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Primary Producer Sales Prices and Cooperatives: A Cross-Country, Multi-Product Analysis

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Abstract

Using data from field surveys of maize farmers in Lao People's Democratic Republic , herders in Mongolia, and fruit farmers in Uzbekistan, this paper presents new evidence concerning the relationship between cooperative membership and producer sales prices. Controlling for covariates previously considered in the literature, and using a range of estimation methods to control for alternative sources of endogeneity bias, the analysis finds three key empirical results that are robust to country, product and estimation methods for farmers in Lao People's Democratic Republic and Uzbekistan.

First, it documents positive relationships between land size under cultivation and farmer sales prices, highlighting the differential marketing challenges faced by smallholder farmers. Second, the results indicate that cooperative membership approximately offsets the relative price disadvantages associated with small farm size. Third, evidence is reported that failing to control for self-selection produces estimates that exhibit a significant downward bias for the effects of cooperatives on farmer sales prices. In contrast to the above results, no statistically significant relationships were found between average sales prices reported by Mongolian herders and either herd size or membership of producer cooperatives.

Key words: farmer sales prices, producer cooperatives, landlocked developing countries

JEL classifications: Q11, Q13, C31

Contents

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1 Introduction

An extensive literature has explored the role that producer marketing cooperatives can play in improving the economic sustainability of agricultural producers by increasing their earnings. This literature is particularly relevant in developing countries, where the agricultural sector is often a key source of national income and employment, and where the multitude of challenges faced by smallholder primary producers are of intense policy interest. The general finding of the related empirical literature is that marketing cooperatives are associated with higher producer sales prices. Yet it is difficult to draw more nuanced conclusions from the existing literature because each study typically focuses on an isolated market context, and comparisons between studies are complicated by the diverse limitations of the survey data and estimation methods used.

This study seeks to expand the set of “stylized facts” concerning the relationship between prices received by agricultural producers and cooperatives marketing their products. Using survey data collected from three developing landlocked countries for diverse agricultural products, the study evaluates the link between cooperatives and prices received by producers using a common set of empirical methods designed to address alternative forms of estimation bias. The robust empirical findings highlight the role that producer marketing cooperatives can play in offsetting competitive challenges that smallholder farmers otherwise face in terms of average sales prices.

The agricultural sector is important for many developing countries, accounting for a considerable share of aggregate income and employment, especially in rural areas. For example, with regard to the three countries that are the focus of the current study, data for 2019 indicate that the combined value added of the agriculture, forestry and fishing sectors accounted for 15 per cent of GDP in Lao People’s Democratic Republic, 11 per cent in Mongolia and 26 per cent in Uzbekistan.[1] At the same time, these three sectors are estimated to have accounted for 61 per cent of total employment in Lao People’s Democratic Republic, 25 per cent in Mongolia and 26 per cent in Uzbekistan. Furthermore, agriculture can play a disproportionately important role in poverty alleviation by enhancing food security (Christiansen et al. 2006), and by improving the market opportunities of vulnerable population subgroups, including women and rural inhabitants.

Consequently, an extensive research effort has considered what factors increase the economic returns from agriculture. The primary strand of this research focuses on agricultural productivity. Dethier and Effenberger (2012) survey this literature and identify a need to conduct agricultural research adapted to local conditions, and to address existing barriers to the adoption of more productive methods in agriculture. Echoing these findings, Alston and Pardey (2014) analyse relationships between agricultural inputs and agricultural sector productivity in alternative countries. The authors highlight the importance of evolving best-practice methods for increasing agricultural productivity, supported by public and private agricultural research investment. In a similar vein, Ruttan (2002) shows how labour and land productivity in

[1] World Bank, World Development Indicators. The importance of agriculture in each of the three countries was appreciably larger in the past: in 1994, agriculture accounted for 44 per cent of GDP in Lao People’s Democratic Republic, 28 per cent in Mongolia and 34 per cent in Uzbekistan. In terms of total employment, agriculture accounted for 86 per cent in Lao People’s Democratic Republic, 45 per cent in Mongolia and 41 per cent in Uzbekistan. UNCTAD (2019) reports that between 2013 and 2017, 37 countries had exports from agriculture that accounted for at least 60 per cent of total goods exported.

agriculture has evolved in response to technological innovation in fertilizers, crop protection chemicals, and crop varieties.

From a development perspective, Restuccia et al. (2008) show that low agricultural productivity, and a high share of labour in agriculture, explain differences in aggregate productivity between rich and poor countries. Gollin et al. (2014) use disaggregated data for rice, maize and wheat to confirm that cross-country differences in labour productivity in agriculture are large. De Janvry and Sadoulet (2010) show that GDP growth that originates in agriculture is especially effective in reducing poverty. Within this literature, a number of studies (Ma et al. 2021; Larson et al. 2012) also explore how farm (herd) size is related to agricultural productivity. This issue is empirically important, as smallholder farmers dominate farming in developing countries.[2]

Although methods of production represent an important differentiator among agricultural producers, how agricultural products are brought to market is also crucially important. Increased prices for produce received by farmers can foster investment, especially in credit-constrained contexts, encourage technological adoption, and improve the quality of produce along the value chain. Higher prices that support increased farmer incomes can also help to ensure that the farming sector remains a viable alternative for employment and entrepreneurship in rural areas, especially in the context of challenges posed by climate change, which are particularly acute for smallholders.

Market power along different segments of agricultural value chains is a key theme running through much of the literature concerning farmer sales prices (Kopp and Sexton 2020; Sexton 2013).[3] Smallholder farmers often have few potential buyers of their produce in the geographic area where they produce, and they face high transport costs to widen their marketing options.[4] Producers of perishable products without adequate storage capacity are vulnerable to opportunistic behaviour by marketing intermediaries (Bergquist and Dinerstein 2020; Sexton and Iskow 1988). Producers in remote locations may lack information about market alternatives (Courtois and Subervie 2014; Mitra et al. 2018), have access to few potential buyers within their geographic region and face high transport costs to widen their marketing options (Bernier and Dorosh 1993; Mérel et al. 2009). These marketing challenges are generally considered to be inversely related to farm size (Ma et al. 2021).

The formation of agricultural marketing cooperatives has long been considered a way to increase farmers' incomes.[5] These cooperatives allow farmers to integrate vertically

[2] Lowder et al. (2016) analysed data for 111 countries and territories between 1990 and 2000 reported by the World Census of Agriculture and found that 84 per cent of farms were not more than two hectares and only 6 per cent were larger than five hectares.

[3] Sexton (2013) points out that market power exercised by agricultural intermediaries has distributional consequences that are much larger than the pure efficiency (deadweight) losses associated with it.

[4] For example, in their study of rice production in Madagascar, Bernier and Dorosh (1993: 23, table 12) show survey data indicating that farmers selling to village collectors have very few choices: in six out of 11 regions surveyed, the average number of collectors available to farmers was one or less, while in only three regions the average number of collectors was more than two.

[5] In addition to their marketing role, cooperatives can perform other functions that boost farmers' profits (Sexton and Iskow 1988). In particular, cooperatives can source and provide agricultural inputs and services to members, including (i) seeds, fertilizers, herbicides, pesticides and other physical inputs; (ii) services related to the use of capital goods such as machinery (both for production or processing of produce); (iii) financial services by benefiting from having collateral or access to official credit that can then be divided among members; and (iv) management services for a collectively used input (i.e. which has characteristics of a public good), such as water access and pasture land (which is subject to

by coordinating horizontally (Sexton 1986). Sexton and Iskow (1988) suggest that marketing cooperatives can increase the prices received by producers in three ways: (i) by reducing marketing margins where private providers of marketing services exercise appreciable market power; (ii) by improving the efficiency of marketing activities in the presence of inefficient private providers of marketing services;[6] and (iii) by exercising a preferential trading position relative to private providers of marketing services to obtain higher prices in the next stage of the value chain.

Marketing cooperatives may increase the prices received by farmers regardless of whether or not they are cooperative members because the influence on prices of non-members of a cooperative is sometimes referred to as a "yardstick of competition" effect. Sexton (1990) uses a formal model of spatial oligopsony to show how open membership cooperatives[7] can reduce the price margins of for-profit marketing firms under different assumptions of spatial competition (i.e. Loschian, Cournot).[8] Fulton and Giannakas (2013) extend Sexton's (1990) analysis to show that the existence of a positive yardstick effect of competition depends on competitive conditions in the marketing sector, on whether the cooperative is open or closed to new members, and on the pricing policy implemented by the cooperative.[9] Hence, the effects of marketing cooperatives on producer prices, both for members and non-members, are a priori ambiguous and conditional on a variety of factors.

A varied empirical literature has explored the relationship between cooperatives and farmer prices (Alwang et al. 2019; Carletti et al. 2019; Ebata et al. 2017; Hanisch et al. 2013; Jardine et al. 2014; Kumse et al. 2021; Milford 2012; Sauer et al. 2012; Ssebunya et al. 2018; Wollni and Zeller 2007).[10] A common finding of this empirical literature is that cooperative membership has positive and significant effects on producer prices, estimated using diverse econometric methods for a range of agricultural produce in both developing and developed countries. Furthermore, the literature has considered a range of alternative proxy measures for cooperative membership in empirical studies, including using dummy variables for cooperative membership (Alwang et al. 2019; Jardine et al. 2014; Ssebunya et al. 2018; Wollni and Zeller 2007), proportion of sales to

congestion or degradation), as well as information services (e.g. prices, best practices in production and sale) and dissemination, and facilitating access to finance. Cooperatives often play more than one of these roles, sometimes in combination with providing marketing services to members.

[6] This point is related to the "quiet life" hypothesis of Berger and Hannan (1998), which links cost inefficiency with market power. For efficiency gains to appear in this context, the required assumption is that cooperatives carrying out marketing services would be less inefficient than existing profit-oriented firms.

[7] An "open membership cooperative" is one that allows a member to join at any time, typically by purchasing a share of membership stock at a nominal fee. A "closed membership cooperative," in contrast, obtains most of its working capital during an initial membership drive. Usage rights to the facilities and services of a closed cooperative are granted by shares of the membership stock. In contrast to the shares of an open cooperative, shares of a closed cooperative are generally limited to the initial issue, and can represent a substantial investment.

[8] Other important factors to consider when analysing the yardstick effect of open cooperatives are whether they apply net average revenue product (NARP) pricing or net marginal revenue product pricing, and whether they operate in the upward- or downward-sloping parts of their NARP curves.

[9] For open membership cooperatives, a positive yardstick effect requires that (i) the prices of marketing first be strategic complements; and (ii) cooperatives seek to increase the prices paid to farmers. For closed membership cooperatives, the fixed costs of the cooperative are also important.

[10] Throughout this paper, the terms "farmer prices," "producer prices," and "prices received by farmers" are used interchangeably.

cooperatives (Carletti et al. 2019; Ebata et al. 2017; Hanisch et al. 2013; Sauer et al. 2012), and geographic indicators linked to cooperatives.[11]

One feature that all of the studies cited above share is that they focus on relationships between prices and a proxy for cooperative membership, omitting any interaction effects of the latter with other explanatory variables, including farm (herd) size. This type of specification is useful, as associated parameter estimates then represent average correlations between cooperative membership and producer prices as described by the survey data. Yet this feature of the literature also may obscure systematic differences in the way that marketing cooperatives influence prices received by agricultural producers.

This paper tests for a joint hypothesis derived from two key observations reported by the literature discussed above. If small farmers suffer from marketing disadvantages, and marketing cooperatives are effective in offsetting these disadvantages, then one should find the strongest positive effects of cooperatives on farmer sales prices among the smallest producers. This hypothesis is important because it would suggest that the average effects of cooperatives on farmer sales prices reported by the existing literature understate the effects relevant for the smallest producers, and overstate those for larger producers. These observations, in turn, have implications for the incentives of farmers of different sizes to be members of a cooperative.

Whereas the existing literature typically focuses on a single product in a single country, the above hypothesis is tested here on survey data collected from a diverse set of producers: maize farmers in Lao People’s Democratic Republic, apricot, grape and plum farmers in Uzbekistan, and herders in Mongolia.[12] The surveys to collect the data were designed to facilitate comparisons between the different countries and products surveyed. These data are used to estimate a common empirical specification for producer sales prices, using four alternative econometric methods that are designed to control for alternative forms of endogeneity bias (Wooldridge 2010), in addition to ordinary least squares estimated for reference purposes.

There are two key findings from the empirical analysis. First, the results highlight the extent to which smallholder farmers received lower prices for produce than larger farmers: in both Uzbekistan and Lao People’s Democratic Republic, farmer sales prices increase with the area of land under cultivation. Second, in both of these countries, the results indicate that participation in cooperatives is associated with a fixed increase in average sales prices, offset by a muted relationship between farm size and sales prices. Taken together, these results suggest that cooperatives are effective actors for “levelling the playing field” in support of smaller agricultural producers.

Furthermore, the analysis finds that controlling for self-selection is statistically important, and the results indicate the extent to which the influence of cooperative membership on farmer sales prices suffers a downward bias if self-selection is not controlled for.

[11] Milford (2012) employs the number of organic cooperatives divided by number of coffee producers in each municipality.

[12] Hanisch et al. (2013) and Sauer et al. (2012) consider cross-country data, with the former analysing data for milk producers from the EU-27 countries and the latter also considering milk producers, but for Armenia, the Republic of Moldova and Ukraine.

In the case of Mongolian herders, no significant and robust correlations are found between cooperative membership and producer sales prices.[13] This finding is consistent with the view that cooperatives operating in the Mongolian livestock sector play more of a resource management role (i.e., related to management of grazing land) than a marketing role. The finding highlights the diversity of potential roles played by cooperatives in assisting agricultural producers.

The next section of this report describes the data considered for analysis and the econometric methods employed. Empirical results are reported in Section 3, and policy implications are discussed in Section 4.

2 Survey data and empirical methods

2.1 Survey data

The analysis in this study is based on data collected via field surveys administered to primary producers in three landlocked developing countries: Lao People's Democratic Republic, Uzbekistan and Mongolia. Each survey focuses on agricultural products that are, or have the potential to be, important export products in the respective countries. The surveys were conducted with the collaboration of official representatives from each country The Lao survey focuses on maize producers, the survey for Uzbekistan focuses on grape, plum and apricot producers, and the survey for Mongolia focuses on livestock herders.[14]

2.1.1 Questionnaire design

The survey questionnaires were designed to elicit details concerning producer characteristics, production quantities, sales prices and marketing activities, including variables that are generally found to be important determinants of producer prices in the existing literature. Each of the three survey questionnaires used in the study was designed by an UNCTAD research team working in collaboration with consultants located in the three respective countries who were also engaged to conduct the surveys in the field.

All three questionnaires start from a common base structure that organizes questions by topic area, including (i) "identification", reporting the date and regional information for each survey respondent; (ii) "producer characteristics", describing features of the respondent's productive activity, including size, range of products, production volumes, income sources and participation in producer groups; (iii) "processing and transport", detailing pre-sale product processing and transport of goods for sale; (iv) "trade", describing the timing of sales, the characteristics of customers and customer relationships, and average sales prices for alternative products during the year preceding each survey; and (v) "pre-sales agreements", recording the incidence and terms of use of such agreements. While each survey incorporated a number of questions tailored to specific geographic and product circumstances, the main strength

[13] In common with much of the related literature, limitations of the survey data used (including potential measurement error) do not permit a detailed empirical analysis of causality. Where discussion of results depends upon causality, this causality is assumed in the current text. For an example of an empirical study of the causal effects of cooperatives on producer prices, see Jardine et al. (2014).

[14] See Cárcamo-Díaz (2020) and Cárcamo-Díaz et al. (2021) for further details concerning the respective value chains for export.

of the surveys in the three countries is that they were designed to facilitate comparisons between them.

2.1.2 Sample design and administration

Survey respondents were selected using a stratified sampling approach based on the geographic distribution of productive activities of interest. Only commercially active farmers were selected for inclusion in the survey, ex post verified by measures of self-consumption. The same consultants who participated in the design of the survey questionnaires were commissioned to identify the sample pool and conduct the survey in their respective countries.

Respondents to the Lao survey of maize producers were selected from the three largest maize-producing provinces in that country: Xayaboury, Oudomxay and Xiengkhuang. These provinces together accounted for 64 per cent of the total harvested area of maize in Lao People's Democratic Republic in 2017 (Lao Statistics Bureau 2018). The three sampled regions represent diversity in the export value chains for maize from Lao People's Democratic Republic: Xayaboury, in the west of the country, has extensive trading links with Thailand; Oudomxay, in the north, trades mostly with China; and Xiengkhang, in the east, has strong trade links especially with Viet Nam. The Lao survey team worked in collaboration with the provincial and district agriculture and forestry offices, as well as with the offices of industry and commerce, to select representative districts and villages for the survey sample. The Lao survey includes data for 181 farmers distributed across 15 villages in six districts (60 farmers each in Oudomxay and Xiengkhang, and 61 in Xayaboury). Data were collected via in-person field surveys conducted between May and June 2019.

Respondents to the Uzbekistan survey of fruit producers were selected from five of the principal fruit-growing regions: Andijon, Fergana, Namangan, Samarkand and Tashkent. These regions together accounted for 62 per cent, 61 per cent and 72 per cent of the national planted area of grapes, apricots and plums, respectively, in 2018 (Cárcamo-Díaz et al. 2021). The survey reports data for 103 farms collected between March and April 2020. Data were collected via in-person field surveys of farmers in all regions other than Samarkand, where interviews were conducted remotely due to COVID-19 restrictions imposed in that region during the sampling period.

In Mongolia, the survey sampled 168 herders from eight Mongolian aimags: Arkhangai, Bulgan, Dornod, Dornogobi, Khentii, Selenge, Tuv, and Uvurkhangai.[15] These aimags are situated predominantly in the centre and east of Mongolia near important border crossings with approvals to transport meat, including Zamiin Uud (Dornogobi aimag, exports to China) and Altanbulag (Selenge aimag, exports to the Russian Federation). The survey was conducted between March and April 2020 via in-person interviews in tandem with telephone and email correspondence, as dictated by circumstances including the limitations imposed by the COVID-19 pandemic.

2.2 Econometric methods

Three alternative econometric methods are employed to estimate relationships between producer sales prices and a set of assumed covariates (including cooperative membership). These three econometric methods each have strengths and weaknesses, and thereby permit an empirical evaluation of the robustness of the reported results.

[15] Aimags are a local level of government in Mongolia.

The focus here is primarily on estimates obtained using an endogenous treatment-regression model (Wooldridge 2010).[16] This instrumental variable method is well suited for answering the research question at hand, as it allows for estimating the average treatment effect of cooperative membership on prices received by farmers, while controlling for omitted variable bias (including self-selection). The approach employed consists of an "outcome" linear regression equation and a binary "treatment" model represented as an implicit variable subject to normally distributed residuals. This is similar to the two-stage least squares instrumental variables methods applied elsewhere in the literature (Alwang et al. 2019; Kumse et al. 2021; Wollni and Zeller 2007), but is especially adapted to account for non-linearity arising from the binary treatment model (see Angrist and Pischke, 2008, on the "forbidden regression"). We are unaware of any prior empirical study of primary producer sales prices and cooperative membership that applies these methods.

In this paper, the outcome equation describes producer sales prices with respect to an assumed set of covariates, and the treatment equation represents the decision to participate in a cooperative. Self-selection bias is addressed by allowing for correlation between the residuals of the outcome and treatment equations.[17] The model is evaluated using maximum likelihood, with standard errors calculated to be robust to some forms of misspecification.[18]

Sensitivity of results to measurement error is explored by estimating the same linear outcome equation considered under the first method via three "robust" estimation procedures. As discussed by Fox (2015), bounded-influence estimators like the least trimmed squares (LTS) estimator and the MM estimator can address the problem of measurement error affecting high-leverage observations in a dataset.[19] This analysis uses an MM estimator based on the bi-square function, an MM-estimator using Tukey's bi-weight function and fixed scale, and an LTS estimator.[20] These three alternative methods are all similar in purpose in that they employ weighting to reduce the influence of isolated observations on results, based on measures of the influence that individual observations have on estimated coefficients and the disparity of observations with the remainder of the survey sample.

Finally, an ordinary least squares (OLS) model is estimated. Although OLS is exposed to all three sources of estimation bias (measurement error, omitted variable, and simultaneity; see Wooldridge 2010), it remains a useful reference for discussion, having been used in previous studies of this literature (Milford 2012).

The analysis focuses on the sign, significance and robustness of estimated relationships, noting that limitations associated with the empirical identification of functional forms imply that point estimates should be treated as indicative only.

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[16] Also referred to as an "endogenous binary-variable model" or "endogenous dummy-variable model;" see the Stata reference manual entry for the "etregress" procedure. Maddala (1983) describes the approach as an "endogenous-switching model."

[17] Reported as "rho" in table 7 in Section 3.2.

[18] The estimation was conducted using the "etregress" function in Stata, and the "selection" function of the *sampleSelection* R package (Toomet and Henningsen, 2008).

[19] See Berk (1990) for an accessible introduction to robust regression methods and Fox (2016: chapter 19) for a modern discussion of the use of robust regression methods.

[20] For all three methods, we used the "lmrob" function of the *robust* R package, the "rlm" function of the *MASS* R package (Venables and Ripley 2002), and the "ltsReg" function of the *robustbase* package in R (Maechler et al. 2021), respectively

3 Empirical analysis

This section first discusses the variables considered for analysis, and then reports a number of econometric relationships estimated for producer sales prices.

3.1 Variables considered for analysis

Building on previous research, and following extensive analysis of the survey data,[21] the following six covariates were included in the empirical analysis of prices received by agricultural producers: *producer size, cooperative membership, product processing*; *transport, provision of inputs*; and *geographic location*. This section begins by describing the measures of producer sales prices before describing each covariate in turn.

3.1.1 Producer sales prices

Data collection

Producers were asked to report their average sales prices for products sold in the year preceding the survey. Lao maize farmers were asked to report their average sales prices (measured in LAK per kilogram) distinguishing sales in grain from sales on the cob. Uzbekistani fruit farmers were asked to report their average sales prices (measured in UZS per kilogram) separately for grapes, apricots and plums, distinguishing dried from fresh fruit sales. Mongolian herders were asked to report average sales prices (measured in MNT per kilogram) distinguishing between horses, sheep, goats and cows (yaks), and between live and butchered animal sales.

The price data were used to calculate a single average sales price for each genus of product (maize, grapes, apricots, plums, horses, sheep, goats and cows) for each producer. In all cases, the analysis focused on prices reported for “best-quality” products.[22] Where the producer sold multiple types of products (e.g., maize on the cob and grain in Lao People’s Democratic Republic, dried and fresh fruit in Uzbekistan, and live and butchered animal sales in Mongolia; see Section 3.1.4), weighted averages of reported prices were evaluated based on the reported sale volumes. This method of analysis was complicated in the case of Lao maize farmers, for whom separate volumes of sale on the cob and in grain form were not available. In this case, for the 20 per cent of maize farmers who reported selling maize in both grain and cob form, a simple average of the prices they reported for each type of product was assumed.[23]

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[21] Preliminary analysis focussed on identifying statistically significant relationships within the survey data under analysis, which are broadly robust to empirical methods and sample outliers. The survey data used for the current analysis includes a broad range of variables that a priori may vary with prices, but failed exploratory robustness checks.

[22] All farmers were asked to distinguish prices between “best” and “other” quality products. Herders were not asked to distinguish animal sales prices by quality. However, the number of survey responses for qualities other than “best” quality dropped substantially for most surveyed products, complicating statistical inference.

[23] The associated empirical literature typically assumes prices in either levels or logs as the dependent variable for regression analysis. For studies that assume prices in levels, in common with the results reported here, see Jardine et al. (2014), Hanisch et al. (2013) and Wollni and Zeller (2007), The signs and significance of estimated coefficients reported in table 7 between prices received by producers, cooperative membership, and farm/herd sizes are robust to a log transformation of prices; see table A.5 in the Appendix,

Summary statistics

Table 1 reports univariate summary statistics for producer prices distinguished by product. The sample mean for the annual average sales prices reported by Lao farmers is 1,429 LAK/kg. This was equivalent to US$160 per ton when the data were collected in early 2019. Similarly, in Uzbekistan, average annual sales prices are 8,280 UZS/kg (937 US$/ton) for apricots, 11,432 UZS/kg (1,300 US$/ton) for grapes, and 3,959 UZS/kg (448 US$/ton) for plums. These values are comparable to contemporary sales prices reported by third-party statistical agencies.[24] Mongolian herders reported average sales prices of 4,987 MNT/kg for horses, 4,886 MNT/kg for sheep, 4,171 MNT/kg for goats and 5,535 MNT/kg for cows. These prices are approximately two-thirds of the respective market prices reported by the Mongolian statistical authority for meat and bones, with the largest disparities for mutton and beef.[25]

Comparing the median with the mean statistics reported in table 1 reveals that each of the distributions is approximately symmetric, with those for fruit displaying some positive skew. Furthermore, the standard deviations reported for fruit prices in the table, as a fraction of the respective means, are also appreciably larger than those reported for either maize or animal sales. The differences in dispersion of reported prices are also displayed graphically in figure 1.

Table 1 Sample summary statistics for reported prices by product

	Minimum	Maximum	Median	Mean	Standard deviation	Observations
Maize	780	2,500	1,453	1,429	290	180
Grapes	3,000	35,385	10,437	11,432	7,161	47
Apricots	2,882	18,000	8,043	8,280	3,998	27
Plums	1,302	9,091	3,046	3,959	2,221	35
Horses	1,833	17,500	4,936	4,987	1,986	58
Sheep	1,000	10,000	5,000	4,886	1,422	82
Goats	1,800	8,000	4,150	4,171	951	68
Cattle	1,055	9,778	5,550	5,537	1,489	66

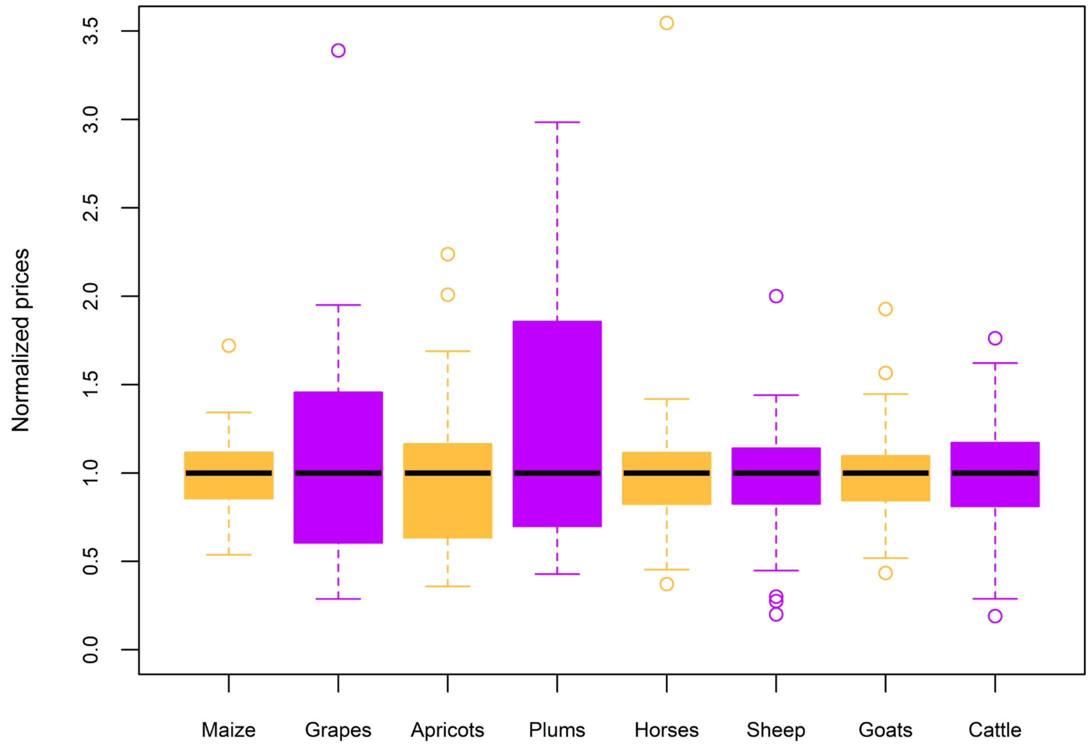
Source: Authors' calculations on UNCTAD data.

Notes: All prices reported in domestic currency per kilogram. Listed products by country: Lao People's Democratic Republic: maize; Uzbekistan: grapes, apricot and plums; Mongolia: horses, sheep, goats and cattle.

[24] Based on an exchange rate of 8,679.4 LAK per US$ in 2019 (World Bank, World Development Indicators). The Federal Reserve Bank of St Louis reports that the global price in January 2019 for maize was US$166.8 per ton fresh apricots, US$885 per ton; for dried apricots, US$1,375 per ton; for fresh "taifi" grapes, US$700 per ton; for yellow (golden) raisins, US$1,400 per ton; and for dried plum (prunes) with pit (bone), US$1,005 per ton (sale prices as of 9 September 2019 reported by the Ministry of Investments and Foreign Trade of the Republic of Uzbekistan). No prices are reported for fresh plums. The mean price reported by farmers in the survey for prunes is 9,859 UZS/kg (US$1,115 per ton).

[25] Prices reported between March and April 2019 by the Mongolian Statistical Authority, General Statistical Database are as follows: horse meat with bones 6,733 MNT/kg, mutton with bones 8,326 MNT/kg, goat meat with bones 6,212 MNT/kg, and beef with bones 9,507 MNT/kg.

Figure 1 Median-adjusted summary distribution of producer prices, by product



Source: Authors' calculations on UNCTAD data.

Notes: Prices adjusted with respect to product-specific sample medians. Listed products by country: Lao People's Democratic Republic: maize; Uzbekistan: Grapes, apricot and plums; Mongolia: horses, sheep, goats and cattle.

3.1.2 Producer size

Producer size is included to reflect the potential influence of indivisibilities in production, search and transaction costs. If buyers incur (significant) fixed costs when finding and transacting with individual producers, for example, then smaller producers will suffer a competitive disadvantage in sales reflected in the costs per unit of the product received (Sauer et al. 2012).

Data collection

In Uzbekistan and Lao People's Democratic Republic, survey respondents were asked to report the size of the land they had under cultivation, distinguished by crop grown. In Mongolia, herders engage in nomadic grazing without privately held land rights. Mongolian herders were consequently asked to report the total numbers of different types of animals in their herd, instead of their area of land use.

Summary statistics

Table 2 describes broadly similar distributions of farm sizes reported by surveyed maize farmers in Lao People's Democratic Republic and fruit farmers in Uzbekistan. In both countries, farms in the bottom quintile reported between one and two hectares of land under cultivation, rising to approximately 2.5 hectares in the second quintile and four hectares in the middle quintile. The upper tail of the distribution of farm sizes reported by Uzbekistani fruit farmers, however, displays a more pronounced right-skew than Lao maize farmers, so the average farm size in the Uzbek sample is 49 per cent larger than the Lao sample.

Table 2 Sample distributions of producer sizes and normalized sales prices

	Lao maize farms		Uzbekistani fruit farms		Mongolian herders	
Quintile	**Size**	**Price**	**Size**	**Price**	**Size**	**Price**
Bottom	1.6	91	1.1	94	82	117
2	2.6	101	2.3	121	254	109
3	3.7	100	4.0	96	434	108
4	4.9	100	7.0	92	746	116
Top	7.2	101	16.0	142	1,101	103
Mean	4.3	99	6.4	110	523	111

Source: Authors' calculations using UNCTAD data.

Notes: Farm sizes measured in hectares of land under cultivation, and herd sizes measured in numbers of animals. "Price" reports sales prices normalized by product-specific medians and weighted by the share of each individual product (e.g. grapes) in the total revenue of each producer. "Quintile" statistics obtained by ranking observations in order of reported farm/herd size from smallest to largest, and taking averages for successive 20 per cent population shares.

In comparison, Lowder et al. (2016) report that 84 per cent of the world's farms are smaller than two hectares, and 94 per cent are smaller than five hectares. The observation that the sample for the present report is composed of substantially larger farms than world averages reflects the sample design, which focuses on farms engaged in commercial trade (rather than self-consumption).

The statistics reported for Mongolian herd sizes in table 2 describe broadly similar dispersion as reported for sampled farm sizes: this similarity is displayed graphically in figure 2. The lowest-quintile herd size reported in table 2 averages 82 animals, based on underlying data varying between 11 and 153 animals. Hence, approximately one-fifth of all surveyed Mongolian herders report herd sizes below 150 animals, which is generally regarded as "the minimum necessary to maintain a household's livelihood (Reading et al. 2006: 9). Moreover, risks associated with herding in Mongolia have also risen during recent decades as the quality of land for grazing has degraded under the combined effects of overgrazing and global warming.[26]

The price indices reported in table 2 suggest that farmers with the smallest farms typically reported lower sales prices for their products than those with larger farms in both the Lao and Uzbekistani samples. In the case of the Uzbekistani sample, the highest prices are also reported by the largest 20 per cent of farms, which is of note given that reported price dispersion is greatest in the sample of fruit growers reported here. These observations may reflect underlying differences by farm size in product quality or bargaining power (Mosheim 2002). In contrast, there is little appreciable price variation by herd size evident in the data reported by Mongolian herders.

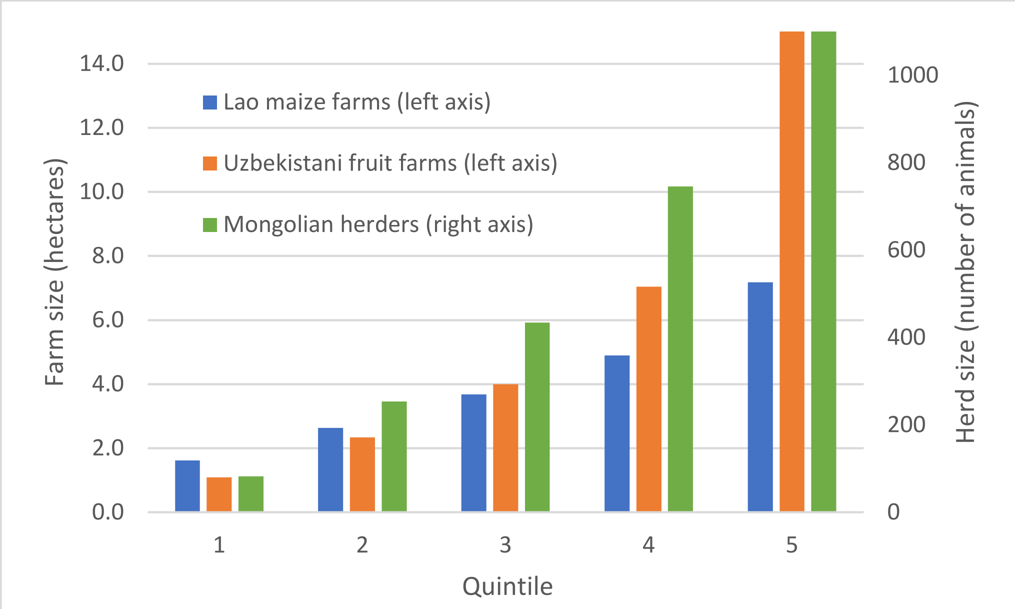
Producer size is also positively correlated with the use of post-harvest storage reported by farmers in the data.[27] This suggests that larger farms are better suited to bear the costs associated with storage, which include post-harvest treatment to reduce the risks

[26] Hence, care should be exercised in inferring numbers of animals to maintain a livelihood during recent decades. The total livestock numbers on the Mongolian steppe have increased by a factor of 3 since the dissolution of the Soviet Union, from 25.5 million head in 1991 to 71 million in 2019 (Mongolian Statistical Information Service, "Number of Livestock" table).

[27] The sample correlation coefficient between storage time and farm size for Lao maize farmers is 0.14 (p-value 0.053), and for Uzbekistani fruit farmers it is 0.20 (0.048). Associated considerations for Mongolian herders include the availability of suitable grazing, livestock age, and broader environmental considerations impacting the evolution of livestock health. This range of considerations is more difficult to identify empirically than the use of post-harvest warehousing, and is consequently not explored further here.

of product spoilage, maintenance, capital investment, and the opportunity cost of funds. Use of pre-sale storage also introduces a delay in cash receipt that may represent a substantial barrier to liquidity-constrained farmers, as is often the case of smallholders in developing countries.

Figure 2 Distribution of reported Lao and Uzbekistani farm sizes and Mongolian herd sizes



Source: Authors' calculations based on UNCTAD data for Lao maize farmers, Uzbekistani fruit farmers and Mongolian herders.

The practice of storage is of interest for the current study because it gives farmers greater flexibility in choosing the timing of their sales, which may influence sales prices. Furthermore, post-harvest processing of products to facilitate storage can also improve product quality (e.g., drying of maize and fruit) and thereby its sales price. Nevertheless, storage is omitted from the empirical specifications reported in Section 3.2 because robust regression results could not be obtained with the data. An implication of these observations is that the effects of storage on producer prices will be reflected, in part, by the estimated coefficients for producer size that are reported in Section 3.2.

3.1.3 Producer cooperatives

Data collection

All producers were asked to respond to questions concerning the existence of producer cooperatives in their geographic area of operation, and whether they were a member of such an organization at the time of the survey.

As mentioned in the Introduction to this report, cooperatives can provide a range of services to their members, including aggregation-marketing, management of natural resources, access to productive inputs and credit, support for storage and product processing, policy advocacy and local development (Rondot and Collion 2001: 2; Sexton and Iskow 1988). To narrow down diversity of function, teams conducting the surveys were asked to focus explicitly on producer organizations whose services included some marketing assistance to their members.

Summary statistics

The reported rates of cooperative membership by product type in the survey data are displayed in the second column from the left in table 3. Membership rates are lowest among Lao maize farmers (13 per cent), and highest among Uzbekistani apricot producers (41 per cent). Approximately one in three Mongolian herders reports membership in a cooperative.

Table 3 Rates of cooperative membership, prices and producer sizes by product type

		Mean sales prices		Producer size	
Product	**Coop**	**Coop**	**Non-coop**	**Coop**	**Non-coop**
Maize	0.1326	1,365	1,439	6.51	3.91
		(195)	(301)	(7.12)	(2.06)
Grapes	0.3617	8,133	13,301	3.76	10.52
		(5,370)	(7,445)	(2.42)	(8.54)
Apricots	0.4074	6,989	9,167	5.07	6.92
		(2,861)	(4,493)	(6.48)	(7.44)
Plums	0.2286	4,645	3,756	2.65	7.22
		(2,001)	(2,277)	(1.15)	(6.50)
Horses	0.3448	4,663	5,158	685	620
		(1,256)	(2,275)	(381)	(347)
Sheep	0.3537	4,384	5,161	663	563
		(1,495)	(1,316)	(390)	(343)
Goats	0.3088	4,238	4,140	664	582
		(939)	(965)	(350)	(357)
Cows	0.3030	5,241	5,666	678	520
		(1,878)	(1,288)	(410)	(384)

Source: Authors' calculations using UNCTAD data.

Note: "Coop" indicates reported membership in producer service cooperative, and "non-coop" indicates non-membership. "Mean sales prices" reports sample subgroup average sales prices by product, measured in national currency per kilogram; standard errors are reported in parentheses. "Producer size" statistics for farmers refer to land under cultivation measured in hectares, and for herders to herd size in head of livestock. Listed products by country: Lao People's Democratic Republic: maize; Uzbekistan: Grapes, apricots and plums; Mongolia: horses, sheep, goats and cattle.

In the case of Lao maize farmers, the incidence of cooperative membership in the survey data is concentrated in the Parklai district of Xayaboury province (18 observations, 41 per cent of sampled population), with the remaining members identified in Kenethao district, also in Xayaboury province, and two members identified in the Houne district of Oudomxay province. No cooperative members were identified among the surveyed maize farmers in Xiengkhuang province.

Four of the five sampled districts in Uzbekistan include at least one farmer reporting cooperative membership, with no members identified in the Tashkent region. In contrast, all of the (15) farmers surveyed in Andijon province were identified as being members of a cooperative, while membership rates in the remaining three provinces sampled in Uzbekistan varied between 23 and 36 per cent.

The price statistics reported in table 3 indicate that cooperative members generally reported lower sales prices than non-cooperative members, with the exception of plum farmers and herders selling goats. All product-specific differences between average prices reported by cooperative and non-cooperative members are within a single standard deviation of the respective statistics. Nevertheless, the observation of lower average prices reported by cooperative members may appear counter-intuitive, given the typical finding reported in the empirical literature that cooperative membership is positively related with sales prices.

Part of the explanation for the lower sales prices associated with cooperative membership reported in table 3 is provided by the producer size statistics also reported in the table. Producer size statistics for Uzbekistani fruit farmers indicate that cooperative members tend to have smaller farms than non-members. Furthermore, average farm sizes of cooperative members are smaller than those of non-members in five of the seven product-region combinations that report a mix of members and non-members in the survey data (not displayed in the table), with the outliers being apricot producers in Namangan (Uzbekistan) and maize producers in Parklai (Lao People's Democratic Republic). These two regions also report the highest rates of cooperative membership of the seven regions that include a mix of cooperative members and non-members. As discussed in Section 3.1.2, prices are generally negatively related to farm size in the survey data, so the lower prices reported by cooperative members may be partially attributable to their respective farm sizes.

3.1.4 Product processing

Product processing distinguishes two processing alternatives for each product genus. In the case of maize, analysis distinguishes between produce sold on the cob or as (shelled) grain. Fruit is distinguished by whether it is sold fresh or dried, and herders distinguish between live and butchered sales.[28]

Data collection

All producers were asked to provide information about the form in which they sold their product(s) during the year preceding the survey. Specifically, maize farmers were asked to declare whether their maize was sold on the cob or in grain form. Fruit farmers were asked to report their production of apricots, plums and grapes in tons, and their sales volumes of both fresh and dried fruit. Mongolian herders were asked to report the number of horses, cows (yaks), sheep and goats sold, distinguishing between live and butchered sales.

Summary statistics

Table 4 reports statistics for pre-sale product processing, distinguished by product type, and producer cooperative membership. With respect to maize farmers, the share of maize sold on the cob averaged over all sampled farmers is approximately 40 per cent. Note, however, that most surveyed maize farmers reported selling their product entirely on the cob or in grain form (20 per cent reported selling both), so the associated statistic reported in table 4 approximately reflects the proportion of farmers who reported selling their maize on the cob.

In contrast, almost all of the sampled Uzbekistani fruit farmers reported selling both dried and fresh fruit: 3 per cent of sampled Uzbekistani fruit farmers reported selling their produce entirely as fresh fruit, and 18 per cent reported selling only dried fruit, while the remainder of the surveyed population is approximately evenly distributed

[28] Although each survey was designed to solicit further detail distinguishing product quality, associated responses were insufficiently informative to include in the empirical analysis.

between these two extremes.[29] On average, surveyed fruit farmers reported selling over half of their crops, and up to three-quarters in the case of plums, as fresh fruit.

Table 4 Pre-sale processing by product type and cooperative membership

	Share sold unprocessed			Sales prices	
Product	**All**	**Coop**	**Non-coop**	**Processed**	**Unprocessed**
Maize	0.4171	0.9375	0.3376	1,591	1,126
Grapes	0.6979	0.7477	0.6697	23,156	5,250
Apricots	0.6470	0.7138	0.6010	15,729	4,673
Plums	0.7492	0.6613	0.7753	9,859	2,287
Horses	0.7358	0.7331	0.7369	5,516	5,110
Sheep	0.6219	0.6833	0.5916	5,616	5,015
Goats	0.5769	0.6313	0.5541	4,515	4,040
Cows	0.4136	0.3448	0.4418	5,888	5,246

Source: Authors' calculations using UNCTAD data.

Notes: "Coop" denotes members of producer service cooperative. "Processed" refers to maize sold in grain rather than cob form, fruit sold dried rather than fresh, and animals sold butchered rather than live. "Sales prices" are reported in national currency per kilogram. Listed products by country: Lao People's Democratic Republic: maize; Uzbekistan: Grapes, apricots and plums; Mongolia: horses, sheep, goats and cattle.

Rates of pre-sale processing reported by Mongolian herders are broadly similar to those reported by Uzbekistani fruit farmers, with most reporting sales predominantly of live animals. The exception in the case of herders is the sale of cows, with just under three-fifths of sales reported to be in butchered form.

Table 4 indicates that cooperative members tend to report less pre-sale product processing than non-members in all three surveyed countries. This is particularly clear for Lao maize farmers, with 94 per cent of cooperative members reporting product sales on the cob, compared with 34 per cent of non-members. Similarly, among all Uzbekistani grape and apricot growers and Mongolian herders selling sheep and goats, the proportion of sales in unprocessed form is approximately 10 per cent higher among cooperative members than non-members.

The average sales prices reported for processed and unprocessed products in the two columns on the right-hand side of table 4 clearly indicate the price premia associated with product processing. The biggest premia are reported for fruit, where the price of dried fruit exceeds that of fresh fruit by a factor of four.[30] Shelled maize, in contrast, is reported to sell at a 40 per cent premium to maize on the cob, and butchered animals are reported by Mongolian herders to attract a price premium of approximately 10 per cent.

The price premia associated with pre-sale processing are driven, in part, by underlying weight conversion ratios, in addition to processing costs such as shelling maize or drying fruit. The conversion ratio of maize cob to grain, for example, is typically 1.25:1,

[29] Recall that the survey sample was designed to capture fruit farmers engaging in some drying activity.

[30] This is unsurprising, given that there is a technical conversion ratio from fresh to dry fruit. See Cárcamo-Diaz et al. (2021).

whereas for fresh grapes to raisins it ranges from 3.54:1 to 5.42:1.[31] The relatively thin premia reported by Mongolian herders, in contrast, reflect in particular the low overhead associated with informal butchering activities. Most butchering in Mongolia takes place on the farm, with formal abattoirs accounting for only up to 10 per cent of processed meat (World Bank 2019: 40).

The price premia for processed products cited above, in combination with the relatively high prevalence of cooperative members reporting selling their produce in unprocessed form, provide an added explanation for why cooperative members generally report lower average sales prices than non-members, as discussed in Section 3.1.3. The regression analysis reported in Section 3.2 controls for these systematic differences.

3.1.5 Transport

Transport is a well-recognized reason why prices received by farmers may differ, as farmgate sales do not require a farmer to incur delivery costs. In the absence of transaction-level data that would permit measurement of distance-to-market (Ebata et al. 2017), the survey distinguishes sales by whether they are reported to be at the farmgate.

Data collection

Farmers in Uzbekistan were asked to define the proportion of their product sales conducted at the farmgate. A similar question was not submitted to maize farmers in Lao People's Democratic Republic because pre-survey data-gathering suggested that farmgate sales are universal for maize farmers there. This observation was confirmed by questions about the location of buyers and by a parallel survey of maize traders in Lao People's Democratic Republic. Similarly, the nomadic nature of Mongolian herders complicated identification of a suitable corollary for the "farmgate."

Summary statistics

Table 5 reports statistics that describe the incidence of farmgate sales reported by surveyed farmers in Uzbekistan, distinguished by cooperative membership.

Table 5 Uzbekistan: Incidence of farmgate sales by fruit type and cooperative membership

	Share farmgate sales			Sales prices	
Product	**All**	**Coop**	**Non-coop**	**Farmgate**	**Other**
Grapes	0.3553	0.7235	0.1467	9,317	14,549
Apricots	0.7204	0.9136	0.5875	7,791	12,193
Plums	0.5543	0.8500	0.4667	3,525	4,791

Source: Authors' calculations using UNCTAD data,

Note: "Coop" denotes members of producer service cooperatives, and "non-coop" denotes non-members. "Sales prices" report sample averages for UZS per kilogram.

Table 5 indicates that farmgate sales are common among the sampled Uzbekistani fruit farmers. This is particularly true for apricot farmers, who reported an average share of sales at the farmgate in excess of 70 per cent, and for plum farmers, who reported an average share of 55 per cent. Underlying the statistics reported in table 5, three-quarters

[31] For maize, see Tandzi and Mutengwa (2020); for grapes see Christensen and Peacock (2000: table 26.1).

of surveyed fruit farmers reported owning at least one vehicle for transporting their produce to customers, and 36 per cent reported owning more than one such vehicle.

Average sales at the farmgate are reported to be approximately twice as prevalent among cooperative members as non-members in Uzbekistan, which may reflect the role of cooperatives as market aggregators. The sales prices reported in table 5 indicate that sales at the farmgate are associated with a price discount of approximately 50 per cent relative to other sales. Hence, the transport statistics provide yet another reason why cooperative members report lower average sales prices than non-members.

3.1.6 Provision of inputs

Input provision by buyers is another practice that has been observed in countries such as Lao People's Democratic Republic (Cárcamo-Díaz 2020) that can be correlated with farm sales prices. The practice is particularly prevalent among liquidity-constrained farmers. It occurs when prospective buyers (i.e., intermediaries, traders) provide a loan, either in-kind or as cash credit, to finance the investment costs of production, including input acquisition (e.g., seeds, chemicals). The loan is repaid at the time of sale, often (but not always) in the form of a discounted price per unit of produce.

Data collection

All primary producers were asked to indicate whether they received pre-sale production inputs from their customers, and, if so, what form of inputs they received. Analysis here is limited to indicator variables for receipt of inputs from customers.

Summary statistics

Table 6 reports statistics describing the incidence of receiving inputs from buyers, as reported in the survey samples, distinguished by product and cooperative membership in addition to associated means for sales prices. Statistics for Mongolian herders are not reported in table 6, as no herders reported receiving inputs from their customers. Mongolian herders also report transacting with a larger number of customers, whom they have known for a shorter period, than surveyed farmers. Taken together, these statistics suggest that Mongolian herders have a more pronounced "arms-length" relationship with their customers.[32]

Table 6 indicates that the receipt of inputs from customers is widely prevalent in the farmer sample, reported by approximately one-third of maize farmers, just over one-quarter of four grape farmers, one in five apricot farmers, and one in seven plum farmers. For all but the sample of apricot farmers, rates of reported input receipt are substantially higher among cooperative members than non-members. This is consistent with the role of cooperatives in helping members access productive inputs. Among maize and grape farmers, who report the highest rates of input receipt, average sales prices reported by farmers who receive inputs are lower than those of farmers who do not report receiving inputs, which provides a further explanation for the lower sales prices reported for cooperative members in Section 3.1.3.

[32] A large literature analysing customer-farmer relationships indicates that loans for input provision are common in persistent "relational contracts" (written or unwritten) between farmers and buyers (intermediaries or processors). See Macchiavelo and Morjaria (2021) and the references therein.

Table 6 Incidence of customer inputs by product type and cooperative membership for Lao People's Democratic Republic (maize) and Uzbekistan (grapes, apricots, plums)

	Share of producers receiving inputs			Sales prices	
Product	**All**	**Coop**	**Non-coop**	**Inputs**	**No inputs**
Maize	0.3389	0.6250	0.2949	1,370	1,460
Grapes	0.2766	0.5882	0.1000	9,735	12,081
Apricots	0.2222	0.0000	0.3750	10,025	7,781
Plums	0.1429	0.3750	0.0741	5,769	3,657

Source: Authors' calculations using UNCTAD data.

Note: "Coop" denotes members of producer service cooperatives, and "non-coop" denotes non-members. "Sales prices" report sample averages for domestic currency per kilogram.

The next section presents econometric estimates that explore the relationship between producer prices and cooperative membership, controlling for the range of variables discussed throughout this section.

3.2 Regression analysis of producer prices

Table 7 presents the results of the endogenous treatment regression for producer sales prices. These regression estimates control for self-selection and simultaneity bias concerning cooperative membership. Coefficient estimates for the outcome variable (sales prices of each product in the respective countries, measured in domestic currency) are reported in the top half of the table, and the treatment variable (cooperative membership) in the middle panel of the table. Selected estimation statistics are reported at the bottom of the table.

The selection (or treatment) equation includes three covariates that can affect cooperative membership across different products and countries: farm (herd) size, measured as the number of hectares under cultivation (animals in the herd); the share of produce that is sold unprocessed; and an indicator variable, equal to one where producers reported receiving business (labour) income and zero otherwise. The first two of these explanatory variables are in common with the outcome equation. Discussion in Section 3.1 suggests negative relationships between cooperative membership and both farm size and product processing. Furthermore, the existence of business (labour) income is included as a proxy for business skills and human capital considered elsewhere in the literature (Wollni and Zeller 2007).

The outcome equation contains as covariates, in addition to the fitted (binary) values derived from the treatment equation for cooperative membership, farm (herd) size, the share of produce sold unprocessed, an indicator variable that registers whether farmers receive inputs from buyers, an indicator variable that registers whether sales are mostly conducted at the farmgate, and indicator variables for producer region.

Region identifiers were selected after extensive experimentation to focus on robust statistical relationships, in common with the choice of reported regression specifications more generally. The region identifier for Lao maize farmers distinguishes Xayaboury from the remainder of the sample, as that is the province where cooperative membership is reported to predominate in the survey data (Section 3.1.3).[33] The regression specifications for grape and plum farmers in Uzbekistan distinguish Tashkent from the remainder of the sample population, reflecting the importance of Tashkent as a regional trading centre. The sample of apricot farmers in Uzbekistan is drawn exclusively from Fergana and Namangan, and the associated region identifier consequently distinguishes Namangan in the absence of any observations from Tashkent. Regression specifications for Mongolian herders, in contrast, include a full set of region identifiers. This reflects the propensity of herders in the sample to sell a mix of animal types across all of the surveyed regions.

Input and farmgate sale indicators are omitted from the regressions for Mongolian herders, as discussed in Section 3.1. Interaction terms between cooperative membership and producer size are included in the target model for all products, as well as between region and producer size in selected specifications. Estimates reported in tables 7a and 7b were computed using the etregress procedure using the Stata statistical program.[34]

[33] Furthermore, the mean farm size in Xayaboury province in the sample was 26 per cent larger than in Xiengkhuang province and 47 per cent larger than in Oudomxay province. Also, two-thirds of the largest 5 per cent of observations of farm size in the whole sample are located in Xayaboury province.

[34] We also calculated the same specifications using the *selection* function of the *sampleSelection* package in R and obtained qualitatively similar results. These statistical packages differ in terms of the numerical methods used to optimize regression objective functions.

Table 7a Estimation statistics for producer sales prices for maize in Lao People's Democratic Republic and fruit in Uzbekistan, allowing for endogenous treatment effects of cooperative membership

	Apricots (Uzbekistan)		Grapes (Uzbekistan)		Plums (Uzbekistan)		Maize (Lao People's Democratic Republic)	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Sales prices (domestic currency per kilogram)								
Sales fresh (fraction)	-12148 ***	1691	-26534***	3229	-5418***	1674	-626***	58
Cultivated hectares	633 ***	67	655***	138	370***	161	2	8
Customer inputs	-6564 ***	958	6623***	2596	124	1295	-39	37
Farm gate sales	-40 ***	9	-15	27	11	23	-	-
Region	-5976 ***	488	1254	1708	2021	1914	-113	82
Region x hectares	-	-	-604***	146	-229**	125	31***	15
Coop member	6906 ***	684	3220*	2006	4223***	1777	658***	107
Coop x hectares	-813 ***	133	-776***	364	-511***	193	-30***	12
Intercept	16794 ***	1421	24163***	2243	4324	3801	1613***	48
Incidence of cooperative membership								
Sales fresh (fraction)	1.427 ***	0.711	2.401***	0.943	-1.873	2.430	2.938***	0.474
Cultivated hectares	-0.003	0.015	-0.224***	0.037	-0.277***	0.084	0.052***	0.022
Business income	0.122	0.191	0.661**	0.400	-0.421	0.883	-1.052***	0.320
Region	-	-	-	-	-	-	0.558**	0.308
Intercept	-1.119 ***	0.488	-0.894	0.668	1.888	1.940	-3.783***	0.601
Regression summary statistics								
Rho	-1.000 ***	0.000	-1.000***	0.000	-0.775	0.460	-0.922***	0.099
Sigma	2157 ***	228	3685***	404	1246***	414	228***	19
Observations	27		47		35		180	
Wald test (p-value)	0.000		0.000		0.370		0.015	

Source: Authors' calculations based on UNCTAD data.

Note: Linear regression with endogenous treatment effects estimated using the Stata etregress procedure. Region = Namangan for apricots, Tashkent for grapes and plums, and Xayaboury for maize. Rejected as insignificant at the 85 per cent (*), 90 per cent (**), and 95 per cent (***) confidence intervals. "rho" is the estimated correlation between residuals reported in the outcome and selection equations, "sigma" is the estimated standard error of the outcome equation, and the null hypothesis of Wald test is that rho is equal to 0

Table 7b Estimation statistics for producer sales prices for herders in Mongolia, allowing for endogenous treatment effects of cooperative membership

	Horses		Goats		Sheep		Cows	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Sales prices (domestic currency per kilogram)								
Sales live (fraction)	-48	538	-248	246	-632**	356	-476*	328
Herd size (head)	0	1	0	0	0	1	0	1
Region identifiers								
Arkhangai	1019***	0	371	556	187	418	623	479
Bulgan	628***	0	50	298	587***	294	205	351
Dornod	859	845	276	235	-104	435	963***	302
Dornogobi	1983***	0	259	634	1595***	707	111	1293
Khentii	943***	0	146	567	-843	604	827	678
Selenge	1269***	0	504	388	1302***	381	80	444
Tuv	876*	552	-122	265	340	416	1200***	436
Coop member	3166***	0	-117	626	-1361***	619	1471	1029
Coop x herd size	-2***	0	-1*	1	-1**	1	-1	1
Intercept	3653***	626	4292***	321	5842***	381	4972***	345
Incidence of cooperative membership								
Sales live (fraction)	-0.554***	0.220	0.087	0.351	0.263	0.322	-0.301	0.351
Herd size (head)	0.000	0.000	0.000	0.000	0.001**	0.000	0.001**	0.000
Labour income	-1.699***	0.490	-0.637	0.443	-0.864***	0.393	-1.280***	0.498
Intercept	0.327	0.332	-0.757**	0.417	-0.854***	0.360	-0.690***	0.334
Regression summary statistics								
Rho	-1.000***	0.000	0.490*	0.265	0.586***	0.223	-0.591	0.373
Sigma	2279***	658	965***	124	1348***	169	1476***	308
Observations	58		68		82		66	
Wald test (p-value)	0.000		0.125		0.048		0.236	

Source: Authors’ calculations based on UNCTAD data.

Notes: Linear regression with endogenous treatment effects estimated using the Stata etregress procedure. Uvurkhangai region assumed as a reference. Rejected as insignificant at the 85 per cent (*), 90 per cent (**), and 95 per cent (***) confidence intervals. “rho” is the estimated correlation between residuals reported in the outcome and selection equations, “sigma” is the estimated standard error of the outcome equation, and the null hypothesis of Wald test is that rho is equal to 0.

The discussion starts with the results reported for Lao and Uzbekistani farmers in table 7a, which differ in some important respects from those reported for Mongolian herders in table 7b. Estimates in table 7a indicate that average annual sales prices for all four farmer products (i.e., maize, apricots, grapes and plums), increase with farm size.[35] In

[35] For apricots, grapes and plums in Uzbekistan, similar results are obtained when farm size is measured by the number of permanent workers instead of the area under cultivation. This could not be verified for maize in Lao People’s Democratic Republic due to data issues.

Lao People's Democratic Republic, this result is significant only in Xayaboury province. This is important because Xayaboury is where most of the maize farmers reporting membership in a cooperative were located (Section 3.1.3), and it is the province with the largest concentration of large farms reported in the Lao sample.

The positive correlation between farm size and prices received by farmers, as discussed in Section 3.1.2, should be interpreted as including the influence of producer storage, as this variable is positively correlated with producer size. Other relevant (though unobserved) considerations that can explain why farm size is positively correlated with prices include farmer ability (including bargaining skills), education, reduced liquidity constraints, and crop and post-harvest practices influencing product quality, among many other considerations.

A key finding reported in table 7a is that average annual sales prices increase with cooperative membership after controlling for the other considered covariates, confirming previous findings in the literature.[36] However, the interaction term between cooperative membership and farm size is negative and significant for all four products. Furthermore, the scale of the interaction term is not significantly different from the coefficient estimate on farm size in any of the regressions, implying that cooperative membership negates the positive association that farm size would otherwise have with sales prices. Taken together, the results suggest that cooperative membership can be an effective vehicle for small farmers to offset competitive disadvantages reflected by lower produce sales prices. This finding is consistent with previous work that has reported on the role of cooperative membership in strengthening the bargaining power of farmers in Lao People's Democratic Republic (SADU 2012).

As noted in Section 2.2, while the multiple estimation methods used in this study (see Appendix) confirm the robustness of the signs and significance of the correlation between producer prices, cooperative membership and farm (herd) size, survey data limitations imply that the *values* of the parameter estimates reported in table 3.7 should be interpreted as indicative only. With this qualification in mind, using the estimated coefficients, the impact of cooperative membership on sales prices can be calculated for the 20 per cent of surveyed farmers who reported the smallest farms. As discussed in Section 3.1.2, the average farm size reported by these farmers was 1.1 hectares in Uzbekistan and 1.6 hectares in Lao People's Democratic Republic. Given these farm sizes, the coefficient estimates reported in table 7a suggest that cooperative members reported a price premium relative to non-members worth 75 per cent of the median sales price for apricots, 23 per cent for grapes, 120 per cent for plums, and 42 per cent for maize.[37]

The relationship between producer prices, farm size and cooperative membership identified in the results can be further elucidated by calculating "break-even" farm sizes for cooperative membership, where the estimated fixed increases in sales prices associated with cooperative membership are exactly offset by the reduced influence that farm sizes are estimated to have on sales prices.

The break-even farm size is estimated at 22 hectares for Lao maize farmers and, in Uzbekistan, 8.5 hectares for apricot farmers, 8.3 hectares for plum farmers, and 5.1 hectares for grape farmers. The break-even farm size for maize farmers is greater than all but 1 of the 181 farms in the reported sample. Similarly, the break-even farm sizes evaluated for Uzbekistani fruit farms are in the top quartile of the samples reported by

[36] For example, using a probit model, Wollni and Zeller (2007) find a negative and significant correlation between farm size and participation in cooperative marketing channels.

[37] As reported in Section 3.1.1

apricot and plum farmers, and in the top half reported by grape farmers. The results consequently suggest that cooperative membership is an effective tool to increase the prices received for a large proportion of the farmers in the sample, including smallholders and many medium-sized farms.

Table A.6 in the Appendix reports population average correlations estimated by omitting an interaction term between cooperative membership and farm size, as typically considered in the related literature. These indicate average price premia associated with cooperative membership worth 49 per cent of the median sales price for apricots, 14 per cent for grapes, 92 per cent for plums, and 40 per cent for maize. As suggested in the Introduction to this report, these premia are all less than those estimated for the smallest quintile of sampled farmers discussed above.[38]

Turning to the remaining covariates reported for price regressions in table 7a, results generally confirm a priori expectations. The table indicates that average reported sales prices rise with the share of processed goods sold (i.e., dried rather than fresh fruit, and maize sold as grain rather than on the cob). This result confirms the importance of value addition at the farm (including practices to bolster quality) on prices received by farmers.

With respect to coefficients for indicator variables for farmgate sales and receipt of inputs from customers, results are insufficiently precise to come to definitive conclusions.[39] Specifically, associated coefficient estimates in table 7a are either statistically insignificant, or sensitive to estimation methodology, a feature that will be discussed below.

The statistic “rho” reported at the bottom of table 7a is the estimated correlation between residuals reported in the outcome and selection equations. Estimates for this statistic motivate the focus on results that control for endogenous treatment effects. All estimates for “rho” reported in table 7a are negative, implying that omitted characteristics that increase the likelihood that a farmer is a cooperative member are also associated with lower farmer sales prices. The Wald statistics reported at the bottom of the table indicate that estimates for “rho” are statistically significant at the 95 per cent confidence interval for all but Uzbekistani plum farmers.

As discussed in Section 2.2, sensitivity of the estimates reported here was explored by re-estimating each model using four alternative regression methods. Tables A.1 and A.2 in the Appendix report robust and OLS regression results alongside those reported in table 7a. Results regarding the positive relationship of farm size with producer prices and the associated impact of cooperative membership discussed above are robust to all regression methods for all products displayed in table 7a.

Of particular note when comparing results obtained via alternative regression methods is the extent of self-selection bias suggested by the alternative estimates. Specifically, the point estimates for coefficients of cooperative membership evaluated using the method that controls for self-selection bias exceed those obtained by all other methods

[38] Nevertheless, sample size and other data limitations of survey data prevent us, for statistical significance reasons, from categorically claiming that the coefficient for cooperative membership is smaller when the interaction effect of cooperative membership with farm size is omitted.

[39] An explanation for not finding a negative coefficient for inputs received from buyers may lie in measurement error issues, especially in view of the limited number of cases where input provision was observed in the fruit sector in Uzbekistan. Indeed, application of other estimation methods that are more robust to measurement error, specifically the MM estimator (see tables A.1 and A.2 in the Appendix) shows that these coefficients take the expected negative and significant sign for grapes in Uzbekistan and maize in Lao People’s Democratic Republic with these alternative estimation methods.

for all agricultural products except the OLS estimate for grapes.[40] The bias is large, with the estimated coefficient on cooperative membership calculated using the endogenous treatment method exceeding estimates obtained by the other regression methods by an average factor of between 1.4 (grapes) and 3.7 (apricots). This negative bias is anticipated by the sign of the estimate for "rho" discussed above, which implies that unobserved features that increase the likelihood of cooperative membership are negatively correlated with unobserved factors that increase reported sales prices. The bias can also be seen to feed through to imply generally weaker relationships between the interaction of farm size and cooperative membership, and by extension to the relationship between farmer prices and farm size alone.

Turning to results reported in table 7b, estimated relationships between sales prices of Mongolian herders and the set of covariates considered here are noticeably weaker than estimated for the farmers discussed above. Importantly, taking the results reported in table 7b together with the sensitivity analysis reported in tables A.3 and A.4 in the Appendix, there is no evidence that either producer scale (as measured by herd size) or cooperative membership exhibit robust statistically significant relationships with average annual sales prices for any of the four types of animals considered here.

Nevertheless, it noteworthy that wherever statistically significant coefficient estimates are found for Mongolian herders, the sign of the coefficient is consistent with the results reported for Lao and Uzbekistani farmers, with one exception. In contrast to the results reported for farmers, the regression coefficient reported in table 7b for cooperative membership with the average sales prices of sheep is both negative and significant. Note, however, that in this case the empirical support for use of the regression method that controls for self-selection bias is only marginally accepted at the 95 per cent confidence interval (Wald test p-value of 0.048), and the result is not robust to the alternative regression methods considered for analysis (see table A.4 in the Appendix).

The weaker results obtained for Mongolian herders are generally consistent with competitive markets for animals/meat in that country, implying that producer characteristics are less important for determining sales prices than for either maize farmers in Lao People's Democratic Republic or fruit farmers in Uzbekistan. This suggests that cooperative membership among Mongolian herders is likely motivated by considerations other than the price effects of cooperative marketing services.

Although the results reported above generally provide prima facie evidence in support of cooperatives as vehicles to assist smallholder farmers, the success of cooperatives in their various functions, including provision of marketing services, is conditional on a variety of factors investigated elsewhere by the literature (Sexton and Iskow 1988; Markelova et al. 2009; Cook and Grashuis 2018). Among the key features identified by this literature as impacting the efficacy of cooperatives, are (i) the characteristics of cooperative members (e.g., member heterogeneity along different dimensions);[41] (ii) whether cooperatives are open or closed; (iii) cooperative management and decision-making; (iv) pricing policies towards members and non-members; (v) the specific functions carried out by the cooperative; and (vi) the approach to produce quality control and pricing (Mérel et al. 2009, 2015). Consideration of the "how" of cooperatives (i.e., how to foster cooperatives that succeed in increasing farmers' prices) requires data and

[40] For grapes, as shown in table A.1 in the Appendix, only the OLS estimate for cooperative membership of grape farmers is larger than the coefficient for farm size. However, this method estimated the coefficient with relatively little precision, as it is significant only at 10 per cent.

[41] Note that our results about the differential attractiveness of cooperative membership for large and small farmers also tend to reinforce the importance of member heterogeneity discussed in this literature.

analysis specific to the conditions affecting each market and on geography, which merits further research.[42]

4 Conclusions and Policy Implications

This study reports three robust empirical findings with respect to maize farmers in Lao People's Democratic Republic and grape, apricot and plum farmers in Uzbekistan. First, average sales prices increase with farm size, measured as hectares of land under cultivation. Second, cooperative membership is associated with fixed increases in farmer sales prices. And third, as the size of farms increases, the positive relationships between cooperative membership and prices are progressively offset. The results for surveyed farmers in Lao People's Democratic Republic and Uzbekistan confirm previous empirical findings of positive effects of cooperative membership on farmer sales prices, but qualify the result to exclude surveyed farmers with the largest farms. In contrast, analysis of the sales prices reported by Mongolian herders revealed no statistically significant relationships with either herd size or cooperative membership.

The impact of farm size on prices observed for farmers in Lao People's Democratic Republic and Uzbekistan could be explained by diverse underlying factors, of which two candidates are considered here as especially plausible: unobserved differences in product quality, and marketing advantages that vary positively with farm size. Each of these candidates is examined below in turn.

Starting with unobserved quality, the results could indicate that larger farms tend to sell higher-quality produce, and that for this reason they receive a premium in sales prices. Larger farms might produce higher-quality produce if farm size, at least in a certain range, is positively related to physical and human capital endowments that influence the quality of produce. For example, post-harvest quality control often depends on access to capital goods, including storage facilities and drying and fumigation equipment. These capital goods may exceed the available budgets of capital-constrained farmers, or may only become profitable with sufficient scale. Furthermore, quality produce usually requires costly inputs – including seeds, trees, fertilizer, knowledge of good agricultural practices, and access to machinery and labour – that larger farms may be better able to obtain, especially in developing countries where agricultural input markets and rural credit are often less developed.

If unobserved quality differences motivate price differences among producers, cooperatives might provide a vehicle that mitigates the binding financial constraints of their members by pooling physical and human capital resources, thereby permitting delivery of produce that attracts a quality sales price premium. As the quality of agricultural produce is becoming increasingly important for successful participation in both domestic and, especially, international agricultural markets (Reardon et al. 2009), quality problems upstream in the value chain can also translate into problems downstream.[43]

Nevertheless, more appears to be at work than quality differences alone in explaining the relationships reported in this study between farmer prices and cooperative membership. One reason for this view is that the estimated coefficients suggest that

[42] See Gezahegn et al. (2019) and Giannakas et al. (2016).

[43] See Cárcamo-Díaz et al. (2021) for further discussion of this point in relation to the dried fruit value chain in Uzbekistan.

most sampled farmers would enjoy a price premium as members of a cooperative.[44] If attributed entirely to quality differences, these results suggest that cooperatives in Lao People's Democratic Republic help their members deliver higher-quality produce than maize produced by most other sampled farmers, which seems unlikely. The price premium for high-quality maize reported by surveyed traders in Lao People's Democratic Republic is only 15 per cent of the median sales price, which is approximately one-third as large as the increase in sales prices estimated for incidence of cooperative membership in the results presented in Section 3.2. Additionally, buyers of dried fruit in Uzbekistan reported that they rely mostly on subjective criteria for determining quality, which complicates measurement of associated quality price premia.[45] This suggests that not all of the identified price differences between farmers with different characteristics can plausibly be attributed to unobserved quality differences.

Consequently, the results presented here are believed to be driven, at least in part, by heterogeneity of marketing advantages among surveyed farmers. Interpreted in this way, the results suggest that farmers with larger farms tend to enjoy more favourable marketing conditions, and that these marketing advantages are partially offset for small farmers through cooperative membership. This view reflects the observation that search, transport and other marketing costs are fixed at the transaction level, and hence lower per unit for larger transactions. Taking this perspective, the analysis highlights the potential market headwinds that small farmers face, motivating policy interest in initiatives targeted to assist smallholders. Furthermore, the results suggest that producer cooperatives should be included among the range of marketing initiatives that policymakers consider to assist smallholders.[46]

As discussed by Mérel et al. (2009), transport costs are an important factor underlying market integration of farmers in developing countries due to geography (notably, distance from markets and difficult terrain), limitations of transport infrastructure, and issues of access to idoneous transport equipment. Reducing transport costs via investment in infrastructure can consequently foster market integration by farmers and reduce their vulnerability to asymmetric bargaining power with local buyers. It can also potentially lower the fixed search and transaction costs incurred by produce buyers.

As indicated by an extensive literature (Sexton and Iskow 1988), by pooling produce from different producers, cooperatives can bring down the per-transaction costs of smallholders, levelling the playing field vis-à-vis large farmers. Cooperatives can also increase the number of possible buyers beyond the immediate geographical area, also potentially reducing the market power faced by small producers.

Access to credit, discussed above, can also help reduce producer vulnerability to disparities in market power, as when input loans are used by customers as "leverage" for post-harvest transactions (McAffee et al. 1989). This applies in particular to regions and markets where relationships between agricultural product buyers and sellers are close and persistent, and where buyers (i.e., intermediaries, processors) provide inputs on credit to producers. Macchiavello and Morjaria (2021) and the references therein discuss the role of "relationship contracts" in input provision in developing countries. For example, Cárcamo-Díaz (2020) found that loans by buyers of maize are widespread

[44] See the discussion of the "break-even" farm sizes reported in Section 3.2.

[45] See Cárcamo-Díaz (2020: section 3.2.2) and Cárcamo-Díaz et al. (2021: section 3.2).

[46] This is in addition to other roles that cooperatives can play in agricultural value chains in developing countries, including providing inputs at a lower cost to farmers, and providing competition to processing facilities (Sexton and Iskow 1988).

among maize producers in Lao People's Democratic Republic: 58 per cent of surveyed farmers in two districts of Oudomxay province and 35 per cent of those in two districts of Xayaboury province indicated receiving inputs from buyers or having to repay them at the time of selling maize to these buyers.

The role of cooperatives in coordinating member activities can also be leveraged in other ways to support agricultural producers. For example, some recent studies suggest that cooperatives are currently playing an important role in addressing the problems of over-grazing that threaten Mongolia's livestock sector (Binswanger and Himmelsbach 2010). This role of cooperatives is not dissimilar to the roles of cooperatives facilitating access to essential inputs like seeds or fertilizers, with the difference that grazing land is a public good that is exposed to a situation where individual users who have shared access to a resource unhampered by formal rules act according to their own self-interest and contrary to the common good, causing depletion of the resource as a result of uncoordinated action.

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Appendix: Supplementary regression statistics

Table A.1 Estimation statistics for producer sales prices, by product and regression method: Apricots and grapes (Uzbekistan)

	Self-selection		M-method		MM-method		Least trimmed square method		Ordinary least square	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Apricots (27 observations)										
Unprocessed (fraction)	-12148***	1691	-10690***	1567	-14849***	1309	-15101***	1187	-10276***	2217
Cultivated hectares	633***	67	570***	97	521***	26	539***	53	576***	39
Customer inputs	-6564***	958	-5616***	1681	-6115***	954	-3122***	1222	-5841***	2448
Farm gate sales	-40***	9	-27	17	-42***	10	-6	15	-28	28
Region	-5976***	488	-5459***	998	-11529***	1406	-4647***	756	-5771***	1591
Coop member	6906***	684	2966***	1144	1934***	634	1093	919	2835**	1396
Coop x hectares	-813***	133	-729***	146	-525***	54	-260	213	-707**	345
Intercept	16794***	1421	16411***	1984	21094***	1738	17931***	1771	16258***	3023
Grapes (47 observations)										
Unprocessed (fraction)	-26534***	3229	-21247***	3024	-16878***	1500	-16723***	1025	-22305***	4838
Cultivated hectares	655***	138	494***	65	-42	57	-56	43	617***	148
Customer inputs	6623***	2596	3027***	1305	-2827***	1045	-2956***	610	7662***	3105
Farm gate sales	-15	27	-13	17	8	6	9*	6	-38	38
Region	1254	1708	3906***	1729	2221***	341	2234***	564	4503**	2431
Region x hectares	-604***	146	-632***	101	-86	56	-72	49	-741***	166
Coop member	3220*	2006	2635*	1524	1863***	695	1858***	522	4241*	2847
Coop x hectares	-776***	364	-1029***	263	-58	75	-43	98	-1641***	631
Intercept	24163***	2243	22516***	2000	20644***	1189	20507***	687	22697***	2733

Source: Authors’ calculations based on UNCTAD data.

Table A.2 Estimation statistics for producer sales prices, by product and regression method: Plums (Uzbekistan) and maize (Lao People's Democratic Republic)

	Self-selection		M-method		MM-method		Least trimmed square method		Ordinary least square	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Plums (35 observations)										
Unprocessed (fraction)	-5418***	1674	-7398***	978	-7336***	709	-6806***	357	-6607***	2163
Cultivated hectares	370***	161	335***	51	47	72	212***	45	290*	171
Customer inputs	124	1295	541	593	175	427	-174	218	703	1132
Farmgate sales	11	23	7	8	10	11	25***	3	2	32
Region	2021	1914	1965**	957	1710***	702	2811***	353	1204	3638
Region x hectares	-229**	125	-294***	66	-19	81	-137***	48	-215	216
Coop member	4223***	1777	2793***	1021	2054***	532	3117***	364	2843***	1350
Coop x hectares	-511***	193	-748***	273	-426***	151	-637***	97	-698***	325
Intercept	4324	3801	7013***	1303	7502***	1522	5108***	538	6844**	3339
Maize (180 observations)										
Unprocessed (fraction)	-626***	58	-577***	63	-581***	55	-662***	49	-560***	55
Cultivated hectares	2	8	-2	10	-2	9	-10	8	2	8
Customer inputs	-39	37	-59*	36	-58**	32	-45	29	-69***	32
Region	-113	82	-127	85	-127	118	-195***	71	-84	96
Region x hectares	31**	15	51***	18	52**	29	42***	15	38*	22
Coop member	658***	107	397***	89	412***	165	619***	80	313***	121
Coop x hectares	-30***	12	-38***	16	-39	27	-27**	13	-27	23
Intercept	1613***	48	1633***	49	1630***	50	1686***	39	1620***	48

Source: Authors' calculations based on UNCTAD data.

Table A.3 Estimation statistics for producer sales prices, by product and regression method: Horses and goats (Mongolia)

	Self-selection		M-method		MM-method		Least trimmed square method		Ordinary least square	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Horses (58 observations)										
Live sales (fraction)	-48	538	-254	332	-273	398	-679***	292	138	780
Herd size (head)	0.02	0.75	-0.38	0.46	-0.50	0.45	-0.47	0.40	0.23	0.77
Arkhangai province	1019***	0	856**	439	835*	482	928***	396	1182*	803
Bulgan province	628***	0	514	450	436	427	488	382	737	519
Dornod province	859	845	559	522	570*	353	651	442	555	465
Dornogobi province	1983***	0	2367***	784	2092***	816	1713***	698	3086***	1461
Khentii province	943***	0	-579	444	-1214	1215	297	499	1571	2583
Selenge province	1269***	0	1569***	559	1470***	492	1222***	486	1864**	928
Tuv province	876*	552	82	383	94	313	31	326	193	371
Coop member	3166***	0	116	574	-29	668	-368	504	410	809
Coop x herd size	-1.69***	0.00	-0.98	0.79	-0.48	1.24	0.09	0.74	-2.10	1.95
Intercept	3653***	626	5080***	455	5143***	509	5469***	405	4375***	940
Goats (68 observations)										
Live sales (fraction)	-248	246	-210	265	-226	242	-244	241	-282	295
Herd size (head)	0.31	0.35	0.07	0.37	0.03	0.37	0.07	0.34	0.17	0.42
Arkhangai province	371	556	419	541	360	623	280	490	327	852
Bulgan province	50	298	3	414	5	314	-22	375	22	357
Dornod province	276	235	351	405	354	240	317	367	291	287
Dornogobi province	259	634	-81	531	-162	671	149	521	267	879
Khentii province	146	567	-50	393	-252	396	-325	369	155	666
Selenge province	504	388	393	431	405	432	440	391	468	501
Tuv province	-122	265	-88	300	-60	285	21	276	-115	306
Coop member	-117	626	474	531	443	390	504	482	605	528
Coop x herd size	-1.07	0.70	-0.86*	0.75	-0.69	0.64	-0.69	0.69	-0.99	0.96
Intercept	4292***	321	4172***	360	4194***	317	4183***	327	4161***	348

Source: Authors' calculations based on UNCTAD data.

Table A.4 Estimation statistics for producer sales prices, by product and regression method: Sheep and cows (Mongolia)

	Self-selection		M-method		MM-method		Least trimmed square method		Ordinary least square	
	estimate	standard error	estimate	Standard error	estimate	standard error	estimate	standard error	estimate	standard error
Sheep (82 observations)										
Live sales (fraction)	-632**	356	-811***	335	-874***	324	-799***	339	-760**	407
Herd size (head)	0.02	0.57	-0.21	0.50	-0.09	0.45	0.14	0.51	-0.24	0.54
Arkhangai province	187	418	126	493	158	447	397	494	184	494
Bulgan province	587***	294	602	551	615***	285	560	552	579**	341
Dornod province	-104	435	15	519	-62	479	-133	520	-26	527
Dornogobi province	1595***	707	1512***	664	1550**	860	1314**	665	1614**	930
Khentii province	-843	604	-706	488	-656	942	-1396***	502	-773	721
Selenge province	1302***	381	1278***	566	1211***	391	1058**	568	1270***	466
Tuv province	340	416	259	384	148	317	77	391	382	442
Coop member	-1361***	619	-86	627	33	492	107	634	-134	590
Coop x herd size	-1.33**	0.77	-1.42	0.89	-1.55**	0.74	-1.26	0.90	-1.28	0.86
Intercept	5842***	381	5628***	462	5598***	340	5379***	468	5604***	387
Cows (66 observations)										
Live sales (fraction)	-476	328	-577*	322	-527**	252	-713***	274	-598*	362
Herd size (head)	-0.12	0.66	0.29	0.46	0.26	0.33	0.67*	0.39	0.21	0.47
Arkhangai province	623	479	737	469	842***	349	760**	402	574	571
Bulgan province	205	351	177	715	122	388	114	599	210	465
Dornod province	963***	302	942	595	941***	304	690	499	978***	368
Dornogobi province	111	1293	-101	878	-380	802	-488	740	164	2993
Khentii province	827	678	1062***	475	1327***	473	1066***	428	817	798
Selenge province	80	444	-115	507	-324	422	-140	428	45	562
Tuv province	1200***	436	881**	451	802**	395	681*	381	1145***	498
Coop member	1471	1029	-283	600	-735	509	-541	520	139	941
Coop x herd size	-0.85	1.32	0.07	0.82	1.21	0.83	0.77	0.76	-0.95	1.73
Intercept	4972***	345	5243***	441	5249***	291	5227***	372	5277***	405

Source: Authors' calculations based on UNCTAD data.

Table A.5a Estimation statistics for producer sales prices for maize in Lao People's Democratic Republic and fruit in Uzbekistan, allowing for endogenous treatment effects of cooperative membership

	Apricots (Uzbekistan)		Grapes (Uzbekistan)		Plums (Uzbekistan)		Maize (Lao People's Democratic Republic)	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Log sales prices								
Sales fresh (fraction)	-1.321***	0.1749	-2.365***	0.2016	-1.264***	0.3632	-0.451***	0.0413
Cultivated hectares	0.039***	0.0072	0.048***	0.0098	0.069***	0.0059	0.004	0.0054
Region	-0.729***	0.1324	0.161***	0.0061	0.337**	0.2033	-0.081	0.0667
Region x hectares	-	-	-0.048***	0.0085	-0.039**	0.0214	0.028***	0.0132
Coop member	0.444*	0.2897	0.149***	0.0168	1.032***	0.2451	0.407***	0.1202
Coop x hectares	-0.050***	0.0107	-0.023***	0.0023	-0.154***	0.0663	-0.026***	0.0120
Intercept	9.610***	0.1545	10.475***	0.1408	8.491***	0.3867	7.361***	0.0298
Incidence of cooperative membership								
Sales fresh (fraction)	0.616	0.859	2.140***	0.808	-2.808	2.220	2.659***	0.802
Cultivated hectares	-0.026	0.043	-0.168***	0.034	-0.210***	0.084	0.079***	0.031
Business income	0.282	0.708	1.244***	0.144	-0.546	0.910	-1.261**	0.672
Region	-	-	-	-	-	-	1**	0
Intercept	-0.688	0.588	-1.487***	2.463	1.861	1.940	-3.713***	0.852
Regression summary statistics								
Rho	-0.444	0.5286	-1.000***	0.0000	-0.328	0.5329	-0.630**	0.2567
Sigma	0.234***	0.0585	0.298***	0.0329	0.333***	0.0747	0.155***	0.0114
Observations	27		47		35		180	
Wald test (p-value)	0.469		0.000		0.569		0.082	

Source: Authors' calculations based on UNCTAD data.

Note: Linear regression with endogenous treatment effects, estimated using Stata etregress procedure. Region = Namangan for apricots, Tashkent for grapes and plums, and Xayaboury for maize. Rejected as insignificant at 85 per cent (*), 90 per cent (**), and 95 per cent (***) confidence intervals. "rho" is the estimated correlation between residuals reported in the outcome and selection equations, "sigma" is the estimated standard error of the outcome equation, and the null hypothesis of Wald test is that rho is equal to 0

Table A.5b Estimation statistics for producer sales prices for herders in Mongolia, allowing for endogenous treatment effects of cooperative membership

	Horses		Goats		Sheep		Cows	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Log sales prices								
Sales live (fraction)	-	-	-0.025	0.0752	-0.141	0.0988	-0.101	0.0772
Herd size (head)	-	-	0.000	0.0001	0.000	0.0002	0.000	0.0002
Region identifiers								
Arkhangai	0.196 ***	0.0891	0.143	0.1500	-0.019	0.1065	0.095	0.1316
Bulgan	0.158 ***	0.0751	0.040	0.0941	0.174 ***	0.0850	0.055	0.0778
Dornod	0.195	0.1524	0.067	0.0541	-0.083	0.1014	0.183 ***	0.0595
Dornogobi	0.399 ***	0.0847	0.031	0.1241	0.488 ***	0.2106	0.028	0.3224
Khentii	-0.015	0.1511	0.050	0.1629	-0.285 ***	0.1411	0.067	0.1623
Selenge	0.282 ***	0.1036	0.147 *	0.0929	0.300 ***	0.1094	0.055	0.1022
Tuv	0.123	0.1170	-0.042	0.0623	0.057	0.0891	0.246 ***	0.0886
Coop member	0.433 ***	0.1279	-0.191 **	0.1083	-0.441 ***	0.1504	0.498 **	0.2568
Coop x herd size	-	-	0.000 *	0.0002	-0.001 ***	0.0003	0.000	0.0004
Intercept	8.206 ***	0.1022	8.351 ***	0.0897	8.698 ***	0.1009	8.476 ***	0.0753
Incidence of cooperative membership								
Sales live (fraction)	-0.433 ***	0.151	0.196	0.352	0.206	0.290	-0.214	0.390
Herd size (head)	0.000	0.000	0.000	0.000	0.001 ***	0.000	0.001 **	0.000
Labour income	-1.725 ***	0.536	-0.307	0.505	-0.611 **	0.337	-1.312 ***	0.528
Intercept	0.254	0.318	-0.813 ***	0.369	-0.896 ***	0.320	-0.748 ***	0.333
Regression summary statistics								
Rho	-0.981 ***	0.0261	0.882 ***	0.1476	0.878 ***	0.1192	-0.712	0.4276
Sigma	0.398 ***	0.0838	0.292 ***	0.0699	0.402 ***	0.0840	0.367 ***	0.1020
Observations	58		68		82		66	
Wald test (p-value)	0.000		0.037		0.009		0.304	

Source: Authors' calculations using UNCTAD data.

Note: Linear regression with endogenous treatment effects, estimated using Stata etregress procedure. Uvurkhangai region assumed as a reference. Rejected as insignificant at 85 per cent (*), 90 per cent (**), and 95 per cent (***) confidence intervals. "rho" is the estimated correlation between residuals reported in the outcome and selection equations, "sigma" is the estimated standard error of the outcome equation, and the null hypothesis of Wald test is that rho is equal to 0

Table A.6 Estimation statistics for producer sales prices for maize in Lao People's Democratic Republic and fruit in Uzbekistan, allowing for endogenous treatment effects of cooperative membership and omitting interaction between cooperative membership and farm size

	Apricots		Grapes		Plums		Maize	
	estimate	standard error	estimate	standard error	estimate	standard error	estimate	standard error
Sales prices (domestic currency per kilogram)								
Sales fresh (fraction)	-8384 ***	2948	-21016 ***	2149	-5497 ***	1514	-635 ***	56
Cultivated hectares	248 *	169	748 ***	194	326 ***	27	4	8
Region	-5155 ***	0	2190 ***	629	936	1020	-10	69
Region x hectares	-	-	-753 ***	187	-186 **	103	3	10
Coop member	3946 ***	0	1455 ***	141	2797 ***	801	586 ***	58
Coop x hectares	-	-	-	-	-	-	-	-
Intercept	11710 ***	1989	20582 ***	2001	5594 ***	1297	1597 ***	46
Incidence of cooperative membership								
Sales fresh (fraction)	0.534	0.953	0.696 ***	0.654	-2.597	2.112	2.726 ***	0.316
Cultivated hectares	-0.122	0.065	-0.222	0.029	-0.272 ***	0.082	0.048	0.057
Business income	0.485 ***	0.078	0.429	0.128	-0.839	0.878	-0.859 ***	0.165
Intercept	-0.435	0.628	0.142 ***	0.539	2.565 *	1.740	-3.509 ***	0.383
Regression summary statistics								
Rho	-1.000 ***	0.000	-1.000 ***	0.000	-0.796 **	0.218	-0.976 ***	0.024
Sigma	3241 ***	520	4128 ***	626	1306 ***	287	240 ***	18
Observations	27		47		35		180	
Wald test (p-value)	0.000		0.000		0.067		0.000	

Source: Authors' calculations based on UNCTAD data.

Note: Linear regression with endogenous treatment effects, estimated using Stata etregress procedure. Region = Namangan for apricots, Tashkent for grapes and plums, and Xayaboury for maize. Rejected as insignificant at the 85 per cent (*), 90 per cent (**), and 95 per cent (***) confidence intervals. "rho" is the estimated correlation between residuals reported in the outcome and selection equations, "sigma" is the estimated standard error of the outcome equation, and the null hypothesis of Wald test is that rho is equal to 0