a county
Mean slope	Mean slope (slope= rise/run*100)
Provincial controls	
GDP	GDP of a province in 2018, by billions of MNT
Provincial population	The population of a province
Number of shops	Number of shops
Weather controls	
Temperature	The air temperature 2 metres above land, sea, or inland waters, by K
Wind	The northward component of the 10-metre wind, by m/s
Snow depth	Average of the snow thickness on the ground, by m
Household controls	
Household head's age	Household head's age
Household head's years of education	Household head's years of schooling
Household size	Number of family members
Car (dummy)	1 has a car, 0 otherwise
Motorcycle (dummy)	1 has a motorcycle, 0 otherwise
TV (dummy)	1 has a TV, 0 otherwise
Internet (dummy)	1 has internet, 0 otherwise
Mobile (dummy)	1 has mobile, 0 otherwise
Electricity (dummy)	1 if connected with central electricity, 0 otherwise
Water distance (dummy)	1 if below 200 metres to get water, 0 above 200 metres
Produce (dummy)	1 if the household has non-livestock business past 12 months, 0 if otherwise
Cattle	Number of cattle of a household
Horse	Number of the horse of a household
Camel	Number of the camel of a household
Sheep	Number of sheep of a household
Goat	Number of the goat of a household
Dummies for 21 provinces	
	21"Dornod" 22"Sukhbaatar" 23"Khentii" 41"Tov" 42"Govisumber" 43"Selenge" 44"Dornogovi" 45"Darkhan-Uul" 46"Omnogovi" 48"Dundgovi" 61"Orkhon" 62"Ovorkhangai" 63"Bulgan" 64"Bayankhongor" 65"Arkhangai" 67"Khovsgol" 81"Zavkhan" 82"Govi-Altai" 83"Bayan-Olgii" 84"Khovd" 85"Uvs"
Public goods controls	
Schools	Number of schools
Doctors	Employment in public health (person, province)
Number of hospital beds	Number of public hospital beds
Instruments for 2SLS	
Weighted minimum slope	Weighted minimum of slope to province, by metres
Straight-line distance	Straight-line distance from herder household to the nearest province

Table 7: Summary statistics

	Mean	Std. dev.	Min	Max	N
Dependent variables					
Livestock-related income (MNT)	567,120	582,679	5,792	3,221,667	1,345
Variable of interest					
Distance (kilometres)	141	84	5	430	1,345
County controls					
County population	3,860	2,614	1,058	27,241	1,345
Mean slope	1.047	0.172	0.590	2.102	1,345
Provincial controls					
GDP	456.1	130.2	98.7	842.1	1,345
Provincial population	86,111	23,828	17,444	133,258	1,345
Number of shops	5.9	8.0	1	98	1,345
Weather controls					
Temperature	274.04	3.18	265.72	281.39	2,969,640
Wind	-0.16	0.47	-1.19	1.34	2,969,640
Snow depth	2.36	4.99	0.01	50.24	2,969,640
Household controls					
Household head's age	44.0	12.4	17	92	1,345
Household head's years of education	7.2	3.6	0	14	1,345
Household size	3.8	1.7	1	11	1,345
Car (dummy)	0.5	0.5	0	1	1,345
Motorcycle (dummy)	0.7	0.5	0	1	1,345
TV (dummy)	0.9	0.3	0	1	1,345
Internet (dummy)	0.2	0.4	0	1	1,345
Mobile (dummy)	1.0	0.1	0	1	1,345
Electricity	0.2	0.4	0	1	1,345
Water distance (dummy)	0.8	0.4	0	1	1,345
Water	35.3	18.2	5	120	1,336
Produce	1.0	0.1	0	1	1,345
Cattle	22.2	30.0	0	369	1,345
Horse	23.1	42.4	0	730	1,345
Camel	6.1	33.7	0	839	1,345
Sheep	183.5	217.5	0	1,850	1,345
Goat	160.3	147.9	0	1,155	1,345
Public goods controls					
Number of school	1.2	0.7	1	8	1,338
Number of doctors	4.0	4.3	1	48	1,345
Number of hospital beds	15.0	14.3	4	170	1,345
Instruments for TSLS					
Weighted min slope	27.93	20.37	0.21	67.34	1,345
Straight-line distance	104.61	56.54	1.25	311	1,345

Table 8: First-stage regressions

Variables	Dependent variable: Distance				
	(1)	(2)	(3)	(4)	(5)
Weighted min slope	0.20***	0.21***	0.20***	0.19***	0.12*
	(0.070)	(0.070)	(0.069)	(0.068)	(0.066)
Straight-line distance	11.15***	1.16***	1.15***	1.13***	1.18***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.025)
Household controls	N	Y	Y	Y	Y
County controls	N	N	Y	Y	Y
Provincial controls	N	N	N	Y	Y
Weather controls	N	N	N	N	Y
N	1,345	1,336	1,336	1,336	1,336
R^2	0.764	0.777	0.779	0.783	0.797

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1