# COMPETITION AND RELATIONAL CONTRACTS IN THE RWANDA COFFEE CHAIN*

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How does competition affect market outcomes when formal contracts are not enforceable and parties resort to relational contracts? Difficulties with measuring relational contracts and dealing with the endogeneity of competition have frustrated attempts to answer this question. We make progress by studying relational contracts between upstream farmers and downstream mills in Rwanda's coffee industry. First, we identify salient dimensions of their relational contracts and measure them through an original survey of mills and farmers. Second, we take advantage of an engineering model for the optimal placement of mills to construct an instrument that isolates geographically determined variation in competition. Conditional on the suitability for mills' placement in the catchment area, we find that mills surrounded by more suitable areas (i) face more competition from other mills, (ii) use fewer relational contracts with farmers, and (iii) exhibit worse performance. An additional competing mill also (iv) reduces the aggregate quantity of coffee supplied to mills by farmers and (v) makes farmers worse off. Competition hampers relational contracts directly by increasing farmers' temptation to default

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on the relational contract and indirectly by reducing mills' profits. *JEL Codes:* D43, D86, L14, O13, Q13.

## I. Introduction

Markets in developing economies are often portrayed as dysfunctional: thin, scarcely competitive, and harboring unproductive firms. This suggests an important role for increased competition in improving firm performance and management via selection and incentives (Syverson 2004; Bloom and Van Reenen 2010; Bloom et al. 2015). Yet these same markets are often characterized by weak contract enforcement (Greif 1993; Simeon et al. 2003). This generates an important role for relational contracts—informal agreements sustained by the future value of the relationship (Baker, Gibbons, and Murphy 2002). In settings with limited competition but also weak contract enforcement, the effects of increased competition on firm performance are then theoretically ambiguous: on the one hand, competition might improve a firm's performance; on the other hand, by tempting parties with alternative trading opportunities and reducing profits, it may weaken relational contracting and reduce efficiency. What is the impact of competition in such second-best institutional environments?

Answering this question empirically has been challenging for two reasons. First, relational contracts are implicit and context-specific, making such contracts difficult to measure. Second, identification of the causal effects of competition is complicated by the endogeneity of market structure. This article identifies the effect of increased competition on firm outcomes in a weakly institutionalized environment in which relational contracts are needed to sustain trade. We address these challenges by studying relational contracts between upstream farmers and downstream mills in Rwanda's coffee industry, a context that affords us progress in both measurement and identification.[1]

The context allows us, first, to identify specific, salient dimensions of relational contracts. Mills operate a simple technology but, due to poorly functioning input and financial markets typical of agriculture in developing countries (see, e.g., Bardhan 1989), sourcing coffee cherries from farmers at harvest is bundled

1. Coffee is the main source of livelihood for about 25 million farmers worldwide and features many aspects common to other agricultural chains in developing countries.

with legally unenforceable provision of services before, during, and after harvest. We measure the use of these relational contracts by conducting an original survey of mills and farmers in the sector.

Second, we construct an instrument for competition, building on an engineering model that specifies detailed criteria for the optimal placement of mills. The instrument isolates geographically determined variation in the presence of mills, which we argue affects relational contracting only through the intensity of mill competition.

We find that conditional on the suitability for mills in the catchment area, mills surrounded by more suitable areas (i) face more competition from other mills, (ii) use fewer relational contracts with farmers, and (iii) exhibit worse performance. We also show that an additional competing mill (iv) makes farmers worse off and (v) reduces the aggregate volume of coffee supplied by farmers to mills. We find that competition hampers relational contracts directly by tempting farmers to default on the relational contract and indirectly by reducing mills' profits.

These findings must be interpreted cautiously. We identify the effect of an additional competitor for a mill that competes with six other mills on average. Our findings are thus not in conflict with Adam Smith's remark that "monopoly is a great enemy to good management."[2] The finding that increased competition downstream leaves all market participants—including upstream producers—no better off provides novel evidence on the functioning of markets in second-best environments (Rodrik 2008). In particular, it suggests the possibility of socially excessive entry when contracts are hard to enforce and a potential role for policy to improve efficiency.

The article proceeds as follows. Section II provides industry background and presents our measure of relational contracts between mills and farmers. In our context, a relational contract is a legally nonbinding agreement between a mill and supplying farmers that describes how farmers and mills should behave over the course of the coffee season. We focus on three relational practices: inputs and loans provided by the mill to the farmers before harvest, coffee sold on credit by farmers to the mill during harvest, and assistance from the mill to the farmers unrelated to (that is, post) harvest. We measure the use of each relational

2. Adam Smith, *The Wealth of Nations*, book I (1776), chapter XI.

practice surveying mills' managers and randomly sampled farmers. We aggregate the mill managers' and farmers' responses into a relational-contracts index. The relational-contracts index displays significant variation and correlates well with mills' performance, giving us confidence that it measures relevant practices for this industry.

Section III presents a theoretical framework that captures the key aspects of the relationship between mills and farmers. The model isolates two distinct channels. First, there is a direct effect through which competition between mills increases farmers' temptation to renege on the relational contract. Second, competition reduces mills' processed volumes and profits. This makes it harder to sustain relational contracts with farmers, even those for which the temptation to renege has not increased. We label this the indirect effect. Higher competition might reduce parties' ability to sustain a relational contract. When this occurs, the model delivers a cluster of additional predictions, including an aggregate reduction in cherries procured by mills and lower welfare for farmers.

The empirical analysis proceeds in three steps. Section IV asks whether competition breaks relational contracts; Section V explores the consequences of a breakdown in relational contracts; and Section VI investigates the mechanisms.

With regard to the role of competition in sustaining relational contracting, we begin by outlining stylized features of coffee production. Coffee cherries must be processed within hours of harvest, and roads are often in poor conditions. Mills thus mainly compete with nearby mills. We measure competition as the number of mills within a 10-km radius from the mill and find that competition negatively correlates with the relational-contract index. OLS estimates, however, are likely biased: unobservable factors might correlate with competition and with the desirability or feasibility of relational contracts; competitors might locate near mills with either worse or better relational practices; and competition could be measured with error.

To address these concerns, we implement an instrumental variable strategy. We need a variable that, conditional on controls, correlates with competition (first stage) and only influences mills' and farmers' operations through its effect on competition (exclusion restriction). We construct our instrument combining the spatial nature of competition with an engineering model for the optimal placement of mills in Rwanda. In the early 2000s, when only a handful of mills were established, a team of engineers and agronomists developed a model to identify suitable sites for mill construction. The model, however, was never implemented because the required GIS data were not available at the time. Subsequent entry of mills was not restricted to locations satisfying the model's criteria. We assembled ex novo the data required for the model. We predict actual mill placement with the model's criteria and other controls obtaining a "suitability score" for a mill's placement at the 1 $km^2$ resolution for the whole of Rwanda. For each mill we aggregate the suitability score in the area within a 5 km radius (the catchment area) and in the surrounding area between 5 and 10 km from the mill (the instrument). The exclusion restriction is satisfied if, conditional on suitability in the mill's catchment area, suitability in the surrounding area affects mills' and farmers' operation only through its effect on competition.

The instrument yields a strong first stage, and the second stage finds that an additional mill within 10 km reduces the relational-contract index at the mill by 0.28 standard deviations, suggesting that competition has a negative effect on relational contracts. We discuss extensive evidence mitigating concerns about violations of the exclusion restriction. First, presence of roads and local density of coffee trees are among the variables used to predict the suitability score at the 1 $km^2$. These variables could potentially violate the exclusion restriction and be bad controls. We show that we can omit road density, coffee tree density, or both from the construction of the instrument without altering the results. We can omit those variables from the set of controls in the mill's catchment area without affecting our estimates. Second, our instrument could correlate with farmers' economic opportunities outside coffee, thus reducing the demand for relational contracts. We show that the instrument is uncorrelated with farmers' outside economic opportunities, including access to agricultural markets, labor market opportunities, and financial services.[3]

The evidence in Section IV suggests that competition leads to a breakdown in relational contracts between mills and farmers. When this happens, the model yields a cluster of additional predictions. Section V tests these predictions and finds ample support.

3. Online Appendix B and D explore robustness to alternative definitions of competition, the size of mills' catchment areas, alternative assumptions on the structure of the error term, and additional threats to identification, including strategic entry effects and differences in market access.

First, competition reduces relational practices before, during, and after harvest by a nearly identical magnitude. Second, at the mill level, competition lowers the amount of cherries processed by the mill and leads to more irregular procurement of cherries. This results in higher average processing cost. We also detect a negative effect of competition on lab-tested quality of random samples of coffee produced by mills, particularly on quality dimensions that depend on farmers' practices. Third, at the farmer level, competition lowers the amount of coffee that farmers sell to any mill without increasing output or prices. When farmers do not sell cherries to mills, they process at home. Given the lower prices fetched by home-processed coffee, an additional mill reduces farmers' revenues by about 8%.

Finally, Section VI investigates mechanisms. We provide evidence consistent with both mechanisms highlighted in the model being at work. Conditional on the number of competing mills and on the farmer's distance to the mill, the relational-contract index is lower when the farmer is closer to competing mills. This is consistent with competition directly affecting the farmer's temptation to renege on the relational contract. We also show that, conditional on the number of competing mills to which the farmer can sell, higher competition from mills to which the farmer cannot sell also reduces the relational-contract index. This is consistent with competition indirectly affecting the relational contract through its negative effect on mills' performance.[4] Concluding remarks and policy implications are discussed in Section VII.

This article contributes to three strands of literature. First, to the literature on relational contracts and, more broadly, on management practices (Bloom and Van Reenen 2007, 2010). The work by Bloom and Van Reenen (2007, 2010) shows that the adoption of certain well-codified management practices is associated with better firm performance. This raises the question of why many firms fail to adopt these management practices. A possibility is that a firm's ability to introduce, and benefit from, these practices

4. The finding that an additional competitor reduces the aggregate volume of coffee supplied by farmers to mills distinguishes our mechanism from Mankiw and Whinston (1986). In Mankiw and Whinston (1986) an additional entrant increases the total quantity of the good sold in the market and makes consumers better off. Adapting the logic to our context, these predictions are inconsistent with our findings that competition reduces the aggregate quantity processed by mills and makes farmers worse off. Online Appendix D provides additional evidence on this point.

depends on relational contracts within and across the firm's boundaries (Baker, Gibbons, and Murphy 2002; Gibbons and Henderson 2012; Helper and Henderson 2014). Relational practices are, by definition, difficult to codify, context-specific, and therefore hard to measure. This article provides an example of how relational practices can be systematically measured, documents significant dispersion in the adoption of complementary relational practices among firms competing in a narrowly defined industry, and confirms that their adoption correlates with firm performance.[5]

Second, we study the effect of competition in an environment characterized by poor contract enforcement.[6] There is abundant evidence that competition is associated with higher productivity and better management practices. For example, Syverson (2004) shows that in the United States, larger, more competitive markets are associated with stronger selection in concrete manufacturing. Schmitz (2005) shows that in response to competition from Brazilian producers, U.S. iron ore manufacturers increased efficiency and adjusted working arrangements (see also Bloom et al. 2015, 2019 on competition and better management practices). In developing countries, Andrabi, Das, and Khwaja (2017) and Jensen and Miller (2018) show positive effects of competition on schools in Pakistan and boat builders in Kerala, India, respectively. These papers study institutionally developed environments or contexts in which relational contracts are not key. Our analysis suggests that the benefits of competition might be hampered by the presence of other market failures which are mitigated by relational contracts.

Third, the article relates to the literature on how competition affects relational lending and trade credit. Petersen and Rajan (1995) is a seminal article on how competition might be detrimental to relational lending. McMillan and Woodruff (1999) provides

5. A growing literature studies relationships between firms, often in the context of international markets (see Banerjee and Duflo 2000; Macchiavello 2010; Antràs and Foley 2015; Macchiavello and Morjaria 2015b; Startz 2018; Macchiavello and Miquel-Florensa 2019; Blouin and Macchiavello 2019; Cajal–Grossi, Macchiavello, and Noguera 2020). This literature highlights how relationships mitigate contracting problems due to lack of enforcement and/or asymmetric information. We complement this agenda asking how competition affects the sustainability of these relationships.

6. The question of how competition affects welfare has long been regarded as central to economics (see Schumpeter 1942; Stigler 1956; Arrow 1962).

empirical evidence on how firms' outside options affect the ability to sustain relational agreements in a context characterized by weak contract enforcement. Fisman and Raturi (2004) find that monopoly power is negatively associated with credit provision, using data on supply relationships in five African countries. Our article differs from these contributions in several ways. First, we instrument for smoother changes in competition within an oligopolistic setting. Second, we study a context with two-sided moral hazard: both mills and farmers can cheat, just at different points during the harvest season. In contrast, the trade credit literature often considers one-sided moral hazard (suppliers offering trade credit to buyers) and thus when competition increases firms might compete by extending trade credit. Ghani and Reed (2020) find evidence consistent with this mechanism, exploiting the sudden entry of a new ice manufacturer in Sierra Leone. Casaburi and Reed (2020) find that traders that were randomly offered higher resale prices extended more credit to farmers.[7]

## II. Industry Background

### II.A. Coffee in Rwanda

*1. Overview.* Coffee is produced in about 50 countries around the world. Certain aspects of coffee cultivation, harvesting, processing, and commercialization differ across countries. This section focuses on Rwanda's industry. At the time of our survey in 2012, there were around 350,000 smallholder farmers growing coffee. Coffee accounted for almost 20% of the country's exports and 12%–15% of Rwanda's GDP.

*2. Harvest and Processing.* The coffee cherry is the fruit of the coffee tree. Cherries are ripe when they change color from green to red, at which point they should be harvested. The harvest season typically lasts three to four months, and its timing varies across regions depending on altitude and rainfall patterns. Coffee cherries are harvested by hand, a labor-intensive process

7. There has been renewed interest in interlinked transactions in agricultural chains in developing countries (see, e.g., Casaburi and Willis 2018; Casaburi and Macchiavello 2019; and Emran et al. 2020 for recent contributions). The literature typically focuses on a single interlinkage at a time (credit, saving, insurance) while we focus on bundles of complementary interlinked transactions and study how they are affected by competition.

requiring care and effort. Coffee cherries, even from the same tree, do not ripen for harvest all at once. Although it is less laborious, harvesting cherries all at once compromises quality.

Upon harvest, the pulp of the coffee cherry is removed, leaving the bean, which is dried to obtain parchment coffee. There are two processing methods to obtain parchment coffee: the dry method and the wet method. In the dry method, farmers clean cherries at home using rocks before drying them on mats. This process produces coffee cherries of lower and less consistent quality. By contrast, cherries processed with the wet method are taken to a mill (often referred to as coffee washing stations or wet mills) within hours of harvest. If not taken immediately, the cherries will start to ferment and rot. Mills are scattered around the countryside; farmers closest to the mill often take cherries to the mill's gate directly. Those who are further afield bring cherries to collection sites where coffee collectors buy coffee.

The wet method requires specific equipment and substantial quantities of clean water. After the cherry skin and pulp are removed with a pressing machine, cherries are sorted by immersion in water. The bean is then left to ferment for about 30 hours to remove the remaining skin. When fermentation is complete, the coffee is thoroughly washed with clean water. The beans are then spread out on drying tables and frequently turned by hand until completely and uniformly dry.[8]

The wet method yields significantly higher value addition for the Rwandan coffee chain as a whole. At the time of our survey, export gate prices for wet-processed coffee (known as fully washed coffee) were around 40% higher than for dry-processed coffee (see Macchiavello and Morjaria 2015a for details). Selling cherries to mills also yields higher revenues at the farm gate. The average price of cherries sold to a mill was about 200 Rwandan francs (RWF) per kilogram. In contrast, home-processed parchment coffee fetched an average price of 760 RWF per kilogram. Since it takes approximately 5.5 to 6.0 kg of cherries to produce 1 kilogram of home-processed parchment irrespective of the processing method, the price of cherries under home processing is approximately 140 RWF per kilogram, substantially lower than the corresponding figure for cherries sold to mills.

8. After the drying process is completed, the coffee is hulled and consolidated for exports. Hulled coffee is referred to as green coffee. This last step is carried out by separate plants (dry mills) located around the capital city. This step of the chain is not part of our analysis.

The difference in prices underestimates the returns from selling cherries to mills for farmers since home-processed coffee entails additional processing costs for the farmers. As a result, farmers overwhelmingly report that selling cherries to mills is more profitable than home processing. For instance, when asked in our 2012 survey about which kind of buyer offers the highest price, only 2% of farmers answered traders buying home-processed coffee. In a subsequent farmer survey in 2019 that confirms the price difference, we asked farmers directly about the relative profitability of the processing methods. Most of the farmers (98%) report that selling cherries to mills is more profitable than home processing.

Why do farmers engage in home processing at all, given its much lower returns relative to selling cherries to mills? In the 2012 and 2019 surveys, farmers reported that they would sell home-processed coffee after the harvest period when they were in need of cash, effectively treating this production as a very expensive savings tool. This observation raises the question: why are mills unable to buy cherries at harvest and defer farmers' payments to the postharvest period?

### *II.B. Mills and Farmers*

*1. Survey.* To understand constraints to the operations of mills and farmers, we designed and implemented a survey in collaboration with the National Agricultural Exporting Board (NAEB), the government institution in charge of the coffee sector. The survey was implemented toward the end of the 2012 harvest campaign (May–July) by four survey teams led by a qualified NAEB staff member.[9]

*2. Descriptive Statistics, Mills.* There were 214 processing mills in the country in 2012 (Online Appendix Figure C1). Summary statistics for mills in Rwanda are reported in Table I, Panel A. The survey covered all operating mills in the 2012 harvest season. The response rate was close to 100%.

The average mill employs around 35 seasonal employees and sources from close to 400 smallholder farmers. Coffee mills are thus large firms by developing countries' standards (see, e.g., Hsieh and Olken 2014). There is dispersion in installed

9. We complement our analysis with data from a farmer survey undertaken during the 2019 harvest.

TABLE I
SUMMARY STATISTICS

| | Mean (1) | 25th pct. (2) | Median (3) | 75th pct. (4) | Obs (5) |
|---|---|---|---|---|---|
| Panel A: Mill characteristics | | | | | |
| Mill age, years | 4.090 | 2 | 4 | 6 | 178 |
| Theoretical capacity (tons of cherries) | 423.1 | 250 | 340.9 | 500 | 173 |
| Production (tons of parchment coffee) | 46.01 | 15 | 32 | 60 | 177 |
| Cherries purchased (tons) | 294.8 | 102.4 | 199.9 | 400 | 174 |
| Seasonal employees | 35.13 | 16 | 30 | 50 | 171 |
| Cooperative status, dummy | 0.466 | 0 | 0 | 1 | 178 |
| Farmers in catchment area that sell to mill | 396.0 | 170 | 310 | 500 | 170 |
| NGO-supported mill, dummy | 0.264 | 0 | 0 | 1 | 178 |
| Total unit cost (RWF per kg) | 1,793 | 1,600 | 1,800 | 1,956 | 178 |
| Total processing unit cost (RWF per kg) | 705.3 | 500.0 | 699.0 | 831.0 | 177 |
| Number of mills within 10 km | 6.539 | 3 | 6 | 10 | 178 |
| Score within 5 km of mill | – | −0.826 | −0.276 | 0.714 | 177 |
| Score within 5–10 km of mill | – | −0.762 | −0.230 | 0.648 | 177 |
| Average elevation (m) within 5 km | 1,625.8 | 1,511 | 1,630.4 | 1,730.1 | 177 |
| Average slope (°) within 5 km | 10.93 | 8.859 | 10.87 | 12.87 | 177 |
| Average river density (m) within 5 km | 320.5 | 205.5 | 319.5 | 423.2 | 177 |
| Average tree density within 5 km ('000) | 11.53 | 5.152 | 9.499 | 14.64 | 177 |
| Average spring presence within 5 km | 0.033 | 0.012 | 0.025 | 0.049 | 177 |
| Kilometers of road within 5 km | 1.769 | 1.452 | 1.674 | 2.008 | 177 |
| Overall quality score | – | −0.473 | 0.150 | 0.745 | 159 |
| Given inputs to farmers | 0.222 | 0 | 0 | 0 | 176 |
| Has made a second payment in the past | 0.784 | 1 | 1 | 1 | 176 |
| Provides help/loans to farmers | 0.773 | 1 | 1 | 1 | 176 |
| RC index, mill outcomes | – | −0.894 | 0.252 | 0.252 | 177 |
| RC index, overall | – | −0.502 | 0.114 | 0.453 | 175 |
| Panel B: Farmer characteristics | | | | | |
| Farmer age, years | 46.44 | 36 | 47 | 56 | 875 |
| Female, dummy | 0.287 | 0 | 0 | 1 | 881 |
| Schooling, years | 5.339 | 4 | 6 | 7 | 879 |
| Distance to mill, km | 5.480 | 1.194 | 2.689 | 7.182 | 615 |
| Cooperative membership, dummy | 0.552 | 0 | 1 | 1 | 881 |
| Farmer's trees | 975.5 | 250 | 500 | 1,000 | 881 |
| Cherry price (RWF per kg) | 208.2 | 200 | 200 | 220 | 881 |
| Share sold as cherries (%) | 0.792 | 0.764 | 1 | 1 | 872 |
| Home process for saving, dummy | 0.232 | 0 | 0 | 0 | 881 |
| Job satisfaction index | – | −0.457 | 0.026 | 0.499 | 868 |
| Number of other mills in own quadrant | 1.506 | 0 | 1 | 2 | 615 |
| Received input from mill | 0.176 | 0 | 0 | 0 | 881 |
| Expects to receive a second payment | 0.795 | 1 | 1 | 1 | 881 |
| Expects to receive help/loan | 0.637 | 0 | 1 | 1 | 877 |
| RC index, farmer outcomes | – | −0.659 | 0.413 | 0.413 | 881 |

*Notes.* Mill characteristics are obtained from the survey of mills and the authors' GIS data set. Farmer characteristics are obtained from a survey of four or five random farmers supplying to the surveyed mill. Both surveys took place at the same time and were fielded in the harvest season of 2012. Relational-contract index measures, referred to as relational practices in the text, are dummy variables: *Given inputs to farmers*, *Has made a second payment in the past*, and *Provides help / loans to farmers* are responses from mill managers; *Received input from mill*, *Expects to receive a second payment*, and *Expects to receive help / loan* are responses from farmer surveys. Competition is defined as the number of mills within 10 km. Means of standardized variables ($z$-scores) are denoted by —.

capacity, measured in tons of cherry processing per season. Small mills have capacity up to 250 tons; medium-sized mills, which constitute the majority, typically have a capacity of 500 tons; and a handful of large mills have a capacity in excess of 1,000 tons.

Mills are characterized by a relatively simple technology that facilitates the calculation of unit costs of production. It takes approximately 5.5 to 6.0 kg of coffee cherries to produce 1 kg of mill parchment coffee, the mill output. Under a Leontief technology approximation, the cost of producing 1 kg of parchment coffee is the sum of (i) the price paid to farmers for cherries and (ii) other operating costs, including labor, capital, procurement, transport, marketing, and overheads. The former accounts for 60–70% of the total cost of processing.

*3. Descriptive Statistics, Farmers.* Summary statistics for farmers from the survey are reported in Table I, Panel B. The typical farmer is a smallholder who has completed primary education and owns a small coffee plantation of 500 to 1,000 coffee trees.

The sample of surveyed farmers was constructed as follows. When surveying a mill, we used a list of farmers from the coffee board's district office to randomly select five farmers from the sector in which the mill is located.[10] The farmer survey is thus meant to be representative of all farmers located in sectors with mills, irrespective of whether the farmer sells to the mill.

We match our surveyed farmers in 2012 to a National Coffee Census conducted in 2009 to check whether our sample is representative of the population of farmers. We are able to locate the village of around 70% of the surveyed farmers in the census.[11] Online Appendix Table B1 compares our surveyed farmers

10. Districts are the second-level administrative units in Rwanda. Sectors are the third-level administrative units, with an area of approximately 50 $km^2$. They are the lowest level at which the coffee board keeps regularly updated lists of active farmers.

11. We only know the name of the farmer and the village where the farmer's plot is located. This would not per se be a major limitation given that the average village has an area just larger than 1 $km^2$. Unfortunately, village names do not uniquely identify villages, and respondents of different age and ethnicity often refer to the same village using different names. We look for each surveyed farmer in a deanonymized version of the national census of coffee farmers to assign farmers to a village and thus location. We are able to precisely locate approximately 70% of our surveyed farmers. We are able to locate an additional 10% of farmers through a fuzzy-match procedure and find similar results when including those in our

in 2012 with those in the 2009 National Coffee Census. Within the relevant administrative sectors in which mills operate, farmers in the survey are similar to the wider population along a range of characteristics (household size, age, distance to the capital city, distance to the sector capital, distance to the nearest market trading center, and geophysical conditions such as elevations, slope, Food and Agricultural Organization (FAO) coffee suitability conditions, presence of roads and rivers) but have more coffee trees and are closer to the mill.[12]

### *II.C. Relational Practices between Mills and Farmers*

To operate efficiently, mills rely on relationships with farmers in the surrounding areas. Smallholder farmers in developing countries typically lack access to well-functioning input and financial markets. Farmers resort to interlinked transactions (Bardhan 1989) in which a variety of services are exchanged over time with the buyers of their produce. Coffee cherries in Rwanda are no exception; transactions between mills and farmers go beyond the simple exchange of coffee cherries for cash at harvest.

The survey focused on different aspects of these transactions between mills and farmers. We refer to each aspect as a practice. Given the lack of enforceable contracts in the rural areas of Rwanda, coffee farmers and mills must rely on informal relationships to sustain these transactions. We refer to the set of practices between a mill and the supplying farmers as the relational contract.

Table I presents summary statistics for the main relational practices. We focus on practices for which the mill and the farmer exchange promises that are then fulfilled or reneged on several weeks later, that is, those relationships for which lack of contract enforcement matters. We distinguish between practices that are relevant before, during, and after harvest. We refer to postharvest as practices involving exchanges separate from harvest operations. For these practices, we asked both the farmers and the manager about their use at the mill.

analysis. All results in our main tables are robust if we limit the analysis to this restricted sample of farmers.

12. The distance difference is likely due to the fact that the survey was conducted at the mill, and thus participation costs were higher for more distant farmers.

Before harvest, the main aspect of the relational contract is whether the mill provides farmers with inputs, extension services, and preharvesting loans. Gains from such practices arise from the relevant markets functioning poorly and/or from the mill's ability to more effectively organize procurement of those inputs in bulky purchases. This type of arrangement is commonly observed in agricultural chains in developing countries, particularly in those involving large buyers sourcing from smallholders (e.g., in contract farming). Due to lack of contract enforcement, it is often difficult for the mill to ensure that, at harvest time, farmers that received inputs and loans actually deliver to the mill. Approximately 20% (80%) of the farmers report that they have received inputs (loans) from the mill (Table I, Panel B). The mill managers' survey yields similar figures (Table I, Panel A).

During harvest, the main aspect of the relational contract is whether cherries are sold on credit to the mill in exchange for part of the payment being made after the end of harvest, possibly in the form of so-called second payment. This is beneficial for farmers and mills alike. As mentioned already, farmers report that a main motivation for home processing is to be able to sell coffee when they need cash, rather than at harvest. Receiving part of the payments for cherries sold to mills during harvest as second payments after the end of harvest might thus help farmers overcome saving constraints. Mills might also benefit from purchasing cherries from farmers to reduce working capital requirements.[13]

Due to the lack of contract enforcement, farmers might be concerned that after the end of harvest the mill might not be able or willing to pay the full balance still due to farmers for their deliveries. Because farmers would provide trade credit in-kind (in the form of coffee cherries), input diversion on the part of the mill is unlikely to be the key concern (Burkart and Ellingsen 2004). Farmers, however, might be concerned that the mill would renege on promised second payments. In the 2019 survey, we asked farmers whether they are concerned about mills defaulting on second payments. Of those that reported second payments, a third

13. In the survey mills report that limited access to working capital finance is one of the main constraints to operation. This is consistent with evidence that coffee mills have large working capital requirements and are often credit constrained (Blouin and Macchiavello 2019). For simplicity, in the theoretical section we model farmers' saving constraints and abstract from mills' credit constraints.

reported having experienced defaults on second payments in the past.

We asked managers whether the mill “has made second payments in the past” and farmers whether they “expect a second payment from the mill.” The farmers’ question captures the idea that, in relational contracting models, defaults occur off the equilibrium path. Concerns about default imply that promises of second payments might be constrained. On the extensive margin, the majority of managers and farmers report their use. Amounts typically are 5%–10% of total payments.

Finally, as part of the relational contract, the mill and the farmers can also transact services that are not related to harvest operations. For instance, mills can help farmers with loans for bulky or unexpected expenses. Those might be related to coffee farming (e.g., help to cover the costs of replanting or mulching trees) or not (e.g., assistance with school fees). Due to lack of contract enforcement, it might be difficult for mills to ensure that farmers repay those loans. On the extensive margin, 64% of farmers expect to be able to access help from the mill in case of need, while 77% of mills’ managers report that they have occasionally helped farmers with loans. These qualitative dummies can be aggregated across the five surveyed farmers to measure how often farmers can rely on the mill for help/loans unrelated to harvest season. The provision of loans and inputs before harvest is also consistent with farmers’ saving constraints ahead of the following harvest cycle.

In sum, we focus on the following practices: (i) before harvest, did the farmer receive inputs and loans from the mill; (ii) at harvest, did the farmer sell on credit in exchange for second payments; and finally, (iii) postharvest, do mills help farmers with loans? We ask farmers and managers about the use of each of the three practices at the mill. After standardizing the responses, we construct indices for the intensity of the relationship before, during, and after harvest, giving equal weight to the managers’ response and the average of the farmers’ responses. Our main dependent variable is the overall relational-contract index that aggregates the three period subscores.

There is significant dispersion in the adoption of relational practices. Figure I shows that the use of relational practices preharvest, at harvest, and postharvest are positively correlated across mills. The relational-contract index thus captures a set of complementary relational practices. Online Appendix

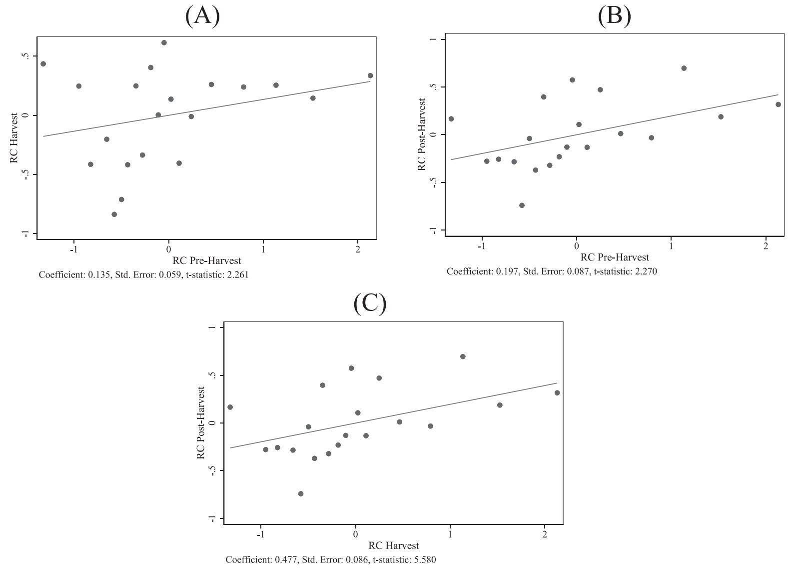


FIGURE I

Relational-Contract Practices

Binned scatter plot of mill-level regressions. All regressions control for mill characteristics (NGO-support, cooperative status, mill age, mill age squared, and mill coordinates). Controls also include average engineering suitability score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. RC preharvest ($z$-score) is constructed based on farmer- and mill manager–based indicators of mill-provided inputs. RC harvest ($z$-score) is constructed from farmer- and mill manager–based indicators of trade credit and second payments. RC postharvest ($z$-score) is constructed from farmer- and mill manager–based indicators of loans and/or help provided to farmers unrelated to harvest operations. In all RC index $z$-scores, farmer and mill manager responses are equally weighted.

Figure C2 shows that the relational-contract index correlates negatively with unit processing costs (Panel A) and positively with capacity utilization (Panel B). The relational-contract index thus captures aspects of managerial practices that are appropriate to this industry.

## III. THEORY

This section lays out a theoretical framework that guides the empirical analysis. A mill interacts repeatedly with a population of farmers. In exchange for coffee cherries, the mill provides farmers with productivity-enhancing inputs and access to a saving tool through delayed payments. In the rural areas of developing countries, this type of intertemporal exchange is hard to enforce with formal contracts, so the parties have to rely on relational contracts.

The model establishes two sets of results. First, we provide conditions under which competition between mills reduces parties' ability to sustain the relational contract. We derive predictions on mill- and farmer-level outcomes under these conditions. Second, we identify two distinct channels through which competition between mills affects relational contracts and we offer guidance on how to empirically disentangle them. The first channel, which we refer to as the direct effect, arises from the fact that after a farmer has already received productivity-enhancing inputs from a mill, she can choose to either deliver coffee cherries to that mill or sell them to an alternative mill. A larger number of competing mills makes this alternative more tempting, so that the original mill may be more reluctant to provide the farmer with productivity-enhancing inputs to begin with. The second channel, which we refer to as the indirect effect, arises from the fact that competition with other mills reduces a mill's profits. This will reduce the value of future rents, which are necessary to sustain the relational contract.

The model focuses on the most salient relational practices in our context: second payments, input extension, and farmers' side-selling behavior. We model second payments' role in alleviating farmers' saving constraints and the difficulty in enforcing them because they are critical in our context and not well emphasized in the literature. Besides empirical relevance, modeling input extension allows us to rationalize its complementarity with second payments despite the absence of a technological connection between the two. Finally, modeling side selling offers a convenient way to tie temptations to deviate in the relational contract to the degree of competition.[14]

We model competition as a parameter that affects spot prices at which farmers can sell during the harvest season. This provides a parsimonious approach that still captures the

14. We model input provision as affecting the volume of production, rather than its quality, and abstract from farmers' heterogeneity in dimensions other than exposure to competition. Such extensions would match additional empirical findings.

direct and indirect effects of competition that are key to our analysis.[15]

### III.A. Setup

*1. Players and Preferences.* A risk-neutral mill operates in an area populated by a unit mass of farmers, indexed $i \in [0, 1]$. Time is represented by an infinite sequence of identical seasons, indexed $t = 0, 1, 2..., \infty$. In each season, there are three subperiods, corresponding to preharvest (subindexed by 0), harvest (subindexed by 1), and postharvest (subindexed by 2). Farmers derive utility from consumption at harvest, $c_1$, and postharvest, $c_2$, with preferences given by $u(c_1, c_2) = \min\{c_1, c_2\}$. Consumption in each subperiod is equal to the sum of the transfer that the farmer receives from the mill and the revenue she earns from selling externally. These preferences capture farmers' demands for within-season consumption smoothing. The mill and the farmers have a common discount factor $\beta < 1$ across seasons. There is no discounting within season. In any season, the mill continues operation with probability $\theta$ (later endogenized) and ceases to operate with probability $(1 - \theta)$. Denote $\delta = \beta\theta$.

*2. Technology.* At harvest, farmer $i$ produces $Q_i^t$ units of coffee cherries. We describe $Q_i^t$ momentarily. Cherries must be processed at harvest. Once cherries are processed, they become storable. Two technologies are available: home processing and mill processing. Both technologies yield one unit of output per unit of cherries. Home processing is performed by the farmer at home and entails no additional cost. Home-processed coffee can be sold at harvest and postharvest at exogenous unit price $\rho$. Mill processing is performed by mills at constant marginal cost $c$. The mill sells production at exogenous unit price $v$. As discussed in Section II, mill processing is more efficient. We make this precise in Assumption 2.

*3. Timing of Events.* Each season $t$ unfolds as follows (illustration of the timing is provided in Online Appendix Figure C3):

15. Both effects would also arise in a model in which entry is endogenized and mills compete offering relational contracts. Such a model introduces additional features that are not central to our analysis.

Preharvest: (i) Mill draws an i.i.d. fixed cost $F^t \sim H(F^t)$; (ii) mill decides whether to pay the fixed cost and continue the game or exit. If the mill exits, the game ends and all parties get a payoff equal to 0; (iii) mill chooses whether to provide inputs to farmer $i$ at cost $k$, $\mathbf{I}^t_{k_i} \in \{0, 1\}$.

At harvest: (i) Farmer $i$ harvests $Q^t_i = (1 + \mathbf{I}^t_{k_i}\pi)q$, $\pi > 0$ capturing increased yields from input extension; (ii) mill offers a payment $P^t_{1,i}$ in exchange for $Q^t_i$; (iii) each farmer decides whether to sell to the mill, $x^t_i \in \{0, 1\}$.[16]

Postharvest: The mill decides whether to offer a second payment, $P^t_{i,2}$.

We make the following assumption:

ASSUMPTION 1. (Contracts and Markets)

i. The farmer does not have access to either input, credit, or saving markets;
ii. There is no formal contract enforcement: all promises must be self-enforcing.

The first part of the assumption introduces the motivation for interlinked transactions. The farmer lacks access to input, credit, and saving markets. She needs to consume at harvest and postharvest. She can do that on her own through home processing, but that is inefficient. Alternatively, she can rely on the mill to get inputs to increase production and for savings through a postharvest payment.[17]

The second part of the assumption states that the mill's provisions of inputs and payments must be self-enforcing. Furthermore, the farmer's promise to sell to the mill after receiving inputs is also nonenforceable, capturing the well-documented side-selling problem in agricultural chains.

*4. The Relational Contract.* A relational contract between the mill and farmer $i$ is a plan that specifies $\mathcal{R}_i = \{\mathbf{I}^t_{k_i}, x^t_i, P^t_{i,1}, P^t_{i,2}\}^{\infty}_{t=0,1,\ldots}$ for all future seasons as a function of the past history of the game. We assume perfect public monitoring

16. For simplicity, we assume that the mill either buys all cherries produced by the farmer or buys none. Results are qualitatively similar if farmers can sell a share of their harvest to the mill.

17. The mill is assumed to have perfect access to the credit market.

between the mill and the farmer. A relational contract is self-enforcing if it constitutes a subgame-perfect equilibrium of the repeated game between the mill and the farmer.

We characterize the optimal relational contract that maximizes the mill's profits. Specifically, before the beginning of season $t = 0$, the mill offers a relational contract to each farmer $i$ to maximize profits. Each farmer $i$ independently either accepts or rejects the offer, taking as given the actions of other farmers. If she rejects, both parties earn their outside option forever. If she accepts, parties enter the relational contract.[18] We focus on stationary relational contracts with grim-trigger punishment.[19]

Along an equilibrium path in which farmer $i$ sells to the mill in season $t$ ($x_i^t = 1$), the farmer's payoff is given by $min\{P_{i,1}^t, P_{i,2}^t\}$. The mill payoff conditional on operation and net of fixed costs $F^t$ is

$$\Pi^t = \int_0^1 (x_i^t((v-c)Q_i^t - P_{i,1}^t - P_{i,2}^t) - \mathbf{I}_{k_i}^t k)di. \quad (1)$$

*5. Outside Options.* We now define outside options for the mill and for farmer $i$. In principle, there are two distinct outside options: before parties enter the relational contract and following a deviation from either party after they have entered the relational contract. In both cases, we assume that parties stop trading with each other forever. This is also the case when the mill ceases operations.

The mill's outside option is given by $u_m = 0$ because the mill does not process any of the farmer's coffee. To be precise, the mill sources coffee from other farmers. However, conditional on the mill operating, contracting and punishment are bilateral and therefore the mill's payoff from interacting with other farmers on and off the equilibrium path is independent of the relationship with farmer $i$.[20]

Farmer $i$'s outside option is defined as follows. If the farmer does not sell to the mill, she can sell cherries to other mills at

18. When the farmer is indifferent, she is assumed to accept the offer. This rules out trivial coordination failures in which farmers reject simply because they think enough other farmers reject.

19. A relational contract is stationary if $\mathbf{I}_{k_i}, q_i, P_{i,1}, P_{i,2}$ do not depend on $t$. When referring to stationary relational contracts, we drop the $t$ superscript.

20. Farmers know the mill's exit probability (which depends on other farmers' actions) but are unable to coordinate punishment with other farmers scattered around the catchment area.

harvest and home-processed coffee to traders at exogenous price $\rho$ at harvest and postharvest.[21] Specifically, farmer $i$ can sell cherries at harvest to competing mills indexed $z \in \mathbf{C}_i \equiv \{1, ..., C_i\}$. $C_i$ ($\mathbf{C}_i$) is thus the number (set) of competing mills to which farmer $i$ can sell. Competing mills buy from the farmer using spot contracts only. In a spot contract, mill $z$ pays price $\rho_z$ at harvest and price of zero postharvest.

When selling to mill $z$, farmer $i$ faces iceberg transportation costs $(1 - \tau_{i,z})$. Denote with $z_i$ the mill that offers the best price net of transport costs and let $\rho_i = max_{z\in\mathbf{C}_i}\{\rho_z\tau_{i,z}\}$ denote the best such price. The farmer's outside option is as follows. If $\rho > \rho_i$, the farmer home processes all her coffee and sells half of it at harvest and half postharvest. This gives her payoff $\frac{Q_i^t \rho}{2}$. Otherwise, the farmer sells at harvest a share $\frac{\rho}{\rho + \rho_i}$ of her production to mill $z_i$ as cherries at price $\rho_i$. She home processes the remaining share of her production and sells it postharvest for price $\rho$. This gives her payoff $\boldsymbol{Q}_i^t \times \frac{\rho\rho_i}{\rho + \rho_i}$.

The farmer's payoff in the outside option is thus equal to $\boldsymbol{Q}_i^t \times \rho \times \frac{max\{\rho_i,\rho\}}{\rho + max\{\rho_i,\rho\}} = \boldsymbol{Q}_i^t \times u(\rho, C_i)$ which is (weakly) increasing in the price for home-processed coffee $\rho$ and in the number of competing mills $C_i$ the farmer can sell to. The reduced-form outside option $u(\rho, C_i)$ captures the idea that in the absence of a relational contract with the mill, the farmer sells at least part of her production as home-processed coffee postharvest to save. The remaining part of her production will be sold at harvest either as cherries or as home-processed coffee. The value of the outside option (weakly) increases with exposure to other mills, $C_i$, which is assumed to vary across farmers depending on their location.

We make the following assumption:

ASSUMPTION 2. (Technology) $v - c > u(\rho, C_i)$ and $k < q\pi(v - c)$.

The first part of the assumption captures the fact that mill processing is efficient (see the discussion in Section II). The second part of the assumption states that preharvest inputs given by the

21. We take the price for home-processed coffee $\rho$ to be an exogenous parameter not affected by competition. The empirical analysis shows that competition between mills does not lead to higher prices for home-processed coffee. This is probably due to free entry of traders with constant returns to scale and an exogenous world price for home-processed coffee at the export gate.

mill are also efficient: they increase joint surplus by $q\pi(v-c)$ and only cost $k$.

*6. Incentive Compatibility Constraints.* We derive conditions under which the following actions occur in each period of a stationary relational contract: (i) preharvest either $\mathbf{I}_{k_i}=1$ or $\mathbf{I}_{k_i}=0$; (ii) the farmer sells to the mill, $x_i=1$; and (iii) the mill makes payments $P_{i,1}$ and $P_{i,2}$ at harvest and postharvest.

The two key incentive compatibility constraints are the ones ensuring that the farmer doesn't side sell and that the mill pays the second payment $P_{i,2}$.[22]

At harvest, the farmer must prefer to sell to the mill rather than side sell and then lose access to the mill in the future. The farmer's per period payoff in the relational contract is given by $u(c_{i,1}, c_{i,2}) = \min\{P_{i,1}, P_{i,2}\}$. If the farmer side sells she gets $(1+\mathbf{I}_{k_i}\pi)q \times u(\rho, C_i)$ this season and her outside option $q \times u(\rho, C_i)$ forever after. This gives the no side-selling incentive constraint:

$$min\{P_{i,1}, P_{i,2}\} + \frac{\delta}{1-\delta}min\{P_{i,1}, P_{i,2}\} \geqslant (1+\mathbf{I}_{k_i}\pi)qu(\rho, C_i) + \frac{\delta}{1-\delta}qu(\rho, C_i). \tag{2}$$

Postharvest, the mill must prefer to pay the second payment $P_{i,2}$ and continue the relationship rather than defaulting and obtaining her outside option equal to zero from then on. The incentive constraint is given by:

$$\frac{\delta}{1-\delta}((v-c)(1+\mathbf{I}_{k_i}\pi)q - P_{i,1} - P_{i,2} - \mathbf{I}_{k_i}k) \geqslant P_{i,2}. \tag{3}$$

*7. Which Farmers Can Sustain the Relational Contract?* The relational contract maximizes the mill's profits, and thus it must be that $P_{i,1} = P_{i,2}$ and that inequality (2) is binding. This implies

$$P_{i,1} = P_{i,2} = ((1-\delta)(1+\mathbf{I}_{k_i}\pi) + \delta) \times qu(\rho, C_i). \tag{4}$$

Substituting equation (4) into inequality (3) we obtain the necessary condition under which a self-enforcing relational

22. The incentive compatibility constraints associated with input provision and payment of $P_{i,1}$ are slack. Details of all incentive constraints and proofs are provided in Online Appendix A.

contract exists. The condition is given by:

$$\frac{\delta}{1-\delta}((v-c)(1+\mathbf{I}_{k_i}\pi)q-\mathbf{I}_{k_i}k) \geqslant u(\rho, C_i)q(1+(1-\delta)\mathbf{I}_{k_i}\pi). \tag{5}$$

This condition states that the net present value of the per period rents generated by selling cherries to the mill (given by $(v-c)(1+\mathbf{I}_{k_i}\pi)q-\mathbf{I}_{k_i}k)$) ought to be larger than the aggregate temptation to deviate (which is equal to the second payment $P_{i,2}$).

### *III.B. The Direct and Indirect Effects of Competition*

Condition (5) gives:

PROPOSITION 1. (Direct Effect of Competition)

i. For each farmer $i$ there exist unique thresholds $\delta_i^{\mathbf{I}_{k_i}}$ such that if $\delta \geqslant \delta_i^{\mathbf{I}_{k_i}}$ a self-enforcing relational contract between farmer $i$ and the mill with $\mathbf{I}_{k_i}$ exists.
ii. The two thresholds $\delta_i^{\mathbf{I}_{k_i}}$ are increasing in farmer $i$'s exposure to competition $C_i$.
iii. If $(v-c)q < \frac{k}{\delta}$ relational contracts with postharvest payments but no input provision are never sustainable.

The first statement in Proposition 1 follows standard logic: a self-enforcing relational contract exists if the discount factor is sufficiently large.

The second statement in Proposition 1 gives us the direct effect of competition. The right-hand side of condition (5) is increasing in farmer $i$'s exposure to competition $C_i$. All else equal, farmers with higher access to competing mills will find it harder to sustain the relational contract with the mill than farmers with lower access to competing mills.

Finally, the third statement in Proposition 1 states that under certain conditions, relational contracts with postharvest payments but no input provision cannot be sustained.[23] When this happens, relational practices are complementary in the sense that they move together with a change in the underlying competition parameter (see Brynjolfsson and Milgrom 2012).

23. This is because input provision has an ambiguous effect on the sustainability of a relational contract. On the one hand, it increases joint profits and thus makes it easier to enforce a relational contract. On the other hand, it increases the farmer's current outside option and the second payment $P_{i,2}$, making it harder to sustain a relational contract.

Competition can also have an indirect effect on the relational contract between the mill and farmer $i$. Recall that $\delta = \beta\theta$, with $\beta$ the common discount factor between parties and $\theta$ the probability that the mill continues operations. We now endogenize $\theta$.

In the stationary equilibrium, the mill's variable profits are constant over time and increasing in the (mass of the) set of farmers with whom the mill sustains a relational contract. Denote such set $i \in \mathcal{R} \subset [0, 1]$. We have

$$\Pi = \int_{i \in \mathcal{R}} (q(v - c)(1 + \pi \mathbf{I}_{k_i}) - \mathbf{I}_{k_i} k) di. \tag{6}$$

At the beginning of every season $t$, the mill draws fixed costs $F^t$ from the cumulative distribution $H(F^t)$. The draws are i.i.d. over time. Upon observing the fixed costs $F^t$, the mill decides whether to pay the fixed costs and continue operations or not, in which case it exits the market and all relationships with farmers come to an end.[24]

The mill exits when fixed costs $F^t$ are above a threshold $\overline{F}(\Pi)$ increasing in $\Pi$. The probability that the mill continues operation, $\theta$ is given by $\theta = H(\overline{F}(\Pi))$ and is thus increasing in $\Pi$.

Mill-level competition is defined as the union of the sets $\mathbf{C}_i$, that is, $\mathbf{C} = \cup_{i \in [0,1]} \mathbf{C}_i$.

PROPOSITION 2. (Indirect Effect of Competition). Consider an increase in mill-level competition $\mathbf{C}$ induced by an expansion in the sets $\mathbf{C}_i$ for a positive mass of farmers $i \in \mathcal{R}^C \subset \mathcal{R}$. Suppose the increase in competition destroys the relational contract through its direct effect for a positive mass of farmers $i \in \mathcal{R}^C$. Then the relational contract might no longer be an equilibrium for some other farmers $j \in \mathcal{R}$, $j \notin \mathcal{R}^C$.

Proposition 2 follows from the fact that an increase in competition that destroys the relational contract for a positive mass of farmers leads to a decrease in the mill's processed volume and thus in variable profits $\Pi$. This lowers the probability that the mill continues operation $\theta$ and therefore $\delta$. By the first statement in Proposition 1, this can further destroy the relational contract for farmers $j \in \mathcal{R}$ that were not directly affected by the original

24. Exit means that the current owner sells the mills to a new owner and relational contracts in place end. Changes in ownership are not uncommon in the industry (see Macchiavello and Morjaria 2020a).

increase in competition (that is, $j \notin \mathcal{R}^C$). This is the indirect effect of competition of relational contracts.

The indirect effect of competition might kick in only when there are sufficiently many competing mills. The effect of an additional competing mill on the sustainability of relational contracts between the mill and surrounding farmers might become stronger as competition intensifies.

When competition destroys relational contracts, the model delivers a cluster of predictions on additional mill-level and farmer-level outcomes.

First, higher competition $C_i$ can make the farmer worse off when it destroys a relational contract with $\mathbf{I}_{k_i} = 1$. Since the side-selling constraint (2) is binding, the farmer's utility in a relational contract with $\mathbf{I}_{k_i} = 1$ is strictly higher than the utility under no relational contract or in a relational contract with $\mathbf{I}_{k_i} = 0$. Note that farmers can be worse off even when competition increases prices for cherries at harvest. Due to the lack of saving tools, a farmer cares about when she is paid, not just how much.

Second, when the relational contract cannot be enforced there is no spot price at which farmers sell all their production as cherries at harvest. This is because the farmer has a demand for postharvest income that spot market competition, no matter how intense, simply cannot meet. Hence, the quantity of cherries sold for processing at harvest declines at the farmer, at the mill, and at the aggregate level. Given fixed costs and constant variable processing costs, the lower quantity processed by the mill also implies higher average cost.

An extension of the model in which farmers also exert costly, noncontractible effort yields that prices paid at harvest could also decrease due to competition. In such an extension, the price paid by the mill must compensate farmers for the effort and, if competition makes it impossible to sustain effort, observed prices paid by the mill might also decrease. The effect of competition on prices is thus ambiguous. In a similar vein, if the farmer's noncontractible effort increases the quality of the coffee, competition can lower the quality of coffee produced by the mills.

### *III.C. Summary of Predictions*

We summarize the predictions of the model as follows:

**i.** Competition might reduce relational contracts between farmers and mills.

**ii.** When this happens, the following is observed:
   (a) The use of all relational-contract practices (inputs pre-harvest, second payments, and help/loans to farmers) decreases.
   (b) Mills process lower volumes of cherries, have higher average costs, and produce lower quality.
   (c) Farmers sell fewer cherries at harvest to any mill, have lower revenues, and are worse off.
   (d) Prices paid to farmers at harvest may increase or decrease.

**iii.** Competition reduces relational contracts with farmers that can directly sell to the competing mill as well as indirectly with farmers that cannot sell to those mills.

These predictions are empirically tested in the rest of the article. Section IV asks whether competition breaks relational contracts (prediction **i**). Section V explores the consequences of relational contracts' breakdown for mills and farmers (prediction **ii**), while Section VI tests for mechanisms (prediction **iii**).

## IV. Does Competition Break Relational Contracts?

### *IV.A. Measuring Competition*

We take a conservative approach and define the catchment area to have a 5 km radius.[25] Two mills compete with each other if their catchment areas overlap. Given this definition, the baseline measure of competition is the number of mills within a 10 km radius from the mill (see Online Appendix Figure C4 for an illustration).

There is significant dispersion in the intensity of competition faced by mills (see Online Appendix Figure C5). Although there are quite a few isolated mills, the average mill has six competitors. We can use the survey to check whether our measure of competition captures the degree of competition actually experienced by the mill's managers. The survey asked the mill's manager the number of other mills that source coffee cherries inside the mill's catchment area. The average manager reported competition from about six mills in the catchment area. The correlation coefficient between the survey measure and our baseline

25. On average, mills' managers report catchment areas with a radius of $\approx 4.5$ km.

measure is 0.77 and highly significant. The baseline measure thus captures well the intensity of competition actually experienced by mills.

The baseline measure takes a one-size-fits-all approach to define competition. Mills, however, are heterogeneous with respect to both installed capacity and the density of coffee trees in their catchment area. A mill-specific measure of competition might be better suited for our analysis. The reason we prefer our baseline approach is that a mill's specific conditions might endogenously respond to competition and the mill's practices. Mill-specific measures of competition thus introduce additional sources of bias. The baseline measure avoids that. To the extent that the baseline measure suffers from measurement error, OLS results will be biased toward zero. For simplicity, we present OLS and IV results using the baseline measure and discuss robustness checks that use mill-specific measures of competition in Online Appendix D.

### *IV.B. Competition and Relational Contracts (Prediction i): OLS*

Denote with $RC_m$ the relational-contract index at mill $m$ and with $C_m$ the number of competing mills within 10 km of mill $m$. The OLS specification is given by

$$RC_m = \alpha + \beta C_m + \eta X_m + \gamma Z_m + \varepsilon_m, \tag{7}$$

where $X_m$ and $Z_m$ are vectors of controls at the mill level ($m$) and $\varepsilon_m$ is an error term. The vector $X_m$ includes the mill's characteristics (age, NGO support, cooperative status, and mill coordinates). The vector $Z_m$ includes geographic controls for potential drivers of the mill's performance within the mill's catchment area: elevation, slope, presence of spring, density of coffee trees, length of roads and rivers, and coffee suitability from FAO's Global Agro-Ecological Zones (FAO-GAEZ).

Table II, column (1) shows that competition negatively correlates with relational contracts: an additional competing mill is correlated with a 0.116 standard deviation lower relational-contract index. The OLS estimates might be biased due to a number of concerns and cannot be interpreted as conclusive evidence of a negative effect of competition on relational contracts. For example, unobserved local conditions, such as farmers' skills or entrepreneurial attitude, might both be conducive to establish relational contracts and attract more competition in the area. In this

TABLE II

COMPETITION AND RELATIONAL CONTRACTS

| Dependent variable | RC index ($z$-score) (1) | Competition (2) | RC index ($z$-score) (3) | RC index ($z$-score) (4) |
|---|---|---|---|---|
| Competition | −0.116 | | | −0.283 |
| | (0.025)$^{***}$ | | | (0.095)$^{***}$ |
| | <0.025>$^{***}$ | | | <0.075>$^{***}$ |
| | [0.026]$^{***}$ | | | [0.060]$^{***}$ |
| Score within 5–10 km of mill | | 1.610 | −0.455 | |
| | | (0.329)$^{***}$ | (0.105)$^{***}$ | |
| | | <0.313>$^{***}$ | <0.107>$^{***}$ | |
| | | [0.419]$^{***}$ | [0.063]$^{***}$ | |
| Score within 5 km of mill | Yes | Yes | Yes | Yes |
| Geographic controls | Yes | Yes | Yes | Yes |
| Mill controls | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.27 | 0.70 | 0.25 | 0.10 |
| Observations | 175 | 177 | 175 | 175 |
| Model | OLS | First stage | Reduced | IV |

*Notes.* Standard errors are denoted as follows: (Bootstrap in which mills are resampled with replacement and the regression is repeated to generate the distribution of the coefficient); <Standard errors adjusted for arbitrary spatial clustering using the *acreg* package written by Konig and coauthors and used in Konig et al. (2017)>; [Standard errors that adjust for spatial clustering as in Conley (1999), implemented by Conley's *x_gmm Stata* package]. Stars $***$ ($**$) [$*$] indicate significance at the 0.01 (0.05) [0.1] level. The RC index is a $z$-score of the three aggregate indices: preharvest, harvest, and postharvest indices with equal weighting of farmer and mill responses. Preharvest $z$-score is constructed based on farmer- and mill manager–based indicators of mill-provided inputs. Harvest $z$-score is constructed from farmer- and mill manager–based indicators of promised second payments postharvest. Postharvest $z$-score is constructed from farmer- and mill manager–based indicators of loans or help provided after the harvest. Competition is measured as the number of mills within a 10 km radius and is instrumented with the engineering model suitability score in locations 5 km to 10 km away from the mill (referred to in the table as "Score within 5–10 km of mill." For ease of comparison between the OLS and IV estimates, column (1) already includes the average suitability score within 5 km as a control (referred to in the table as "Score within 5 km of mill"). The average suitability scores from the engineering model are all $z$-scores. Mill controls include whether the mill is NGO-supported, cooperative status, mill age, mill age squared, and mill coordinates. Geographic controls include average engineering suitability score, average spring presence, road density, tree density, rivers, flexible control for coffee suitability, elevation, and slope, all within 5 km of the mill. Coffee suitability is from the FAO's Global Agro-Ecological Zones (FAO-GAEZ) data set. Estimates for crop suitability are available for various input levels. To match conditions for Rwanda, the data chosen were for low-input and rain-fed conditions. The resolution is at the five arc-minute level, which at the equator is almost a resolution of 9 km $\times$ 9 km; see http://www.fao.org/nr/gaez/about-data-portal/agricultural-suitability-and-potential-yields/en/.

case the OLS coefficient is upwardly biased. Conversely, better access to inputs and/or financial services could attract competition to the area but reduce farmers' demand for relational contracts. Potential entrants might also locate next to poorly run mills that score badly on relational contracts practices. In such cases, the OLS coefficient is biased downward. Furthermore, as noted already, the one-size-fits-all approach in our baseline measure of competition introduces measurement error that could bias the OLS estimate toward zero.

*IV.C. Construction of the Instrument: Entry Model*

Given these concerns, we turn to an IV strategy to investigate the causal impact of competition on relational contracts. The ideal instrument is a variable that, conditional on controls included in the model (i) strongly correlates with competition (the first stage), and (ii) does not influence the use of relational contracts with farmers other than through its effect on competition (the exclusion restriction). To construct our instrument we combine (i) the spatial nature of competition embedded in the notion of a catchment area defined above with (ii) drivers of suitability for mill placement (suitability). Conditional on suitability within the mill's catchment area, competition is instrumented with suitability in the adjacent area around the mill's catchment area. Given our baseline definition of catchment area, the instrument for competition is then given by suitability for mill placement between 5 km and 10 km radius from the mill, conditional on suitability (and other controls) within the 5 km radius catchment area.

We build on an engineering model to construct our measure of suitability. In the early 2000s, when only a handful of mills were operating in Rwanda, a program coordinated by USAID involving engineers, agronomists, and GIS specialists developed an engineering model for the optimal placement of mills in Rwanda (see Schilling and McConnell 2004). Given the particularly rugged nature of Rwanda, the model intended to identify suitable sites for mill construction at a high spatial resolution, taking into account a vector of characteristics to be then aggregated into a suitability score. The model, however, was never fully implemented because the required GIS data were not readily available for all of Rwanda at the time. Subsequent entry of mills was thus not restricted nor limited to locations satisfying the engineering model's criteria. We assembled all the data required ex novo and are thus able to implement the engineering model for the first time. Using remote sensing and GIS tools on ortho-photos at the $25\,m^2$ resolution we run the engineering model for Rwanda at a resolution of $1\,km^2$.

The engineering model specified four criteria for a mill's placement: (i) mills should be outside national parks, nature reserves, and other protected and conservation areas; (ii) in sectors with at least 30,000 coffee trees; (iii) within 3 km of a spring source, at an elevation between $-10\,m$ and $-30\,m$ from the spring; and (iv) within 1 km of a road. For each $1\,km^2$ square in Rwanda (grid) we define dummies for whether it satisfies these four criteria. Online Appendix Figure C6 illustrates spatial variation in the engineering model's criteria.

We build on the engineering model and construct our instrument as follows. There are thousands of potential grids where mills could have entered and 214 in which a mill had entered by 2012. All mills that have entered satisfy criteria (i) and (ii). Grids not satisfying these two criteria are thus assigned a suitability score of zero. Within the sample of grids satisfying criteria (i) and (ii) we run a probit model to predict mill entry. The probit model includes dummies for the remaining criteria (iii) and (iv), their interaction, and additional controls (polynomials in distances to springs and roads, average elevation and slope in the grid, longitude and latitude of the grid box centroid, density of coffee trees in the grid box, size of the sector, and interactions of these variables).

The probit model lends support to the engineering model. Online Appendix Table B2 shows that the interaction between dummies for criteria (iii) and (iv) predicts mills' placement ($p < .01$). We use estimates from column (4) to predict a suitability score for each 1 $km^2$ grid (Online Appendix Figure C7 illustrates the results). Finally, we aggregate the predicted suitability scores at the mill level. The average suitability score in the grids within a 5 km radius from the mill gives us a control for suitability in the mill's catchment area. Our instrument is the average suitability score within the area of 5–10 km radius from the mill, akin to a cross-section surface of a donut.

The engineering model criteria and the controls raise a number of concerns about the identification strategy. First, coffee trees and roads inside the catchment area could be endogenous. This could generate a "bad control" problem. Second, conditional on these controls, trees and roads outside the mill catchment area could influence mill and farmers inside the catchment areas through channels other than competition (a violation of the exclusion restriction). We first present our main result and then present robustness checks that address these threats to our identification strategy and also explore robustness of our results along other dimensions.

### *IV.D. Competition and Relational Contracts (Prediction i): IV*

We instrument for competition using the average predicted score from the engineering model in the donut area between 5 km

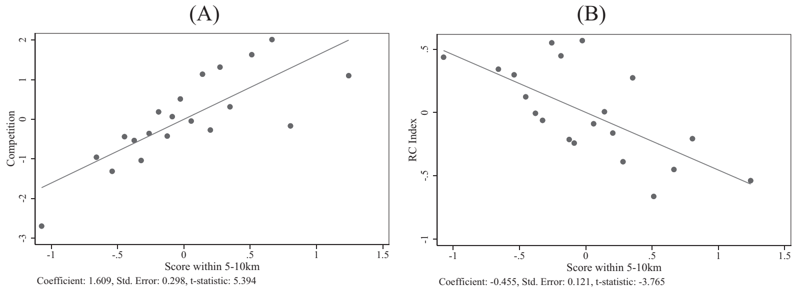


FIGURE II

Instrumental Variable: First Stage and Reduced Form

Binned scatter plot of mill-level regressions. All regressions control for mill characteristics (NGO support, cooperative status, mill age, mill age squared, and mill coordinates). Controls also include average engineering suitability score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. The RC index is an aggregate of farmer- and mill manager–based indicators of mill-provided inputs, second payments, and postharvest loans. Farmer and mill manager responses are equally weighted. Competition is measured as the number of mills within 10 km.

and 10 km radius from the mill. Specifically, the first stage is given by

$$C_m = \alpha + \widehat{\beta} S_m^{5/10} + \beta S_m^{0/5} + \widehat{\gamma}_0 X_m + \widehat{\gamma} Z_m + \mu_m, \tag{8}$$

where $S_m^{5/10}$ is the average predicted engineering model suitability score in the donut area between 5 km and 10 km from mill $m$, $S_m^{0/5}$ is the average predicted engineering model suitability score inside the mill's catchment area, and $C_m$ is the number of mills within 10 km from mill $m$. The vectors $X_m$ and $Z_m$ are mill controls described in equation (7). The exclusion restriction is satisfied if, conditional on suitability in the mill's catchment area, average suitability in the 5–10 km area only affects a mill's operation through its effect on competition.

Figure II, Panel A shows a strong first stage: the predicted score $S_m^{5/10}$ strongly correlates with competition $C_m$. Table II, column (2) reports the results. An increase of one standard deviation in the instrument $S_m^{5/10}$ is associated with mill $m$ facing competition from 1.610 additional mills ($p < .01$).

Figure II, Panel B shows a strong reduced-form relationship between the instrument, $S_m^{5/10}$, and the relational-contract index,

$RC_m$. Table II, column (3) reports the estimates. A one standard deviation increase in the instrument $S_m^{5/10}$ is associated with a reduction of 0.455 standard deviations in the relational index ($p < .01$).

Table II, column (4) reports the 2SLS estimates. An additional mill within a 10 km radius from the mill causes a reduction of 0.283 standard deviations in the relational-contract index. The effect is economically sizable. The comparison between the IV estimates in column (4) and the OLS estimates in column (1) reveals that the IV estimates are more than twice as large as the OLS estimates (−0.116 versus −0.283). This is consistent with either measurement error or the source of bias in the OLS estimation being the presence of unobserved features that correlate with entry of competitors and the use of relational contracts.

The specification assumes a linear effect of the number of competing mills on the relational-contract index. In the model the relationship might be nonlinear: relational contracts break down only when there is competition beyond a certain threshold. Aggregating over mills with heterogeneous thresholds, we expect the negative effect of competition to become stronger as competition intensifies, at least up to a certain point. Online Appendix Figure C8 explores the functional form of the relationship between competition and relational contracts reporting results from nonparametric IV estimation. The estimates indeed exhibit a decreasing and concave relationship between relational contracts and competition over the entire range of observed competition levels. The slope is relatively flatter for competition from fewer than four mills and then becomes steeper once competition intensifies. This pattern is consistent with the predictions of the model in Section III.

### *IV.E. Threats to the Identification Strategy*

We discuss threats to the identification strategy. First, we consider the role of the presence of roads and tree density as ingredients of the instrument and their potential role as bad controls. We then consider several mechanisms that could lead to a violation of our exclusion restrictions. Online Appendix D further explores robustness along other dimensions, including the definitions of competition and catchment areas and other potential threats to the identification strategy.

*1. The Exclusion Restriction and Bad Controls: Roads and Coffee Trees.* The logic of the identification strategy is that, conditional on road access and coffee tree density inside the mill's catchment area, roads and coffee tree density in the donut area do not directly affect farmers and mills. The logic is potentially undermined by two distinct sets of concerns. First, coffee tree density levels and road access outside the catchment area could affect mills and farmers directly. For example, a road in the donut area could still be used by the mill or by farmers; prices for home-processed coffee might depend on harvest levels in the donut area through general equilibrium effects, and so on. If that is the case, the exclusion restriction is violated. Second, if road construction and coffee tree density in the catchment area respond to mills' operations, conditioning on these variables in the catchment area could induce a bad control problem.

Online Appendix Table B3 investigates the robustness of our baseline results to these concerns. Column (1) reports, for ease of comparison, our baseline specification. Columns (2) and (3) considers road presence. Column (2) removes roads from the IV, that is, from the engineering model used to predict the suitability score inside the donut area. This addresses the concern about the violation of the exclusion restriction but not concerns about roads being a bad control. Column (3) thus goes one step forward and removes roads from the construction of the IV and the suitability score inside the catchment area, as well as a control. In both cases, results are robust: the first stage (reported in Panel B) and the second stage (Panel A) remain highly statistically significant with a similar magnitude as the baseline in column (1).

Columns (4)–(8) consider coffee trees. First, the second criteria of the engineering model restricts the sample of suitable grids to those in sectors (the administrative unit of Rwanda) with the presence of a least 30,000 coffee trees. Column (4) replaces this criterion in the entry model presented in the Online Appendix Table B2 with a restriction requiring that the grid has a suitability for coffee cultivation (from FAO-GAEZ) equivalent to at least 460 tons per hectare. Results are virtually unchanged.

Column (5) removes tree density from the construction of the instrument. Analogously to column (2) for roads, this is meant to address concerns about violations of the exclusion restriction. The specification thus leaves only suitability for coffee from FAO-GAEZ as an indicator of coffee activity in the entry model predicting suitability of mill placement. Results are again essentially unchanged. We interpret the similarity between the baseline specification in column (1) and the results in columns (2) and (5) in the spirit of an overidentification test: because our instrument relies on multiple sources of variation, we can construct alternative instruments exploiting only subsets of these sources and we obtain similar results.

Column (6) further removes tree density as a control and from the construction of the suitability score inside the catchment area. The magnitude of the second-stage point estimate drops by about a third (from −0.283 to −0.182). Although the first and second stages are still significant, this suggests that tree density in the catchment area could be a bad control.

Although tree density in the mill's catchment area might respond to the mill's entry and operations and thus can be a potential bad control, it seems a priori important to control for it. For example, the same level of competition could have different effects on the mill depending on how much coffee is grown in the region around the mill. To this end, FAO-GAEZ suitability for coffee cultivation is not a sufficiently precise control for two reasons: (i) it is defined at a much higher level of aggregation (at the 9 $km^2$ resolution) than our analysis and is thus weakly related to variation in local conditions; (ii) there are places that are suitable for coffee cultivation but are occupied by other economic activities (e.g., urban developments, conservation zones, and mines).

Columns (7) and (8) therefore repeats the exercise computing coffee tree density using the National Coffee Census conducted in 1999; at that time, only two mills had been built in Rwanda. Tree density in 1999 is thus not the result of subsequent mill entry by the time of the survey in 2012. Although changes in administrative boundaries introduce measurement error, this strategy nearly halves (from −0.182 to −0.224) the gap in the point estimate relative to the baseline (−0.283).

A potential concern is that both roads and tree density feature exclusion restriction violations. In such case, the results could remain (erroneously) robust when retaining at least one of the two in the calculation of the instrument. Column (9) reports results from a specification in which both tree and road density have been removed from the construction of the instrument and shows that the results are robust.[26]

26. As a further robustness test, column (10) shows that estimating the engineering entry model at the grid level with an OLS rather than with a probit

*2. Farmers' Outside Options.* Although the results are robust to the exclusion of roads and coffee tree density from the instrument, it is still possible that suitability for mill entry in the donut area around the mill catchment area affects farmers' and mills' operation through channels other than competition for coffee. For instance, the instrument could correlate with better access to or wages in work outside the coffee sector; access to alternative saving or other financial services beyond the mill; and convenience of or price available for postharvest sales of home-processed coffee or other crops. In all these cases, the demand for interlinked transactions with the mill is lower for reasons unrelated to competition between mills.

We directly check for these potential exclusion restriction violations in the data. We first consider whether our instrument correlates with farmer characteristics that should not be affected by coffee production or sales. We check whether our instrument correlates with economic opportunities for farmers. Finally, we explore whether the results are robust controlling for farmers' proxies for market access. In all these cases, we use farmer-level specifications that include farmer's age, gender, place of birth, education level, cognitive skills, distance from the mill, and the farmer's coffee tree holdings as additional controls.

Online Appendix Table B4 explores farmer characteristics from our 2012 survey (age, gender, schooling, cognitive test) and from the 2009 National Coffee Census (household size and age). Panel A finds no correlation between our instrument and farmers' demographic characteristics. Panel B finds some correlation between competition and farmers' demographics.

Online Appendix Table B5 explores the correlation between our instrument and measures of farmers' outside economic opportunities. Unfortunately, our 2012 farmer survey did not include much information on farmers' economic activities outside of coffee production. We conducted a representative survey of farmers in the 2019 season to gather direct evidence on the extent to which our instrument is correlated with better outside options and/or access to financial services.

The results support our exclusion restriction. We find that the instrument does not correlate with the percentage of coffee

model yields nearly an identical first stage and slightly larger second-stage point estimates.

income in the farmer's total income (column (1)); the likelihood the farmer has other sources of income (column (2)); the likelihood of the farmer being employed by others on the extensive (column (3)) and the intensive (column (4)) margin; conditional on employment, the wage rate (column (5)) and the total wage income (column (6)); the payment due to employing additional labor on the farm (column (7)); the likelihood the farmer sells milk (column (8)); conditional on selling milk, the price and amount of milk sold (columns (9) and (10)); access to formal saving accounts from banks and/or local saving cooperatives (columns (11) and (12)). This survey evidence suggests that our instrument does not correlate with economic opportunities that might lower the demand for relational contracts with the mill and thus supports the validity of our exclusion restriction.

Online Appendix Table B6 considers an alternative strategy that controls for farmers' market access. A potential concern with the results in Online Appendix Table B5 is that the survey evidence was gathered in the 2019 season, seven years after our baseline evidence. For farmers for whom we have exact location information in 2012, we construct measures of market access along the lines suggested by Donaldson and Hornbeck (2016) using urban population (from the 2012 National Population and Housing Census) and the most detailed road infrastructure data we have from the 2008/09 aerial ortho-photos. For ease of comparison, columns (1) and (2) report our baseline results on the full sample of farmers and on the sample of farmers for which we have exact village location information respectively. Columns (3)–(6) include measures of market access, defining markets relative to any of the 62 officially designated urban centers (weighted by population), sector capital (weighted by population), to the capital city (Kigali), and last of all official market trading centers. Results are robust across all these specifications.

## V. The Consequences of the Breakdown of Relational Contracts

The previous section shows that competition decreases the use of relational contracts. When this happens, the model delivers a cluster of additional predictions about how relational practices move together and about mill-level and farmer-level outcomes. This section tests these additional predictions.

### V.A. Complementarities in Practices (Prediction ii.a)

The model implies that relational practices might be complementary. Competition alters only farmers' ability to sell cherries at harvest to a competing mill. When competition increases, however, all practices might become unsustainable. Table III reports OLS (Panel B) and IV (Panel A) specifications considering relational practices one at a time. For each practice, the table reports specifications using farmers' responses, managers' responses, and the aggregate of the two.

Columns (1)–(3) ask whether competition reduces relational practices in which the mill provides inputs and loans to farmers before harvest. Regardless of whether we ask farmers or managers, competition causes a reduction in use of this practice. Aggregating farmers' and managers' answers, we find that competition from an additional mill reduces the use of this practice by 0.220 standard deviations (column (3)).

Columns (4)–(6) ask whether competition reduces sourcing of cherries on credit at harvest for which the mill pays second payments to farmers. Regardless of whether we ask farmers or managers, competition causes a reduction in use of this practice. When answers from farmers and managers are aggregated, competition from an additional mill reduces the use of this practice by 0.203 standard deviations (column (6)).

Finally, columns (7)–(9) ask whether competition reduces assistance and help to farmers postharvest. Competition from an additional mill reduces the use of this practice by 0.180 standard deviations (column (9)). Column (10) aggregates the three relational-contract practices by respondents and creates an index. The relational-contract indices are also separately reported by respondent type (columns (11) and (12)).

The model focuses on relational practices for which lack of contract enforcement matters, that is, those in which the mill and the farmer exchange nonenforceable promises across several weeks. In contrast, we expect lack of contract enforcement to be less of a concern for exchange of promises over very short periods. We consider short-term credit and advances during harvest, two practices driven by liquidity considerations and that are not part of the relational contract between the mill and the farmer. Results in column (13) confirm that competition does not affect this type of short-term credit between the mill and the farmers.

TABLE III

UNPACKING COMPLEMENTARY RELATIONAL PRACTICES

| Dependent variable | Received input from mill (1) | Given inputs to farmers (2) | RC pre-harvest z-score (3) | Expects to receive a second payment (4) | Has made a second payment in the past (5) | RC harvest z-score (6) | Expects to receive help/ loan (7) | Provides help/ loans to farmers (8) | RC post-Harvest z-score (9) | RC index (10) | RC index, farmer outcomes (11) | RC index, mill outcomes (12) | Placebo: short-term credit (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A: IV | | | | | | | | | | | | | |
| Competition | −0.064*** | −0.085** | −0.220** | −0.063*** | −0.077** | −0.203*** | −0.066*** | −0.026 | −0.180* | −0.283*** | −0.237*** | −0.215** | 0.017 |
| | (0.014) | (0.036) | (0.112) | (0.017) | (0.035) | (0.074) | (0.020) | (0.034) | (0.099) | (0.098) | (0.045) | (0.094) | (0.082) |
| Panel B: OLS | | | | | | | | | | | | | |
| Competition | −0.011** | −0.030** | −0.062*** | −0.038*** | −0.041*** | −0.121*** | −0.021*** | −0.015 | −0.065** | −0.116*** | −0.086*** | −0.102*** | −0.041 |
| | (0.005) | (0.012) | (0.022) | (0.006) | (0.013) | (0.038) | (0.007) | (0.014) | (0.033) | (0.029) | (0.016) | (0.029) | (0.033) |
| Score within 5 km of mill | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mill controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Farmer controls | Yes | – | – | Yes | – | – | Yes | – | – | – | Yes | – | – |
| Adjusted $R^2$ | 0.05 | 0.13 | 0.11 | 0.15 | 0.16 | 0.21 | 0.03 | −0.01 | 0.00 | 0.10 | 0.07 | 0.12 | 0.04 |
| Observations | 869 | 176 | 176 | 869 | 176 | 176 | 865 | 175 | 175 | 175 | 869 | 176 | 172 |

*Notes.* Bootstrapped standard errors are in parentheses. *** (**) [*] indicates significance at the 0.01 (0.05) [0.1] level. RC preharvest $z$-score is constructed based on farmer- and mill manager–based indicators of mill-provided inputs. RC harvest $z$-score is constructed from farmer- and mill manager–based indicators of promised second payments postharvest. RC postharvest $z$-score is constructed from farmer- and mill manager–based indicators of loans or help provided after the harvest. The RC index (column (10)) is an aggregate of these three indices with responses from the farmer and the mill manager equally weighted. Aggregate relational practices from the farmers' perspective and mill managers' perspective are reported in columns (11) and (12), respectively. Column (13) captures if there was any short-term credit provided to the farmer by the mill. Mill controls include NGO-supported, cooperative status, mill age, mill age squared, and mill coordinates. Geographic controls includes average engineering score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. Farmer controls include farmer age, education, gender, schooling, distance to mill, cognitive test ($z$-score), and cooperative membership. Farmer responses are from the 2012 farmer survey. Competition is measured as the number of mills within a 10-km radius and is instrumented with the engineering model suitability score in locations 5 km to 10 km away from the mill. Adjusted $R^2$ is provided for Panel A (IV). For additional variable definitions refer to notes in Table II.

In sum, the evidence supports the idea that relational practices are complementary: competition reduces the use of all relational-contract practices simultaneously.

### *V.B. Mill Outcomes: Operations and Quality (Prediction ii.b)*

*1. Operating Costs.* The model predicts that a breakdown in the relational contract with farmers is associated with changes in mills' outcomes. Table IV investigates these predictions. Column (1) shows that unit costs of processing 1 kg of the output increase by 4.6% with an additional competing mill. Columns (2) and (3) show no effect on prices for cherries paid to farmers during harvest nor on the price for home-processed parchment in the area, as reported by the mill manager. Column (4) presents a placebo: competition has no effect on the conversion ratio from coffee cherries to processed parchment, a parameter of the production function. The combination of columns (2) and (4) implies that competition has no effect on the cost of cherries. The cost of cherries accounts for about 60% of the overall unit costs of output production at the typical mill. The coefficient in column (1) must thus be explained by increases in other operating costs. Accordingly, column (5) shows that an additional competing mill increases processing unit costs by approximately 7%.

The increase in unit costs arises from both lower and more-sporadic deliveries. Column (6) shows that competition reduces the total volume of coffee cherries processed by the mill. An additional competing mill is associated with approximately five fewer tons of processed cherries. This translates into 7.5% lower capacity utilization, a sizable effect given that the average capacity utilization in the industry is around 50%.

The breakdown in relational contracts with farmers makes deliveries harder to plan for. Column (7) shows that competition does not affect the number of weeks the mill is in operation during the harvest. Competition, however, increases the likelihood that the manager reports that they have had days with too many and too few workers at the mill (columns (8) and (9)).[27] The difficulty

27. Labor costs increase as mills do not perfectly adjust labor to irregular deliveries. While 65% of mills revise employment plans weekly depending on cherry procurement and market conditions, arrangements between mills and workers also include elements of relational contracting. The majority of seasonal workers are paid weekly, biweekly, or monthly, rather than daily. Firms thus do not turn down workers when there are not enough cherries to process. For example, 73%

TABLE IV
COMPETITION AND MILL OUTCOMES

| Dependent variable | Total unit cost (RWF, ln) (1) | Cherry price (RWF, ln) (2) | Home-processed parchment price (RWF, ln) (3) | Conversion ratio (ln) (4) | Total processing unit cost (RWF, ln) (5) | Cherries purchased (tons) (6) | Weeks mill processed (7) | Days with too many workers (8) | Days with too few workers (9) | Unit labor costs (RWF, ln) (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Panel A: IV | | | | | | | | | | |
| Competition | 0.046* | 0.013 | −0.007 | −0.007 | 0.071** | −4.984* | −0.202 | 0.227** | 0.095* | 0.107* |
| | (0.026) | (0.013) | (0.011) | (0.016) | (0.031) | (2.877) | (0.322) | (0.099) | (0.055) | (0.058) |
| Panel B: OLS | | | | | | | | | | |
| Competition | 0.010* | 0.002 | −0.001 | −0.011*** | 0.017 | −0.733 | 0.090 | 0.107*** | 0.044* | 0.068*** |
| | (0.005) | (0.004) | (0.003) | (0.004) | (0.011) | (0.591) | (0.142) | (0.032) | (0.026) | (0.019) |
| Score within 5 km of mill | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Engineering controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mill controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | – | 0.24 | 0.28 | −0.02 | −0.08 | 0.24 | 0.08 | 0.13 | 0.01 | 0.16 |
| Observations | 177 | 163 | 176 | 145 | 176 | 169 | 160 | 173 | 174 | 176 |
| Dep. var. mean | 7.48 | 5.34 | 6.64 | 4.17 | 6.51 | 27.17 | 15.11 | 2.20 | 1.29 | 5.44 |

*Notes.* Bootstrapped standard errors are in parentheses. *** (**) [*] indicates significance at the 0.01 (0.05) [0.1] level. Column (1) is the total unit cost of producing 1 kg of the output (parchment). Mill managers' response to prices paid to farmers for cherries (ln) and local home-processed parchment price (ln) are reported in columns (2) and (3) respectively. Column (4) is the physical efficiency ratio between the input (cherry) and output (parchment). Column (5) reports the processing cost (excluding cost of cherry) from the unit cost of processing reported in column (1). Column (6) is the total cherries purchased by the mill as reported to the coffee board in the 2012 season, mill capacity is controlled for in this specification. Column (7) is the number of weeks the mill is operational in the 2012 season. In columns (8) and (9) the dependent variables, "Days with too many workers" and "Days with too few workers" are all dummy variables reported by the mill manager. Competition is measured as the number of mills within 10 km and is instrumented with the engineering model suitability score in locations 5 km to 10 km away from the mill. Mill controls include NGO-supported, cooperative status, mill age, mill age squared, and mill coordinates. Engineering controls and geographic controls include average engineering score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. Adjusted $R^2$ is provided for Panel A (IV). Responses are provided by the mill manager. For additional variable definitions refer to notes in Table II.

in planning results in higher labor costs. Column (10) shows that the labor component of unit costs increases with competition: an additional mill increases unit labor costs by nearly 11%.[28]

*2. Product Quality.* The model also predicts that when relational contracts break down, the quality of the coffee produced by the mill suffers. This happens because the mill does not provide inputs to farmers, and farmers might not exert appropriate effort. In particular, farmers harvest less frequently and end up mixing cherries that are ripe with others that are either too ripe or not ready yet to be processed.

To test this prediction we collected random samples of processed coffee from each mill. Each sample was inspected and "cupped" at the national coffee board's laboratory in Kigali. The cupping process scores each sample along several dimensions of quality related to both physical characteristics of the processed coffee (parchment) as well as defects that emerge following the roasting process. Physical characteristics and defects can be classified depending on their most likely origin: plant genetics, farmer's husbandry practices, and mill processing.

Table V presents the results. Column (1) shows that competition decreases the overall quality score of coffee processed by the mill. An additional competing mill reduces the quality score by 0.15 standard deviations. Columns (2)–(4) separate the quality score into different quality components depending on whether they are mostly under the control of the farmer (column (2)), mill (column (3)), or are genetically predetermined (column (4)). We construct an index that captures aspects of quality that are under the direct control of farmers. The index aggregates two dimensions of quality: parchment bean size and pest damages. Given planted variety, smaller bean size is a consequence of poor harvesting practices. Severe insect and pest damages arise from inadequate use of insecticides at the farmer level. Column (2) shows that an additional competing mill decreases the index of farmer-related quality by 0.172 standard deviations.

(12%) of mill managers report that they would turn down only some (none) of the workers if there were few cherries to process. Mills are located in densely populated rural areas with few employment opportunities, so competition has no effect on wage rates or on the manager reporting difficulties in hiring workers.

28. Capital, transport, and procurement are the main other sources of operating costs. We do not find significant effects of competition on these other costs.

TABLE V
COMPETITION AND QUALITY OF MILL OUTPUT

| Dependent variable | Overall quality score (1) | Farmer-controlled quality (2) | Mill-controlled quality (3) | Plant genetic properties (4) |
|---|---|---|---|---|
| Panel A: IV | | | | |
| Competition | −0.146* | −0.172* | −0.034 | 0.018 |
| | (0.087) | (0.089) | (0.085) | (0.062) |
| Panel B: OLS | | | | |
| Competition | −0.039 | −0.051* | −0.043 | 0.024 |
| | (0.034) | (0.031) | (0.037) | (0.021) |
| Score within 5 km of mill | Yes | Yes | Yes | Yes |
| Engineering controls | Yes | Yes | Yes | Yes |
| Geographic controls | Yes | Yes | Yes | Yes |
| Mill controls | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | −0.075 | 0.040 | 0.19 | −0.013 |
| Observations | 158 | 155 | 156 | 157 |

*Notes.* Bootstrapped standard errors are in parentheses. *** (**) [*] indicates significance at the 0.01 (0.05) [0.1] level. Column (1) is the overall quality score constructed from the farmer and mill quality indices with equal weighting to all indicators, plus an indicator of the ideal conversion ratio, an indicator of specialty status, and standardized cupping points. Column (2) is the farmer-controlled quality outcome as a standardized index of an indicator of large beans and severe insect damage. Column (3) is the mill-controlled quality index constructed from an indicator of high moisture, floaters, and broken beans. All components of indices are rescaled so that higher values indicate higher quality. Mill controls include NGO-supported, cooperative status, mill age, mill age squared, and mill coordinates. Engineering controls and geographic controls include average engineering suitability score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. Competition measure is the number of mills within a 10 km radius, and is instrumented with the engineering model suitability score in locations 5 km to 10 km away from the mill. Adjusted $R^2$ is provided for Panel A (IV). For additional variable definitions refer to notes in Table II.

We also construct an index that captures quality dimensions that are mostly influenced by sorting and drying practices at the mill. The index aggregates moisture content, floating beans, and broken beans as dimensions of quality. Column (3) shows no impact of competition on the index of mill-related practices. Column (4) shows that competition has no effect on a dimension of quality directly related to the genetic variety of coffee grown by the farmer.

In sum, the evidence is consistent with competition increasing mills' operating costs and reducing the quality of the coffee produced through its negative effect on relational practices with farmers.[29]

29. Online Appendix Table B7 shows that the main mill-level results are robust to the main robustness checks performed in Table B3 and to the alternative measure of competition in Table B8.

*V.C. Farmer Outcomes (Prediction ii.c)*

The model predicts that a breakdown in the relational contract with the mill is associated with the following changes in farmer-level outcomes: (i) an ambiguous effect on prices paid to farmers, (ii) a drop in the share of cherries sold to mills (since farmers cannot rely on the mill's second payments to smooth cash flows), (iii) a reduction in access to inputs, and finally, (iv) lower revenue and welfare.

Table VI tests these predictions with farmer-level specifications. Column (1) confirms the finding of Table IV, column (2): competition has at best a small effect on prices received by farmers. While the detected effect is positive and statistically different from zero, it is very small. An additional mill increases prices reported by farmers by around 1%. Note that this is the price farmers report for sales of cherries during harvest. Because competition reduces second payments after the end of harvest, this estimate provides an upper bound on the effect of competition on the net present value of payments to farmers. Furthermore, column (2) shows that competition between mills does not change prices received for home-processed parchment coffee. This result, in line with Table IV, column (3), confirms that the effect of competition on prices received by farmers is negligible and supports our approach, which models the price of home-processed parchment as an exogenous parameter.[30]

Column (3) shows that competition reduces the share of a farmer's production sold as cherries to any mill during harvest. That is, competition between mills actually increases the share of coffee that is home processed. Column (4) finds that competition increases the likelihood that farmers report saving as the main motivation for processing coffee at home rather than selling cherries at harvest to the mill. Together, these results confirm the key mechanism in the model: due to saving constraints, farmers have an unmet demand to receive part of their coffee income after harvest. Competition destroys the relational contract between the farmer and the mill, in particular the mill's ability to credibly

30. Because competition reduces quality, we might potentially underestimate the quality-adjusted price received by farmers. We think this is unlikely because mills did not pay farmers based on quality. Limited quality price premia at the farm-gate are not specific to our context (see e.g., Minten et al. 2018; Morjaria 2020 for Ethiopia; Macchiavello and Miquel-Florensa 2019 for Colombia; Morjaria and Sprott 2018 for Uganda).

TABLE VI

COMPETITION AND FARMER OUTCOMES

| Dependent variable | Cherry price (RWF, ln) (1) | Home-processed parch-ment price (RWF, ln) (2) | Share sold as cherries (%) (3) | Home process for saving, dummy (4) | Self-financed inputs (5) | Yield (ln) (6) | Input usage (RWF, ln) (7) | Farmer's trees (ln) (8) | Farmer revenues (RWF, ln) (9) | Job satis-faction index (10) | Pay is good (11) | Freedom to decide how to do my job (12) | Work is stressful (13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A: IV | | | | | | | | | | | | | |
| Competition | 0.012*** | −0.004 | −0.075*** | 0.059*** | 0.034* | −0.004 | −0.024 | 0.057 | −0.081* | −0.059** | −0.065* | −0.047* | 0.076*** |
| | (0.003) | (0.004) | (0.017) | (0.020) | (0.019) | (0.032) | (0.063) | (0.036) | (0.048) | (0.024) | (0.036) | (0.029) | (0.033) |
| Panel B: OLS | | | | | | | | | | | | | |
| Competition | 0.004*** | 0.007*** | 0.003 | 0.007 | 0.025*** | 0.039*** | −0.016 | 0.017 | 0.083*** | −0.035*** | −0.030*** | −0.035*** | −0.005 |
| | (0.001) | (0.001) | (0.005) | (0.006) | (0.006) | (0.010) | (0.021) | (0.015) | (0.014) | (0.009) | (0.011) | (0.009) | (0.010) |
| Score within 5 km of mill | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Engineering controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Geographic controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Mill controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Farmer controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.26 | 0.32 | – | 0.00 | 0.08 | 0.14 | 0.06 | 0.14 | 0.36 | 0.12 | 0.11 | 0.07 | −0.02 |
| Observations | 869 | 869 | 860 | 869 | 869 | 865 | 472 | 869 | 848 | 856 | 855 | 856 | 855 |
| Dep. var. mean | 5.33 | 6.63 | 0.79 | 0.23 | 0.35 | 0.38 | 3.30 | 6.22 | 4.84 | −0.00 | 2.96 | 3.61 | 3.48 |

*Notes.* Bootstrapped standard errors are in parentheses. *** (**) [*] indicates significance at the 0.01 (0.05) [0.1] level. Column (1) reports farmers' cherry price and column (2) reports local home-processed parchment price. Column (3) reports share of farmers' coffee output sold as cherries to mills. Column (4) is the farmers' response to an open-ended question on why they would home process coffee, with a dummy variable created for the responses that state saving as the main motive. Column (5) is a dummy variable indicating if the farmer self-financed input purchases for their plot. Column (6) is the yield (in ln), and column (7) is the amount of self-financed inputs per kg of output (cherries). Column (8) is the farmer's tree holdings (ln), and column (9) is the farmer revenues (sums of revenues received from coffee sold as cherries and as home-processed parchment). Column (10), is a $z$-score of 1–4 (4 being strongly agree) responses of agreements to statements: "My job gives me a chance to do the things I do best," "The pay is good," "I learn new things," "I am treated with respect," "I have freedom to do my work," and "I do not find work stressful." Columns (11)–(13) are some of the individual components of the job satisfaction index. Mill controls include NGO-supported, cooperative status, mill age, mill age squared, and mill coordinates. Engineering controls and geographic controls include average engineering score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. Competition is measured as the number of mills within 10 km, and is instrumented with the engineering model score in locations 5–10 km away from the mill. Farmer controls include farmer age, education, gender, schooling, distance to mill, cognitive score, cooperative membership, and log number of coffee trees (except in column (7)). All farmer outcomes/responses are from the 2012 farmer survey. Adjusted $R^2$ is provided for Panel A (IV).

promise payments after the harvest. Farmers are then forced to process part of their coffee at home to save income until after harvest.[31]

Column (5) shows that competition increases the likelihood that farmers have to self-finance inputs without an increase in yield (measured as kg of cherries per coffee tree, column (6)) or an increase in overall input usage (measured as RWF spent per kg of cherries, column (7)). Column (8) also shows that competition does not lead farmers to invest in their plantation and increase the number of coffee trees.[32]

The lack of an effect of competition on prices, yields, and input usage suggests that competition does not increase farmers' returns from coffee cultivation. It is notoriously difficult to measure profits for farming enterprises.[33] We nevertheless compute overall revenues from coffee cultivation, adding reported sales of home parchment and cherries sold to mills. Column (9) finds that competition reduces revenues by 8% ($p < .10$). This is due to no change in overall production, a higher share sold as home-processed parchment coffee, and the lower prices fetched by home-processed coffee. The estimated effect on revenues likely understates the negative effect on farmers' profits and welfare since (i) holding prices constant, farmers have to save through a very costly mechanism (home processing); (ii) farmers incur higher costs in order to home process coffee.

Given difficulties in measuring revenues and profits, we also consider the effect of competition on an overall index of job satisfaction as our preferred proxy for farmers' welfare. Table VI, column (10), shows that competition has a strong negative effect on farmers' overall reported satisfaction. Columns (11), (12), and (13) open up the job satisfaction index and find that competition lowers the likelihood that the farmer reports that the pay from the coffee business is good, further supporting our results on

31. The results show that the aggregate amount of cherries sold by farmers to mills decreases as a result of competition. We discuss this further at the end of Section VI and in Online Appendix B.

32. In contrast to the model's prediction, we do not find evidence that competition lowers the volume of production.

33. These difficulties are particularly pronounced in our context as (i) farmers have low literacy levels, (ii) coffee cultivation coexists alongside several other farming and nonfarming activities, (iii) we implemented our survey before the end of the harvest season, (iv) the length of the farmer survey we could implement at the mill was severely constrained.

income. Therefore, the evidence supports the model's predictions on farmer-level outcomes and suggests that farmers might not benefit from competition.[34]

## VI. Mechanisms and Discussion

### VI.A. Mechanisms: "Temptation" versus "Profits" (Prediction iii)

The model highlights two distinct mechanisms through which competition erodes mills' ability to sustain relational contracts with a given farmer. First, there is a direct temptation mechanism: when competition increases the farmer's outside option it becomes harder to sustain the relational contract between the mill and the farmer. Second, there is an indirect profit mechanism: competition reduces the mill's profits and likelihood of operating in the future and thus makes it harder to sustain a relational contract even with farmers not directly affected by competition.

Table VII untangles the two mechanisms. The intuition is as follows. Holding constant mill-level competition and a farmer's distance to the mill, the nearer is the farmer to competing mills, the higher is the farmer's outside option. We thus expect that proximity to competing mills is correlated with a lower relational-contracting index between the mill and the farmer. To explore this hypothesis, we need to compute distances between each farmer and all mills. We are able to do so for 70% of the surveyed farmers (see note 11).

Column (1) reports for convenience our baseline specification at the farmer level. Column (2) repeats the exercise on the sample of farmers we can match to an exact location and for which we can compute distance to mills. Column (3) then adds a measure of farmer-specific mill access to our baseline farmer-level specification. Analogously to Donaldson and Hornbeck (2016), mill access is constructed as the inverse of the sum of the distance to the nearest and second-nearest competing mills to the farmer.[35] We find

34. In the Online Appendix Table B6, columns (7)–(12) shows that the main farmer-level results are robust to controlling for market access. Similarly, Table B7 shows that the main farmer-level results are robust to the main robustness checks to the exclusion restriction performed in Table B3 and to the definition of catchment area performed in Table B8.

35. We take exponent $\epsilon = 2$ but results are robust to alternative $\epsilon$. This approach parallels the robustness checks on farmer market access in the Online Appendix Table B6.

TABLE VII

RELATIONAL CONTRACTING AND COMPETITION: FARMER LEVEL

| | Baseline (1) | Reduced sample (2) | Distance to nearest mill (3) | Distance to second-nearest mill (4) | RC index, farmer outcomes (5) | Farmer competition (6) | Mill competition (7) | RC index, farmer outcomes (8) |
|---|---|---|---|---|---|---|---|---|
| Competition | −0.237*** | −0.213*** | −0.205*** | −0.209*** | | | | |
| | (0.047) | (0.053) | (0.057) | (0.055) | | | | |
| Farmer mill access | | | −0.042* | −0.083** | | | | |
| | | | (0.022) | (0.042) | | | | |
| Farmer-level competition | | | | | −0.055** | | | −0.342*** |
| | | | | | (0.025) | | | (0.123) |
| Mill-level competition | | | | | −0.103*** | | | −0.223** |
| | | | | | (0.017) | | | (0.085) |
| Engineering score in own quadrant | | | | | | 0.870*** | −0.579*** | |
| | | | | | | (0.104) | (0.116) | |
| Engineering score in other quadrants | | | | | | −0.274*** | 1.417*** | |
| | | | | | | (0.106) | (0.226) | |
| Equality of Coefficients, $p$-value | | | | | | | | .101 |
| Competition definition | | | | | # mills in quadrant (farmer), # mills in other quadrants (mill) | – | – | # mills in quadrant (farmer), # mills in other quadrants (mill) |
| Instrument | | | | | – | – | – | Score in quadrant, score in other quadrants |

TABLE VII
CONTINUED

| | Baseline (1) | Reduced sample (2) | Distance to nearest mill (3) | Distance to second-nearest mill (4) | RC index, farmer outcomes (5) | Farmer competition (6) | Mill competition (7) | RC index, farmer outcomes (8) |
|---|---|---|---|---|---|---|---|---|
| Mill controls | | | Yes | Yes | Yes | Yes | Yes | Yes |
| District fixed effects | | | | | Yes | Yes | Yes | Yes |
| Farmer controls | | | | | Yes | Yes | Yes | Yes |
| Quadrant fixed effects | | | | | Yes | Yes | Yes | Yes |
| OLS/IV | | | | | OLS | OLS | OLS | IV |
| Adjusted $R^2$ | 0.07 | 0.11 | 0.13 | 0.12 | 0.18 | 0.47 | 0.64 | −0.00 |
| Observations | 869 | 606 | 606 | 606 | 606 | 606 | 606 | 606 |

*Notes.* Bootstrapped standard errors are in parentheses. ∗∗∗ (∗∗) [∗] indicates significance at the 0.01 (0.05) [0.1] level. The dependent variable across all columns is the relational-contract index for farmer outcomes. Column (3) includes "farmer mill access": this is a measure of a farmer's access to a mill, analogous to Donaldson and Hornbeck (2016); the measure is constructed as the inverse sum of the distances to the nearest and second-nearest competing mills to the farmer with no restriction on the radius. In column (4) the "farmer mill access" measure is now the inverse of the distance to the second-nearest competitor with no restriction on the radius. Farmer controls include distance to mill, farmer age, education, gender, schooling, cognitive score, cooperative membership, and holdings of coffee trees (ln). Mill controls include NGO-supported, cooperative status, mill age, mill age squared, and mill coordinates. Additional geographic controls include the average engineering suitability score, average spring presence, road density, tree density, rivers, flexible control of FAO-GAEZ coffee suitability, elevation, and slope, all within 5 km of the mill. Quadrants are adjacent 10 km by 10 km squares with the mill situated at the shared corner. Quadrant fixed effects refer to dummies for the northeast, southeast, and so on, quadrant. Main farmer outcomes included in the relational-contract index measure are receiving fertilizer from the mill, receiving a second payment, and expecting a loan or help after harvest. The number of observations falls when quadrant-level competition is introduced because we only have exact village location information for 70% of our surveyed farmers in 2012. $p$-value is reported for the test that farmer and mill effects are equal.

that conditional on mill-level competition, a farmer's proximity to competing mills is correlated with a lower relational-contract index.

A potential concern is that the farmer's mill access might be endogenous. To assuage this concern, column (4) repeats the exercise only including the inverse of the distance to the second-nearest competitor and finds similar results. Ideally, we would like to instrument for the farmer's access to mills following an IV strategy similar to that used for mill-level competition. To do so, we would like to construct an instrument for the suitability of mills in a donut area around the farmer. Such an approach yields instruments for mill-level competition and for farmer-level access to mills that are strongly correlated.

We therefore pursue an alternative strategy in the remaining columns of Table VII. The approach relies on dividing the area surrounding the mill into four "quadrants" (that is, quarters of a circle): northwest, northeast, southeast, and southwest. Each farmer is assigned to a quadrant. For each farmer we split competition into the number of mills in the farmer's quadrant (hence, farmer competition) and in the three other quadrants (mill competition).

Conditional on suitability in the farmer's quadrant of the mill's catchment area, we instrument competition in the farmer's quadrant with the average suitability score in the relevant portion of the 5–10-km donut. We construct an instrument for competition from mills in other quadrants in the same way, controlling for average suitability in the remaining quadrants of the mill catchment area.

The approach relies on the idea that competition from mills in other quadrants only affect farmers through the indirect profit mechanism. In contrast, competition from mills in the farmer's quadrant affects the farmer both through the direct temptation mechanism and through the indirect profit mechanism. Although the strategy only proxies for the two distinct channels through which competition operates, the two instruments are computed on different regions of the donut (the farmer quadrants versus all remaining quadrants) and are thus distinct from each other.

Table VII, column (5) reports OLS estimates splitting the number of mills within 10 km from the mill into farmer competition (mills in the farmer's quadrant) and mill competition (mills in the remaining quadrants). The estimates confirm a negative correlation between measures of competition and the use of relational contracts as reported by the farmer.[36]

Column (8) explores the IV specification in which we separately instrument for farmer competition and mill competition. Columns (6) and (7) present the first stages for farmer-level and mill-level competition, respectively. Reassuringly, the two instruments are positively correlated with the corresponding measure of competition.

We find evidence that both mechanisms are at play. An additional competing mill in the farmer's quadrant reduces the relational-contract index by 0.342 standard deviations. This is the effect of competition operating through the direct temptation and the indirect profit mechanisms. An additional mill in other quadrants reduces the relational-contract index by 0.223 standard deviations. This is the effect due to the indirect profit mechanism only. The difference between the two estimates, 0.119 standard deviations ($p = .10$), isolates the direct temptation mechanism.

In industries with fixed costs and in which an additional entrant lowers output of incumbent firms (business stealing), average costs increase and entry is more desirable to the entrant than to the industry as a whole (Mankiw and Whinston 1986). Although this mechanism is similar to the indirect effect in our model, the two can be empirically distinguished. In our model, an additional entrant makes it harder to sustain relational contracts for rivals, leading to a knock-on effect in which other relational contracts break down and aggregate amounts of cherries supplied to mills declines. In our context, instead, the model in Mankiw and Whinston (1986) would imply that an additional entrant raises the aggregate amount of cherries processed by mills (and increases the price paid to farmers).

This prediction is inconsistent with evidence that an additional competitor lowers the volume of cherries supplied by farmers to all mills (Table VI, column (3)). In Online Appendix D we also show that (i) there is great abundance of coffee cherries to be processed and thus business-stealing effects alone are unlikely to drive mill-level outcomes (see Online Appendix Figure D2); (ii) our instrument for competition displays an inverted-U shaped

36. Relative to the specification in Table II, there are two more sources of measurement error in this specification. First, mills in other quadrants might also directly affect the farmer. Second, the process through which farmers are assigned to quadrants is noisy.

relationship with the aggregate amount of cherries processed (see Online Appendix Figure D3, Panel B): as predicted by our model, past a certain level of entry, aggregate volumes processed decline with further entry.

## VII. Conclusion

In settings where formal contracting institutions are poor, parties rely on relational contracts—informal agreements sustained by the future value of the relationship—to deter short-term opportunism and facilitate trade. Empirical evidence on the scope, structure, and determinants of these informal arrangements has the potential to identify key market failures and inform policy, particularly in developing economies.

This article presents an empirical study of the effect of competition on the relational contracts between coffee mills and farmers in Rwanda, a context that is of intrinsic interest but is also convenient from a methodological point of view. We make two contributions. First, we contribute to the literature on relational contracts and, more broadly, on management practices. We systematically measure relational practices in a sample of large firms; we document significant dispersion in the adoption of these practices; we show these practices are complementary; and confirm that their adoption is strongly correlated with firm's performance. Relational practices, by definition, are difficult to codify and context specific. Although the practices we measure are relevant in our setting and in other agricultural value chains in developing countries, we hope to offer an example of the value of measuring relational contracts in other contexts as well.

Second, we study the role of competition as a determinant for adopting relational practices. We argue this is the key comparative static to understand whether poor contract enforcement alters market functioning. In a first-best world, we expect competition to have a positive effect on management quality and productivity. A distinctive feature of relational contracts is that rents are relied on to curb opportunism and, to the extent that competition erodes those rents, it could lead to worse outcomes. We find a significant negative effect of competition between mills on the use of relational contracts between mills and farmers. The breakdown in relational contracts lowers mills' efficiency and output quality. More surprisingly, competition between mills lowers the aggregate amount of coffee supplied by farmers to any mill and, if anything, makes farmers worse off. This provides novel evidence on the functioning of markets in second-best environments.

These findings must be interpreted cautiously. Our results demonstrate that in a second-best world the benefits of competition might be hampered by the presence of other market failures that are mitigated by relational contracts: the design of adequate industrial policies needs to take into account informal arrangements and market institutions operating in specific contexts. Our analysis identifies the average effect of adding an additional competitor for a mill that is already subject to intense competition. The results should not be interpreted as supporting monopsony.

The evidence suggests the possibility of excessive entry when contracts are hard to enforce. A direct policy recommendation, then, is to improve contract enforcement in agricultural chains. Although it might be too much of a task to improve a country's formal court system, industry regulators can improve contract enforcement in specific agricultural chains.[37] Such policy interventions, however, must be evaluated on a case-by-case basis because partial improvements in contract enforcement could undermine relationships and worsen market functioning (Baker, Gibbons, and Murphy 1994).

The industry in this article harbors (too) many unproductive firms—a rather typical portrait of markets in developing economies. In such contexts, processes of consolidation (e.g., ownership changes through mergers and acquisitions) can potentially reduce inefficiencies but are often stifled by dysfunctional institutional environments. Indeed, in our context, such a process has started to emerge in recent years as more productive and better-managed foreign exporters have acquired mills to integrate backwards (see Macchiavello and Morjaria 2020a).

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37. For example, in Costa Rica the Instituto del Cafe de Costa Rica monitors the coffee value chain and enforces contracts between mills and farmers and between mills and exporters.

## Supplementary Material

An Online Appendix for this article can be found at *The Quarterly Journal of Economics* online.

## Data Availability

Data and code replicating the figures and tables in this article can be found in Macchiavello and Morjaria (2020), in the Harvard Dataverse doi: 10.7910/DVN/IGJFVP.

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