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Price Gap along the Ugandan Coffee Value Chain

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Relation between price transmission and structure of agricultural markets is strongly debated in the literature and no consensus has been reached about symmetry, degree of such transmission and its mechanisms, so that further research is needed. This paper tests whether in markets where infrastructure quality is poor and transport costs are relevant, geographic dispersion of smallholder farmers allows traders to exploit their market power against farmers with a large impact on market structure and reduction of farmers' welfare.
Following the intuition of (Fafchamps et al., 2005), (Sexton, 2013) and (Swinnen and Vandeplas, 2014), the study provides a structural approach based on a set of well-founded behavioural equations to evaluate whether spatial oligopsony power is prevailing in agricultural markets and in case how strong it is. The paper designs also a far-reaching empirical test of the hypotheses through the seemingly unrelated regression technique. Moreover, it provides a strong empirical base to value chain studies, by exploiting the database of the Living Standard Measurement Study. The paper addresses the issue of transportation infrastructure as hindering factor of development in Uganda as outlined in several reports by World Bank, FAO and MAFAP and assesses the costs of such bottleneck, which are larger than transport expenditures.
Results confirm that geographic dispersion of smallholder farmers plays a significant role on price margin and that there is room for local oligopsony, because traders overcharge transport and transaction costs to farmers.

Keywords: coffee value chain, wholesale-farm gate price spread, spatial dispersion, revenue distribution, traders' market power
JEL codes: O13, Q12, Q13

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Introduction

Coffee, after petroleum, is the commodity with the highest turnover in international trade. Annual value of export revenues exceeds US$10 billion while annual retail sales of coffee are estimated at approximately US$50 billion. It is a highly labour intensive industry employing an estimated 100 million people in over 60 developing countries. It is particularly important to African economies, which represent a large share of exporting countries and is often a vital source of export revenues and income to producers, many of whom are smallholders (Collinson et al., 2005, 13).

The attempt of some governments to liberalize in the last few decades at least partially domestic agricultural markets, to integrate and upgrade their status in the global value chain is relevant for impact assessment of the structure of agricultural value chain on social welfare and development perspectives of developing countries. Due to this process the role of state-owned enterprises shrank and it was allowed to national and international private companies to participate in production, distribution, export of several agricultural products. Nevertheless, in many cases transition was not well managed: previously state-controlled markets did not turn in competitive ones, but in oligopsonistic markets with a large number of farmers and very small numbers of private or public traders (Fafchamps and Hill, 2008, 2).

Distribution of revenues along the value chain is of key interest for policy-makers, since modalities of participation of smallholder farmers in the value chain can be important in terms of poverty reduction and welfare and for regional food security. i.e. quantity and price of food supplied on the markets (Fafchamps and Hill, 2008, 2). Indeed, a larger or smaller spread can provide different incentives to farmers to cultivate some crops, to invest in order to increase productivity and yields as well as to market agricultural products.

In particular, coffee plays a significant role in the economy of Uganda in spite of several attempts by the government to diversify the national productive structure. This sector has a significant impact in terms of fight against poverty and income security, because coffee production is almost entirely dependent on about 500,000 smallholder farmers, 90 % of whose average farm size ranges from less than 0.5 to 2.5 hectares (MAFAP, 2012a, 5-6) (UCDA, 2015).

The paper tests whether in markets where infrastructure quality is poor and transport costs are relevant, geographic dispersion of smallholder farmers allows traders to exploit their market power against farmers with a large impact on market structure and reduction of farmers' welfare. In this context, investments in infrastructure quality can foster competition, by reducing traders' market power, and curb poverty of rural areas.

The response variable which was chosen in order to assess the existence and the degree of spatial oligopsony is the wholesale-farm gate price spread, i.e. the difference between the wholesale export or domestic price net of marginal transport costs and the farm gate price. Several factors as small plot size hold by farmers, shortage of inputs, distance can affect such a spread. The paper disentangles the impact of such components.

Following the intuition of (Fafchamps et al., 2005), (Sexton, 2013) and (Swinnen and Vandeplas, 2014), the study provides a structural approach to evaluate whether spatial oligopsony power is prevailing in the market and how intense it is.

By building upon (Sexton, 1990), the study brings an original contribution to the literature, since (Sexton, 1990) develops just a theoretical model and it is not interessed to do any econometric exercise. (Sexton, 1990) employs a single spatial price gap equation instead of a system of well-founded behavioural equations in agricultural markets, which is indeed a major improvement delivered by this paper.

Moreover, in this analysis the approach to spatial price gap determination is combined with the oligopsony modelling and SUR technique in order to produce empirically testable hypotheses. Without such transformations the approach by (Sexton, 1990) cannot be employed for any empirical exercise. Indeed, the idea of the role of distance is taken from (Sexton, 1990) and introduced in an original way in a more sophisticated model, which is micro-founded at three levels, i.e. demand and supply of agricultural commodities by traders and farmers as well as conditional demand of inputs by farmers.

At the same time, the SUR estimation technique is not applied in the same way like in other oligopoly or oligopsony analyses. Indeed these previous articles ignore completely the issue of distance, which implies different problems of derivation and interpretation to be tackled. Seemingly unrelated regression framework is useful, in order to exploit simultaneity between equations and increase efficiency. Tests give proof that there is a significant correlation among the equations and that the empirical approach is justified.

Moreover, in this work there is a contribution in terms of empirical methodology, since SUR technique is run on a panel dataset, which is an econometrically sound, but a rarely employed approach. This work exploits a rich microeconomic database (World Bank, 2015) and provides a strong empirical base to value chain studies.

Finally, the paper addresses the issue of transportation infrastructure as hindering factor of development in Uganda as outlined in (Gollin and Rogerson, 2010), (MAFAP, 2012a), (MAFAP, 2012b) and (Ranganathan and Foster, 2012) and assesses the costs of such bottleneck, which are larger than transport expenditures. Results confirm that geographic dispersion of smallholder farmers plays a significant role on price margin and that there is room for local oligopsony based on transport and transaction costs.

Literature review

Relation between price transmission and structure of agricultural markets is strongly debated in the literature and no consensus has been reached about symmetry, degree of such transmission and its mechanisms (Vavra and Goodwin, 2005) (Meyer and Cramon-Taubadel, 2004).
Transmission between international and domestic prices and vice versa is referred as *spatial price transmission*, while transmission of price from consumers, triggered from demand shocks, to producers and vice versa is defined as *vertical price transmission* (Swinnen and Vandeplas, 2014).
A first contrast among researchers is about symmetry of price transmission. On the one hand, a branch of literature points out that symmetry is prevailing in the market (Ben-Kaabia and Gil, 2007) (Serra and Goodwin, 2003). On the other hand, some authors support the view that agents in the market pass more likely downstream price decreases than increases and pass on changes with delay (Vavra and Goodwin, 2005) (Zachariasse and Bunte, 2003) (Abdulai, 2000) (Abdulai, 2002) (Abdulai, 2000) (Frey and Manera, 2007). A further point of conflict among economists who show significant asymmetry and imperfection in the market concerns the mechanisms of price transmission.
Imperfect spatial transmission has been attributed to government intervention as tariffs and price stabilization measures, transport and marketing costs, degree of processing, market structure and consumer preferences (Rapsomanikis and Mugera, 2011), while imperfect vertical transmission to market failure and exercise of market power by processing companies or retailers (Wohlgenant, 2001) (Meyer and Cramon-Taubadel, 2004).
For instance, in the EU prices increase in 2007/2008 was passed on to consumers, but decrease in 2008/2009 was not fully transmitted, hindering demand recovery and exacerbating negative impact of declining producer prices on farm household (European Commission, 2009). European Commission stressed that such discrepancies in price transmission were due to an excessive number of intermediaries along the value chain and inequalities in bargaining power between contracting parties (European Commission, 2009).
Nevertheless, this point cannot be always generalized, since the fact that producer prices vary more than consumer prices does not necessarily imply asymmetric changes (Swinnen and Vandeplas, 2014) (Bukeviciute et al., 2009).
Existing literatures focuses on consumer welfare and assumes a positive correlation between degree of downstream vertical price transmission and consumer welfare. Indeed, a lower degree of price transmission would imply a larger share of rents captured by powerful intermediaries in the chain (Swinnen and Vandeplas, 2014, 3-4).
(Sexton, 2013) points out that increasing concentration, vertical coordination in food industry worldwide and growing relevance of differentiated products in terms of taste, appearance, brand appeal, fairness of production process and environment sustainability make easier to support the view that monopolistic competition is prevailing in the market. In this environment some firms are able to exert some market power and set prices with a significant impact on welfare and

rent distribution among the actors involved in the value chain (Swinnen and Vandeplas, 2014) (Swinnen and Vandeplas, 2010) (Kikuchi et al., 2015) (Mesa and Gómez, 2011) (Fałkowski, 2010) (Osborne, 2005). According to this branch of literature several agricultural markets are oligopolistic or oligopsonistic and concentrated processors capture welfare against small and dispersed farmers.
Moreover, other authors express the view that asymmetry in price transmission is not due to exploitation of market power, but to vertical coordination, increasing returns to scale, risk-mitigating behaviour of agents and degree of processing (Swinnen and Vandeplas, 2014) (Wohlgenant, 2001) (Weldegebriel, 2004) (McCorriston et al., 2001) (Wang et al., 2006). In particular, the more stages in vertical market structure, the lower the pass-through of price changes along the value chain, independently from exploitation of market power by agents (Peltzman, 2000) (McCorriston and Sheldon, 1996) (Wang et al., 2006).
Disruptions in price transmission can also occur when there are large menu costs as advertising and labelling, information asymmetries and uncertainty about whether the shock is transitory or permanent (Ball and Mankiw, 1994) (Zachariasse and Bunte, 2003) (Owen and Trzepacz, 2002) (Levy et al., 1997) (Levy et al., 2002) (Blinder et al., 1998).
(Ball and Mankiw, 1994) point out that firms increase prices more quickly than decrease them, because they react to accumulated and anticipated inflation, particularly relevant in case of positive shocks.
Furthermore, actors can be reluctant to change prices because of reputation costs, inventory or selling strategies. Indeed, they are not sure whether competitors will do the same. Moreover, frequent price changes can reduce reputation and actors can postpone such adjustment to be sure that the shock is permanent (Blinder, 1994).
Such delays in price transmission could also come from risk minimization in inventory management. If prices reduce much and quickly, traders or retailers can run out of stock; if they increase suddenly, agents can be left with much unsold spoiled product (Ward, 1982) (Reagan and Weitzman, 1982).
Interpretation of the link between price transmission and market structure is ambiguous according to some researchers. For instance, Wang et al. stress that the interaction between industry technology and market power is puzzling and that in case of economies of scale price transmission can be stronger, weaker or identical to the competitive case (Wang et al., 2006).
Moreover, in most of countries agricultural markets are subject to large public intervention. If agents have expectation that government will more likely intervene if shocks reduce producer price rather than they increase it, expectation-induced price transmission could be asymmetric (Kinnucan and Forker, 1987). A relevant role is played in small and open economies by external shocks which determine prices at the wholesale level (Vavra and Goodwin, 2005). Such disruptions are more relevant in developing countries than advanced economies, given higher adjustment and transaction costs in the former group and that external shocks play a key role in small producer countries (Vavra and Goodwin, 2005). Some authors argued that both consumers

and producers in developing countries were hurt by food price spikes over the period 2007-2011, because farmers did not get significant benefits from high prices. Nevertheless, in this context empirical results of the effect of price volatility on consumers and farmers welfare as well as food security are mixed (Swinnen and Vandeplas, 2014).

In some industries oligopolistic or oligopsonistic structure can be offset by economies of scale with higher price transmission than expected (McCorriston et al., 2001).

(Sexton, 2013) and (Crespi et al., 2012) emphasize that in today's agricultural markets to guarantee consistency and strict adherence of products and production processes to quality and safety standards is crucial. Therefore, exploitation of short-run oligopsony power by buyers against farmers could be detrimental to their long-run interests because such strategy reduces resources available in production and prevent enforcement of adequate standards (Crespi et al., 2012).

(Sexton, 2013) expresses the view that in high-quality supply chain, where buyer sunk and transaction costs for finding new suppliers are high, such buyers can opt for vertical integration or pay farmers as much and even more than in a competitive market.

(Swinnen and Vandeplas, 2014) show also that buyers can pay to farmers efficiency premia to ensure quality standards in environments with unequal bargaining power and market imperfections. Price transmission depends then on nature of vertical coordination and different types of transaction costs in the supply chain (Swinnen and Vandeplas, 2014). Moreover, partial price transmission can also take place in competitive markets due to intertemporal optimizing behaviour by agents, who respond more quickly to price increase than decrease (Azzam, 1999).

In general, empirical evidence about the process of price transmission along the value chain seems to be inconclusive and varies widely across countries and commodities, so that further research is needed (Vavra and Goodwin, 2005) (Meyer and Cramon-Taubadel, 2004).

In particular, some robustness analysis is necessary, because in some industries the functional form of costs determines the level of price transmission, unless there is a relevant knowledge about cost formation (Weldegebriel, 2004). This paper aims at testing the empirical hypothesis whether, in markets where infrastructure quality is poor and transport costs are relevant, geographic dispersion of smallholder farmers allows traders to exploit their market power against farmers with a large impact on market structure and reduction of farmers' welfare.

The result of the study is that traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers. Farmers are not able to skip traders in the value chain, because a significant information asymmetry is prevailing in the market. Traders exploit farmers' ignorance because the latter are small and dispersed as well as they lack information about current market prices because of villages remoteness and poor communications with marketplaces (Courtois and Subervie, 2015). Moreover, farmers are not aware of actual transport costs faced by traders, which carry larger quantities of coffee than single smallholder farmers and spread fixed costs over a larger amount of crop.

On basis of empirical output entailed in this paper, some policy implications are discussed. In particular, the model studies the causes which contribute to the spread between the price ob-

tained by traders at the point of competition (domestic market or borders for exports), net of marginal transport costs, and the farm gate price, *wholesale-farm gate price*. Such indicator assesses the degree of competition and revenue distribution between farmers and traders.
This spread will be positive in some cases, since traders can exploit their market power against spatially dispersed farmers. Indeed, traders will not increase the farm gate price, even if they are able to receive higher consumer or export price.
This paper is thematically close to the branch of literature which deals with exploitation of market power by some actors in complex value chains (Peltzman, 2000) (McCorriston and Sheldon, 1996) (Sexton, 2013) (Vavra and Goodwin, 2005) (Swinnen and Vandeplas, 2014) and addresses the coffee sector in Uganda, which is the main cash crop for Ugandan farmers.

Ugandan coffee value chain analysis

Coffe is an important cash crop for Ugandan smallholder farmers.
Both Arabica and Robusta are produced in Uganda in the ratio of 1:4 and coffee plants are inter-cropped with food crops like bananas and beans. Robusta is used as a "filler" in roasted and ground blends, and in instant coffee, while Arabica is sold as specialty or fair trade product (Collinson et al., 2005, 14).
Mostly, family labour is employed with a minimal use of agrochemicals (fertilizers, pesticides and fungicides), since part of production comes from wild forest coffee, which does not require any large human intervention (MAFAP, 2012a, 6).
Domestic consumption of coffee is small and it was around 4-10% of production in the period 2004-2010, in spite of some attempts by the authority to increase this value (MAFAP, 2012a, 8) (ICO, 2015).
Uganda ranks fourth after Burundi, Ethiopia and Honduras in terms of contribution of coffee exports in total export earnings in the period 2000-2010 with an average share of 18% during this time (ICO, 2015).
In spite of that, ability of Uganda to increase international price by restricting exports or increasing domestic consumption is very limited, because its share in the global coffee market is small (MAFAP, 2012a, 8). Main export destination of Ugandan coffee is the European Union (over 70% of total exports) followed by Sudan (over 10%) and USA (about 3%). Remaining 15% of coffee exports is delivered in other 13 countries. Export market is very concentrated with 10 exporters making up 85% of exports. In particular, the leading company Ugacof Ltd. controls 15% of trade (MAFAP, 2012a, 8).
After coffee harvest of Robusta species, farmers usually sun-dry red cherries on the farm and sell their coffee as Kiboko (dry cherries). Most coffee sales are made at the farm gate to small traders who tour the countryside on bicycles or motorcycles. These Kibobo small-scale traders act as intermediaries either for bigger independent traders or for exporters. Generally, they dehull the cherries and sell occasionally the rough hulled green bean (referred to as "FAQ" or fair average

quality) directly to exporters but more often to FAQ traders. The FAQ traders sell then to exporters' district depots or to exporters' yards in Kampala (Hill, 2010, 437) (MAFAP, 2012a, 10). After cleaning, sorting, grading, and drying of rough-hulled beans exporters or freight companies carry coffee by train, ferry or truck to the port of Mombasa, which it is the main sea outlet for Ugandan exports. From there, coffee is transported by sea to export destinations in 60 kilogram bags, which are stuffed into 20 feet or occasionally 40 feet containers (MAFAP, 2012a, 10).

Ugandan Arabica coffee is mostly grown in the districts of Kapchorwa and Mbale. Its value chain is similar to the one of Robusta, but in generally shorter, with more direct overseas marketing links than that for the latter variety (Collinson et al., 2005, 20). In the following figures the value chains for Robusta and Arabica are illustrated.

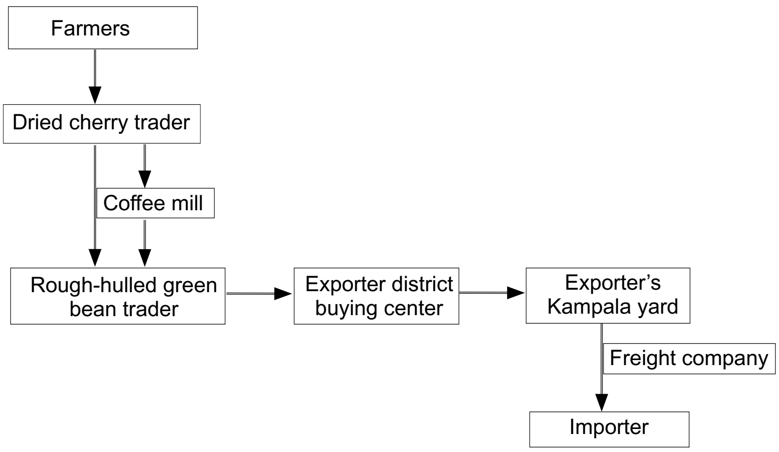

Figure 1: Robusta Value Chain in Uganda (Collinson et al., 2005, 19)

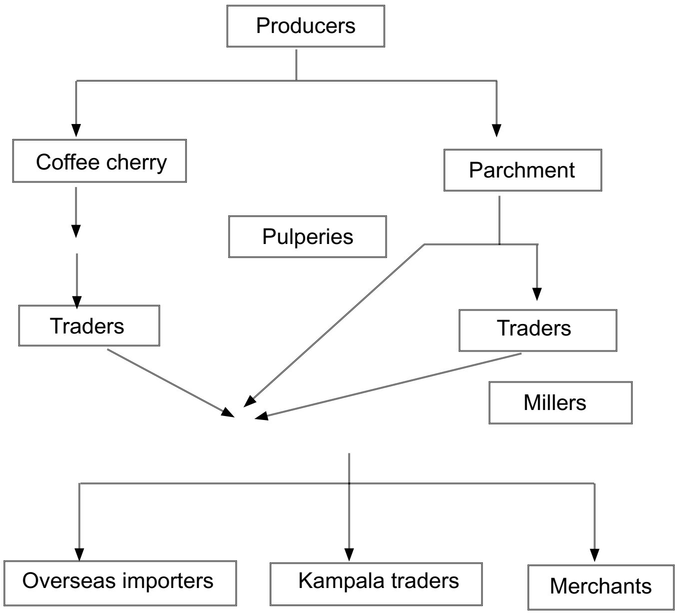

Figure 2: Arabica Value Chain in Uganda (Collinson et al., 2005, 20)

Model

Consider an agricultural market, where traders and farmers negotiate for quantity and price. The hypothesis to be verified is that, in markets where infrastructure quality is poor and transport costs are relevant, geographic dispersion of smallholder farmers allows traders to exploit their market power against farmers with a large impact on market structure and reduction of farmers' welfare.

In this paper, to reasonably investigate the Uganda coffee sector, several stages in the value chain are aggregated. In particular, for simplicity's sake farmers are implementing within the farm the entire production process before sale to domestic consumers or export, even if more actors of the value chain are involved in the actual process.

Collection of agricultural products and marketing services are core business of traders, who do not transform at all any agricultural products. Traders are homogeneous in behaviour and available technology; therefore the market area, where they compete, extends in n identical directions and is measured by a radius L.

Traders are willing to expand their supply markets to provide domestic consumers or exporters with larger amount of agricultural products.

Without loss of generality it is assumed that farmers produce and sell a quantity R of a single homogeneous crop. The farmer supply function is conditional on available technology T and a vector E of some exogenous factors, like climate, plot size and price received for the sold quantity:

$$R = f(T, E) \tag{1}$$

As confirmed by LSMS-ISA data and reports by MAFAP, fertilizers and pesticides are little used and coffee production is mainly a very labour intensive activity in a very labour-abundant country, where there is little incentive to substitute labour with more expensive inputs (MAFAP, 2012a, 6). Therefore, in Ugandan coffee production process there is low substitution between processing inputs. Moreover, a fixed ratio between inputs and agricultural output is prevailing, given the limited labour productivity increase in picking coffee cherries. Based on the analysed production process, Leontief production function seems to be the most suitable one (Sexton, 1990) (MAFAP, 2012a) (Collinson et al., 2005) (Wohlgenant, 2001).
Therefore, technology T can be described by the following Leontief production function (Diewert, 1971):

$$R = Min_i \left\{ \frac{x_i}{b_i} : i = 1, ..., K \right\} \tag{2}$$

where x_i is the conditional factor demand by the farmers and b_i is the relative technological conversion factor between inputs x_i and output R. In this functional form no substitution between the processing inputs is possible. According to the standard microeconomic theory the Leontief production function corresponds to the Leontief Cost function, which can be expressed in the following Gorman polar form:

$$C(R, p_i^x) = \sum_i b_i p_i^x + \sum_i \sum_j b_{i,j} (p_i^x p_j^x)^{1/2} R \tag{3}$$

where p_i^x and p_j^x are the prices of the *i-th* and *j-th* processing input and b the relative coefficient, given that $b_{i,j} = b_{j,i}$ (Appelbaum, 1982, 289). Gorman polar form has several advantages for empirical studies and estimation, given its aggregation properties, then it is used implicitly in many production studies. In particular, such a functional form allows different firms to have different cost curves but all of them are linear and parallel (Appelbaum, 1982, 291).
By applying Shephard's Lemma to equation 3, it is possible to derive conditional factor demand of processing inputs by farmers, x_i (Diewert, 1971):

$$x_i = \left[\frac{\partial C(R, p_i^x)}{\partial p_i^x} \right] = \left[b_{i,i} R + \sum_i b_{i,j} \left(\frac{p_j^x}{p_i^x} \right)^{1/2} R + b_i \right] \tag{4}$$

Traders face variable and fixed costs for delivery and marketing services:

$$C(R) = wR + t(R) + f \quad \textbf{if} \quad \mathbf{R > 0} \tag{5}$$

where w is the farm gate price of agricultural products, $t(R)$ variable transport costs paid by traders due to f.o.b pricing and f set-up fixed costs of delivery and marketing service.
In particular, cost function of processing inputs is negative exponential. By assumption, trans-

port technology available to traders exhibits constant returns to scale and marginal variable costs t' can be taken as constant and not dependent on R. Nevertheless, some economies of scale occur over some R >*0*, because strictly positive fixed set-up costs are spread over increasing inputs. Moreover, w is a function of agricultural product R and distance L (Sexton, 1990, 711).
In a competitive market traders maximize profit and equilibrium condition is reached when marginal revenues are equal to marginal costs, under the constraint of costs and quantity demanded of R:

$$Max\,[\Pi = PR - t(R) - wR - f] \rightarrow \frac{d\Pi}{dR} = 0 \tag{6}$$

where P is wholesale domestic or export price for agricultural products. By taking the first-order derivative:

$$\frac{d\Pi}{dR} = P - t' - w - R(\frac{dw}{dR}) \tag{7}$$

At this point, it is possible to take in account distance L, which introduces a wedge between price obtained by farmers and the one paid by traders. In spite of such wedge, positive transport costs do not necessarily imply imperfect competition, if transport costs, which are charged to farmers by traders, are equal to actual transport expenditures. In this case, transports cost play a similar role to expenditures for production factors.
When all markets are served, equilibrium condition is reached, if farm gate price net of transport costs is equal for all rival farmers at common borders:

$$w_i + tL_{ij} = w_j - tL_{ji} \tag{8}$$

where t is transport costs for unit of geographical distance, L_{ij} and L_{ji} represent geographical distance. Since distance is fixed in the short run as well as rival traders are symmetric, the radius of market area for each trader is symmetric in all n directions, i.e. $L_{ij} = L_{ji}$. This assumption corresponds to the one of standard oligopsony theory that the number of firms is fixed in the market in the short run (Sexton, 1990, 712).
By assumption, transport technology available to traders exhibits constant returns to scale and t can be taken as constant and not dependent on R. Solve equation 8 for L:

$$L = \frac{1}{2t}[w_i - w_j] \tag{9}$$

Take first-order derivative of 9 with respect to R:

$$\frac{dL}{dR} = \frac{1}{2t}\left[\frac{dw_i}{dR} - \frac{dw_j}{dR}\right] \tag{10}$$

By applying total derivative theorem, $(\frac{dw}{dR})$ can be written as:

$$\frac{dw}{dR} = \frac{\partial w}{\partial R} + \frac{\partial w}{\partial L}\frac{dL}{dR} \tag{11}$$

Given that firms are symmetric, in equilibrium $w_i = w_j = w$.
Let define $\frac{dL}{dR} = \theta\,(\partial w/\partial R)$ as a general conjecture and introduce it in equation 11 in order to get the following result:

$$\frac{dw}{dR} = \frac{\partial w}{\partial R} + \frac{\partial w}{\partial L}\theta\frac{\partial w}{\partial R} \tag{12}$$

By plugging 12 in equation 7 and re-ordering members, it is possible to get:

$$(P - t' - w) = R\frac{\partial w}{\partial R} + R\frac{\partial w}{\partial L}\theta\frac{\partial w}{\partial R} \tag{13}$$

After some manipulation, previous equation becomes:

$$(P - t' - w) = R\frac{\partial w}{\partial R}[1 + \frac{\partial w}{\partial L}\theta] \tag{14}$$

which is an equivalent expression to the *mark-up pricing policy* with respect to the spread between the wholesale domestic or export price net of marginal transport costs and the farm gate price. In particular, $\left(\frac{\partial w}{\partial R}\right) = \left(\frac{\partial \sum_i p_i^x}{\partial R}\right)$, where $\sum_i p_i^x$ is the sum of the costs paid by farmers for all production inputs. Therefore equation 14 can be expanded taking in account all three market levels, although the market of agricultural products, where the traders and the farmers negotiate for quantity and price, is the main focus of the study:

$$(P - t' - w) = \left(\frac{\partial w}{\partial R}\right) R\left[1 + \theta\left(\frac{\partial w}{\partial L}\right)\right] = \left(\frac{\partial \sum_i p_i^x}{\partial R}\right) R\left[1 + \gamma L\right] \tag{15}$$

given that $\theta\left(\frac{\partial w}{\partial L}\right) = \gamma L$. Under the assumption of f.o.b. pricing, transport costs are transferred from exporters entirely to traders and at least partially to farmers. This price transmission process has also an impact in terms of production. If traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers, the latter are willing to supply less coffee for a given price.
The sketched model can be empirically tested in order to assess whether traders exploit their market power against farmers, based on geographical dispersion of the latter.

Data

The model can be applied to data collected by the Ugandan Statistical Office and the World Bank team within the framework of the Living Standard Measurement Study (LSMS). This database is integrated with data coming from Doing business and World Development Indicator database. A panel dataset is build for the waves 2010-2011 and 2011-2012.
The Agriculture survey of the LSMS concerns agricultural firms of small and middle size and it is very valuable for the analysis entailed in this paper. Indeed, coffee production is almost entirely dependent on about 500,000 smallholder farmers, 90 % of whose average farm size ranges from less than 0.5 to 2.5 hectares (MAFAP, 2012a, 5-6) (UCDA, 2015). The database contains

information about employed production factors, i.e. organic and inorganic fertilizers, pesticides, hired and family labour. Such variables are taken as production inputs x_i.
For each factor the quantity purchased and the expenditure are provided. Factors for which a price cannot be recorded were probably obtained by the farmer for free and then they will be not regarded as cost in the production function.
Indeed, it is very likely, that not all inputs are bought by farmers on the market, since some of them are easily obtained by animal dung, which are raised within the farm, or saved from the previous seasons, like seeds, or exchanged with fellow farmers, like some chemical fertilizer or pesticides. Inability to record use of such inputs would bias a productivity estimate. Nevertheless, in this work the focus is on cost structure and price formation and not on productivity. Therefore, as long as farmers have not used or used, but not purchased such production factors, setting the relative costs to zero seems not be wrong, since these farmers did not pay out any money for them. Moreover, limited use of agrochemicals, as documented by the MAFAP, makes not surprising that many farmers report no employment of some of the mentioned inputs (MAFAP, 2012a, 6).
In a similar way, reported non-hired labour other than family work, provided by neighbours as exchange or for social reasons, is not going to be taken in account, since it does not contribute to costs.
For each household total costs of hired labour and workdays are available. On the basis of these values, it is possible to compute an average daily wage for each household across the different tasks, gender and age of the workers (men, women and children). This daily wage is applied for person-workdays for family members to get total opportunity cost of family labour. For some hired jobs, no workdays are available, since it was possibly a piecework, to which the average daily wage across all households is assigned. This information available at the household level enables to take in account regional wage differentials.
The model takes also in account spatial dimension of the market. In this insight, transport costs play a role in determination of the spread between wholesale domestic or export price and farm gate price. From the database it seems that there are several ways to deliver agricultural products, which lead to different transport costs. Very frequently, dry cherries are collected at the farm gate by kiboko traders who tour the country by motorcycle or bicycle, which leads to zero or low transport costs for farmers.
Uganda is a landlocked country and its main sea outlet for exports is the port of Mombasa in Kenya. This aspect represents a major constraint to transaction cost efficiency, since transport costs between Kampala and Mombasa are a burden on the industry and reduce net prices to producers, as Uganda must remain competitive on world markets in relation to other origins which do not have to bear high internal costs of this kind (Collinson et al., 2005, 26).
Therefore, transaction costs for Ugandan coffee are quite high and made of transport costs between the farm and the exports' yard in Kampala, costs to export, i.e. for inland transportation between Kampala and the port of Mombasa and for loading and customs procedures there, which cannot be identified separately from each other.

Costs of export can be taken for the year of the LSMS survey from the Doing Business Database. They are expressed in deflated US Dollars for a 20 feet container of a weight of 10 tonnes, it is possible to obtain the average costs to export per kilo and to convert it to Ugandan Shillings like the other variables in the LSMS with the *PPP Conversion Factor to Market Rate* (World Bank, 2014) (World Bank, 2015).

Costs to export are paid by exporters, who are not able to increase export price to take in account such expenses, because international demand is exogenous. Such costs to export correspond to the variable t in the equations 5, 6 and they are reasonably variable within a given range. Marginal cost t' as in equation 7 are constant by assumption and therefore equal to the average costs to export per kilogram given in the Doing Business Database. It can be assumed that costs to export are transferred by exporters to traders and by the latter to farmers, based on the experience that historically low prices have squeezed trader margins to an average of less than 1% of revenue, and grower price levels to close to, or less than, the cost of production (Collinson et al., 2005, 24). Wholesale export price net of marginal transport costs $(P - t')$ is equivalent in this sense to the *f.o.b. price* at the port of Mombasa.

Moreover, transport costs between the farm and Kampala are sometimes carried by farmers, sometimes by traders. It is expected that traders who collect the kiboko at the farm gate will pay lower farm gate price on average (Fafchamps et al., 2005).

Through these operations it is possible to get a database of 1041 households which harvested coffee during the LSMS-ISA survey wave 2010-2011 or 2011-2012 or during both.

Uganda LSMS sampling design warrants representativeness at national and sub-national level, like for agro-ecological zones (Himelein, 2012). Such sampling algorithm implies that the selected sub-sample of 1041 households is representative of the population of coffee producers, because coffee production is regionally concentrated in few districts (Bundibugyo, parts of Hoima, Kabarole, Mbarara, Bushenyi, Mubende, Luweero, Mukono, Masaka, Iganga, Jinja, Kalangala, Mpigi and Kampala) which make up a specific agro-ecological zone (Mwebaze, 2006).

Empirical Strategy

In the specific case of the Ugandan coffee value chain, domestic price spread can be ignored, because domestic consumption of coffee is negligible. Indeed, from the ICO data it is possible to compute that domestic consumption was around 4-10% of production in the period 2004-2010 (MAFAP, 2012a, 8) (ICO, 2015). Therefore, just demand for exports and international price spread are taken in account. In particular, international demand is taken as exogenous, given that Uganda has a small share of world coffee market.

The following model is run for empirical estimation:

$$F = \begin{cases} \ln R_i = \ln a + \eta \ln \left(\frac{w_i}{S}\right) + \beta C + \xi_1 & \text{(a)} \\ x_i/R_i = b_{i,i} + \sum b_{i,j} \left(\frac{p_j^x}{p_i^x}\right)^{1/2} + b_i/R_i + \xi_2 & \text{(b)} \\ (P_{int} - t' - w_i) = \frac{\left(\sum_i b_i p_i^x + \sum_i \sum_j b_{i,j} (p_i^x p_j^x)^{1/2} R_i\right)}{\left[1 + \theta_{int} \left(\partial w_i/\partial L\right)_{int}\right]^{-1}} + \gamma L + \xi_3 & \text{(c)} \end{cases}$$

where *t'* are transport costs between the exporter yard and the border paid by traders (f.o.b. pricing), C are climatic control variables for rainfall estimates, L distance variables, S is the implicit GDP deflator, P_{int} the international price and ξ_r is the disturbance term of the *r-th* equation of the system. All other variables have been already defined.
Since it is assumed that transport technology available to traders exhibits constant returns to scale, marginal and average transport costs are equal and correspond to parameter *t'*.
C consists of C_1, the average 12-month total rainfall (mm) for the time 2001-2010, and C_2, 12-month total rainfall (mm) between January and December for the survey year (2010 or 2011). L is made of L_1, distance from Kampala (km), and L_2, remoteness index. L_1 is calculated as the geographic distance between the GPS co-ordinates of the plot and the city of Kampala, while L_2 is an average of distance of the village centre from some facilities of primary importance for the community.
Other control variables in (a) like parcel size were tested, but they are not significant. Main reason for this insignificance is that much coffee is wild and collected by farmers in the forest and on common land.
Variables *t'*, P_{int}, $p^x_{i/j}$, C, w and L are exogenous, because farmers are small and dispersed.
Equation (a) describes microeconomic supply function by farmers, given farm gate price, exogenous climatic variables and the prevailing market structure. Equations (b) and (c) describe behavioural microeconomic relations, i.e. optimal substitution strategy between production factors, given exogenous prices of inputs, and pricing behaviour of farmers, given production function and the prevailing market structure.
Equation b corresponds to conditional factor demand, equation 4, and consists of two sub-equations b.1 and b.2 for two groups of inputs employed in production process, respectively other inputs (fertilizer, pesticides, etc.) and labour. Equation (c) corresponds to equation 15 and is the focal point of analysis, since the wholesale-farmgate price spread assesses market competition degree and revenue distribution between farmers and traders.
Availability of panel data for the waves 2010-2011 and 2011-2012 increases quality of estimation and allows to take in account household heterogeneity. If the model is run on the unbalanced panel instead of the balanced one there will be an efficiency increase, therefore no balanced panel is extracted from the unbalanced one (Baltagi, 2006).
Given the panel structure of the database, all previous equations should be indexed by h (house-

hold ID) and t (year). In order to simplify notation, indexes h and t were not introduced in the equations, but the two dimensions are taken in account in the estimation.

Microeconomic supply, substitution between production factors and pricing behaviour cannot be regarded as contemporaneously uncorrelated with each other. Indeed, farmers decide at the same time how much coffee they supply and which inputs they employ in production, given exogenous factor prices, transport costs for unit of geographical distance and farm gate price offered by traders.

The empirical approach is data-driven. In particular, the alternative between SUR, which implies correlation between the equations in the system through the disturbance term, and equation-by-equation OLS, which means that there is no correlation between such equations, is checked through the likelihood ratio and Breusch-Pagan test for indipendent errors. Both tests conclude that SUR is the most adeguate technique. In particular, likelihood ratio test confirms that the null hypothesis, that correlation between the equations is zero, is easily rejected as shown in table 3.

Breusch-Pagan test for independent errors informs that several correlation coefficients between the residuals of equations in regarded specifications are significantly different from zero, as it can be easily seen in tables 4 and 5. Therefore, to employ a seemingly unrelated equations (SUR) model seems to be fully justified. This methodology allows to exploit simultaneity between equations and to increase efficiency (Zellner, 1962).

Due to significant correlation of disturbance terms across the different equations, an equation-by-equation OLS produces consistent, but inefficient estimates. Therefore, a GLS- SUR estimation is required because of its sizeable advantages in terms of efficiency over an OLS estimation (Greene, 2008, 254-257). Although the number of observation units is much larger than the time periods, the system can be successfully estimated. Indeed, by means of a pre-multiplied matrix, which maps the unrestricted coefficients into the restriction set by the sketched model, the dimension of the covariance matrix is reduced and its generalized inverse can be easily computed (Henningsen and Hamann, 2007, 7-8).

There could be endogeneity due to household unobserved heterogeneity in the database. Equation-wise Hausman test between fixed and random effect estimators produces mixed results as shown in table 6 and does not fully support random effect specification. In order to carry out some robustness analysis, a seemingly unrelated regression - least square dummy variables (SUR-LSDV) and a seemingly unrelated regression - random effect (SUR-RE) are estimated.

SUR-LSDV accounts for household fixed effects: from results in table 7 it is possible to see that share of household effects, which are significant at least at 5 %, amounts to 75.6 % in equation c, but barely to 23.3% in equation a, to 0.6% in equation b.1 and to 4% in equation b.2.

Both specifications control for cross-equation correlation through residuals and for household heterogeneity, but they are based on different assumptions. While SUR-LSDV leaves the relation between household heterogeneity and covariates in all equations unconstrained as well as allows to estimate and test household effects, SUR-RE assumes that household heterogeneity

and covariates in all equations are orthogonal and that household heterogeneity behaves like idiosyncratic error term.
From this output it is possible to conclude that entrepreneurial ability of farmers is not very relevant, if production of green coffee is achieved without employment of advanced techniques or by collecting coffee cherries in forests as it is the case in Uganda. On the contrary, given the impact of transport costs on raw agricultural commodity final price, distance plays an important role. In this sense, distance represents a large part of heterogeneity among farm household. Indeed, distance affects very likely farm gate price in equation c, but not other inputs and labour requirement in equations b.1 and b.2 or supplied quantity in equation a. Distance influences supplied quantity only through farm gate price.
Therefore, endogeneity due to household unobserved heterogeneity is very attenuated, since farmers are small, dispersed and accept the farm gate price offered by traders as well as production of coffee in Uganda does not require very relevant level of ability. In this case, an IV approach will not produce any significant improvement, given that instruments are weak. Moreover, estimated simultaneous equation model SUR controls for residual minor endogeneity.
While SUR-RE introduces some bias since the orthogonality assumption is not fully supported, this distortion is little since farmer heterogeneity comes mostly from distance and not from farmers' entrepreneurial ability or other omitted variables. Moreover, SUR-LSDV does not make possible an appropriate identification strategy, because it does not allow to identify separately distance as explanatory variable. Therefore, a SUR-RE model is also estimated with four different specifications.
System F is the most general version of the model. For robustness analysis, the model is run with five different specifications. Specification 1 is estimated as SUR-LSDV. Specifications 2, 3, 4, 5 are SUR-RE models. In particular, in specification 1 there are neither L nor C, but household dummy variables are separately identified, specification 2 is run with L and C. Specification 3 is estimated with C, but without L. Specification 4 includes L, but not C. Specification 5 does not entail neither C nor L.
Specifications 1, 2 and 3 are reference approaches for the analysis carried out in this paper. Nevertheless, specifications 4 and 5 were also estimated in order to provide a complete picture. Indeed, variables C and L have many missing data which cannot be otherwise imputed, therefore their introduction results in a significant reduction in sample size. In spite of these shortcomings, asymptotic validity of the specifications 1, 2 and 3 is not undermined and their evaluation can be regarded as main contribution to the analysis of the topic dealt with in this paper.

Estimation results

The output of all specifications is reported in tables 7, 8, 9, 10 and 11.
Goodness-of-fit of specification 1 (SUR-LSDV) is high because Mc Elroy R^2 is 0.68. Goodness-of-fit of specifications 2, 3, 4, 5 (SUR-RE) decreases, but it is still good. In particular, for

specifications 2 and 3 the Mc Elroy R^2 is between 0.29 and 0.34[1].
In all specifications, all variables in the second equation on other input requirement are not significant, while in the third equation on labour requirement the reciprocal of coffee supply is large and highly significant. This result confirms that coffee production is a labour-intensive process and that Ugandan farmers employ small quantity of fertilizers and pesticides. In general, low levels of wages in agricultural sector fosters a substitution of other inputs (fertilizer, pesticides, etc.) with labour. The most interesting result is given in the fourth equation. Only in specification 5 the marginal effect of labour costs is significant, but still quite small. In all other specifications any input costs variable is not significant.
Regression output is able to confirm also the hypothesis made in the first part of the paper, i.e. that traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers. In specification 2 only D_1, distance from Kampala (km), is significant and its magnitude is between 10^4 and 10^5 times the value of the coefficients of the factor costs in all specifications.
As shown in table 12 marginal effect of distance on wholesale-farm gate price spread is between 2.3 and 2.4 Ugandan Shillings (UGX) each kilogram of coffee and kilometre of distance. Since wholesale-farm gate price spread is defined as $(P_{int} - t' - w)$ and t' and P_{int} are exogenous and constant across households, the mentioned marginal effect implies a reduction of the farm gate price by 2.3 and 2.4 Ugandan Shillings (UGX) each kilogram of coffee for each kilometre far away from Kampala. This value corresponds to an average decrease between 6 % and 7 % of the farm gate price each kilometre, because the average farm gate price is about 35 UGX each kilogram. This result confirms that traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers.
The remoteness index is not significant in all models. Only actual distance from the export yard in Kampala and not accessibility to primary community services, e.g. outlet markets, is relevant for coffee revenue distribution.
At the same time, distance from Kampala and the remoteness index are negatively correlated ($\rho = -0.62^{***}$), which can give a hint that some primary services in the surroundings of Kampala could be less accessible to citizens because of city size and higher population density. In spite of that, farmers could regard as more convenient to own a plot in the surroundings of Kampala, in order to overcome more easily distance barriers and take on a larger share of coffee price.
To have a better insight in the impact of distance on market structure, direct effect of supply on price and the one of price on supply as well indirect effect of distance on both can be computed and compared. From results of specification 2 relevant partial elasticity parameters are calculated and reported in table 12.

[1]Mc Elroy R^2 is computed in the following way: $R^2_{McE} = 1 - \frac{\hat{\epsilon}'\hat{\Omega}^{-1}\hat{\epsilon}}{y'\hat{\Omega}^{-1}y}$ where $\hat{\Omega}^{-1}$ is the estimated positive definite contemporaneous covariance matrix, $\hat{\epsilon}$ the error vector and y the dependent variable (McElroy, 1977). This measure of goodness-of-fit should be evaluated with caution, because some doubts on its reliability were cast (Srivastava and Giles, 1987, 346-351) (Jitthavech, 2010).

From this computation it is evident that direct effect of supply on price and of price on supply is smaller than indirect effect of distance on both. In this context, geographical distance determines market structure and plays a significant role for farmers' welfare, since this cash crop provides a large part of income for over 500,000 households.
Due to this empirical relevance, any policies should take in account such aspect as a barrier to competitive coffee market and to poverty reduction of rural areas. On the basis of the output analysed, in the last part of this work some policy implications are discussed in order to design a strategy to foster a structure of the agricultural value chain which maximizes social welfare and increase competitiveness of the sector.

Policy implications

Empirical analysis proved the relevance of distance as disincentives to farmers in supplying larger quantity of coffee. Indeed, traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers.
Farmers are not able to skip traders in the value chain, because a significant information asymmetry is prevailing in the market. In particular, traders exploit farmers' ignorance because the latter are small and dispersed as well as they lack information about current market prices because of villages remoteness and poor communications with marketplaces (Courtois and Subervie, 2015). Moreover, farmers are not aware of actual transport costs faced by traders, which carry larger quantities of coffee than single smallholder farmers and spread fixed costs over a larger amount of crop.
The market share in world coffee export of Uganda is quite small, therefore an increase in coffee supply could have a positive impact on the available income of households without worsening the international coffee price.
This paper shows that costs increase more quickly because of bottlenecks in transportation infrastructure than of expenditures for production factors.
Improvement of transportation network can lead to larger production and higher efficiency of the coffee value chain, by reducing traders' market power. Indeed, there are no other major constraint in increasing coffee supply by farmers (Gollin and Rogerson, 2010) (Ranganathan and Foster, 2012). Labour is indeed largely available in a country with fast-growing and young population (World Bank, 2014). Other factors like small parcel size do not seem to represent a significant barrier to increase in supply, as long as competition for wild coffee or common land does not become too fierce. This perspective is not probably immediate, because population density in Uganda is not very high (World Bank, 2014).
Geographical distance is obviously a physical constraint which cannot be easily overcome. Proposals to provide incentives to farmers to move closer to Kampala cannot be regarded as a reasonable policy recommendation. Indeed, increasing agglomeration could have large negative side-effects and worsen even more the quality of accessibility to primary services in the area of

Kampala and increases household poverty.
A more sustainable solution could be to improve quality of transportation and roads in Uganda in order to reduce delivery time and costs. Improvement of transport quality could have very positive side-effects, providing to businesses in other sectors incentives to delocalize production outside the central region and reduce the negative impact of congestion in the area of Kampala. This policy could indirectly foster a more balanced regional development.
The estimated model is not able to clearly distinguish between the trading behaviour of Kiboko and FAQ traders, nevertheless it gives some hints that the complexity of the coffee value chain reduces also revenues of farmers. Indeed, since the quantity supplied by each farmer is too small to be accepted by FAQ traders or exporters, the Kibobo small-scale traders act as intermediaries. The Kibobo small-scale traders face large delivery costs, while transporters waste much time for stopping at different farms and load very little quantity of coffee at each place (Fafchamps and Hill, 2005, 419). A farmer association, which could aggregate locally tiny amounts of coffee or bypass small-scale traders in a more efficient way, could reduce production costs, improve farmers' welfare and set incentives for larger coffee production.

Conclusions

This study was able to deal with revenue distribution along the Ugandan coffee value chain and to prove that spatial dispersion of farmers is a very important factor in the relationship between farmers and traders, which provides market power to the latter. The analysis gave hints that there is a large room for local oligopsony by traders, based on high delivery costs. In particular, traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers. Marginal effect of distance on wholesale-farm gate price spread is between 2.3 and 2.4 Ugandan Shillings (UGX) each kilogram of coffee and kilometre of distance. This value corresponds to an average decrease between 6% and 7% of the farm gate price each kilometre, because the average farm gate price is about 35 UGX each kilogram. From the computation entailed in this paper it is evident that direct effect of supply on price and of price on supply is smaller than indirect effect of distance on both. In this context, geographical distance determines market structure and plays a significant role for farmers' welfare, since this cash crop provides a large part of income for over 500,000 households.
Farmers are not able to skip traders in the value chain, because a significant information asymmetry is prevailing in the market. In particular, traders exploit farmers' ignorance because the latter are small and dispersed as well as they lack information about current market prices because of villages remoteness and poor communications with marketplaces (Courtois and Subervie, 2015). Moreover, farmers are not aware of actual transport costs faced by traders, which carry larger quantities of coffee than single smallholder farmers and spread fixed costs over a larger amount of crop.

This study confirms also that coffee production is a labour-intensive process and that Ugandan farmers employ small quantity of fertilizers and pesticides. In general, low levels of wages in agricultural sector fosters a substitution of other inputs (fertilizer, pesticides, etc.) with labour. A set of adequate policies to address the exploitation of market power by traders would consist of investment in quality of transportation and roads in order to reduce delivery time and costs. This strategy would shrink the ability of traders to exploit information asymmetry against farmers and to overcharge transport costs to the latter.
Such approach is able to produce further positive side-effects and foster de-localization of other businesses outside the central region of Kampala and lower negative effects of congestion around Kampala. Moreover, an increase in coffee supply could also have a positive impact on the available income of households without worsening the international coffee price, since the market share in world coffee export of Uganda is quite small.
Since there are many open questions and a strong interest for the analysed field, the author is keen to expand this analysis in future research works. For instance, it would be stimulating to disentangle the complex trading relations between Kiboko and FAQ traders and to figure out how the complexity of the value chain impacts sector efficiency.
An interesting research purpose would be also to model the optimal area of local oligopsony for traders and which effect specific policies can have on the market structure. Moreover, the role of availability of credit for production could be assessed as determinant of coffee supply by farmers and as an item of bargaining in a set of incomplete contracts with traders. Finally, interaction between international coffee market and behaviour of domestic actors was not investigated. This issue could be also an another stimulating avenue for further research.

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Mathematical annex

In this annex an alternative derivation of spatial equilibrium analysis is given, which makes clear the similarity of the model developed in this paper with (Sexton, 1990)'s approach. Equation 13 can be also expressed in form of elasticity.

Given the general conjecture $\frac{dL}{dR} = \theta\,(\partial w/\partial R)$ employed in the analysis, dividing both sides of equation 15 by w as well as multiplying and dividing the second addend of the right-hand side for L, equation 13 becomes:

$$\frac{P - t' - w}{w} = \frac{R}{w}\frac{\partial w}{\partial R} + \frac{\partial w}{\partial L}\frac{dL}{dR}\frac{R}{w}\frac{L}{L}$$

Then, it is possible to get relative wholesale-farm gate price spread in terms of elasticity:

$$\frac{P - t' - w}{w} = \epsilon_{w,R} + \epsilon_{w,l} \cdot \eta_{L,R}$$

because relative total and partial derivatives can be expressed in terms of elasticity by means of total derivative theorem:

$$\eta_{w,R} = \epsilon_{w,R} + \epsilon_{w,l} \cdot \eta_{L,R}$$

In particular, $\epsilon_{w,l}$ is partial elasticity of farm gate price to geographical distance and depends on transport costs under the assumption of f.o.b. pricing. These costs are transferred from exporters entirely to traders and at least partially to farmers.

$\epsilon_{w,R}$ is inverse elasticity of supply of agricultural products. The $\eta_{L,R} = \left(\frac{dL}{dR}\frac{R}{L}\right)$ represents the market area competition and it is analogue to the conjectural variation of the standard oligopoly/oligopsony theory (Sexton, 1990, 711). In equation 11 it seems to be more natural to regard $\left(\frac{dR}{dL}\right)$, which by symmetry of derivatives, is equivalent to $\left(\frac{dL}{dR}\right)$.

The latter point can be made clearer by applying the implicit function theorem. It can be indeed showed that $\left(\frac{dR}{dL}\right)$ is the negative of the ratio between marginal effect of market area on farm gate price and marginal effect of supply of agricultural product on farm gate price:

$$\left(\frac{dR}{dL}\right) = -\frac{dw/dL}{dw/dR}$$

Indeed, it is possible to resolve the equation for $\left(\frac{dw}{dR}\right)$ and replace the result in equation 7. Then, total derivative theorem is applied to $\left(\frac{dw}{dL}\right)$ and it is possible to get the same equation 14.

$\left(\frac{dR}{dL}\right)$ describes the perception by traders how a pure change in market area is going to affect supply by farmers, net of the effect that a change of farm gate price will have on the supply of agricultural products by farmers. If traders exploit their market power overcharging transport costs between farm and exporter yard in Kampala to farmers, the latter are willing to supply less coffee for a given price. The parameter $\left(\frac{dR}{dL}\right)$ corresponds to the conjectural variation of the standard oligopsony theory (Sexton, 1990, 711).

Table 1: Acronyms and Abbreviations

Symbol	Meaning
UCDA	Uganda Coffee Development Authority
UGX	Ugandan Shilling
WDI	World development Indicators (World Bank)
ICO	International Coffee Organisation
OLS	Ordinary Least Squares
FGLS	Feasible Generalized Least Square
SUR	Seemingly Unrelated Regressions
MAFAP-FAO	Monitoring and Analysing Food and Agricultural Policies - Food and Agriculture Organization
FAQ	Fair Average Quality (Coffee)
f.o.b.	Free On Board
LSMS-ISA	Living Standards Measurement Study - Integrated Surveys on Agriculture
f	Fixed costs in the farmers production function
b_i	Technological Conversion Factor between inputs x_i and output R (Leontief production function)
θ	Conjectural Variation
$\eta_{w,R}$	Total Elasticity of farm gate price to coffee supply
$\epsilon_{w,R}$	Partial Elasticity of farm gate price to coffee supply
$\epsilon_{w,l}$	Partial Elasticity of farm gate price to market area radius
$\eta_{L,R}$	Total Elasticity of market area radius to coffee supply

Table 2: Variables

Symbol	Meaning	Level	Source	Notes
L_1	Distance between the household and Kampala (GPS co-ordinates)	Household	LSMS (Uganda)	Specification of L (Market Area Radius)
L_2	Avg. distance between village center and some facilities of primary importance	Community	LSMS (Uganda)	Specification of L (Market Area Radius): Remoteness Index
R	Quantity of coffee sold	Household	LSMS (Uganda)	
w	Farm gate price (UGX)	Household	LSMS (Uganda)	Ratio between Value of sale and Quantity of coffee sold
x_i	Quantity of i-th input (conditional factor demand)	Household	LSMS (Uganda)	Labour; Other inputs (Pesticides, Organic and inorganic Fertilizers)
$p^x_{i/j}$	Input Costs	Household	LSMS (Uganda)	Labour; Other inputs (Pesticides, Organic and inorganic Fertilizers)
P_{int}	International coffee price	International	ICO	ICO composite indicator price
S	World GDP deflator	International	WDI (World Bank)	Average of the GDP deflator of the consumer countries
t	Cost to export	Country	Doing Busines (World Bank)	Converted in UGX per kilogram of coffee

Table 3: Likelihood ratio test

$$F = \begin{cases} \ln R_i = \ln a + \eta \ln\left(\frac{w_i}{S}\right) + \beta C + \xi_1 & \text{(a)} \\ x_i/R_i = b_{i,i} + \sum b_{i,j}\left(\frac{p_j^x}{p_i^x}\right)^{1/2} + b_i/R_i + \xi_2 & \text{(b)} \\ (P_{int} - t' - w_i) = \frac{\left(\sum_i b_i p_i^x + \sum_i \sum_j b_{i,j}(p_i^x p_j^x)^{1/2} R_i\right)}{\left[1 + \theta_{int}\left(\partial w_i/\partial L\right)_{int}\right]^{-1}} + \gamma L + \xi_3 & \text{(c)} \end{cases}$$

H_0: Residuals of the m equations are uncorrelated.

Model	Degree of freedom (model)	LR test	Degree of freedom (statistic)	p-value
OLS (restricted) (H_0 valid)	17			
SUR (not restricted) (H_0 not valid)	26	34. 33	9	7.8e-05 ***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 4: Residuals Correlation *(Specifications 1, 2, 3)*

Specification 1				
	Eq. a	Eq. b.1	Eq. b.2	Eq. c
Eq. a	1.00	-0.02	0.05	-0.62***
Eq. b.1	-0.02	1.00	0.04	-0.06*
Eq. b.2	0.05	0.04	1.00	-0.32***
Eq. c	-0.62***	-0.06*	-0.32***	1.00

Specification 2				
	Eq. a	Eq. b.1	Eq. b.2	Eq. c
Eq. a	1.00	-0.02	-0.42***	-0.21***
Eq. b.1	-0.02	1.00	0.04	0.00
Eq. b.2	-0.42***	0.04	1.00	-0.04
Eq. c	-0.21***	0.00	-0.04	1.00

Specification 3				
	Eq. a	Eq. b.1	Eq. b.2	Eq. c
Eq. a	1.00	-0.02	-0.37***	-0.17***
Eq. b.1	-0.02	1.00	0.04	-0.03
Eq. b.2	-0.37***	0.04	1.00	-0.30***
Eq. c	-0.17***	-0.03	-0.30***	1.00

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 5: Residuals Correlation *(Specifications 4, 5)*

Specification 4

	Eq. a	Eq. b.1	Eq. b.2	Eq. c
Eq. a	1.00	-0.03	-0.10**	-0.17***
Eq. b.1	-0.03	1.00	0.04	0.01
Eq. b.2	-0.10**	0.04	1.00	0.04
Eq. c	-0.17***	0.01	-0.04	1.00

Specification 5

	Eq. a	Eq. b.1	Eq. b.2	Eq. c
Eq. a	1.00	-0.02	0.03	-0.44***
Eq. b.1	-0.02	1.00	0.04	-0.03
Eq. b.2	0.03	0.04	1.00	-0.33***
Eq. c	-0.44***	-0.03	-0.33***	1.00

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 6: Equation-wise Hausman test

$$F = \begin{cases} \ln R_i = \ln a + \eta \ln\left(\frac{w_i}{S}\right) + \beta C + \xi_1 & (a) \\ x_i/R_i = b_{i,i} + \sum b_{i,j}\left(\frac{p_j^x}{p_i^x}\right)^{1/2} + b_i/R_i + \xi_2 & (b) \\ (P_{int} - t' - w_i) = \frac{\left(\sum_i b_i p_i^x + \sum_i \sum_j b_{i,j}(p_i^x p_j^x)^{1/2} R_i\right)}{\left[1 + \theta_{int}\left(\partial w_i/\partial L\right)_{int}\right]^{-1}} + \gamma L + \xi_3 & (c) \end{cases}$$

H_0: Random effect estimator is consistent
(individual heterogeneity and covariates are uncorrelated)

Model	χ^2 test	Degree of freedom	p-value
Eq. a	0.035	1	0.85
Eq. b.1	1.19	2	0.55
Eq. b.2	27.94	2	8.6e-07***
Eq. c	8.53	3	0.036*

Note: Equation b consists of two sub-equations b.1 and b.2 for two groups of inputs employed in production process, respectively other inputs (fertilizer, pesticides, etc.) and labour.

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 7: Specification 1 (SUR-LSDV)

Dependent Variables	Eq. a Coffee Supply (log)	Eq. b.1 Other inputs requirement	Eq. b.2 Labour requirement	Eq. c Farmgate- wholesale price spread
Deflated farm gate Price (log)	0.52^{***} (0.038)			
Ratio input prices (labour/other inputs)		-0.0074 (0.014)		
(1/Coffee Supply)		5.08 (6.21)	354^{***} (48.9)	
Ratio input prices (other inputs/labour)			21 (104.7)	
Labour Costs				0.00035 (0.00019)
Costs (other inputs)				-0.0009 (0.0006)
Labour/other inputs costs (interaction)				-0.00002 (0.000013)
Share of significant household dummy variables (%)				
Significance level (s_f)	Eq. a	Eq. b.1	Eq. b.2	Eq. c
$s_f \leq 0.1\%$	**0.8**	**0.45**	**2.4**	**71.6**
$0.1\% < s_f \leq 1\%$	**9.8**	**0.15**	**0.2**	**3**
$1\% < s_f \leq 5\%$	**12.7**	**–**	**1.4**	**1**
$5\% < s_f \leq 10\%$	10.9	–	1	23.95
$s_f > 10\%$	65.8	99.4	95	0.45
Mc Elroy R^2 (system-related)		0.68		
Num. obs. (each equation)	1041	1041	1041	1041

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$ *(Standard error in brackets)*

Table 8: Specification 2 (SUR-RE)

Dependent Variables	Eq. a Coffee supply (log)	Eq. b.1 Other inputs requirement	Eq. b.2 Labour requirement	Eq. c Farmgate- wholesale price spread
Intercept	5.2	4.7	59.1^{*}	5938.3^{***}
	(4.3)	(3.0)	(24.4)	(189.1)
Deflated farm gate Price	0.3^{***}			
	(0.0326)			
Avg 12-month total rainfall (2001-2010)	-2.8^{*}			
	(1.1)			
12-month total rainfall (2010)	2.5^{*}			
	(1.1)			
Ratio input prices (labour/other inputs)		−0.0034		
		(0.008)		
(1/Coffee Supply)		−0.3	348.1^{***}	
		(4.6)	(39.3)	
Ratio input prices (other inputs/labour)			40.9	
			(52.1)	
Labour Costs				0.00001
				(0.00005)
Costs (other inputs)				−0.00007
				(0.00014)
Labour/other inputs (interaction)				0.00007
				(0.000003)
Distance from Kampala				2.3^{***}
				(0.5)
Remoteness Index				5.3
				(3.5)
Mc Elroy R^2 (system-related)		0.34		
Num. obs. (each equation)	544	1041	1041	544

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$ *(Standard error in brackets)*

Table 9: Specification 3 (SUR-RE)

Dependent Variables	Eq. a Coffee Supply (log)	Eq. b.1 Other inputs requirement	Eq. b.2 Labour requirement	Eq. c Farmgate- wholesale price spread
Intercept	6.7	4.3	21.3	8518.5^{***}
	(4.4)	(3.0)	(24.2)	(71.5)
Deflated farm gate Price	0.3^{***}			
	(0.03)			
Avg 12-month total rainfall (2001-2010)	-2.5^{*}			
	(1.1)			
12-month total rainfall (2010)	1.9			
	(1.1)			
Ratio input prices (labour/other inputs)		−0.004		
		(0.008)		
(1/Coffee Supply)		1.0	489.1^{***}	
		(4.6)	(38.1)	
Ratio input prices (other inputs/labour)			33.5	
			(51.8)	
Labour Costs				0.00018
				(0.00009)
Costs (other inputs)				−0.00033
				(0.00026)
Labour/other inputs (interaction)				−0.00001
				(0.00001)
Mc Elroy R^2 (system-related)		0.29		
Num. obs. (each equation)	544	1041	1041	1041

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$ *(Standard error in brackets)*

Table 10: Specification 4 (SUR-RE)

Dependent Variables	Eq. a Coffee Supply (log)	Eq. b.1 Other inputs requirement	Eq. b.2 Labour requirement	Eq. c Farmgate-wholesale price spread
Intercept	1.6^{***}	5.1	62.0^{*}	6002.8^{***}
	(0.1)	(3.0)	(25.1)	(190.8)
Deflated farm gate Price (log)	0.6^{***}			
	(0.03)			
Ratio input prices (labour/other inputs)		−0.003		
		(0.008)		
(1/Coffee Supply)		−1.1	358.2^{***}	
		(4.6)	(41.3)	
Ratio input prices (other inputs/labour)			48.0	
			(54.8)	
Labour Costs				0.000006
				(0.00005)
Costs (other inputs)				−0.00006
				(0.0001)
Labour/other inputs (interaction)				0.0000002
				(0.000003)
Distance from Kampala				2.4^{***}
				(0.5)
Remoteness Index				4.6
				(3.5)
Mc Elroy R^2 (system-related)		0.33		
Num. obs. (each equation)	1041	1041	1041	544

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$ *(Standard error in brackets)*

Table 11: Specification 5 (SUR-RE)

Dependent Variables	Eq. a Coffee Supply (log)	Eq. b.1 Other inputs requirement	Eq. b.2 Labour requirement	Eq. c Farmgate- wholesale price spread
Intercept	1.7^{***}	4.6^{*}	-10.5	8493.5^{***}
	(0.1)	(2.1)	(19.4)	(74.0)
Deflated farm gate Price (log)	0.6^{***}			
	(0.02)			
Ratio input prices (labour/other inputs)		-0.004		
		(0.006)		
(1/Coffee Supply)		0.1	553.2^{***}	
		(3.3)	(31.0)	
Ratio input prices (other inputs/labour)			40.7	
			(42.9)	
Labour Costs				0.00025^{**}
				(0.00009)
Costs (other inputs)				-0.00041
				(0.00024)
Labour/other inputs costs (interaction)				-0.00001
				(0.00001)
Mc Elroy R^2 (system-related)	0.19			
Num. obs. (each equation)	1041	1041	1041	1041

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$ *(Standard error in brackets)*

Table 12: Estimated elasticities [based on specification 2 (SUR-RE)]

Partial elasticity of farm gate price to distance	$\left(\frac{\partial w}{\partial L}\frac{L}{w}\right)$	**-11**
Partial elasticity of coffee supply to distance	$\left(\frac{\partial R}{\partial L}\frac{L}{R}\right)$	**-3.72**
Partial elasticity of farm gate price to coffee supply	$\left(\frac{\partial w}{\partial R}\frac{R}{w}\right)$	3.3
Partial elasticity of coffee supply to farm gate price	$\left(\frac{\partial R}{\partial w}\frac{w}{R}\right)$	0.3

Marginal effect of distance on wholesale-farm gate price spread (Eq. c)	Average farm gate price	Partial price elasticity of wholesale-farm gate price spread to distance
2.3 - 2.4 UGX each Kg/Km	35 UGX each Kg	6% - 7%

Note: Elasticity parameters are evaluated at the mean of each variable