

Kopp, Thomas

Article — Published Version

When switching costs cause market power: Rubber processing in Indonesia

Agricultural Economics

Provided in Cooperation with:

John Wiley & Sons

Suggested Citation: Kopp, Thomas (2021) : When switching costs cause market power: Rubber processing in Indonesia, *Agricultural Economics*, ISSN 1574-0862, Wiley Periodicals, Inc., Hoboken, USA, Vol. 53, Iss. 3, pp. 481-495,
<https://doi.org/10.1111/agec.12690>

This Version is available at:

<https://hdl.handle.net/10419/264539>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<http://creativecommons.org/licenses/by-nc/4.0/>

ORIGINAL ARTICLE

When switching costs cause market power: Rubber processing in Indonesia

Thomas Kopp

University of Siegen, Siegen, Germany

Correspondence

Thomas Kopp, University of Siegen,
Siegen, Germany.

Email: thomas.kopp@uni-siegen.de

Abstract

Suppliers of agricultural output incur switching costs (SCs) when choosing new buyers, allowing buyers to exercise oligopsonistic market power, as SCs help buyers to mark down prices for incumbent suppliers. This article conceptualizes the idea of SCs and suggests an empirical strategy for quantifying them through an estimation of farm supply to specific buyers. The model incorporates price differences between buyers, revealing buyers' anticipations of suppliers' SCs. The approach is applied to the Indonesian rubber market, employing a data set of daily purchasing prices and less frequent quantities of individual sales instances. Results indicate that SCs exist and are at about 3% of the farm gate price, leading to substantial redistribution from suppliers to buyers of agricultural output.

KEYWORDS

Bertrand paradox, law of one price, oligopsony, rubber, switching costs, value chain analysis

JEL CLASSIFICATION

L11, L13, Q13

1 | INTRODUCTION

Market power exercised by buyers of agricultural products has become a key topic in agricultural economics research (Dobson et al., 2003; Sexton et al., 2007; Sexton, 2013). Especially in developing and emerging economies (DEE), buyers' power can have substantial detrimental effects on small-scale farmers' welfare (Kopp & Sexton, 2021; Swinnen & Vandeplas, 2010). The main drivers of buyer market power in DEE include small scale farmers' liquidity constraints (Kopp & Sexton, 2021), market interlinkages (Subramanian & Qaim, 2011), concentration and cartelization (Saitone et al., 2008), low quality of institutions (Deininger, 2013), and barriers to entry or leave the market (Hirsch & Hartmann, 2014).

This article adds to that literature by suggesting the presence of a fixed cost component on the supplier's side when

changing buyers, here referred to as *switching costs* (SCs), as an additional basis on which buyers can mark down prices of farm output under Bertrand competition. It models buyers' anticipation of suppliers' costs of switching from one buyer to another and proposes an econometric procedure to quantify these costs. In the agricultural context, suppliers are small-scale farmers and buyers are processors that use farm output as an input. The approach developed here is applied to the Indonesian natural rubber value chain. Distributional consequences are assessed for the observed state and two hypothetical scenarios of reduced SCs.

The presence of SCs enables buyers to exercise market power over suppliers whom they have bought from in the previous period, because a supplier cannot switch easily from one buyer to another. If the buyer anticipates the supplier being partially locked in, he or she can depress input

prices below marginal revenue product. The extent of the markdown is affected by the suppliers' perceived difficulty in switching buyers – the SCs. While a number of studies model SCs (Burnham et al., 2003; Lam et al., 2004), nearly all of them focus on the demand side. This article extends the notion to the supply side by (a) modeling buyer market power based on suppliers' costs of switching among buyers and (b) finding empirical evidence for the presence and size of SCs.

This work also contributes to the literature on the *Bertrand paradox* (Dufwenberg & Gneezy, 2000), which states that oligopsonistic market power could not be exercised in an environment of price setters. The existing literature on the Bertrand paradox offers explanations why buyers that offer higher prices than others do not absorb all demand, even in competitive environments (Bruttel, 2009; Geromichalos, 2014). The presence of a fixed cost component of changing buyers complements these findings with an additional explanation for systematic deviations from the competitive equilibrium under Bertrand competition.

This article develops a theoretical model in which the existence of SCs explains the markdown of prices below the competitive level by different buyers for the same product at the same location at one point in time. These price differences are caused by the buyers' anticipation of the suppliers' partial lock-in situation. SCs are understood as the barriers a supplier has to overcome when changing buyers. They can be pecuniary – such as a price reduction to account for the buyers' risk when buying product of unobservable quality characteristics from previously unknown suppliers – or nonmonetary, such as the negative perception of one's own “disloyal” behavior. The model allows these SCs to be asymmetric, as the costs of switching towards a specific buyer may be different from the costs of switching away.

We next propose an empirical approach to infer the size of revealed SCs from time series data on prices and quantities. We estimate farm supply functions, which include the observed differences between the buying prices offered by different buyers as a covariate. These price differences reveal the buyers' anticipations of suppliers' SCs. A grid search over different specifications of the farm supply functions is exercised, mapping combinations of possible values for the costs of switching. The model specification with the best fitting values for SCs is selected via a profile likelihood approach.

This procedure is applied to the rubber processing industry in Jambi, Indonesia, where indications of market power have been found previously, both at the level of intermediaries (Kopp & Brümmer, 2017; Peramune & Budiman, 2007) and buyers (Arifin, 2005), which causes double marginalization in this value chain (Kopp & Sexton, 2021). We make use of a unique dataset of daily buying prices

for each buyer, as well as selling quantities at the transaction level at irregular frequencies. Our results indicate that the differences in prices between buyers follow a systematic pattern and reveal the suppliers' costs of switching between them, estimated at about 3% of the farm gate price. In a further step, we calculate the distributional consequences of the observed scenario and compare them to two hypothetical scenarios: a reduction of SCs by 50% and a total elimination of all SCs.

Our main contributions to the literature are the conceptualization of production side SCs and an empirical approach to quantify them. These buyer-specific SCs incurred by producers can enable market participants to exercise market power in otherwise competitive environments. The article is structured as follows: the following literature review contextualizes SCs, before the economic model is developed in Section 3. Section 4 describes the empirical approach and methodology and introduces the application – the rubber processing market in Jambi province, Indonesia – including the description of the data. Results are presented and discussed in Section 5, before the final section concludes.¹

2 | SWITCHING COSTS

Most of the existing literature on SCs can be found in consumption theory (Lam et al., 2004; Lee et al., 2001). Consumers' SCs stem from moving between brands and can be understood as a conceptualization of brand loyalty. The literature review by Klemperer (1995) on consumers' SCs includes a comprehensive discussion of the implications of SCs faced by end consumers towards suppliers. While most studies focusing on the consumer dimension predict SCs to reduce competition, Richards and Liaukonyte (2018) recently argued that the existence of costs arising from changing stores can actually be pro-competitive. Burnham et al. (2003) develop a typology to distinguish between different sources of SCs. Applications to food markets have been undertaken by a number of authors: Bonanno (2013), for example, investigates consumers' SCs in the Italian yoghurt market. Regarding business-to-business interactions, Beckmann and Boger (2004) and Gervais and Larue (2009) mention SCs on the demand side.

In contrast to these studies, the present article focuses on the costs incurred by *producers* switching from one buyer to another. In this case, SCs are representative of the “ease with which a farmer can find a new trading

¹ An online appendix provides additional information on the mathematical derivation of the microeconomic model and on the econometric procedure addressing endogeneity issues.

partner” (Mitchell, 2017, p. 5).² The literature on SCs on the (agricultural) supply side is limited. The respective papers analyze, for example, switching of crop insurances (DeLay et al., 2020), of production technology (from conventional to organic, Pietola, 2001) and of changes in the management of agricultural land (starting and ending agri-environmental contracts, Peerlings & Polman, 2008). Boger (2001) mentions Polish hog producers’ costs of switching between market segments (high and low quality) but assumes them to be below the potential gains.

Work on the costs of switching from one buyer to another is even more scarce. To the best of our knowledge, Mitchell (2017) is the only study that explicitly includes an analysis along this dimension, analyzing the effects of the costs of information gathering on suppliers’ buyer decisions. Sexton (2013) does not mention SCs explicitly, but relies on the concept when arguing that buyers and suppliers in agricultural markets seek long-term business partnerships in order to minimize transaction costs (TCs) over time. This is because some components of TCs decrease with each additional interaction between the same trading partners. One component of SCs is therefore the difference between the TCs a supplier faces with different buyers at a given point in time.³ Neither Mitchell (2017) nor Sexton (2013) attempt to measure the magnitude of SCs, or estimate their impact on farm incomes.

The magnitude of the SCs can be affected by a number of factors, depending on their nature. They can either be pecuniary or non-monetary. Pecuniary components of SCs occur in situations of asymmetric information in terms of quality. Henning et al. (2012) discuss the opportunistic behavior of agricultural producers in countries with weak institutions. If the buyer cannot easily assess the quality of the good offered, he or she will keep a risk premium and pay a lower price to mitigate the risk of agreeing to a payment above the actual value of the product. In these cases, the SCs take the form of forgone revenue for the supplier. Once the relationship between supplier and buyer has evolved further, the buyer can better predict the quality of the good and adjust the price accordingly by assuming

the output quality achieved by the supplier to remain similar over time. Once the supplier switches buyers, he or she starts at a low price again.

The second source of monetary SCs is caused by the additional services that are often offered by downstream stakeholders in agricultural value chains to small-scale suppliers. Especially in rural settings in DEE, providing credit is one of these services (Subramanian & Qaim, 2011). Since the debt is usually repaid through the delivery of farm output, the change of a supplier from one buyer to another before paying off the debt would constitute a *de facto* default (Kopp & Brümmer, 2017). This is particularly relevant for suppliers of non-seasonal crops – such as forestry products in tropical environments – characterized by constant income streams over the whole year, who are likely to remain indebted over extended periods of time. As suppliers want to be creditworthy in the future, they are reluctant to sell to another buyer, which adds another hurdle to switching buyers. Another monetary component of SCs incurred by suppliers are the costs of gathering information on each buyer’s price, which would not be required when selling to the buyer whom the supplier last sold to.

Nonmonetary costs may include the uncomfortable feeling of behaving disloyally, as has been observed in other contexts. Crespi and Sexton (2004, p. 673), for example, argue that “noneconomic” factors, such as perceived loyalty and the relation between buyer and supplier “may to some extent also help explain” processors’ bidding decisions they observed on cattle auction markets in Texas.

The SCs are diverse across suppliers and buyers for several reasons. First is the heterogeneity in *causes* of SCs, as laid out in the previous paragraphs. A second source of heterogeneity is heterogeneity in suppliers’ negotiation skills. Another source of variation is that SCs occur as per-TCs. Since the amounts that suppliers deliver vary, the per-unit-SCs vary as well.

3 | MICROECONOMIC FOUNDATION

This section conceptualizes a theoretical model to explain price markdowns due to SCs. It focuses on the interface between suppliers of agricultural outputs (farmers and small-scale traders) and processors (i.e., the buyers), where the exercise of market power (Kopp & Sexton, 2021) and the violation of the law of one price (LOP) in its weak version (Waight, 2018) is frequently observed. This will be explained by nonzero SCs of suppliers, which are anticipated by buyers in their pricing strategies.⁴

² The concept of SCs has parallels to the notion of supplier lock in: a supplier is locked in to a particular buyer because of high SCs. However, there are also substantial differences between the concepts. The equivalent lock-in would be a supplier’s buyer-specific investments. In the case of SCs, no explicit investments are being made. The costs of switching are the result of the succession of previous transactions.

³ Note the difference between TCs and SCs: TCs occur at every single instance of a transaction (such as transport costs). They may be different for each buyer–supplier pair and change over time, for example, due to changing road and weather conditions. SCs occur, on the other hand, *only* when switching buyers. Whenever suppliers sell their produce to the same buyer as in the previous period, there are no SCs. If the switching of buyers causes a change in the TCs of selling, this component of the TCs is then also a component of SCs.

⁴ Chami Batista and Da Silveira Filho (2010) also suggest a model to explain deviations from the LOP. In contrast to the present case, they focus on spatially separated markets and the role of arbitrageurs in correcting deviations from the LOP.

In the model, each supplier has sold his or her output to one of two buyers, i or j , in the previous period, and can choose whom to sell to in the second period.⁵ If suppliers were able to choose a buyer every day without incurring any costs, the buyer paying the highest price would be the first to source the input required to fully utilize capacity, then the second highest, and so on. As SCs are heterogeneous across suppliers, the model enables us to identify the last supplier for whom switching is profitable.

We start with farm output. The key decision parameter of a supplier is to which buyer he or she sells their output. Since suppliers of raw rubber in the Jambi province are price takers, the marginal supplier's decision does not affect the economic outcome for the other suppliers, so the decision matrix based upon aggregated, individual revenue maximization is equal to the outcome of joint revenue maximization of all suppliers.⁶ This means that the supplier who is indifferent between switching and not switching can be identified by maximizing the revenue of all suppliers combined. The aggregate revenue R of all input suppliers combined is given by

$$R = R_{ii} + R_{jj} + R_{ij} + R_{ji}. \quad (1)$$

The total revenue aggregates suppliers' individual marketing decisions and is composed of the revenues generated by four subsets of the suppliers. The subscripts indicate whom the members of the respective group have sold to in the previous period and are selling to in the second one: R_{ii} (resp. R_{jj}) stands for the revenue generated by suppliers who currently sell to buyer i (resp. to j) and did so in the previous period. These groups do not incur SCs. The suppliers generating the revenues R_{ij} and R_{ji} did switch and therefore incur SCs. Including prices, quantities, and the SCs yields:⁷

$$R = r_{ii}Qp_i + r_{jj}Qp_j + r_{ij}Qp_j - \int_0^{r_{ij}Q} SC_{ijm} dm + r_{ji}Qp_i$$

⁵ One dimension along which the model presented here could be extended in the future is to depict it as a dynamic choice problem by basing the decision making process on the discounted TCs of all subsequent periods instead of the costs to be incurred only in the upcoming period. The simplifying approach depicted in this work underestimates the measured SCs, as the suppliers' benefits are underestimated, accounting only for the benefits in the second period, and not all future periods.

⁶ Information asymmetry can be reduced by social networks and peer interaction, as shown by Mwema and Crewett (2019) for Kenya. Kopp & Salecker (2020) find that these processes are also present in the study region. Hartwich et al. (2010) provides additional evidence, finding that social networks affect marketing decisions.

⁷ Given that the suppliers' output is stable, due to long-term investment in perennial crops, we abstract from variable input costs and base the analysis on the calculation of suppliers' revenues instead of profits to identify the supplier who is indifferent between switching buyers and remaining with the previous one.

$$- \int_0^{r_{ji}Q} SC_{jin} dn, \quad (2)$$

in which p_i represents the price the suppliers receive from buyer i and p_j the price received from buyer j . From these base prices there can be discounts, considered as part of SCs. The total supply base is given by the agricultural output quantity Q produced by all smallholders in the region. Q is equal to the sum of the agricultural good purchased by all buyers in the region as an input ($Q = I_i + I_j$), and is assumed to remain constant over time, which is reasonable for perennial crops. The r stand for shares of the output, depending on whom it was sold to in the previous period and in the second period. r_{ii} (resp. r_{jj}) stands for the share of output that is currently sold to buyer i (resp. to j) and was so in the previous period. Neither groups incur SCs.

The cost component subtracted from the suppliers' revenues captures all SCs. They include additional costs and embed the price markdown at the new buyer. r_{ji} represents the share of output whose suppliers incur SCs for changing towards buyer i , and r_{ij} the output-share provided by suppliers who incur SCs for changing away from i . The costs per unit of output for switching towards buyer i , that is, when selling to buyer i now and having sold to j in the previous period, are denoted by SC_{jin} . SC_{ijm} stands for the costs of switching away from i . n and m represent units of output in the respective group, sorted by the size of SCs per unit of output, starting with the lowest. Since the SCs occur on a per-transaction basis, different delivery sizes cause varying SCs per unit of output. The supplier offering the first unit of output in each group incurs low costs when switching – and would therefore do so. The last one incurs the highest SCs, which outweigh the gains he or she could achieve from a higher price offered by the other buyer. In these cases, the supplier would not switch. Differentiating between SC_{ji} and SC_{ij} allows the SCs to be asymmetric.

The per-unit costs that suppliers incur from changing buyers are modeled as functions to allow them to be heterogeneous across units of output. These functions, denoted by $f_{ij}(m)$ and $f_{ji}(n)$, map units of output on the amount of SCs incurred by the suppliers of the respective unit of output. $f_{ij}(m)$ and $f_{ji}(n)$ must be strictly monotonously increasing and take only positive values. Further, they are defined for the definition sets $m, n \in [0; Q]$. Figure 1 illustrates the relation between the SCs, the price differences, and the number of switchers for two scenarios (minor and substantial price differences).

To identify the supplier who is indifferent between switching buyers and not doing so, we first define θ_i as the share of suppliers who have sold to buyer i in the previous period, so $1 - \theta_i$ are suppliers who have sold to buyer j . For the shares in the second period, we consider two cases,

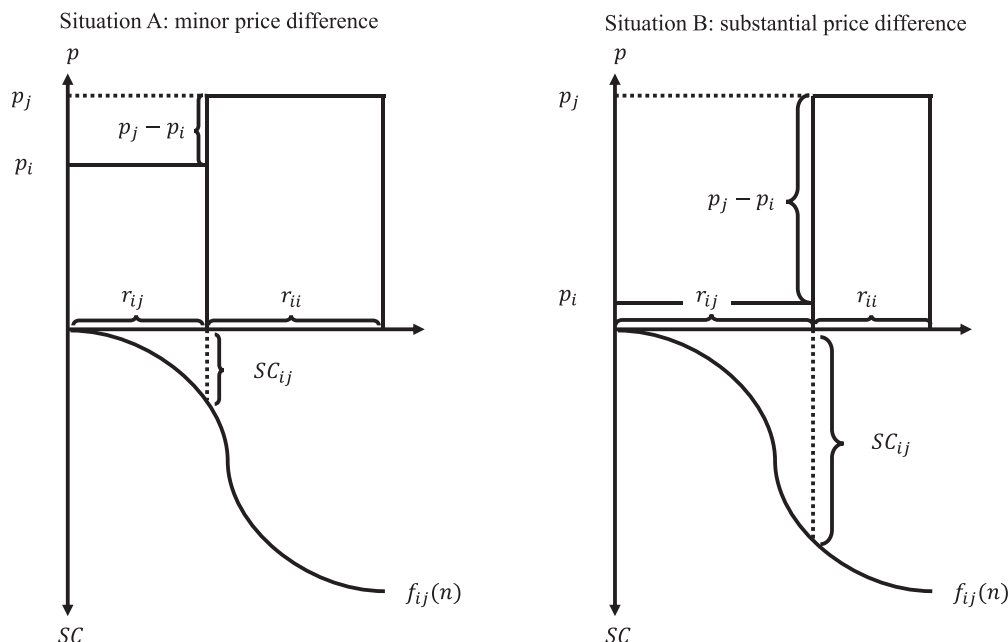


FIGURE 1 Intuition behind suppliers' decision to switch from buyer i to j

Source: Own production. The diagram displays the relation between $f_{ij}(n)$, the cumulative distribution function of SC costs incurred by suppliers switching from buyer i to j , different levels of price differences, $p_j - p_i$, and the resulting number of suppliers willing to switch, r_{ij} . The horizontal axis indicates the shares of suppliers who sold to i in the first period and continue to do so in the second period and the ones who switch, respectively. The northward-directed vertical axis denotes the prices paid by buyers i and j , respectively, and the southward-directed vertical axis the SCs. Note that the latter denotes positive values. Regarding the functional form of $f_{ij}(n)$, see Appendix section A.1. Suppliers for whom the price advantage from switching outweighs the costs of switching, for example, $p_j - p_i > f_{ij}$, will switch, while others remain. The higher the price difference (situation B), the more suppliers will switch.

depending on whom the suppliers had sold to in the first period: ω_{ii} is defined as the share within suppliers who sold to buyer i in the first period and do so again in the second period whereas ω_{ji} stands for the share within suppliers who sold to j in the first period and then switched to i .

We next derive the output share that is sold to buyer i in the second period, ω_i , given the current prices, p_i and p_j , the SCs, as well as the previous periods' output share for buyer i , θ_i .⁸ To do so, we first substitute SC_{ijm} and SC_{jin} in the revenue function (Equation (2)) by the cumulative SC functions, $f_{ij}(m) = c\delta_i n$ and $f_{ji}(n) = c\gamma_i m$, in which $c\delta_i$ and $c\gamma_i$ represent the costs of switching towards buyer i , respectively away from it, as multiples of the processing costs c (see Appendix A.1). Next, joint farm revenues are maximized by differentiating with respect to buyer i 's output share in the second period, ω_i , setting equal to zero, and solving for ω_i . The derivation can be found in Appendix

A.1. This procedure leads to the following output share for buyer i in the second period:

$$\omega_i = \theta_i - .5Q^{-1} \left((p_j - p_i) \left(\frac{1}{\delta_i c} + \frac{1}{\gamma_i c} \right) + \frac{1}{\gamma_i} + \frac{1}{\delta_i} \right). \quad (3)$$

Equation (3) illustrates that a price advantage of p_i over p_j increases the share of suppliers selling to buyer i above the value in the previous period, θ_i . The term that is subtracted from θ_i is positive if $p_j > p_i$, indicating that a price advantage of buyer j over buyer i reduces the share of suppliers selling to i compared to the previous period. With an increasing price advantage of p_j over p_i , the share of suppliers selling to i , ω_i , decreases further below θ_i and vice versa.

The effect of price differences in the second period decreases with the size of SCs. If SCs increase, the term in parentheses converges to 0 and ω_i converges to θ_i , indicating that few individuals switch even when price differences exist. With decreasing SCs, on the other hand, the denominators in the middle term converge to 0, leading the price difference to be multiplied with an increasingly large number, indicating that many suppliers switch when price differences exist.

⁸ The association of suppliers to specific buyers in past periods can be assumed to be exogenous for the case of the rubber sector in Sumatra because a substantial share of today's rubber producers entered the market when it was subject to strong government intervention during the 20th century. More information is provided in Appendix A.2 that discusses endogeneity.

If both buyers pay the same price, that is, $p_j = p_i$, then Equation (3) becomes $\theta_i - \frac{1}{2Q\gamma_i} - \frac{1}{2Q\delta_i}$. As all variables in the denominators are > 1 , ω_i will be close to θ_i , indicating that *nearly* no provider switches. The “nearly” remains because some providers still switch, which is the result of the assumption of bounded rationality (Appendix A.1).

Looking at the demand side, the agricultural output is purchased by buyers. Demand is modeled as a duopsony of two buyers, i and j , which are assumed to be price takers on the world market. International demand is perfectly elastic, so both receive the same output price p_O . The input supply for buyer i is generated by aggregating agricultural output as $I_i^S = \omega_i Q$

$$I_i^S = Q\theta_i - .5 \left((p_j - p_i) \left(\frac{1}{\delta_{ic}} + \frac{1}{\gamma_{ic}} \right) + \frac{1}{\gamma_i} + \frac{1}{\delta_i} \right). \quad (4)$$

Equation (4) is the input supply function that buyer i faces, depending on its own price, p_i , the competitor's price, p_j , modified by the SCs, γ_i and δ_i , and a fixed input quantity (the first term), which depends on the constant total farm output quantity Q and the sales structure in the previous period, θ_i . To simplify the calculus in the next steps, we reformulate Equation (4) by substituting $\left(\frac{1}{2\gamma_{ic}} + \frac{1}{2\delta_{ic}} \right)$ by κ_i and $\left(\theta_i Q - \frac{1}{2\gamma_i} - \frac{1}{2\delta_i} \right)$ by F_i

$$I_i^S = \kappa_i p_i - \kappa_i p_j + F_i. \quad (5)$$

The prices each buyer will pay are found by imposing Bertrand competition, assuming the buyers' ability to anticipate the supplier's SCs. Buyer i 's profits are given by

$$\Pi_i = (p_O - p_i - c)I_i^S = (p_O - p_i - c)(\kappa_i p_i - \kappa_i p_j + F_i). \quad (6)$$

The per-unit processing costs, c , are not denoted by a subscript as they are assumed to be identical for both buyers, as well as the output price the buyers receive on the world market, p_O . Buyer i 's first-order condition is given by

$$\frac{\partial \Pi_i}{\partial p_i} = -2\kappa_i p_i + \kappa_i p_O + \kappa_i p_j - \kappa_i c - F_i = 0. \quad (7)$$

Solving for p_i yields the Bertrand–Nash reaction functions,

$$p_i = \frac{p_O}{2} - \frac{c}{2} + \frac{p_j}{2} - \frac{F_i}{2\kappa_i}, \quad (8)$$

and equivalently for firm j ,

$$p_j = \frac{p_O}{2} - \frac{c}{2} + \frac{p_i}{2} - \frac{F_j}{2\kappa_j}. \quad (9)$$

We solve Equations (8) and (9) simultaneously to yield the Bertrand–Nash equilibrium prices. As i anticipates j 's

behavior, we substitute p_j from Equation (9) in Equation (8) and solve for p_i

$$p_i = p_O - c - \frac{F_j}{3\kappa_j} - \frac{2F_i}{3\kappa_i}. \quad (10)$$

Substituting back κ_i and F_i yields after simplification

$$p_i = p_O - 4/3c - 2/3Qc(1 + \theta_i) \frac{\gamma_i \delta_i}{\gamma_i + \delta_i}, \quad (11)$$

and correspondingly

$$p_j = p_O - 4/3c - 2/3Qc(1 + \theta_j) \frac{\gamma_j \delta_j}{\gamma_j + \delta_j}. \quad (12)$$

From Equations (11) and (12), it follows that if there are no SCs (i.e., γ_i and δ_i are zero), then the prices paid by buyers i and j are identical, and slightly below the Bertrand–Nash price, which would be output price minus processing costs.⁹

If the SCs γ_i and δ_i deviate from zero, on the other hand, the buyers are able to exercise market power over suppliers. Since γ_i and δ_i enter Equations (11) and (12) with a negative sign on the RHS, the presence of positive costs of switching enables buyers to mark down the price for the agricultural input. This means that buyers can pay a price below the Bertrand–Nash level of price minus costs if switching generates costs for suppliers. Buyers offering lower prices than the competitors will still be able to secure input. These results still hold if the SCs were symmetric, that is, if $\gamma_i = \delta_i$.

4 | ESTIMATION OF REVEALED SWITCHING COSTS

As mentioned above, there is little empirical literature on the role of SCs incurred by producers, and to the best of our knowledge, the estimation of SCs on the producers' side has not been done previously.

4.1 | Empirical approach

The logic behind the approach developed here is to econometrically estimate an inverse supply function of the agricultural good. One parameter in this supply function is the difference between the price paid by the buyer under consideration and the competitors' prices. This

⁹ The prices being by $\frac{1}{3}c$ lower than the Bertrand–Nash price are because of the suppliers' bounded rationality (see Appendix A.1). When omitting the smoothing parameter, the price is at the Bertrand–Nash level.

difference is determined by the SCs faced by the marginal supplier.

The SCs enter the supply function in the form of thresholds within the continuum of price differences. These thresholds define regimes of different supply elasticities. They indicate whether the price differences are sufficient for suppliers to switch or not. The relative sizes of the SCs of the different buyers in relation to each other are assumed to remain constant over time, which is reasonable given the possible causes of SCs as laid out in Section 2: for example, the risk premium that a buyer keeps in order to protect themselves from potentially bad quality delivered by new suppliers depends on the mean quality delivered by all suppliers, which may change over time. This, however, affects all buyers in the same way. In order to identify the thresholds (i.e., the revealed buyers' anticipation of suppliers' SCs), a profile likelihood estimation (Hansen, 2000; Samia & Chan, 2011), mapping over a discrete space of candidate values for the SCs, is applied.

The input supply I_{it}^S to buyer i at time t is given by a reparameterization of the inverse supply function (4) in which the input purchased by buyer i is a linear function of the prices it offers, as well as the competitors' prices, given by

$$I_{it}^S(p_t) = I_{it}^S(p_{it}, \tilde{p}_{it}) = \alpha_i p_{it} + \beta_i \tilde{p}_{it} + \zeta_i I_{it-1}^S + \phi_i + \varepsilon_{it}, \quad (13)$$

in which p_{it} refers to the price paid by buyer i at time t . To generalize from duopsony to oligopsony, p_{jt} is replaced by \tilde{p}_{it} , which refers to the maximum price paid by any buyer other than i : $\tilde{p}_{it} = \max(p_{t \sim i})$.¹⁰ The other term of the RHS in Equation (4) refers to the share of total supply purchased by i in the previous period, $Q\theta_i = I_{it-1}^S$, extended by a parameter to be estimated, ζ_i . To capture the final terms of Equation (4), the constant term ϕ_i is included. ε_{it} represents independent Gaussian errors with mean zero.

In what follows, the difference between buyer i 's price and the highest of the competitors, that is, $p_{it} - \tilde{p}_{it}$, is denoted by Δp_{it} . The costs of switching away from i are denoted by SC_{ia} and the costs of switching towards i by SC_{it} .¹¹ Both variables refer to mean per-unit SCs over all input purchased by buyer i . Note the difference to γ_i and δ_i from Equation (4), which are coefficients of linear functions. This replacement is necessary because the direct estimation of γ_i and δ_i would require information on the size of each delivery, which are not available for the case at hand. Instead, we estimate the average SCs that reduce the

price received by all suppliers to buyer i . If $p_i < \tilde{p}_i$, suppliers would only switch away from i if $\Delta p_{it} < -SC_{ia}$. On the other hand, if $p_i > \tilde{p}_i$, suppliers would only switch towards i if $\Delta p_{it} > SC_{it}$. This yields two cases: (a) the price difference is big enough to make suppliers switch, and (b) the prices are only slightly different, resulting in suppliers staying with the incumbent buyer despite a price difference

$$I_{it}^S = \begin{cases} \alpha_{i1} p_{it} + \beta_{i1} \tilde{p}_{it} + \zeta_i I_{it-1}^S + \phi_i + \varepsilon_{it} & \text{if } (\Delta p_{it} < -SC_{ia}) \vee (\Delta p_{it} > SC_{it}) \\ \alpha_{i2} p_{it} + \beta_{i2} \tilde{p}_{it} + \zeta_i I_{it-1}^S + \phi_i + \varepsilon_{it} & \text{if } (\Delta p_{it} \geq -SC_{ia}) \wedge (\Delta p_{it} \leq SC_{it}), \end{cases} \quad (14)$$

where α_{i1} (estimated for observations in which p_{it} is sufficiently different from \tilde{p}_{it} for suppliers to switch) are expected to be positive and significant while α_{i2} are expected to be insignificant and/or negative.¹²

The case distinction is implemented via two dummy variables, Θ_{it}^1 and Θ_{it}^2 , which are set to unity for the respective cases and to 0 otherwise

$$I_{it}^S = \Theta_{it}^1(\alpha_{i1} p_{it} + \beta_{i1} \tilde{p}_{it}) + \Theta_{it}^2(\alpha_{i2} p_{it} + \beta_{i2} \tilde{p}_{it}) + \zeta_i I_{it-1}^S + \phi_i + \varepsilon_{it}. \quad (15)$$

The values of SC_{ia} and SC_{it} that define the observation space indicated by Θ^1 and Θ^2 in Equation (15) are identified via a profile likelihood estimation (Cole et al., 2014; Royston, 2007), that is, a maximum likelihood estimation over a discrete grid of candidate SCs values. To do so, Equation (15) is estimated in logarithmic form for all possible combinations of SCs within the parameter space SC_{ia} and $SC_{it} \in [0 \text{ IDR}; 3000 \text{ IDR}]$ with a step of 100 Indonesian Rupiah (IDR) between the points in the grid. For each of these estimations, the likelihood value is calculated and stored. Then the specification with the best fit is ascertained based on its likelihood value.

An estimate of the precision of the estimates is obtained by a nonparametric, statistical simulation (Efron & Tibshirani, 1994), which repeats the estimation for 1000 bootstrap replications. In each replication, a subsample of the same size as the full sample is generated by randomly drawing observations from the original sample with replacement. Since the simple bootstrap assumes that all observations are independent and identically distributed, which is not the case in this application, we rely on a moving block bootstrap (Künsch, 1989) with random block length (Politis & Romano, 1994). In a first step, a random value, drawn from a distribution normally distributed around four with a standard deviation of one, is assigned to each

¹⁰ There is no reason for expecting the buyers to receive systematically different quality levels in their rubber purchases. If there were, however, these would be captured by the coefficients α_i and β_i .

¹¹ The components of TCs, which are not systematically related to past transactions and therefore do not affect suppliers' decision to switch, are not captured by the SC_{ia} and SC_{it} variables.

¹² The thinking behind the expectation of a possibly negative sign is that if the price differences are below the SCs, the suppliers stay with the current buyer who will – on average – be offering the best price in less than the majority of all cases, considering that there are five buyers. Table 2 displays the share of past periods in which each buyer offered the highest price in row 3.

observation to define the block length, ρ . In each bootstrap replication, the algorithm draws ψ blocks of the length ρ from the original sample, where $\psi = N/4$ to ensure that the number of observations in the respective replication is similar to the number of observations in the original sample. These blocks are aligned and form the sample for the grid search estimation in the respective bootstrap replication, which is carried out as described above. The results of the grid search from each bootstrap replication (SC_{ia} and SC_{it}) are stored, and from these results, we derive 90%, 95%, and 99% confidence intervals.

4.2 | Application to the Indonesian rubber processing industry

The proposed empirical procedure is used to apply the theoretical model to the rubber processing market in the Jambi province on Sumatra island (Indonesia). The characteristics of this market satisfy the model assumptions. First, in contrast to the findings of Sheldon (2017), according to which the share of farm output in a specified region that is marketed via contracts varies widely, there is no contract farming or share cropping arrangements for rubber in Jambi at all (Arifin, 2005; Euler et al., 2016). Hence, no institutional limitations hinder suppliers from selecting the buyers they sell to on a daily basis. Second, Sexton (2013) argues that (for the case of consumer markets) using a whole country as the level of aggregation is inappropriate when providing metrics on market structure because consumers rationally do not travel across the whole country to shop. In our application, the province level seems to be a reasonable choice, given that the selling networks stretch over the whole province (Kopp & Brümmer, 2017, fig. 2).

Around 251,000 rubber farmers are connected to buyers of raw rubber – so-called *crumb rubber factories* – via a complex and dense network of traders (Peramune & Budiman, 2007; Statistics of Jambi Province, 2018). Five of the buyers are located in the province's capital. Some are owned by multinationals while others are Indonesia-based. In addition to their five plants in Jambi City that enter our empirical analysis, there are six plants in other parts of the province, and among those, five are members of the same groups that the plants in the capital belong to. The combined market share of these 10 plants is 71.4%.¹³ The buyers buy raw rubber from smallholders and middlemen, process it to *International Standard Rubber* (SIR20) and then sell it on the world market. While the Jambi rubber buyers are price takers on the world market, they set prices on the domestic procurement market on a daily

basis. The prices change, on average, once every 3 days. There appears to be a fixed cost component when switching from one buyer to another. This is indicated by the constancy of individual suppliers' sales to a specific buyer after price changes (Kopp & Brümmer, 2017). The next section elaborates on the specific sources of SCs in the natural rubber value chain in Jambi.

The first source of SCs in the Jambi rubber processing market is the buyers' risk premium, due to asymmetric information regarding quality, which takes the form of a downward biased quality assessment. According to buyers' representatives, the payment that a supplier receives for his or her delivery is calculated by the buyer's indication price on that day, multiplied by the quantity and an estimate of the dry rubber content (DRC).¹⁴ The indication price itself is set independent of quality issues, as all buyers receive input of the same average quality. From this base price, there can be discounts for inferior quality, which are considered part of SCs because suppliers who have not done business with a specific buyer in the past systematically receive a worse quality assessment. The buyers mark down the estimated DRC for new suppliers as a mean of reducing the risk inherent to the procedure of buying raw rubber. Once a supplier arrives at the buyer, a factory employee and the supplier agree on the price paid for the load (indication price multiplied by DRC), and only *then* are the slabs of raw rubber unloaded from the truck. Once they are unloaded, they will not be reloaded onto the truck again. Hence, buyers face the risk of the quality of the total load delivered being below the quality of the top layer that the assessment was based upon. To avoid paying more than the actual value of the delivery, they systematically offer worse DRC estimates to new suppliers than to established ones for the same observed quality. Once the relation between supplier and buyer has progressed over a period of time, the buyers can use the knowledge generated from previous observations of the mean quality delivered for the assessment of the current delivery.

SCs also emerge whenever buyers provide liquidity to suppliers to pre-finance their delivery. The ones that receive credit risk damaging their reputation if they are seen selling rubber to a buyer other than the creditor. This situation, however, is rather rare due to generally low levels of trust; of the three buyers interviewed, one reported to no longer give credits, and another reportedly only gave credit to suppliers with whom it had a long-standing business

¹³ Based on data provided in Amalia et al. (2013, tab. 2: the table reports an aggregated value for the two locations of the buyer "PT Djambi Waras").

¹⁴ The information given in this section is based on qualitative interviews conducted with representatives of the buyers, that is, the rubber processors in Jambi province, unless indicated otherwise. Out of the five buyers in Jambi City, three were interviewed between October 09, 2017 and October 19, 2017.

relationship. This means that for some suppliers, switching buyers would also reduce the likelihood of getting access to liquidity in the future.

4.3 | Model adaptation

The equation to be estimated, Equation (15), requires some modifications due to data availability and potential bias from endogeneity. First, since data on quantities of buyers' individual input purchases are not available for the case at hand, buyer i 's agricultural input quantity, I_{it}^S , is replaced by its output quantity, O_{it}^S , on which information is available. The lower frequency of sales instances compared to purchases requires the aggregation of multiple input purchasing events. We further account for time-lags due to processing time, as well as the input-output ratio. In order to account for processing time and the fact that input is bought continuously while output is sold at fewer instances, we sum up over the intervals between selling instances in which input was bought and add lags to account for processing time. The result is multiplied by the input-output ratio to generate output quantity

$$O_{it}^S = \lambda \sum_{k=0}^{\sigma} I_{i(t-\eta-k)}^S, \quad (16)$$

with σ representing the time between selling instances, η the processing time, and λ the input-output ratio. Plugging Equation (15) into Equation (16) and simplifying yields

$$\begin{aligned} O_{it}^S = \lambda \left(\alpha_{i1} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^1 p_{i(t-\eta-k)} + \beta_{i1} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^1 \tilde{p}_{i(t-\eta-k)} \right. \\ \left. + \alpha_{i2} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^2 p_{i(t-\eta-k)} + \beta_{i2} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^2 \tilde{p}_{i(t-\eta-k)} \right) \\ + \zeta I_{i(t-\eta-\sigma-1)}^S + \phi_i + \varepsilon_{it}. \end{aligned} \quad (17)$$

To avoid biased results caused by endogeneity in the estimations, that is, a correlation between regressors and the error ε_{it} , Equation (17) requires further modifications. The first possible cause of endogeneity is simultaneity between input prices and purchase quantities. We account for the possible presence of simultaneity through an instrumental variable (IV) approach, implemented via two-stage least squares (2SLS, Angrist & Krueger, 2001). The prices, $p_{i(t-\eta-k)}$ and $\tilde{p}_{i(t-\eta-k)}$, are instrumented by their respective second lag, $p_{i(t-\eta-k-2)}$ and $\tilde{p}_{i(t-\eta-k-2)}$. A description of the approach to address this form of endogeneity is provided in Appendix A.2. To avoid endogeneity from the second potential cause, omitted variables, we control for fac-

tors with the potential to affect the prices offered to suppliers and quantities traded, including the share of total output that is exported, $s_{E,it}$, the quarterly market share of the respective buyer (seventh lag), $\hat{s}_{M,i(t-7)}$, a rainy-season dummy, lagged by the processing time η , $R_{t-\eta}$, and a buyer-specific intercept, ϕ_i . Again, more details can be found in Appendix A.2. The third potential source of endogeneity is measurement error. Buying prices and sales quantities are obtained from the written documentation of institutions who collect them directly from the buyers, so we are confident that the measurement error in the available, original data is small. More elaboration on potential measurement errors in the original data is provided in the upcoming data section and a discussion on measurement error because of a misspecification of the input-output transformation coefficient, λ , is given in Appendix A.2.

The error from the estimation with potential bias in Equation (17), ε_{it} , is replaced by the unbiased error, e_{it} . Implementing these modifications leaves us with the following equation to be estimated.¹⁵

$$\begin{aligned} O_{it}^S = \lambda \left(\alpha_{i1} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^1 p_{i(t-\eta-k)} + \beta_{i1} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^1 \tilde{p}_{i(t-\eta-k)} \right. \\ \left. + \alpha_{i2} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^2 p_{i(t-\eta-k)} + \beta_{i2} \sum_{k=0}^{\sigma} \Theta_{i(t-\eta-k)}^2 \tilde{p}_{i(t-\eta-k)} \right) \\ + \zeta I_{i(t-\eta-\sigma-1)}^S + v_i s_{E,it} + v_i \hat{s}_{M,i(t-7)} + \iota_i R_{t-\eta} + \phi_i + e_{it}. \end{aligned} \quad (18)$$

4.4 | Data

Our analysis is based on daily and individual raw rubber buying prices paid by each of the five buyers, the rubber processors in Jambi City, as well as on data on sales quantities at the transaction level. Prices were provided by the buyers' association, *Gapkindo*, which records each buyer's daily indication price.¹⁶ These data were obtained in the form of photographs and digitized by hand. We are con-

¹⁵ Note that the empirical strategy does allow for asymmetry in SCs to exist but it does not rely on it. The SCs are identified by running a grid search over different candidate SCs. Farm supply is estimated for different combinations of SCs and then compared in their ability to explain the variation in the supplied quantities. This grid search is executed over two dimensions, the switching-towards and the switching-away costs. Restricting the SCs to be symmetric, the grid search over candidate SCs would be limited to the diagonal. This procedure is indifferent to systematically over- or underestimating the SCs.

¹⁶ The five buyers in the capital are multiplant firms, and most of the plants outside Jambi are owned by the same companies that own the Jambi City plants. The prices of the six plants outside the capital are not collected by Gapkindo. Since five of these plants belong to the buyers

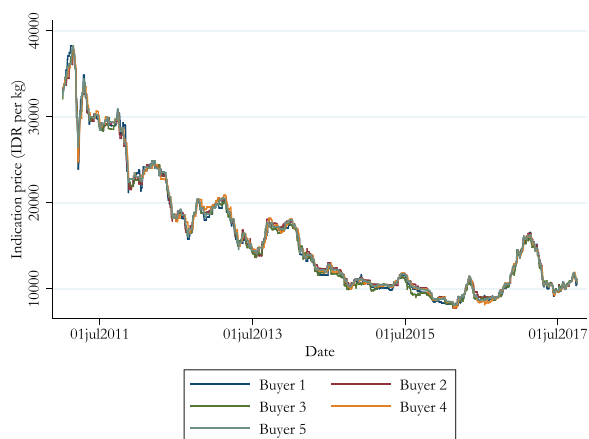


FIGURE 2 Evolution of daily buying prices

Source: Rubber Association of Indonesia (Gapkindo).

fidient that no errors from data entry remain in the final data set because the written notes provided by Gapkindo include the daily mean of the prices, which enabled a simple way of cross-checking the entries.¹⁷ According to information from interviews with representatives of buyers and Gapkindo, locally owned buyers set the prices themselves, while buyers that are part of transnational groups pay prices, which are dictated by their respective head offices in Jakarta. In both cases, the price is set daily, and does not change during the day.

The prices paid by each buyer that enter the analysis are all days between January 1, 2011 and September 30, 2017, excluding Sundays and public holidays. Sales quantities are available for the same period, as well as data on the share of rubber that is exported, $s_{E,it}$. Figure 2 provides an overview of the price time-series for each of the five buyers.¹⁸ The price drop after 2011 was caused by a drop in crude oil prices and a reduction in global demand for natural rubber products following the global financial crisis of 2008 (Romyen et al., 2019). The relationship of the price

located in the capital, we assume that they follow the same pricing strategies.

¹⁷ The chance that two wrong entries have canceled out each other is low, given an observed error rate of 3.6%, indicating a probability of two errors in one line of .12% which would be, given 1990 observations, about three such mistakes. The probability of two errors in one line that exactly cancel each other out is even much lower. In addition, the person who did the data entry was not aware that one of the series displays the average of the others.

¹⁸ Prices were deflated to base year 2010 by daily inflation rates, calculated from annual inflation rates (World Bank World Development Indicators). Note that while the series displayed in the figure are nonstationary, the aggregated values entering the analysis are stationary according to an Augmented Dickey Fuller Test (Dickey & Fuller, 1979). The null hypothesis of nonstationarity could be rejected at a significance level of 1% for each buyer. This is because the values entering the analysis are aggregated values of the series displayed in Figure 2.

of raw rubber to that of crude oil is due to the high substitutability at the margin between natural and synthetic rubber in tire production, which is the main use of natural rubber, as synthetic rubber is produced from crude oil (Amari et al., 1999).

Although Figure 2 indicates that the input prices are similar in the long run, substantial differences in the short run are common, as indicated by Figure 3, which displays the distributions of the price differences between the buyer under consideration and the highest price paid by any of the other buyers at each point in time.

The sales quantities of the buyers were obtained from the Jambi Ministry for Industry and Trade (*Dinas Perdagangan dan Industri*). Before exporting processed SIR20 rubber, the buyers have to apply for documentation at this ministry. The corresponding application form includes questions on output quantity and value. Since these data are on a per-sale basis and were provided in digital form, they can be expected to be exact. To rule out measurement error, the data were tested for plausibility by dividing value by volume, which would have shown errors in the form of outliers in the resulting export unit values.¹⁹ Descriptive information on buying prices and sales quantities are provided in Table 1.

5 | RESULTS AND DISCUSSION

An overview of the estimated SCs is presented in Table 2 and the numbers of observations in the different regimes are listed in Table 3. Out of the 10 estimates for SCs (one set of SC_{ia} and SC_{it} for each buyer), seven are different from zero at a confidence level of at least 90%. Table 2 further displays the aggregated costs of switching towards and away from each buyer as a combined indicator of market power. The aggregation is based upon Equation (3), which illustrates how the market shares (and correspondingly the price markdowns) are affected by SC_{ia} and SC_{it} . Given that there are not two but five players in the empirical application, the costs of switching away from a specific buyer have a different effect on its ability to exercise market

¹⁹ While this documentation is required in every instance of exporting, a comparison between the data on export quantities in our dataset and those published by the statistical office in Jambi (Statistics of Jambi Province, 2018, and editions from earlier years) shows that within the time span of observation 34.5% of all rubber exports from Jambi are accounted for. Since these reports are made via paper, the discrepancy between the numbers indicate that about two thirds of these reports were not filed in the process of data collection and entry at the ministry. We assume that all reports were equally likely to be omitted, causing the said observations to be “missing completely at random” (Cameron & Trivedi, 2005, p. 927), indicating that the available data are representative and the missing of observations does not introduce a systematic bias in the estimation of Equation (18).

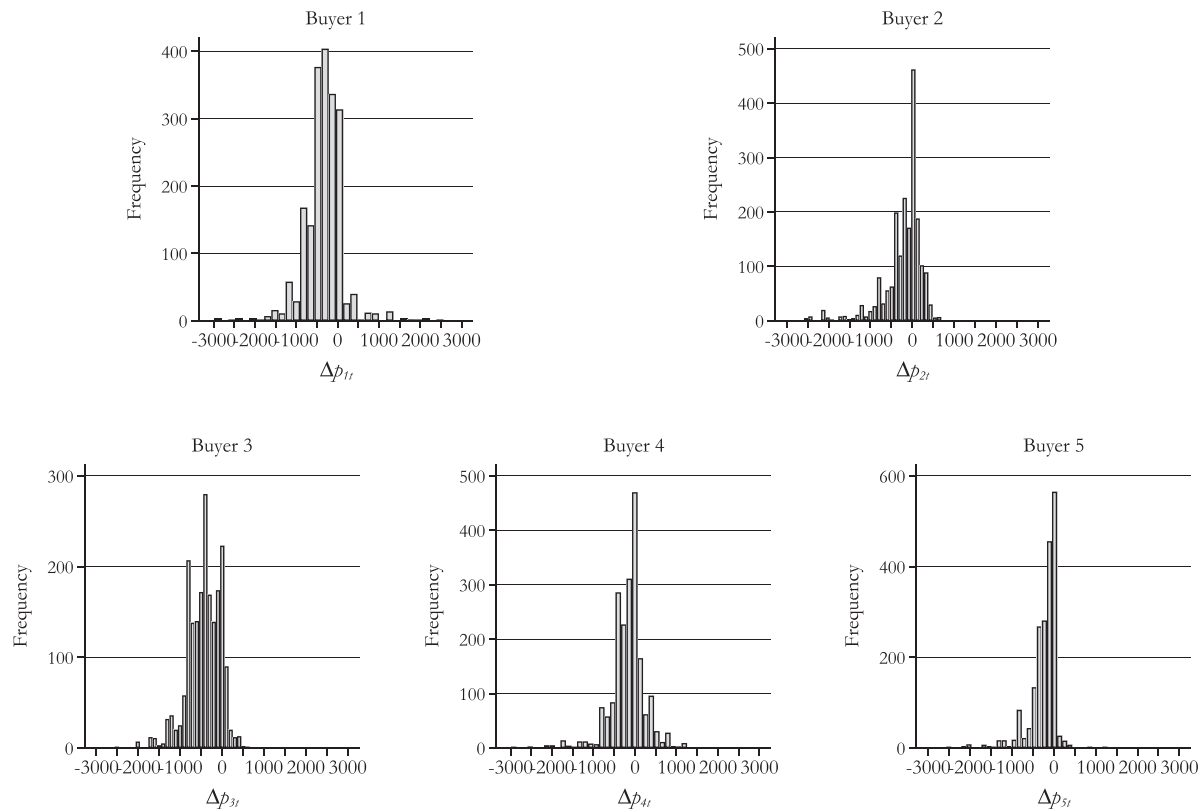


FIGURE 3 Price differences for raw rubber between the buyer under consideration and the highest price paid by any of the other buyers at each point in time in Indonesian Rupiah (IDR) per kg

Source: Own production, based on data from Gapkindo.

TABLE 1 Descriptives of input price and output quantity series

Buyer	Observations (prices)	Mean price (input buying)	SD	Observations (quantities)	Mean quantity (output selling)	SD
Buyer 1	1990	16,099	7236	63	133,516	68,283
Buyer 2	1990	16,201	6992	194	142,673	98,960
Buyer 3	1990	16,029	7146	335	231,110	144,041
Buyer 4	1990	16,237	7166	142	186,827	102,408
Buyer 5	1990	16,232	7118	167	226,490	161,901

Note: Prices are denoted in Indonesian Rupiah (IDR) per kg; quantities are denoted in kg. The number of sales is equal to the number of observations while the number of observations for purchases is equal to the number of days for which price data were available.

Source: Buying prices from Gapkindo, sales quantities from Jambi Ministry for Industry and Trade.

power than the costs of switching towards which requires a weighting of the measured SCs by the share of periods during which the respective SCs applied. Further, whenever the costs of switching towards are included (i.e., when $p_j < p_i$), the SC_{it} must be multiplied by a negative value. The shares of the periods in which the respective buyer offered the highest price during the time span of observation are captured by ξ_i and the periods, during which the buyer did not, by $1 - \xi_i$. The SC_{ia} are therefore weighted with $(1 - \xi_i)$ and the SC_{it} with $(-\xi_i)$.

The supply function estimates of the best-fitting specifications can be found in Table 4. Since α_i and β_i capture the same factors from Equation (4), β_i is expected to be similar to the negative value of α_i . The positive values of the buyer fixed effects, ϕ_i , can be interpreted in the sense that for each buyer, some suppliers exist for whom the SCs are always higher than potential price advantages. This supports the notion that the results underestimate the level of the SCs and that welfare losses are actually higher in reality than measured here.

TABLE 2 Results of grid search

Buyer	1	2	3	4	5
SC_a	100**	800***	800***	700**	100***
SC_τ	300	700**	500	1100**	100
ξ_i	15.8%	30.4%	13.6%	27.1%	13.1%
$(1 - \xi_i) SC_a - \xi_i SC_\tau$	37***	344***	623***	213***	74***

Note: The top row displays the revealed costs that suppliers incur when switching away from each of the five buyers and the second row includes the costs of switching towards each buyer. Row three shows the share of observations in which buyer i paid the highest price, ξ_i , and row four combines rows 1 and 2, weighting the SC_a by $(1 - \xi_i)$ and the negative SC_τ by ξ_i . The relative ordering of buyers by switching cost (SC) does not change when omitting the statistically nonsignificant values. All SCs are measured in Indonesian Rupiah (IDR) per kg.

Levels of statistical significance are derived from statistical simulations: *** indicate that 99% of all BS replications were >0; **: 95% > 0; *: 90% > 0.

All combined SCs are statistically significantly different from zero.

Source: Own production, based on estimation results.

TABLE 3 Number of observations in each regime

Buyer i :	1	2	3	4	5
Regime 1:	55 87%	21 11%	63 19%	13 9%	107 64%
Regime 2:	8 13%	173 89%	272 81%	129 91%	60 36%
Sum:	63	194	335	142	167

Note: Regime 1 includes all periods characterized by price differences above the suppliers' costs of switching buyers while regime 2 stands for times of moderate price differences. The number of observations is constrained by the data with fewer observations, that is, the ones on sales quantities (Table 1).

Source: Own production.

5.1 | Discussion

This section relates the estimation results to the theoretical considerations regarding the exercise of market power derived from SCs as discussed in Section 3. The estimation results displayed in Table 2 reveal that SCs are diverse across the five buyers. On average, the costs of switching towards one specific supplier were 540 IDR/kg in the time span of observation, and the mean costs of switching away were 500 IDR/kg. The estimated processing time, η_i , was similar across the five buyers with all $\eta_i \in [43; 56]$ and consistent with statements made by buyer representatives.

The levels of the SCs can be interpreted along the above mentioned causes of SCs from the theoretical model and based upon each buyer's age and its processing capacity. Table 5 provides information on age and processing capacity and orders the buyers by ability to exercise market power, from most to least powerful. High costs for switching away (SC_{ia}) increase buyers' ability to exercise market power, and high costs for switching towards (SC_{it}) decrease it, so the buyer with the highest values for $(1 - \xi_i) SC_{ia} - \xi_i SC_{it}$ is associated with the greatest ability to

TABLE 4 Estimation of supply

Variables	O_1^S	O_2^S	O_3^S	O_4^S	O_5^S
α_{i1}	.05	.98	.52	5.13	2.73
β_{i1}	-.05	-.96	-.51	-5.11	-2.72
α_{i2}	-22.38	.23	1.01	-.76	19.12
β_{i2}	22.38	-.23	-1.01	.76	-19.12
$I_{it-\eta-k-1}^S$	.02	.08	-.05	-.01	.21
$S_{E,it}$	-3.08	-.56	.57	1.93	-1.66
$\hat{S}_{M,i(t-7)}$	-2.79	.24	.02	.23	-.14
$R_{t-\eta}$	.09	-.25	-.05	.20	.16
ϕ_i	14.50	11.19	12.27	10.16	11.03
Observations	63	194	335	142	167
R^2	.26	.19	.09	.20	.23

Note: The variation in numbers of observations across the five estimations result from the different numbers of selling instances in the time span under consideration as indicated by Table 1. Since the processing time η_i is unknown, it was added as a dimension for the grid search (searching over $\eta_i \in [30; 70]$ days). Because the results are influenced by the value of the (estimated) switching costs (SCs), standard errors are not reported.

Source: Own production.

TABLE 5 Switching costs, regimes, ages, and processing capacities

Buyer ID	$(1 - \xi_i) SC_a - \xi_i SC_\tau$	Regime 2	Capacity	Age
3	623	81%	60	55
2	344	89%	30	58
4	213	91%	25	81
5	74	36%	36	37
1	37	13%	18	57

Note: Switching costs are denoted in Indonesian Rupiah (IDR) per kg (based upon Table 2), capacity in 1000 tons per year (obtained from Gapkindo, 2014), and age in years at time of writing (obtained from Gapkindo, 2014). Regime 2 stands for the share of sales instances in which suppliers did not switch (based upon Table 3).

Source: Own production.

do so. The combined costs of switching towards and away can be categorized into three groups, with relatively low levels (buyers 1 and 5), intermediate (buyers 4 and 2) and high levels (buyer 3).

Results indicate that the buyers' processing capacity, that is, their relative size, is the main determinant of their ability to exercise market power. While the smallest buyer is associated with the lowest SCs, the biggest one is characterized by the highest SCs. Mariuzzo et al. (2003) argue (for the oligopoly case) that relative firm size is positively related to the ability to exercise market power in homogeneous product markets, which can be explained by the phenomenon of "inherent product differentiation" (Rhoades, 1985, p. 349), that is, consumers' (here: suppliers') preference for the larger firm in the presence of identical prices. The reluctance of suppliers to switch away from bigger

buyers once a business relationship is established results in higher observed SCs associated with the larger firms. Within the group of intermediate capacities, the level of SCs can be explained with their respective ages. The five buyers fall into three age groups from old (81 years at the time of writing), intermediate (55–58 years), and rather young (37 years). The younger a buyer is and the less time it had to build up relations with current suppliers, the easier it will be for incumbent suppliers to switch, indicated by lower SCs. Results show that the youngest buyer's ability to exercise market power is indeed negatively affected by the relatively shorter time it had to build up relations with current suppliers, placing it in the group associated with the lowest SCs. Results further indicate that above a certain threshold, the age differences do not play a substantial role for the ability to exercise market power. For the buyers of intermediate and high ages, capacity remains the most important determinant.²⁰

The distributions of each buyer's sales instances between regimes 1 and 2 (Table 3) provide consistent results: following the theoretical model, the suppliers to more powerful buyers are less likely to switch to another buyer, *c.p.* The results indicate that buyers 1 and 5 are the weakest, with the highest proportions of regime 1, respectively, which stands for switching away. Buyers 2, 3, and 4 show to be stronger with the higher proportions of regime 2, which stands for remaining.

5.2 | Distributional consequences

Redistribution from suppliers to buyers results from the price competition between buyers being less fierce than it would be in the absence of SCs, leading to lower prices for the agricultural good than under Bertrand–Nash. Due to SCs, the arbitrage rents from differences in the prices offered by the buyers cannot be collected by suppliers, resulting in the redistribution of these rents to the buyers. Whenever price differences are below the costs of switching (i.e., $-SC_{ia} \leq \Delta p_{it} \leq SC_{it}$), the suppliers who sell in these periods collectively face a loss of the price difference multiplied by the amount sold in the respective period ($|\Delta p_{it}| I_{it}^D$).

To give an estimate of the potential consequences for suppliers' income from a reduction of SCs, two hypothetical scenarios are evaluated in addition to the observed one: the SCs in scenario two are hypothesized to be half

the size of the ones observed in reality, and in scenario three, they are set to zero. Since the calculation of hypothetical scenarios requires the buying quantities on a daily basis, I_{it}^D , which are not observed, they are derived from the total output of each buyer during the entire time for which data are available. We correct for the input–output transformation coefficient, λ , which has been obtained from the interviews with buyer representatives. We further assume a uniform distribution of supplied input over time. This assumption causes the estimates of the suppliers' disadvantage to be lower than they are in fact, representing a lower bound: the reason is that whenever one buyer offers a price above its competitors, it would in fact be able to purchase a quantity above the over-time average of the quantities it absorbs, as the over-time average also includes periods in which it pays less than the competitors. During the periods in which the buyer offers the highest price, suppliers would benefit from switching towards this buyer. As the forgone benefit to suppliers only occurs in the periods when the buyer under consideration offers the highest price, the assumption that leads to an underestimation of the quantities traded in these times consequentially results in an underestimation of the forgone benefits. The derived results can therefore be considered a lower bound for the revenue gains of reduced SCs because in reality the share of the quantity provided by suppliers who benefit would be above the over-time average. To avoid double counting, we only account for the losses resulting from suppliers not switching away from buyer i in times of relatively less favorable prices.

The scenarios are computed based on the mean SCs (500 IDR/kg for switching away and 540 IDR/kg for switching towards) and the mean net indication price across all buyers of 16,156 IDR/kg (Table 1). From the suppliers' perspective, the mean costs of switching towards and away from buyer i represent 3.1% and 3.3% of the price they receive, respectively.

Results show that 25 billion IDR were redistributed annually due to the presence of SCs in the time span under consideration, which corresponds to 5.4% of the suppliers' incomes.²¹ For scenario two, we find that if the SCs were only half of the observed values, the redistributed amount would shrink to 7.6 billion IDR (1.6% of farm incomes), which is equivalent to a decrease in redistribution of 69.6%. In the absence of SCs, the suppliers'

²⁰ Another possible explanation for varying SCs is different risk preferences across buyers regarding the quality of the product purchased. This hypothesis could not be explored further in this work because information on buyers' risk preferences are not available, so this remains a question for future research.

²¹ To provide an intuition for the sensitivity of the estimated income effects to the value of the input–output transformation coefficient, the results for 25% deviations from the assumed λ in both directions, respectively, are given here $\lambda + 25\% \rightarrow$ redistribution = 31 billion IDR, corresponding to 6.8% of farm incomes. $\lambda - 25\% \rightarrow$ redistribution = 19 billion IDR, corresponding to 4.1% of farm incomes.

income would increase by the whole sum of 25 billion IDR.

6 | CONCLUSIONS

This article develops a SC model that explains price mark-downs in a Bertrand setting and deviations from the LOP by a fixed cost component incurred by agricultural suppliers when switching buyers. The SC model has diverse applications. Whenever repeated interactions between market participants continually reduce TCs, agents have to start again at a high level of TCs when changing trading partners. This sudden cost increase is represented by the SCs in this model. The empirical approach proposed in this article allows the quantification of SCs, as revealed by the buyers' pricing strategies, via a profile likelihood estimation.

The SC model is applied to the natural rubber processing market in the Jambi province, Indonesia. We find that SCs are substantial in this market, leading to buyer power and substantial income losses for suppliers due to a mark-down of the farm gate price of about 3%. Simulations show that halving the costs for suppliers to switch buyers would reduce the associated income losses by 70%.

Such a reduction of SCs could be achieved by reducing the risk that buyers face during purchases of agricultural input. In order for them to refrain from charging a risk premium for purchasing rubber of unknown quality, quality standards could be helpful. In the Indonesian case, some standards do already exist, but their enforcement is weak (Arifin, 2005). So the first step might be to increase their strictness and level of enforcement. The second source of SCs is related to the interlinkages between output and input markets, especially in terms of credit. Improving suppliers' access to credit through improved road infrastructure or via an extension of the formal lending system is likely to reduce SCs and result in improved rural livelihoods.

ACKNOWLEDGMENTS

The author is grateful to Bernhard Brümmer and Richard J. Sexton for valuable comments, as well as to the late Quirino Paris, Dela D. D. Fiankor, Ashish Shenoy, and Mirawati Yanita. I also thank editor Ashok K. Mishra and two anonymous referees for valuable comments. This study was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number KO 5269/1-1. Data were collected within the DFG funded Collaborative Research Centre C990. A substantial share of the work was conducted at the University of Göttingen. Sodiq Adeoye, Tim Knöpfel, Dilsuz Nur-mukhanmatova, and Matthew Rudh provided valuable research assistance.

Open access funding enabled and organized by Projekt DEAL.

REFERENCES

- Amalia, D. N., Nurmalina, R., & Rifin, A. (2013). The marketing system of smallholders rubber in Jambi province with structure, conduct, and performance approach. *Journal of Industrial and Beverage Crops*, 4(3), 237–244.
- Amari, T., Themelis, N. J., & Wernick, I. K. (1999). Resource recovery from used rubber tires. *Resources Policy*, 25, 179–188.
- Angrist, J. D., & Krueger, A. B. (2001). Instrumental variables and the search for identification: From supply and demand to natural experiments. *Journal of Economic Perspectives*, 15(4), 69–85.
- Arifin, B. (2005). Supply-chain of natural rubber in Indonesia. *Jurnal Manajemen Agribisnis*, 2(1), 1–16.
- Beckmann, V., & Boger, S. (2004). Courts and contract enforcement in transition agriculture: Theory and evidence from Poland. *Agricultural Economics*, 31(2–3), 251–263.
- Boger, S. (2001). Quality and contractual choice: A transaction cost approach to the polish hog market. *European Review of Agricultural Economics*, 28(3), 241–261.
- Bonanno, A. (2013). Functional foods as differentiated products: The Italian yogurt market. *European Review of Agricultural Economics*, 40(1), 45–71.
- Bruttel, L. V. (2009). Group dynamics in experimental studies – The Bertrand paradox revisited. *Journal of Economic Behavior and Organization*, 69(1), 51–63.
- Burnham, T. A., Frels, J. K., & Mahajan, V. (2003). Consumer switching costs: A typology, antecedents, and consequences. *Journal of the Academy of Marketing Science*, 31(2), 109–126.
- Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: Methods and applications*. Cambridge University Press.
- Chami Batista, J., & Da Silveira Filho, G. B. (2010). Trade costs and deviations from the law of one price. *American Journal of Agricultural Economics*, 92(4), 1011–1023.
- Cole, S. R., Chu, H., & Greenland, S. (2014). Maximum likelihood, profile likelihood, and penalized likelihood: A primer. *American Journal of Epidemiology*, 179(2), 252–260.
- Crespi, J. M., & Sexton, R. J. (2004). Bidding for cattle in the Texas Panhandle. *American Journal of Agricultural Economics*, 86(3), 660–674.
- Deininger, K. (2013). Global land investments in the bio-economy: Evidence and policy implications. *Agricultural Economics*, 44(1), 115–127.
- DeLay, N. D., Chouinard, H. H., Walters, C. G., & Wandschneider, P. R. (2020). The influence of crop insurance agents on coverage choices: The role of agent competition. *Agricultural Economics*, 51(4), 1–16.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366a), 427–431.
- Dobson, P. W., Waterson, M., & Davies, S. W. (2003). The patterns and implications of increasing concentration in European food retailing. *Journal of Agricultural Economics*, 54(1), 111–125.
- Dufwenberg, M., & Gneezy, U. (2000). Price competition and market concentration: An experimental study. *International Journal of Industrial Organization*, 18(1), 7–22.
- Efron, B., & Tibshirani, R. J. (1994). *An introduction to the bootstrap*. Chapman and Hall.

- Euler, M., Schwarze, S., Siregar, H., & Qaim, M. (2016). Oil palm expansion among smallholder farmers in Sumatra, Indonesia. *Journal of Agricultural Economics*, 67(3), 658–676.
- Gapkindo. (2014). *List of members 2014*. Gapkindo.
- Geromichalos, A. (2014). Directed search and the Bertrand paradox. *International Economic Review*, 55(4), 1043–1065.
- Gervais, J. P., & Larue, B. (2009). A joint test of market power, menu costs, and currency invoicing. *Agricultural Economics*, 40(1), 29–41.
- Hansen, B. E. (2000). Sample splitting and threshold estimation. *Econometrica*, 68(3), 575–603.
- Hartwich, F., Fromm, I., & Romero, G. (2010). Innovation trajectories in honduras' coffee value chain. Public and private influence on the use of new knowledge and technology among coffee growers. *International Journal on Food System Dynamics*, 1(3), 237–251.
- Henning, C. H. C. A., Henningsen, G., & Henningsen, A. (2012). Networks and transaction costs. *American Journal of Agricultural Economics*, 94(2), 377–385.
- Hirsch, S., & Hartmann, M. (2014). Persistence of firm-level profitability in the European dairy processing industry. *Agricultural Economics*, 45(S1), 53–63.
- Klemperer, P. (1995). Competition when consumers have switching costs: An overview with applications to industrial organization, macroeconomics, and international trade. *Review of Economic Studies*, 62(4), 515–539.
- Kopp, T., & Brümmer, B. (2017). Traders' market power along Indonesian rubber value chains. *China Agricultural Economic Review*, 9(2), 169–187.
- Kopp, T., & Salecker, J. (2020). How traders influence their neighbours: Modelling social evolutionary processes and peer effects in agricultural trade networks. *Journal of Economic Dynamics and Control*, 117(103944), 1–24.
- Kopp, T., & Sexton, R. J. (2021). Farmers, traders, and processors: Buyer market power and double marginalization in Indonesia. *American Journal of Agricultural Economics*, 103(2), 543–568.
- Künsch, H. R. (1989). The Jackknife and the bootstrap for general stationary observations. *The Annals of Statistics*, 17(3), 1217–1241.
- Lam, S. Y., Shankar, V., Erramilli, M. K., & Murthy, B. (2004). Customer value, satisfaction, loyalty, and switching costs: An illustration from a business-to-business service context. *Journal of the Academy of Marketing Science*, 32(3), 293–311.
- Lee, J., Lee, J., & Feick, L. (2001). The impact of switching costs on the customer satisfaction–loyalty link: Mobile phone service in France. *Journal of Services Marketing*, 15(1), 35–48.
- Mariuzzo, F., Walsh, P. P., & Whelan, C. (2003). Firm size and market power in carbonated soft drinks. *Review of Industrial Organization*, 23, 283–299.
- Mitchell, T. (2017). Is knowledge power? Information and switching costs in agricultural markets. *American Journal of Agricultural Economics*, 99(5), 1307–1326.
- Mwema, C., & Crewett, W. (2019). Social networks and commercialisation of African indigenous vegetables in Kenya: A Cragg's double hurdle approach. *Cogent Economics and Finance*, 7(1), 1–16.
- Peerlings, J., & Polman, N. (2008). Agri-environmental contracting of Dutch dairy farms: The role of manure policies and the occurrence of lock-in. *European Review of Agricultural Economics*, 35(2), 167–191.
- Peramune, M. R., & Budiman, A. (2007). *A value chain assessment of the rubber industry in Indonesia*. U.S. Agency for International Development.
- Pietola, K. S. (2001). Farmer response to policies promoting organic farming technologies in Finland. *European Review of Agricultural Economics*, 28(1), 1–15.
- Politis, D. N., & Romano, J. P. (1994). The stationary bootstrap. *Journal of the American Statistical Association*, 89(428), 1303–1313.
- Rhoades, S. A. (1985). Market share as a source of market power: Implications and some evidence. *Journal of Economics and Business*, 37(4), 343–363.
- Richards, T. J., & Liaukonyte, J. (2018). Switching costs and store choice. In *Proceedings of the 2018 Agricultural & Applied Economics Association Annual Meeting*, 1–48.
- Romyen, A., Wannapan, S., & Chaiboonsri, C. (2019). Bayesian extreme value optimization algorithm: Application to forecast the rubber futures in futures exchange markets. In K. Vladik & S. Songsak (Eds.), *Studies in computational intelligence: Structural changes and their econometric modeling* (pp. 582–595). Springer.
- Royston, P. (2007). Profile likelihood for estimation and confidence intervals. *Stata Journal*, 7(3), 376–387.
- Saitone, T. L., Sexton, R. J., & Sexton, S. E. (2008). Market power in the corn sector: How does it affect the impacts of the ethanol subsidy?. *Journal of Agricultural and Resource Economics*, 33(2), 169–194.
- Samia, N. I., & Chan, K.-S. (2011). Maximum likelihood estimation of a generalized threshold stochastic regression model. *Biometrika*, 98(2), 433–448.
- Sexton, R. J. (2013). Market power, misconceptions, and modern agricultural markets. *American Journal of Agricultural Economics*, 95(2), 209–219.
- Sexton, R. J., Sheldon, I., McCorriston, S., & Wang, H. M. (2007). Agricultural trade liberalization and economic development: The role of downstream market power. *Agricultural Economics*, 36(2), 253–270.
- Sheldon, I. M. (2017). The competitiveness of agricultural product and input markets: A review and synthesis of recent research. *Journal of Agricultural and Applied Economics*, 49(1), 1–44.
- Statistics of Jambi Province. (2018). *Jambi in Figures 2018*. Regional Account and Statistical Analysis Division.
- Subramanian, A., & Qaim, M. (2011). Interlocked village markets and trader idiosyncrasy in rural India. *Journal of Agricultural Economics*, 62(3), 690–709.
- Swinnen, J. F. M., & Vandeplas, A. (2010). Market power and rents in global supply chains. *Agricultural Economics*, 41(1), 109–120.
- Wrights, S. (2018). Does the law of one price hold for hedonic prices?. *Urban Studies*, 55(15), 3299–3317.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Kopp, T. When switching costs cause market power. *Agricultural Economics*. 2022;53:481–495.
<https://doi.org/10.1111/agec.12690>