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Estimating oligopsonistic market power in Uganda's rice industry

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ABSTRACT
The study applies the conjectural variations approach to determine whether Ugandan rice traders exercise oligopsony power in the market for domestic rice. The trader margin for milled rice is found to be 10.20% on average. Using an econometric system of four equations, the null hypothesis of competitive behaviour holds at different price elasticities of farm supply, ranging from inelastic to elastic supply. This implies that there is no evidence that rice traders apply oligopsony power when procuring milled rice from farmers. However, since the study does not examine the existence of trader bargaining power, we cannot completely rule out the existence of market power at this node of the value chain. Therefore, future studies should examine trader bargaining power to be able to ultimately determine if there is need to intervene at this segment of rice value chains to ensure competitive behaviour.

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1. Introduction

Rice is one of the three crops dominating today's global food systems, the other two being maize and wheat (Cordone 2021). During the 2018 High-Level African Ministerial Conference on Rice, African governments reaffirmed their collective policy goal of achieving rice self-sufficiency to avoid a repeat of the food crisis that engulfed the continent in 2008 following a dramatic increase in global food prices (Africa Rice Center 2018). It was noted that demand for rice on the continent exceeds domestic supply, and consumption is projected to reach 35 million tons by 2025, of which 37% will be met by imports. Of the US$21–6 billion needed to achieve self-sufficiency, it was recommended that 80% be invested in increasing farm productivity, and the remaining 20% in strengthening rice marketing by improving processing and storage.

Although investments of such magnitude have the potential to improve the competitiveness of the continent's rice value chains, existence of market power would diminish their impacts. Oligopsony power generally yields low farm prices relative to prices under competitive conditions, thereby depressing market output and raising consumer prices. According to Sexton (2013), severe market power or market power at different segments of a value chain may cause deadweight losses of up to 25% of the total market surplus that would be available under perfect competition. But he also notes that even modest amounts of market power by intermediaries are enough to skew in their favour benefits intended for farmers from programmes aimed at, for instance, enhancing

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research and technology adoption. Huang and Sexton (1996) and Alston, Sexton, and Zhang (1997) have shown that monopsonistic and oligopsonistic processors generally benefit from investments in agricultural research and development at the expense of both producers and consumers. Consequently, market power reduces farmers' incentives to invest in productivity-enhancing programmes. Despite these concerns, the hypothesis of imperfect competition in rural African markets has not been subjected to satisfactory empirical testing (Barrett 2008; Dillon and Dambro 2017).

Since liberalisation of agricultural markets in Africa, it has been alleged that rice traders and processors have been exploiting farmers (Longtau 2003; Kormawa and Toure 2005; Republic of Kenya 2013; Aune et al. 2014; World Bank 2015; Barungi and Odokonyero 2016). As has been the case for other commodities, the allegation has been fuelled by two features of agricultural production, which predispose agricultural markets to market power (Sexton and Lavoie 2001): first, the bulky nature of farm products results in high transportation costs, which in turn restricts farmers to only those buyers located in their proximity. In most of Sub-Saharan Africa (SSA), high transportation costs are also due to the rather poor transport infrastructure in agricultural production sites. This limits the number of buyers purchasing commodities at the farm gate. Dillon and Dambro (2017) refer to this as a natural barrier to entry for additional buyers, leading to a natural oligopsony. For instance, in rural Madagascar, only 6% of rice farmers had access to more than one buyer (Bernier and Dorosh 1993). It was later found that the country's transport costs and rents to spatial arbitrage were substantially high (Moser, Barrett, and Minten 2009). Second, agricultural production is usually characterised by sunk costs and other rigidities that lead to inelastic supply and consequently oligopsony power by buyers of farm commodities. In rice production, a common rigidity is the asset fixity associated with land in the irrigated lowland rice ecology, which may not be suitable for production of other crops. In fact, in an unrelated study, Haile, Kalkuhl, and von Braun (2015) acknowledge this point and exclude rice prices and rice price volatility in modelling worldwide acreage response for key commodities. Unsurprisingly therefore, own-price elasticities of supply of rice are as low as 0.2 in Madagascar (Dorosh and Minten 2006) and South Sudan (Dorosh, Rashid, and van Asselt 2016), 0.03 and 0.16 in South Africa and Egypt, respectively (Haile, Kalkuhl, and von Braun 2015), and about 0.6 on average for Nigeria, Ghana, Burkina Faso, Mali, Uganda, Kenya, Tanzania and Mozambique (Magrini, Balié, and Morales Opazo 2016).

What is the structure of Uganda's rice industry? Is the conduct of rice traders tantamount to exercising oligopsonistic market power? If so, to what degree? This study analyses the degree of oligopsony power held by rice traders in Uganda. Dillon and Dambro (2017) review empirical literature from 1997 to 2015 on the degree of competition in crop markets in SSA. They delineate the literature in four categories: analysis of market prices (to determine the degree of integration between markets, and to examine the price spread in relation to transfer costs), analysis of trader accounts (to measure traders' marketing margins), analyses with farmer and trader survey data (to examine the degree of market concentration, factors associated with trader profits, and trader entry and exit) and experiments and impact evaluations (to examine the presence of trader rents, and the relevance and importance of information on farmer bargaining power). None of these strands of literature reveals evidence of noncompetitive food markets, but the authors acknowledge the inadequacy of each strand. For instance, studies of market integration and market concentration do not provide unequivocal evidence about the degree of competition, while experiments that test the effect of an information intervention assume noncompetitive behaviour by current traders and the existence of barriers to entry by other traders. If carefully undertaken, analysis of traders' marketing margins is very informative, but it involves making assumptions about the level of noncompetitive margins and trader behaviour.

Our study falls in the second category – analysis of trader accounts – and of the six studies reviewed by Dillon and Dambro (2017) in this category, Osborne (2005) is the closest to ours. She analyses imperfect competition in the Ethiopian grain market for teff, wheat, sorghum and barley using the *n*-trader Cournot model of Nash behaviour and finds that traders mark down the price they pay farmers in remote markets by 3%. The model takes the purchases and hence prices of rival traders as given. Our study, however, uses the conjectural variations approach in which a trader presumes that their purchases affect the purchases of rival traders. The approach is rooted in the new empirical industrial organisation literature. Originally developed by Appelbaum (1979, 1982) to assess the degree of monopoly power, the conjectural variations framework has been used in several studies such as Schroeter (1988), Azzam and Pagoulatos (1990), Murray (1995), Morrison Paul (2001), Quagrainie et al. (2003), Wilcox and Abbott (2004), Nzuma (2006) and Rude, Harrison, and Carlberg (2011) to test for oligopsony and/or oligopoly power. Focusing on Africa, Nzuma (2006) finds evidence of oligopoly power in Kenya's maize seed industry, while Wilcox and Abbott (2004) do not find evidence that cocoa traders exert oligopsony power on farmers in Cote d'Ivoire. But Wilcox and Abbott (2004) calculate the conjectural elasticity of each trader using an optimality condition, yet they acknowledge the likelihood of the elasticity varying with factors such as month or season of the year. In this study, we apply the optimality condition associated with the conjectural elasticity, but we model the elasticity as a function of certain variables.

Although the conjectural variations approach is appealing in that it can be used to investigate both the degree of market power and firm conduct and is therefore able to directly link the former to the latter, it has been criticised on several grounds (Majumdar et al. 2011): first, rarely does the estimated value of the conduct parameter exactly equate to any of the three specific firm conduct outcomes – perfect competition, imperfect competition and perfect collusion. This renders the interpretation of the conduct parameter estimate somewhat difficult. In fact, the tendency is for the model to yield a conduct parameter estimate of zero (implying perfect competition) because the generally static nature of the conjectural variations models in which firms concurrently make their output decisions and do so only once means that they do not actually react to each other's actions. Second, the approach quickly becomes intractable when applied to differentiated products markets as opposed to markets of homogeneous products because the number of price elasticities of demand and conjectural elasticities that need to be estimated can be overwhelming. Third, the estimated conduct parameter is sensitive to the underlying data generation process; if the data are not generated by a conjectural variations model, the parameter estimate is not reliable. This is exacerbated by the fact that the approach imposes strong assumptions on the functional form of the underlying functions (Genesove and Mullin 1995). Despite these criticisms, the approach remains a useful tool for modelling market power and firm conduct; for instance, the idea of consistent conjectures has been introduced to ensure that a firm's conjectures at least equate to its rivals' actual reactions (Majumdar et al. 2011). The issue of differentiated products markets does not arise in this study, and we apply a flexible functional form of the underlying profit function.

The study makes two contributions. First, examining market power in Uganda's rice industry is important because of the implications for policy analysis and formulation. The country has formulated the second phase of its National Rice Development Strategy (NRDS II), to be implemented up to 2030. The proposed interventions have generally been predicated on the assumption that the country's rice markets are perfectly competitive. However, should market power exist, the proposed interventions might not yield the expected outcomes. Therefore, the results generated by the study will be informative in contextualising the performance of the NRDS II. Second, a vast majority of studies on rice value chains in East Africa have focused on the behaviour of producers and consumers. Little attention has been given to the mid-stream agents in the value chains. In addition to testing for the existence of oligopsony power, this study provides trader-level information on key parameters such as traded volumes, trading capacity, trader margins and physical distances that characterise wholesale marketing of rice. This information is particularly valuable for industry planners, yet it is difficult to obtain.

We acknowledge that oligopsonistic power is just one form of market power. Another form of market power that might be existent in the rice industry is bargaining power. Bargaining power is the ability of an agent to obtain a concession from another agent in a market transaction through negotiation that may involve a threat to either impose a cost or withdraw a benefit (Kirkwood 2005; Sorrentino, Russo, and Cacchiarelli 2018). It could lead to higher or lower prices relative to those under perfect competition, hence a transfer of surplus (Swinnen 2020). In addition to directly affecting market prices, bargaining power influences other aspects of marketing such as product quality and contracting (Choi and Triantis 2012; Salas 2016; Sorrentino, Russo, and Cacchiarelli 2018), and ultimately governance and performance of value chains. Buyer power has recently become an issue of concern to East African governments. In December 2022, the Ugandan government tabled before parliament the Competition Bill 2022, which addresses noncompetitive behaviour including, but not limited to the misuse of market power by market agents (Government of Uganda 2022). In Kenya, the Competition Act was amended in January 2020 to provide clarity on the enforcement of Abuse of Buyer Power provisions in the Act (Competition Authority of Kenya 2023).

Bargaining power in agricultural markets has been examined extensively, especially in the context of transactions between producers and mid-stream agents including middlemen and processors (see for example, Gervais and Devadoss 2006; Ahn and Sumner 2012; Courtois and Subervie 2014; Ge, Flores-Lagunes, and Kilmer 2015; Salas 2016; Ranjan 2017; Shokoohi, Chizari, and Asgari 2019). Most of the studies have derived and estimated bargaining power parameters by employing the Nash bargaining framework. Others such as Xhoxhi et al. (2014), Fałkowski, Malak-Rawlikowska, and Milczarek-Andrzejewska (2017) and Malak-Rawlikowska, Milczarek-Andrzejewska, and Fałkowski (2019) have relied on farmers' self-reported bargaining power to assess the relationship between farmers and mid-stream, downstream and even other upstream agents such as input suppliers. It would be informative to examine both oligopsonistic and buyer bargaining power in Uganda's rice industry. However, examining buyer bargaining power is beyond the scope of this study as it would require the use of a distinct bargaining framework and a data collection protocol that ensures that the resulting price data conform to bargaining outcomes.

In the next section, we briefly describe Uganda's rice industry, followed by the theoretical model and its econometric implementation in section three. We then present the data and descriptive statistics in section four and discuss the results in section five. Section six summarises and concludes the paper.

2. Overview of Uganda's rice industry

Marketing of locally produced rice in Uganda involves a chain of actors performing the three basic functions of marketing. The three functions of marketing include exchange (price discovery, buying and selling of rice), physical (transportation, storage and processing) and facilitating (information provision, financing, grading and standardisation) functions (Veeman 2009). At the core of these functions are farmers, brokers (also known as agents or collectors), millers, traders (wholesale and retail) and consumers. Figure 1 is a general representation of a typical domestic rice value chain in Uganda.

Generally, smallholder farmers prefer selling milled rice to selling paddy (Nakazi and Sserunkuuma 2013). But most do not own mills, so, they procure milling services from small-scale millers and sell milled rice to local (rural) traders, brokers, millers-cum traders and final consumers. In some cases, however, they sell paddy to rural and urban millers either directly or indirectly through brokers. Brokers are agents that source milled (or paddy) rice on behalf of wholesale traders (or millers). They do not own the rice; they source and deliver rice to the trader/miller upon agreeing on the variety, quantity, quality and the price of rice (to be paid by the trader/miller). The price a broker pays to a farmer is a negotiated price, and therefore the brokerage fees/commission are reflected in the difference between the farmer's selling price and trader's/miller's purchase price. Conceptually, should there be limited competition among brokers, and should their bargaining power be large relative to that of farmers, they would mark down the farmer's price so as to obtain a large commission. In this study, however, we do not focus on brokers because a majority (84%) of traders mainly obtain their rice directly from individual farmers (Barungi and Odokonyero 2016). And in doing so, they inevitably increase competition among brokers.

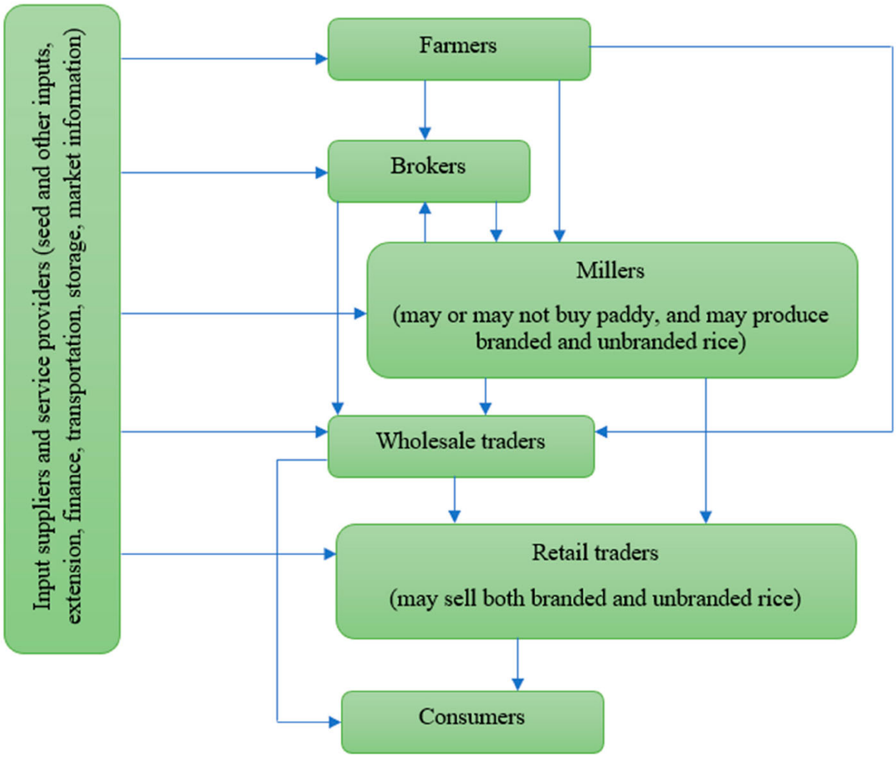

Figure 1. A typical domestic rice value chain in Uganda.

The number of rice farmers in Uganda is estimated at over 95,000 (Ministry of Agriculture, Animal Industry and Fisheries 2020). Small-scale (< 2 ha) and medium-scale (2–6 ha) farmers constitute about 95% and produce about 76% of the country's paddy (Ministry of Agriculture, Animal Industry and Fisheries 2019). The remaining 5% are large-scale, some with estates of more than 1,000 ha, and own rice mills. This indicates the existence of vertical integration between paddy production and milling.

In 2012, there were 645 rice mills in Uganda, of which 74% were stand-alone mills (i.e., without rice farms) that provided milling services and bought and milled paddy for sale as milled rice (Tokida et al. 2014; Kikuchi et al. 2016). By 2018, the total number of mills had grown to 964 (Rice Millers Council of Uganda 2018). Currently, the country has excess milling capacity of about 59% at aggregate level (Barungi and Odokonyero 2016). There are approximately 1060 mills, of which 1030 are small-scale with installed capacity of 1.2 tons of milled rice per hour, and 30 are medium- and large-scale (Barungi and Odokonyero 2016; Nakaweesi 2018; Ministry of Agriculture, Animal Industry and Fisheries 2019). About 52% of small-scale millers sometimes procure paddy for milling in addition to providing milling services (implying that the remaining 48% strictly offer milling services) and 66% of millers also grow paddy, which they mill and sell (Twine et al. 2021). Small-scale millers will typically procure paddy during bumper harvest when the price of paddy is relatively low in order to maximise revenue. However, they are generally averse to buying paddy because they lack information on its quality prior to milling and farmers tend to reject the millers' perception of paddy quality based on the proportion of broken grains after milling. Also, millers hardly purchase milled rice from farmers. Instead, they simply allow farmers to use the milling premises to sell their milled rice to traders and brokers (Nakazi and Sserunkuuma 2013).

The number of milled rice traders (wholesalers and retailers) operating in major public markets countrywide was 4193 in 2012 (Kikuchi et al. 2016). They handle 95% of the rice purchased by consumers, while the remaining 5% goes through supermarkets. According to the authors, wholesalers sell 47 tonnes of milled rice per month on average, compared to 2.3 tonnes for retailers. But it is important to note that about 63% of traders operate as both wholesalers and retailers, 24% as strictly wholesalers and 13% as strictly retailers (Barungi and Odokonyero 2016). Although up-to-date information is unavailable, we believe, based on our knowledge of the rice industry, that traders have increased in number but are still fewer than the number of smallholder farmers. This imbalance may be a catalyst for oligopsony power.

Kijima, Otsuka, and Futakuchi (2013) determined that as the number of millers and traders increased following an increase in farm supply, the market for milled rice became efficient around 2008 as price variations across geographical areas came to depend on transportation costs. But more recently, it has been reported that smallholder farmers perceive the prices they receive for their rice to be unfairly low (Barungi and Odokonyero 2016). They have attributed the low prices to their weak bargaining power because of selling rice individually rather than collectively and because they do not have perfect information about rice prices and the rice market in general. In addition, they tend to sell their rice hastily because they are usually cash constrained at the time of harvest. Therefore, we hypothesise that farmers face oligopsony power in the marketing of rice. Considering that brokers do not own the rice, it is unlikely that they have the incentive to exercise market power. Thus, market power is most likely exercised by traders.

3. Model and empirical estimation

Testing for oligopsonistic behaviour among rice traders involves determining whether they mark down the price they pay for the farmers' rice below its marginal value. Following Rude, Harrison, and Carlberg (2011), assuming perfect competition in the market for traders' rice and for nonfarm inputs, the pricing behaviour of a rice trader in the market for the farmer's rice characterised by oligopsony power requires the trader to maximise profit subject to their production technology:

$$\max \pi_i(p,\ w,\ \boldsymbol{r}) = py_i - wx_i - \boldsymbol{r}\boldsymbol{v_i} \ \ s.t \ \ y_i = f(x_i, \boldsymbol{v_i}) \tag{1}$$

where π_i is profit earned by trader *i*, y_i is quantity of rice sold by the trader, x_i is quantity of rice procured by the trader from the farmer, $\boldsymbol{v_i}$ is a vector of nonfarm inputs, and p, w and $\boldsymbol{r}$ are price received by the trader, price received by the farmer, and a vector of prices of nonfarm inputs, respectively. The profit function in Equation (1) is assumed to be monotonic, non-decreasing in p, non-increasing in w and $\boldsymbol{r}$, and convex and continuous in p and w. If the market for the farmer's rice were perfectly competitive, the optimal pricing decision for the farmer's rice derived from the first order condition for profit maximisation would necessitate the trader to equate their value of marginal product (VMP) to the marginal factor cost (MFC), which would be the market price of the farmer's rice. However, since the trader is assumed to exert some influence on the price they pay to the farmer, the first order condition for profit maximisation with respect to the farmer's rice becomes:

$$p\frac{\partial y_i}{\partial x_i} = w + x_i\frac{\partial w(x)}{\partial x}\frac{\partial x}{\partial x_i} \tag{2}$$

On the left-hand side of Equation (2) is the VMP of the farmer's rice and on the right-hand side is the trader's marginal outlay (MO) – the additional cost of buying an extra unit of rice – also known as the effective marginal cost. The last term on the right hand-side shows that trader *i* conjectures that their purchase of rice affects the purchase of rice by all other traders in the industry. This is known as the conjectural variation, and further algebraic manipulation of Equation (2) results into:

$$p\frac{\partial y_i}{\partial x_i} = w\left(1 + \frac{\theta_i}{\varepsilon}\right) \tag{3}$$

where ε is the industry price elasticity of farm supply of rice and θ_i is the conjectural elasticity of trader *i*; it is trader *i*'s *perceived* percentage change in the rice purchases of all traders in the industry due to a one percent change in his/her own purchases. This is the market conduct parameter in the sense that if the market for the farmer's rice is perfectly competitive, θ_i and hence θ_i/ε would be equal to zero. If the trader is a monopsonist, then $\theta_i = 1$. Thus $\theta_i[0, 1]$. Testing of market conduct essentially requires testing the hypothesis that the conjectural elasticity is equal to zero. If the hypothesis is rejected, the market is noncompetitive, and the degree of market power is simply the deviation of θ_i/ε from zero. From Equation (3), it can be seen that θ_i/ε is the percentage markdown of the farmer's price below the rice's marginal value, and it is a firm-level Lerner-type measure of oligopsony power (Appelbaum 1982; Schroeter 1988; Morrison Paul 2001). At the industry level, the Lerner index for the farmer's rice market can be constructed as illustrated in Morrison Paul (2001): $L = \sum_i \theta_i S_i/\varepsilon$ where S_i is trader i's market share of rice purchases.

Equation (3) is estimated using an econometric model that equates the VMP of rice purchased from the farmer to the trader's MO. Without knowledge of the trader's underlying production function to be able to determine the marginal product of rice, we turn to the duality between profit functions and production functions (Jehle and Reny 2001). As in Quagrainie et al. (2003) and Rude, Harrison, and Carlberg (2011), our econometric model is predicated on a profit function. Assuming the trader's input of rice is quasi-fixed in the short-run because of their capacity constraint, we employ a restricted (short-run) profit function in which profit is a function of output price, input prices and quantity of the quasi-fixed input. The VMP or shadow value of the quasi-fixed input is then calculated as the derivative of the profit function with respect to the quantity of the quasi-fixed input (Behrman et al. 1992; Rude, Harrison, and Carlberg 2011).

Econometric implementation of the restricted profit function requires that we determine and use an appropriate functional form. This is an important consideration because of the implications of functional form on the fulfilment of the theoretical properties of the underlying function. A profit function is fundamentally homogeneous of degree one in prices. However, a restricted profit function is not necessarily linearly homogeneous in the fixed factors, and assuming linear homogeneity in fixed factors implies constant returns to scale – a characteristic of perfect competition (Bergman 1997). Moreover, a technology with constant returns to scale does not invariably guarantee the existence of a profit function. Since this study tests for imperfect competition in the market for the quasi-fixed input, we need a flexible functional form that relaxes the assumption of linear homogeneity in the fixed factor and provides at least a second order approximation of the underlying function.

Bergman (1997) compares the translog and the generalised Leontief flexible functional forms of a restricted profit function, noting that there is no theoretical basis for the notion that the former is not homogeneous of degree one in the fixed factor and the latter is linearly homogeneous. Our preference for the generalised Leontief over the translog is because of the finding that any deviations from actual price elasticities for the generalised Leontief will on average be lower than for a translog specification for an array of underlying production technologies (Thompson and Langworthy 1989; Williamson, Hauer, and Luckert 2004).

Obtaining business-related data from small-scale traders is challenging because they usually do not wish to be interviewed for longer than 20–30 min. Therefore, to ensure reasonable degrees of freedom in the event of getting a relatively small number of respondents agreeing to be interviewed, we opt for a parsimonious specification of the model – one with only two critical non-farm inputs for traders, and for which relatively precise data could be obtained. They include transportation services and jute gunny or woven plastic bags (that can hold up to 80 kg of rice) for transporting and storing rice. Consequently, the generalised Leontief restricted profit function for this study is specified as follows:

$$\pi = \beta_1 p + \beta_2 w^a + \beta_3 w^b + 2\beta_4 (p \cdot w^a)^{\frac{1}{2}} + 2\beta_5 (p \cdot w^b)^{\frac{1}{2}} + 2\beta_6 (w^a \cdot w^b)^{\frac{1}{2}} + \beta_7 x_f^2 + \beta_8 p \cdot x_f + \beta_9 w^a \cdot x_f + \beta_{10} w^b \cdot x_f \quad (4)$$

where w^a, w^b and x_f are price of input a, price of input b, and quantity of rice purchased from farmers, respectively, and β_1, .., β_{10} are parameters to be estimated. If well-defined, the profit function should be increasing in output price and decreasing in input prices. Using Hotelling's lemma, the following output supply and factor demand equations are obtained:

$$\frac{\partial \pi}{\partial p} = y = \beta_1 + \beta_4\left(\frac{w^a}{p}\right)^{\frac{1}{2}} + \beta_5\left(\frac{w^b}{p}\right)^{\frac{1}{2}} + \beta_8 x_f \tag{5}$$

$$\frac{\partial \pi}{\partial w^a} = -x_a = \beta_2 + \beta_4\left(\frac{p}{w^a}\right)^{\frac{1}{2}} + \beta_6\left(\frac{w^b}{w^a}\right)^{\frac{1}{2}} + \beta_9 x_f \tag{6}$$

$$\frac{\partial \pi}{\partial w^b} = -x_b = \beta_3 + \beta_5\left(\frac{p}{w^b}\right)^{\frac{1}{2}} + \beta_6\left(\frac{w^a}{w^b}\right)^{\frac{1}{2}} + \beta_{10} x_f \tag{7}$$

where x_a is quantity of input a, and x_b is quantity of input b. As can be seen in Equations (5)–(7), the profit function imposes symmetry in output supply and input demands. Convexity of the profit function in prices requires that the Hessian matrix of the second-order partial derivatives be positive semidefinite, and that own-price effects be positive for output supply and negative for input demand. However, these conditions may not hold in empirical studies if input markets are not competitive and imposing them on a Leontief profit function would make the function restrictive (Williamson, Hauer, and Luckert 2004).

Testing for oligopsonistic behaviour in the procurement of rice requires the inclusion of Equation (3), in which the price offered to farmers is endogenous in the system of equations to be estimated. Equation (3) can be re-written as $w^f\left(1 + \frac{\theta}{\varepsilon}\right) = \frac{\partial \pi}{x_f}$ where w^f is the purchase price of rice. Thus:

$$w^f = (2\beta_7 x_f + \beta_8 x_f + \beta_9 w^a + \beta_{10} w^b)/\left(1 + \frac{\theta}{\varepsilon}\right) \tag{8}$$

We estimate the system of Equations (5)–(8). To do so, however, requires information about ε and θ. Following Azzam and Pagoulatos (1990), we obtain and impose a scalar value for ε from the literature. Regarding θ, we postulate that it is a function of the distance between the trader's town and place from where they procure rice, d, the trader's maximum trading capacity, c, the number of years of experience in rice trading, t, and the trader's age, z, and can therefore be specified as:

$$\theta = \alpha_0 + \alpha_1 d + \alpha_2 c + \alpha_3 t + \alpha_4 z \tag{9}$$

The distance between the trader's business premises and the place from where they normally procure rice captures the remoteness of rice farmers. Considering the poor network and quality of most rural feeder roads in Uganda, the trader is likely to have a positive conjecture about rival traders' reactions to his/her purchase decisions. That is, the trader will perceive a reduction in rival traders' purchases of rice following a decrease in his/her purchases and vice-versa, hence a reduction in competition. The trader's maximum trading capacity is a proxy measure of their ability to compete with existing rivals. A trader with a relatively large maximum trading capacity is likely to enjoy significant cost economies (scale, scope and utilisation), and in turn greater profitability. This may give the trader positive conjectural variations. The number of years of experience in rice trading is an indicator of the trader's stock of knowledge of the rice industry, including the trader's knowledge of how rival traders will respond to his/her purchase decisions. In fact, a pertinent assumption of the conjectural variations framework is that in long-run equilibrium, firms learn from experience so as to maintain correct (consistent) conjectures about each other's reactions (Koutsoyiannis 1984). Therefore, experience in rice trading shapes the trader's conjectures about other traders' reactions and the conjectures could be positive, hence dampening competition or negative, hence intensifying competition. The age of the trader captures their potential investment in human capital. The Ugandan government and its development partners involved in agricultural value chain development are particularly targeting the youth for skills enhancement to improve entrepreneurship in agribusiness in an effort to counter the bulging youth unemployment rate (Republic of Uganda 2017). Enhanced entrepreneurial skills may increase or reduce competition.

Equation (9) is substituted into Equation (8). To determine if $\theta = 0$, hence perfect competition, the fitted (predicted) values, $\hat{\theta}$, and their standard errors are evaluated at the sample means and their statistical significance is inferred from the chi-square statistic. Statistical insignificance of $\hat{\theta}$ is the necessary condition for perfect competition. A sufficient condition for $\theta = 0$ is the null hypothesis that $\alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. We test the null hypothesis against the alternative that not all the coefficients are equal to zero.

We use nonlinear least squares to fit the system of equations. However, an issue of concern in our model is the potential endogeneity of rice purchases from farmers. Potentially strong predictors of rice purchases and which are unlikely to be correlated with the errors in the main equations are retail price of imported rice in the major market in which the trader sells their rice, wholesale price of maize in the trader's market, and presence of extra (rental) grain storage facilities accessible to the trader.

4. Data and descriptive statistics

To study market power necessitates clearly defining the market in terms of both geography and product form. The relevant geographic dimension of the markets under study are the Eastern and Northern Uganda rice markets. Marketing of rice in Eastern and Northern Uganda is hampered by poor roads and road networks, which makes most of the farmers' markets highly localised. Regarding product form, the study focuses on milled rice rather than paddy because farmers in Eastern and Northern Uganda prefer selling the former to selling the latter in order to obtain higher profits.

The survey was undertaken in the period July–November 2021 in the country's major rice growing districts of Namutumba, Busembatia, Pallisa, Kibuku, Mbale, Bulambuli, Kumi, Bukedea, Soroti, Lira, Kwania and Oyam. In each location, all milled rice wholesalers of the Supa variety, a variety that is by far the most popular among Ugandan consumers and which is normally harvested from October to early January, were identified and those willing to participate in the study were interviewed through face-to-face interviews. Nearly a total of 500 wholesale buyers of locally produced Supa rice were identified in the various study localities but data were obtained from 213 of them. Thus, the number of interviewed traders is fairly representative of wholesale traders dealing in locally produced Supa rice in the region. Although each trader procures rice from multiple locations and at different points in time during the season, they do not face substantial intra-season variation in buying price. Because none of the traders interviewed kept records of their transactions, the aided recall technique was used to elicit responses to questions on volumes and prices of rice traded, and quantities and prices of inputs used, and the period for which data were obtained was restricted to the month preceding that of the interview.

Variables used to estimate the model are described in Table 1 and their summary statistics are presented in Table 2. Data on inputs were obtained for those inputs and marketing services used by all traders, and for which costs were incurred and could be accurately recalled. Traders pay for transporting rice to their shops, but they mostly use bicycles and motorcycle services (boda boda), both of whom are paid according to the number of bags carried. Therefore, we calculate the unit cost of transporting bags (sacks) of rice as a proxy for the cost of transportation services. The other major input is jute gunny or woven plastic bags. On average, the cost of transportation services is 73% of total variable cost, while the cost of jute gunny/woven plastic bags is 27%.[1] Other costs such as rent, annual trading license fees and market dues are fixed costs and hence irrelevant to the analysis.

Traders buy milled rice at an average of USh 2422 per kilogram and sell it at a wholesale price of USh 2669 per kilogram, hence a marketing margin of 10.20%. If determined through markup pricing,

Table 1. Description of variables used in the regression model.

Variable	Description
y	Quantity of milled rice sold by trader (kg)
p	Price of milled rice received by trader (USh/kg)
w^a	Cost of transporting rice (USh/bag)
w^b	Price of jute gunny/woven plastic bags (USh/bag)
x_f	Quantity of milled rice bought by trader (kg)
x_a	Number of rice sacks transported as a proxy for transportation services
x_b	Number of jute gunny/woven plastic bags used
w^f	Purchase price of milled rice offered by trader (USh/kg)
d	Distance from point of purchase to major town where trader sells rice (km)
c	Maximum amount of rice the trader could have purchased in the reference period (kg)
t	Number of years the trader has been in the rice business
z	Age of the trader (years)

USh denotes Uganda Shillings.

margins may result from market power of middlemen and may consist of absolute amounts combined with fixed percentages of the retail price (Wohlgenant 2001). On average, transportation services cost USh 830.27 per sack (USh 8.30 per kilogram), while jute gunny/woven plastic bags cost USh 1027.25 per bag. The ranges of data for transport costs and the cost of bags are rather wide; USh 133–2000 for the former and USh 200–5000 for the latter. These figures are not outliers. Transport costs vary with the mode of transport and location of the trader's shop; use of bicycle services attracts relatively low costs, while use of motorcycles attracts relatively high costs. Traders operating in rural areas incur less transportation costs than those operating in urban centres. The cost of bags varies with the quality of bags, their source (rural or urban areas) and whether or not the bags are purchased as brand new or used. Traders supplying urban markets and institutions tend to use new and good quality bags, while those operating on a small scale and selling mostly to rural markets purchase used and poor-quality bags.

Traders have been in the rice business for eight years on average and are above the Uganda government age definition of youth of 18–30 years (Uganda Bureau of Statistics 2020). The distance between point of purchase and major urban centres is substantially large (25 km), and the price elasticity of farm supply of rice obtained from the literature is 0.60 (Magrini, Balié, and Morales Opazo 2016). These two factors combined are potential catalysts of oligopsony power in rice value chains.

5. Results and discussion

Since the performance of agricultural traders in Africa has been found to depend on factors such as social capital (Fefchamps and Minten 2001), we suspect rice purchases to be potentially endogenous. Therefore, we obtain and apply its predicted values using the retail price of imported rice, wholesale price of maize, and trader's access to extra storage space as its instruments in the two-step

Table 2. Summary statistics of variables used in the regression model.

Variable	Mean	Std. Dev	Min	Max
y	16,850.61	30,060.32	100	200,000
p	2669.01	247.68	2200	3300
w^a	830.27	415.86	133	2000
w^b	1027.25	316.66	200	5000
x_f	21,885.89	36,897.55	300	240,000
x_a	460.76	2737.35	3	36,400
x_b	135.54	275.70	3	2000
w^f	2421.83	231.94	1900	3000
d	24.93	28.40	0	167
c	22,016.06	36,947.63	200	240,000
t	8.13	6.52	0.50	34
z	36.97	8.59	21	69

procedure of the two-stage least squares estimation. The instruments and all other exogenous variables are included in the first step and all instruments are found to be strongly correlated with rice purchases. Regression results for the system of nonlinear Equations (5)–(8) are presented in Table 3.

The parameters for milled rice supply with respect to transportation costs and the price of jute gunny/woven plastic bags are negative as expected but insignificant. The coefficient on the quasi-fixed input (rice purchases from farmers) is positive and statistically significant at one percent in the rice supply equation. The milled rice supply function is upward sloping (that is, increasing in the price of rice received by the trader) and is therefore consistent with profit maximisation. The cross-price effects between demand for transportation services (demand for jute gunny/woven plastic bags) and price of jute gunny/woven plastic bags (price of transportation services) are statistically insignificant. Having obtained several null effects, we undertake a test of the joint significance of slope coefficients to determine if the model is robust enough for testing of the main hypothesis – the existence of oligopsony power. Our null hypothesis is that $\beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$. We obtain a chi-square statistic of 17.60 with a *p* value $\equiv P\,[\chi^2\,(7) > 17.60] = 0.014$, implying that the slope coefficients are jointly statistically significant at five percent, and therefore the model can be used to examine market power.

A test of the null hypothesis of no oligopsony power yields a chi-square statistic of 0.08 with a *p* value $\equiv P\,[\chi^2\,(5) > 0.08] = 0.999$. Thus, we fail to reject the null hypothesis; Ugandan wholesale traders of the Supa rice variety behave competitively in procuring milled rice from farmers. Two probable

Table 3. Nonlinear least squares parameter estimates.

Parameter	Estimate	z-value
β_1	2293.75	0.29
	(7892.21)	
β_2	261.47	0.09
	(2865.83)	
β_3	482.39	0.07
	(6892.97)	
β_4	−181.15	−0.07
	(2670.87)	
β_5	−386.20	−0.07
	(5161.75)	
β_6	107.71	0.04
	(2786.55)	
β_7	1.47	0.09
	(16.49)	
β_8	0.65***	3.16
	(0.20)	
β_9	−0.02	−0.75
	(0.03)	
β_{10}	−0.003	−0.14
	(0.02)	
α_0	9.23	0.29
	(31.81)	
α_1	0.06	0.09
	(0.68)	
α_2	0.0001	0.10
	(0.001)	
α_3	−0.56	−0.06
	(9.01)	
α_4	0.52	0.07
	(7.83)	
N = 173		
R^2 for Equation (5) = 0.08		
R^2 for Equation (6) = 0.02		
R^2 for Equation (7) = 0.08		
R^2 for Equation (8) = 0.71		

Figures in parentheses are standard errors. *** denotes significant at one percent.

reasons are that the nonperishable nature of rice enables farmers to bargain or wait for better prices, and they have the option of profitably selling the rice as either milled rice or paddy (Nakazi and Sserunkuuma 2013) depending on market conditions. Given the seemingly competitive nature of this market, we are not surprised to find that 76% of traders offer credit to farmers and 63% interlink credit with rice purchases by accepting repayment in-kind. Moreover, 69% of traders have informal or formal contracts with farmers that specify conditions for buying rice including amount, price and time. Competition increases the incentive for traders to provide credit, contracts and better contract terms even in the case of interlinked credit-product transactions (Swinnen 2020).

As in Rude, Harrison, and Carlberg (2011), we undertake sensitivity analysis with respect to the price elasticity of farm supply. Since farm supply is already price inelastic, we reduce the elasticity only slightly by about 7%, but increase it to one to make farm supply elastic. The results are presented in Table 4. In either case, the results are quite similar, and traders still behave competitively. For $\varepsilon = 0.56$, a test of the null hypothesis of no market power gives a chi-square statistic of 0.17 with a *p*-value of 0.999, while for $\varepsilon = 1.00$, the chi-square statistic is 0.09 with a *p*-value of 0.999. These results are logical because if traders behave competitively when farm supply is price inelastic, they are unlikely to exercise oligopsony power when farm supply is elastic.

Generally, our results lend support to previous studies that have not found any evidence of market power in Africa's crop markets. But since we have not investigated the possibility that traders exercise oligopoly power, we are cautious not to generalise our results beyond the

Table 4. Nonlinear least squares parameter estimates with $\varepsilon = 0.56$ and $\varepsilon = 1.00$.

Parameter	$\varepsilon = 0.56$ Estimate	z-value	$\varepsilon = 1.00$ Estimate	z-value
β_1	2293.71	0.23	2427.65	0.29
	(9812.26)		(8232.50)	
β_2	261.47	0.10	351.84	0.15
	(2564.09)		(2393.43)	
β_3	482.43	0.05	487.61	0.07
	(9328.93)		(7250.09)	
β_4	−181.07	−0.06	−221.85	−0.09
	(2817.95)		(2417.50)	
β_5	−386.22	−0.06	−391.74	−0.07
	(6661.80)		(5381.40)	
β_6	107.71	0.03	112.59	0.04
	(3239.26)		(2728.36)	
β_7	1.53	0.06	1.71	0.02
	(25.73)		(93.44)	
β_8	0.65***	2.64	0.65***	2.96
	(0.24)		(0.22)	
β_9	−0.02	−0.87	−0.02	−0.80
	(0.02)		(0.02)	
β_{10}	−0.003	−0.10	−0.003	−0.12
	(0.03)		(0.02)	
α_0	8.92	0.34	17.50	0.15
	(26.17)		(116.06)	
α_1	0.06	0.05	0.11	0.02
	(1.14)		(6.28)	
α_2	0.00009	0.06	0.0002	0.02
	(0.001)		(0.009)	
α_3	−0.54	−0.08	−1.05	−0.02
	(6.92)		(61.42)	
α_4	0.50	0.05	0.97	0.01
	(9.56)		(73.18)	
N = 173				
R^2 for Equation (5) = 0.08				
R^2 for Equation (6) = 0.02				
R^2 for Equation (7) = 0.08				
R^2 for Equation (8) = 0.71				

farmer-trader relationship. When farmers receive low prices from traders, it is probably because of certain policy shocks such as the abrupt tax exemptions on imported white and brown rice, which tend to exert downward pressure on farm prices. Also, it is possible that trader market power is localised. Within a region are districts and within a district are counties (and municipalities in some districts), sub-counties (divisions in the case of municipalities), parishes (wards in municipalities) and villages (cells in municipalities). A farmer may be unable to switch from one trader to another within a region when faced with a price lower than the competitive price. Moreover, the different geographical units within a region could uniquely influence the purchasing decisions of a trader. For instance, a trader might not mark down the price they pay to a farmer living in the same village as the trader but could do so to a farmer in a different sub-county. We can see from our results in Table 3 that the coefficient on distance is positive and statistically significant, implying that the remoteness of areas from where rice is procured reduces competition. Therefore, estimating the model for subsamples based on smaller geographical units would be informative. However, given our small sample of 213 observations, estimating the four-equation system would be fraught with the problem of micronumerosity and our results would not be credible.

6. Summary and concluding remarks

The study applies the conjectural variations model to cross-sectional data from Ugandan rice traders to investigate oligopsony power in the wholesale market. We find relatively low trader margins and no evidence of oligopsony power despite the price inelastic farm supply of rice, the absence of rice marketing cooperatives that would serve as the competitive yardstick, and the perception by some farmers and other industry actors that middlemen exploit farmers. We believe that farmers' preference for selling milled rice to selling paddy enables them to avoid oligopsony power, since milled rice has more and widely varying market outlets than paddy. But further research is needed to ascertain this.

This study is timely, and the results are relevant for policy formulation and industry interventions. The NRDS II proposes several interventions aimed at improving, among other things, farm productivity and incomes. If the interventions are implemented, it is expected that farmers will benefit, considering the absence of oligopsony power. However, since the study does not examine the existence of trader bargaining power, we cannot completely rule out the existence of market power at this node of the value chain. Therefore, future studies should examine trader bargaining power to be able to ultimately determine if there is need to intervene at this segment of rice value chains to ensure competitive behaviour.

At a broader level, this study provides evidence to inform the ongoing debate about the need for the government to revitalise marketing cooperatives. The National Planning Authority (2018) observes that the government's efforts to support cooperatives have not yielded much, and cooperatives remain weak organisations. Besides the usual problems associated with traditional cooperatives, it might well be that in the absence of noncompetitive behaviour, cooperatives currently have no role to play as a competitive yardstick in the market. To unequivocally draw such a conclusion, however, necessitates that rigorous testing of market power – both oligopsony and buyer bargaining power – be undertaken and for more food commodities, while also investigating the performance of the brokerage system that to a certain degree undertakes the functions of cooperatives.

A key limitation of this study is that in trying to make the analysis tractable and ensure we could collect the needed data, we considered only one variety, Supa, which can only be grown in the irrigated lowland ecology. It is a late maturing variety that takes up to six months and is therefore grown twice a year at most. Since it is the most popular variety on the market and is grown under irrigation, it is available almost all year round, meaning that seasonality is not a significant issue in this analysis. However, it would be informative to extend our analysis to the varieties for which supply fluctuates seasonally, to be able to account for the effects of seasonality. Specifically, these are varieties grown under upland and rainfed lowland ecologies.

Note

1. Since our model treats milled rice purchased from farmers as a quasi-fixed input, we find the associated quasi-fixed cost to be large enough to merit separate treatment and is therefore not subsumed in total variable cost.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon request.

Ethics declaration

The research was undertaken collaboratively by Uganda's National Agricultural Research Organization (NARO), a semi-autonomous organisation responsible for all agricultural research in Uganda, and the Africa Rice Center, a member of the CGIAR Consortium. Ethics approval for research conducted in Uganda may be provided by the Uganda National Council for Science and Technology (UNCST). UNSCT recommends that in the case of international collaborative research, ethics approval should be provided by the local Research Ethics Committee because of its better understanding of the cultural sensitivities of the population and because it is better placed to monitor compliance. However, this study did not fall under the category of studies for which NARO was to seek ethics approval because it did not include any of the following:

(a) Research requiring access to animals, plants, or any natural resources of the country
(b) Health research involving human subjects
(c) Experiments involving or leading to genetically modified organisms
(d) Data collection from communities living in protected areas

A letter was provided by NARO to each enumerator to present to the respondents. It introduced the purpose of the survey and informed the participant of the voluntary nature of their participation in the survey. Therefore, before interviewing respondents, informed consent from the respondents was obtained and respondents who accepted to be interviewed were informed that they were free to withdraw from the interview at any time if they so wished. Also, respondents were assured that their information would remain confidential. The data will be made available in accordance with the CGIAR Open Access and Data Management Policy.

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