

Relationships on the Rocks: Contract Evolution in a Market for Ice[†]

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Firms use relational contracts to support repeated trade. Do these informal agreements evolve in response to market conditions? In a market for ice, firms reestablish relationships on new terms when a prior agreement breaks down. Using transaction data, we show that ice retailers prioritize deliveries to loyal buyers—fishing firms—when supply from the monopolistic manufacturer is scarce. After an upstream shock to competition increases supply, repeated trade lapses, threatening retailers' positions. Incumbent retailers establish a new agreement expanding trade credit to loyal buyers, which impedes new retailer entry. Upstream competition also increases downstream firms' productivity and lowers consumer fish prices. (JEL D24, D86, L12, L14, L81, O14, Q22)

Economic relationships are observed as repeated trade between agents. Starting with Coase (1937), the literature on relationships has focused on the so-called “make or buy decision”—the choice to procure inputs either through spot markets or through vertical integration. Baker, Gibbons, and Murphy (2002) argue that relational contracts—informal, reciprocal agreements sustained by the value of future repeated trade—are a third organizational form that may provide more flexibility than vertical integration and more stability than spot market transactions. A broad lesson of this literature is that as markets develop, relational contracts become difficult to sustain. For example, when outside options improve on the spot market, making a particular reciprocal agreement less attractive to one party, the standard model predicts that the agreement will lapse (cf. Kranton 1996).

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Little is known about this prediction empirically: if an informal agreement breaks down, does repeated trade continue—and if so, under what terms? In this article, we document how relational contracts may evolve. Agents with a history of repeated trade can establish new informal agreements after changes in market conditions make their prior agreement infeasible. As the economy develops and the availability of outside options improves, there can still be a role for relational contracting.¹

Specifically, we document how a relational contract between buyer and seller may evolve from one providing supply assurance for the buyer to another supporting trade credit for the buyer. In exchange, the seller receives exclusivity and repeated trade. A standard industrial organization interpretation of such services is that they reflect quality differentiation in a model with non-price competition (Stigler 1968). Several recent articles have demonstrated that relational contracting theory provides additional predictions about which customer segments are most likely to receive high-quality services, given the histories of their relationships.² Such predictions do not follow from standard models of non-price competition, in which demand for quality is determined only by preferences (Sutton 1991).

We examine how the history of a relationship predicts who benefits from non-price competition after a dramatic shock to upstream entry, providing insight into how relational contracts evolve as markets develop. Previous research on relational contracts has largely focused on how behavior under a given agreement varies within a fixed market structure.³ We make progress by exploiting unusually rich transaction data from a vertically related industry experiencing entry in the upstream market, which makes a downstream input—ice—less scarce.

Initially, Sierra Leone's ice industry is served by a monopolistic manufacturer, Ice Ice Baby (henceforth, M1), that sells on commission through five independent retailers to over 150 fishing firms (henceforth, fishermen) across three wharves. Ice improves productivity by enabling fishermen to cool their catch, allowing them to remain at sea longer on each trip. As ice shortages are common under the monopolist, retailers and fishermen form downstream relationships based on supply assurance. The timing of the upstream entry shocks, which were unexpected by M1, is plausibly exogenous to other demand and cost factors that may have shaped competition in the downstream market: new manufacturers enter in two cases due to the accumulation of retained earnings by local entrepreneurs, and in two other cases due

¹A large empirical literature documents the prevalence of relational contracts across settings (Greif 1993; Bigsten et al. 2000; Fisman 2001; Fafchamps 2004)—see Gil and Zananone (2017) for a recent review.

²For instance, McMillan and Woodruff (1999) and Antràs and Foley (2015) show how the likelihood that sellers provide trade credit to buyers increases with the length of their relationships (e.g., the number of past interactions); Macchiavello and Morjaria (2015) show how length of relationship relates to the provision of supply assurance through prioritization.

³Recent theoretical work shows how the terms of informal agreements under a given relational contract may vary over time in a fixed market structure due to specific frictions such as the presence of holdup (Board 2011), asymmetric information (Halac 2012), or both (Li and Matouschek 2013). In our setting, no specific investments are required to fulfill a contractual obligation and each party's outside options are common knowledge. An older literature explored how collusive relationships break down (Green and Porter 1984), but does not allow for transferable utility as is relevant here.

to the development of trade finance for imported ice machines, events which may be viewed as inevitabilities of the country's gradual postwar recovery.⁴

Non-price competition in the retail market changes as a consequence of upstream entry. The expansion of trade credit is concentrated among the same fishermen that retailers had previously considered "loyal" in the pre-entry equilibrium, in the sense that they agreed the buyer "will wait for his [retailer] to come even if he has another way of getting ice earlier" (Ghani and Reed 2022). This result is interesting because it is theoretically possible that the fishermen who most value credit are different from those who most value supply assurance, though here it appears a history of loyalty may be a valuable asset. We show retailers' baseline perception of loyalty remains a robust predictor of behavior even when controlling for social factors that might support a relational contract (e.g., length of the relationship, friendship, coethnicity) or shape buyer demand for specific services (e.g., volume of trade, asset wealth, risk tolerance). A history of loyalty is therefore a robust predictor of who benefits from non-price competition, independent of other economic variables. Further, though we observe an increase in buyers switching between retailers immediately after entry—a dissolution of loyalty—the expansion in credit ultimately coincides with a return to more stable relationships. This suggests that retailers and fishermen use trade credit to reestablish previous relationships exchanging a stable demand for high-quality services, albeit this time with a different service.

Ultimately, the benefits of entry in the upstream market show up in downstream markets in the forms of a greater quantity and lower retail price of ice, as well as a greater quantity and lower price of fish caught with ice. In addition to predicting which fishermen benefit from non-price competition during this transition, relational contract theory may also help to explain the persistence of incumbency in retail distribution, as the greater quantity of ice available induces entry into retail. In our setting, incumbent retailers maintain similar market shares as they had before the onset of manufacturer competition, despite the entry of new retailers. This observation is consistent with the idea, proposed by retailers in interviews, that relational contracts may serve to create barriers to entry. In a setting without contract enforcement, retailers rely on the history of past cooperation to support service provision (i.e., supply assurance and trade credit), placing new entrants at a disadvantage in identifying which customers are reliable. Further supporting the idea that relational contracts may serve as a competitive defense, the new trade credit contract is more likely to emerge in the wharf that is most concentrated: the one with multiple retailers at baseline.

Our study of relational contracting within the context of non-price competition also addresses the literature on supply assurance and trade credit services in developing countries. The observation that supply assurance is an important margin of quality in Sierra Leone's ice industry is consistent with the hypothesis that uncertainty and volatility are both higher in developing economies (Collier and Gunning 1999; Asker, Collard-Wexler, and De Loecker 2014), potentially making relational

⁴ Together, these fishing wharves comprise the majority of artisanal fishing activity near Sierra Leone's capital of Freetown. Nationally, the fishing industry accounts for approximately 10 percent of GDP, employing more than 30,000 people and 8,000 boats (World Bank 2006, 2009).

contracting disproportionately important in these settings. Our results also help to build intuition for how trade credit provision is shaped by competition. Consistent with the idea that the improved outside options associated with more market competition may disrupt relational contracts, Macchiavello and Morjaria (2021) find, in a cross section of coffee mills buying from farmers in Rwanda, that a higher concentration of mills is associated with less credit provided by *buyers* to *sellers*. Though our setting differs in that credit transactions cover a few days instead of a whole agricultural season, our finding that credit supply has the greatest response to the upstream entry shock in the most competitive retail market suggests such results need not obtain in all settings. Trade credit provision may increase, rather than decrease, with competition, particularly when provided by *sellers* to *buyers*. Consistent with this intuition, Fabbri and Klapper (2016) find in China that suppliers who face stronger competition are more likely to extend trade credit on favorable terms to their buyers. Fisman and Raturi (2004) provide similar cases in Africa and argue that the result is consistent with a model in which buyers must invest *ex ante* to establish creditworthiness before any credit is provided. Here, a seller's monopoly power should reduce credit provision to the buyer, since the investment will not be made if the buyer anticipates that all surplus will be extracted by the monopolist *ex post*.

The paper proceeds as follows: in Section I, we describe Sierra Leone's ice industry and the shift in market structure that we exploit for variation. This section describes the basic effect of entry into ice manufacturing on ice and fish quantities and prices. Section II describes the data used in the analysis of relational contracting. Section III presents our core results, quantifying the effect of ice manufacturer entry on outcomes in the ice retail market including supply assurance, trade credit, and loyalty. Section IV concludes.

I. The Ice Industry of Sierra Leone

This article is a case study of the ice industry of Sierra Leone, West Africa.⁵ In this section, we provide background on the demand for ice and describe the consequences of a transition from monopoly to competition in ice production. As expected, the quantity of ice rises and its price falls after entry, creating downstream benefits for consumers of fish caught with ice.

A. Demand for Ice

Sierra Leone's ice industry, which is concentrated around the capital, Freetown, on the Western Area peninsula (Figure 1), serves small-scale ("artisanal") fishermen and other consumers in the capital, with artisanal fishermen comprising the largest customer segment.⁶ Despite being considered small in the sense that they do not

⁵In 2014, Sierra Leone had a population of 6.3 million and a PPP per capita GDP of \$1,770 (World Bank 2014). For overviews of the economy and recent history, see Bellows and Miguel (2006) and Collier and Duponchel (2013).

⁶Ice is sold by retailers who operate in the three major fishing wharves around the peninsula. Tombo (W1) is the largest artisanal landing on the peninsula, representing approximately 250 large fishing boats, though only about



FIGURE 1. MAP OF FREETOWN PENINSULA, SIERRA LEONE

Notes: This map shows the approximate location of three major fishing wharves served by the ice factories: Tombo (W1), Aberdeen (W2), and Goderich (W3). It also shows the factory locations of the incumbent manufacturer, Ice Ice Baby (M1), and the new entrant manufacturers (M2, M3, M4, M5), which are highlighted in red and numbered in order of entry.

operate industrial trawlers, these fishermen operate formal firms, paying license fees to access the fishing wharves. The average fisherman in our sample employs a crew of ten and reports assets of over \$9,000 and monthly gross profits of over \$1,000.

Ice is an important input into fishing that raises productivity. On a typical fishing trip, average expenses are \$400, or 5 percent of asset value, of which ice comprises

15 percent of these vessels regularly purchase ice. Low adoption is likely due to the ninety-minute drive between Tombo and the Freetown urban area, where the incumbent manufacturer (M1) is located, which prevents fishermen from being reliably served at scale. The remaining two wharves—Aberdeen (W2), with approximately 100 boats, and Goderich (W3), with 200—are located within a fifteen-minute drive of M1's location in Freetown. In Aberdeen, 30 percent of vessels regularly purchase ice, and 50 percent of vessels regularly purchase ice in Goderich.

26 percent (fuel comprises 44 percent and food comprises 14 percent). With ice, fishermen can cool their catch while at sea and therefore fish longer and further away from shore. Without ice, fishermen must either catch the lower-value fish that swim close to shore or conduct short overnight trips to avoid spoilage. Thus, ice enables fishermen to pursue larger, higher-value types of fish that swim further away from shore and to extend their trips longer while seeking such fish. Fishermen generally purchase ice from independent retailers who sell to all fishermen at a common retail price as set by M1 but differentiate between fishermen by prioritizing orders when supply is scarce (supply assurance) and determining what amount of total cost each fisherman must pay up front or after delivery (trade credit). Ice is perishable, as fishermen and retailers do not have access to large freezers or a reliable supply of electricity with which to operate them. Instead, they rely on the manufacturer to deliver it to the wharf at an appointed time.⁷ Our focus on a homogeneous and perishable commodity should allay concerns that shifts in observed quality (supply assurance and trade credit) are driven by demand for other unobserved product attributes. In this way, the market has similar empirical qualities to the market for ready-mix concrete studied by Syverson (2004) and Collard-Wexler (2013).

B. Entry into Ice Production

Initially, with extremely limited financial system development, the up-front capital costs of the ice manufacturing business created a barrier to entry. The cost of a 13-ton daily capacity machine (less than half of M1's capacity) typically exceeded \$100,000. At the start, M1 is the sole supplier of ice to all retailers.⁸ M1 maintains retail prices by publicly announcing the prices to fishermen and then paying retailers a commission on each 30 kg bag sold equal to 1,000 leones, 5.5 percent of the precompetition price.⁹ The commission is public knowledge, and all retailers receive the same commission from M1. As will become important post-competition, retailers do not receive a fixed wage and are not employees of M1, meaning they are

⁷Fishermen generally pursue certain types of fish on each trip, given orders from fishmongers, and so must plan in advance whether to use ice. Fishermen typically require ice in the morning, immediately before going to sea, and typically make their orders the day prior to departure with a retailer based at the wharf. By the end of the day, retailers aggregate orders and communicate the required quantities to the manufacturer. Retailers sometimes supply trade credit, allowing fishermen to delay some portion of their payment at 0 percent interest until after the trip is completed when fish are sold; the incumbent manufacturer (M1) supports this practice by allowing retailers to borrow against their unclaimed margin. If the ice is not delivered on time, the fishermen lose part or all of the day at sea, paying both the wages of the fishermen they have retained for the day and the opportunity cost of their own time. Since fishermen often arrange in advance to deliver their catch to a specific fishmonger on a specific day, late deliveries often require them to shorten their trips or risk their credibility with customers. Fishermen do not have the option to cancel an order if it is late.

⁸The company has 29-ton daily capacity in one plant and is owned by ManoCap, a private equity fund operating in Sierra Leone, Liberia, and Ghana. Two Sierra Leoneans returned from the diaspora and founded the firm in 2005, launched initial production in fall 2006, and sold to ManoCap in 2008. When M1 entered the market in 2006, it initially competed with two smaller ice manufacturers for the artisanal fishermen market, but these competitors were unable to sustain their operations and soon exited. At the start of our data collection period, the firm made a gross margin of 50 percent, indicative of its market power as a monopolist. At that time, the strongest competition M1 had faced was the government, which in 2012 established a fishing business and ice facilities in a fourth, smaller fourth called Murray Town, forcing M1's exit.

⁹Public announcement of prices is a common resale price maintenance strategy used by large firms in emerging markets—for instance, Coca-Cola. In interviews, both M1 and retailers acknowledged a belief that price stability was important to achieve the maximum level of demand from fishermen.

free to make sales on behalf of other manufacturers. The presence of resale price maintenance makes this an ideal setting to study how relational contracts support quality competition: because competition on price is restricted, retailers must rely on other margins of competition, such as providing supply assurance or trade credit, to retain customers.

Increased competition in ice production is caused by a confluence of the outcomes of ongoing economic development: the emergence of local entrepreneurs with cash to invest and the development of trade finance, specifically for imported capital goods. Eventually, four additional manufacturers will enter the three fishing wharves served by M1, more than doubling industry production capacity. Figure 1 shows the locations of these new entrants, indicated as M2, M3, M4, and M5.

Two of the manufacturers (M2 and M3) were initially operators in Sierra Leone's packaged water and cubed ice market, which has lower entry costs. Having established themselves in these markets, they built up cash and used it to entirely self-finance their expansion into industrial ice production. The other two manufacturers (M4 and M5) used the trade finance facilities of an importer. The importer, who had an established business importing refrigerators and air conditioners for the regional consumer market, began offering buyers of ice machines the opportunity to purchase one without travel abroad and with financing that allowed 25 percent of the cost to be paid after six months of production. Previously, payment terms for machines were typically 50 percent up front and 50 percent on delivery, and purchase required a personal visit to the vendor's facilities abroad, either in China, Germany, or Italy. As Startz (2017) finds in Nigeria, overcoming such frictions may have substantial impacts on trade. Interviews with each of the new manufacturers confirm that the exact timing of entry was determined by a set of idiosyncratic factors unrelated to demand, such as delays in receiving and installing equipment, recruiting skilled staff, and establishing production processes.

C. The Consequences of Entry for Prices

In addition to changing the nature of non-price competition, the primary result of manufacturer entry was to expand the quantity of ice produced and lower prices, as predicted by the theory of supply and demand. We review this primary result here. The growing share of new producers, in terms of quantity, is shown in Figure 2, with vertical lines indicating the date of each subsequent manufacturer's entry. The figure also shows how this increase in quantity coincides with a reduction in the lateness of deliveries, indicating that ice was more available in the market on any given day after entry, as retailers were able to procure ice from other manufacturers when it was not available from M1. Figure 3 shows M1's retail price declining over time as other firms enter. Appendix A reports quantitative estimates of these effects: ice sold to fishermen increased by 15 percent and prices fell by 8 percent.¹⁰

The benefits of entry for the production of the input, ice, are seen in the market for fish, and appear to outweigh substantially the capital costs of new entrants. As

¹⁰These results imply an arc price elasticity of demand of approximately 1.9, consistent with fishermen being fairly price-sensitive.

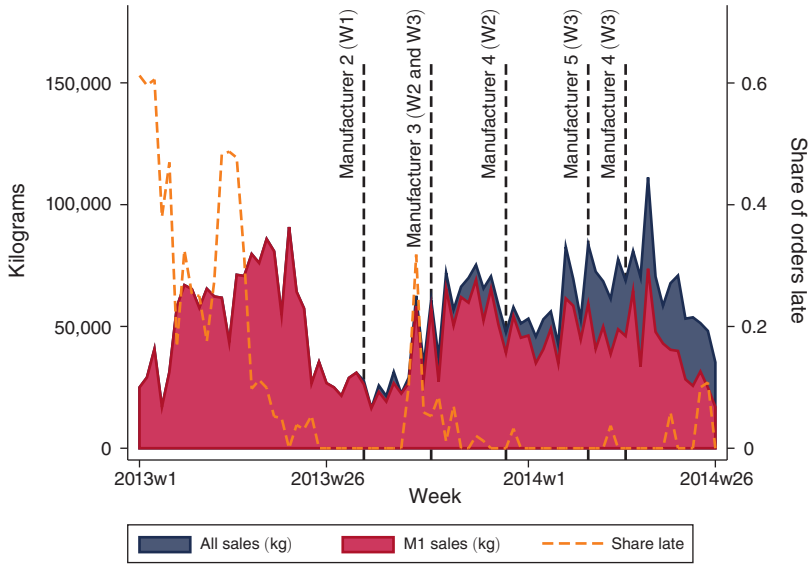


FIGURE 2. TOTAL FISHERMEN ICE SALES AND LATENESS

Notes: This figure presents weekly total sales (in kilograms) to all fishing buyers (separated into Manufacturer 1 [M1] sales and all sales) and the share of orders delivered late. There is an unknown quantity of missing data before February 2013, so those sales are censored. The decrease in total production in the middle of 2013 corresponds to the rainy season, when fishing activity declines due to intense weather conditions. Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

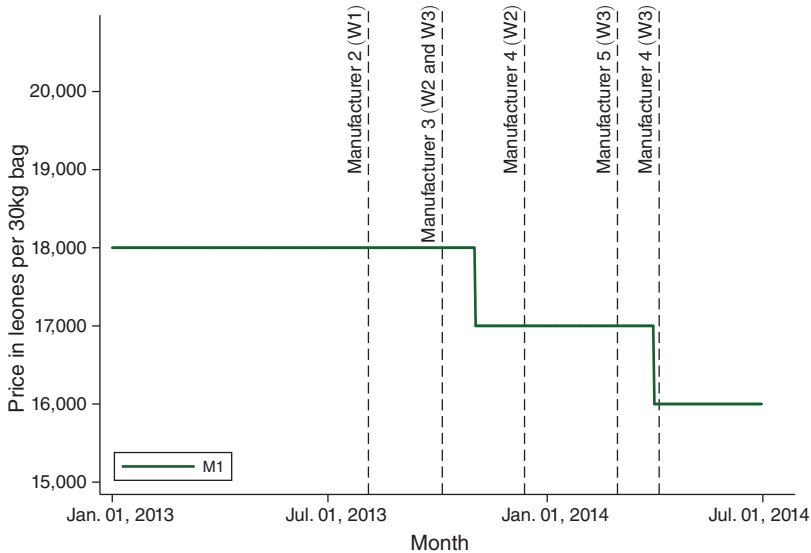


FIGURE 3. ENTRY AND PRICE COMPETITION

Notes: The y-axis shows the incumbent manufacturer’s retail price per 30-kilogram bag of ice sold in all three wharves (Tombo, Aberdeen, and Goderich). Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

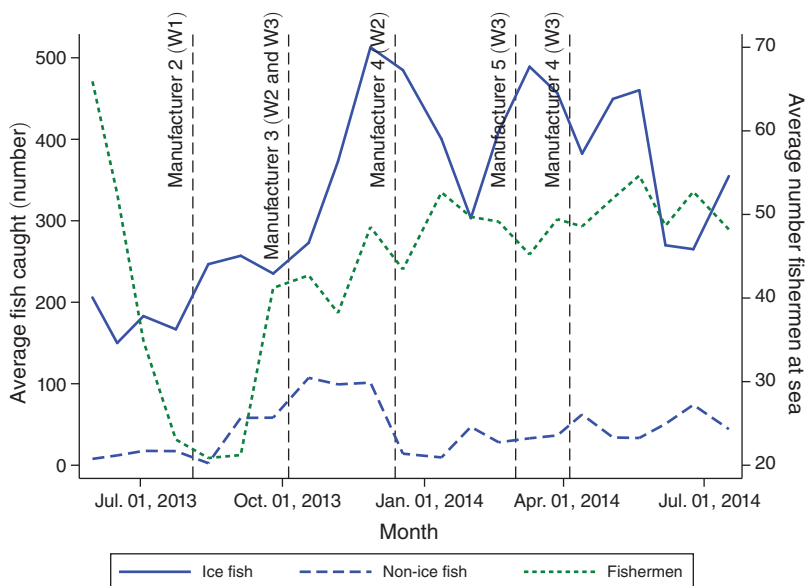


FIGURE 4. FISHING INTENSITY

Notes: This figure presents the average number of fish caught per fisherman and the average number of fishermen at sea during the previous two weeks over 22 high-frequency survey waves from May 2013 to July 2014. The decrease in active fishermen in the middle of 2013 marks the rainy season, when fishing activity declines due to intense weather conditions. Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

described in Appendix A, we employ a difference-in-difference strategy to compare changes in fisherman productivity and retail prices, before and after manufacturer entry, across two groups of fish: “ice fish,” which are caught far from shore and so require ice for production, and “non-ice fish,” which are those caught close to shore and therefore do not require ice for production. Lower ice prices ultimately raise the quantity and lower the price of ice fish. Figure 4 shows this result graphically. Following manufacturer entry, we observe a sharp and sustained increase in the average fish caught per fisherman for ice fish, and a more modest increase for non-ice fish from a far lower base that is not sustained.¹¹ The estimated effect of moving from one to five ice manufacturers is a 10 percent decrease in the price of ice fish. Non-ice fish show no significant price decrease after entry.

¹¹ Our fishermen sample includes the universe of buyers who fish with ice, implying these data include the entire market for ice fish. One concern about measurement is that we observe the number of fish and not their weight, and ice fish and non-ice fish may be of different sizes. If ice fish were systematically smaller in weight, our results could be consistent with no impact of entry on the kilograms of each fish consumed. This is highly unlikely, however, given the nature of the fishing ecology. An independent fishing supply analysis commissioned by M1 observed that fish caught farther from shore are systematically larger, as is typical globally. In this case, our results for counts of fish systematically understate the differences in terms of weight.

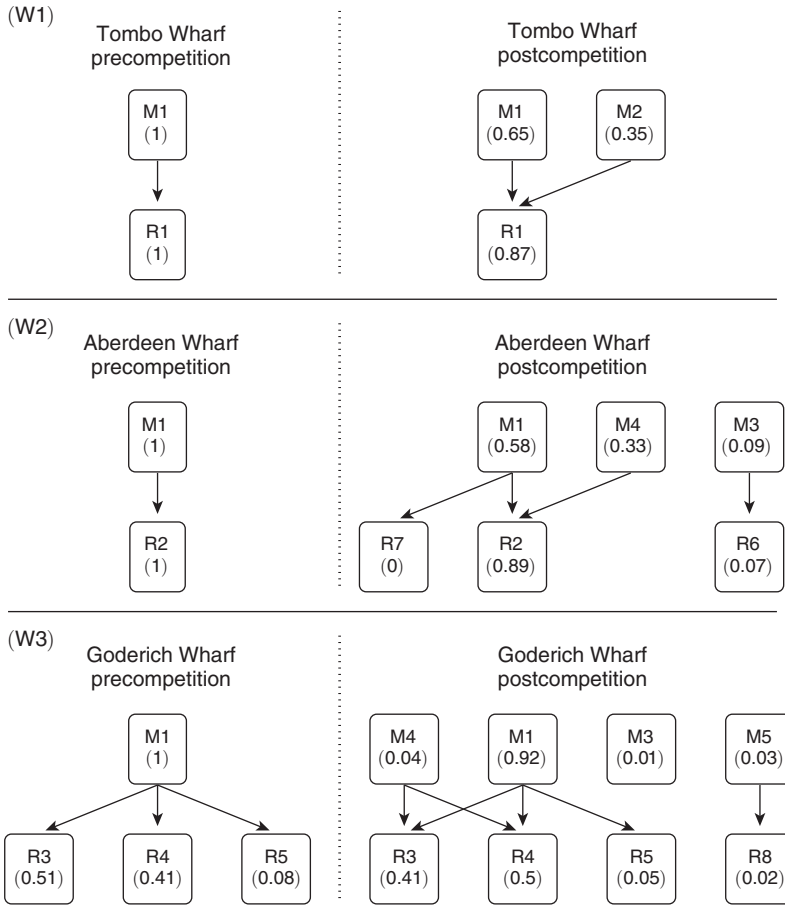


FIGURE 5. MARKET STRUCTURE PRE- AND POSTCOMPETITION

Notes: This figure presents the market structure of manufacturers (designated by M) and retailers (designated by R) in each of the three wharves before and after the onset of new manufacturer entry. Manufacturer and retailer market shares are reported in parentheses, corresponding to the period from January 2013 until the onset of competition in the left panels, and from the onset of competition to July 2014 in the right panels. Retailer market shares do not always sum to 1 due to direct customer sales by Manufacturers 2 and 3. See paper text for details.

We can estimate the (first-order) aggregate benefit to consumers by multiplying the percentage price reduction by an estimate of the value of fish consumed. Specifically, multiply the price decrease (10 percent) by the share of fish that require ice to be caught (50 percent), times the share of fish overall in the CPI consumption basket (5.49 percent), times the consumption share of GDP (100.8 percent in 2014), times the GDP PPP in constant 2011 dollars (\$11.98 billion), resulting in a total of \$33.15 million. Dividing by the total population yields \$5.22 per capita, or 0.3 percent of GDP per capita for that year. The effect is modest, but nonnegligible, especially in a low-income country and when compared to the comparatively small investment required to purchase the 13-ton ice machine necessary to start the business.

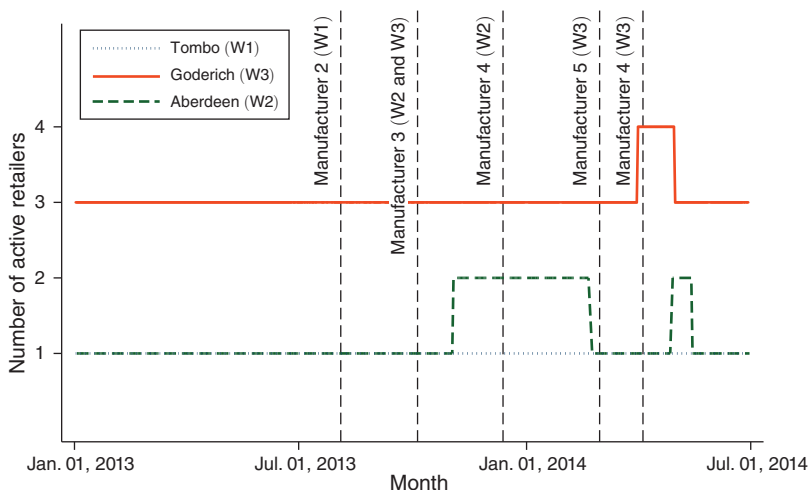


FIGURE 6. NUMBER OF ACTIVE RETAILERS OVER TIME

Notes: This figure presents the number of active retailers in each of the three wharves. Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

D. Retailer Entry and Market Shares

We also find suggestive evidence that relational contracts may serve as barriers to entry at the retail level. Figure 5 shows the structure of retail distribution in each wharf before and after competition, with the arrows indicating supply relationships between manufacturers and retailers. The effects of upstream competition are clear: incumbent M1's market share falls from 1 in each market to 0.65 in Tombo, 0.58 in Aberdeen, and 0.92 in Goderich. In addition, there are three new entrants into retail who source supply from the new producers in two markets: in Aberdeen, R6 enters and buys from M3; in Goderich, R8 enters and buys from M5. As shown in Figure 6, however, each of the new retailers is only active for a short period of time—in each case, less than six months.

Ultimately, despite the reallocation of market share among manufacturers, the five ice retailers (R1–R5) who originally distributed ice for M1 retain most of their original market share: in Tombo, for R1, a market share of 1 becomes 0.87;¹² in Aberdeen, for R2, $1 \rightarrow 0.89$; and in Goderich, for R3, $0.51 \rightarrow 0.41$, R4, $0.41 \rightarrow 0.5$, and R5, $0.08 \rightarrow 0.05$. These changes are shown graphically in Figure 7, which shows the sales of each retailer over time, drawing on administrative data collected from all manufacturers. In general, quantities sold by each retailer are similar when comparing Q1 and Q2 of 2013 and of 2014 except in Aberdeen, where total sales appear to have declined somewhat. Of course, part of the incumbent retailers'

¹²While R1 remained a monopolist retailer, direct sales from M2 to fishermen were unusually high in this wharf. Similar increases are not observed in direct sales by other manufacturers or in other wharves.

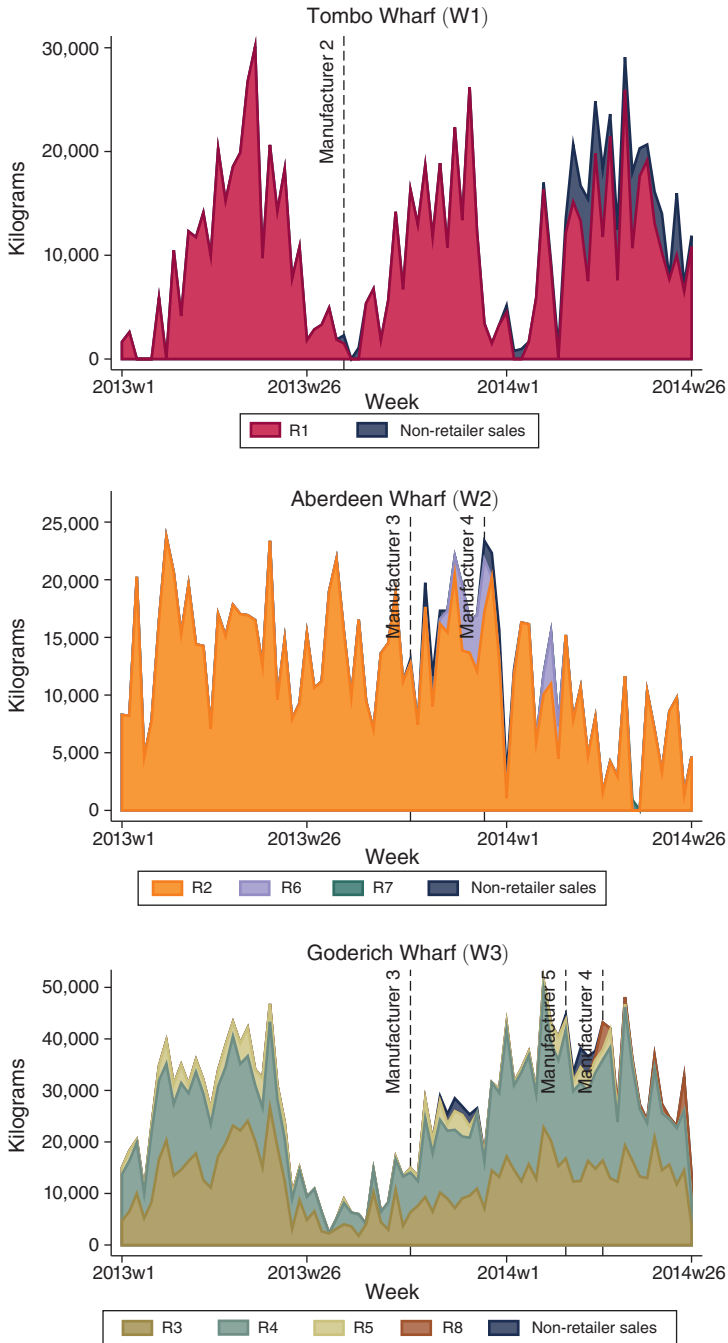


FIGURE 7. RETAILER AND NON-RETAILER SALES, PARTITIONED BY WHARF

Notes: The y-axis shows the weekly total sales (in kilograms) for each retailer or, in the case of “Non-retailer Sales,” the remaining sales made directly by manufacturers to fishermen customers in each wharf. Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

success is that they (i.e., R1, R2, R3, and R4) establish alternative supply relationships with at least one new manufacturer.¹³

II. Data

Our analysis of relational contracts in this industry draws on 18 months of an original panel of transactions in Sierra Leone's ice industry (Ghani and Reed 2022). The data cover all upstream transactions between ice manufacturers and retailers and downstream transactions between incumbent retailers and fishermen buyers.

Upstream, we collected the price schedules and quantities produced and sold on each day from the incumbent and four entrant ice manufacturers. These allow us to observe daily aggregate ice production totals and daily aggregate sales figures by retailer, which were presented in the previous section. These data are complemented by interviews with the leadership of each ice factory, which provided important context regarding specific policies and strategic decisions on production, supply assurance, and credit.

Downstream, in the ice retail market, we constructed a panel of retailer-fishermen transactions. For each sale by an incumbent retailer (those initially working with M1, or R1, R2, R3, R4, and R5) we collected fishermen identifiers, as well as contractual terms (price, quantity demanded, credit), and contractual outcomes (quantity delivered and timeliness).¹⁴ Supply assurance is observed through variations in the observed timeliness of an order, which comes from the retailer's record of whether the order is delivered by the time of day initially specified by the fisherman buyer. Similarly, trade credit is observed by records of delayed payment associated with each transaction. Detailed fishermen transaction data were not forthcoming from new retailers (R6, R7, and R8), but as we documented above, their sales never comprise more than a negligible share of the market.

We complement manufacturer and retailer records with an original survey of fishermen, which is used in Appendix A to report on increases in fisherman productivity (Ghani and Reed 2022). For these data, baseline interviews were conducted in April 2013. The survey recorded information about respondent demographics, fishing practices, experience with the ice retailers, assets, and expenditures. We were able to locate and survey most current customers at the time of the baseline survey, and we continued to add a small number of new fishermen customers to our survey data collection as they entered the sample.¹⁵ Starting in May 2013 and continuing until July 2014, fishermen responded to twice-monthly follow-up phone surveys

¹³Perhaps the most surprising aspect of the case is M1's decision not to vertically integrate with its retailers. In the face of entry, the manufacturer might have better maintained its market share and held up the price of ice under an employment contract with its retailers. Such a contract may have proved hard to enforce after entry placed pressure on retailers (cf. Legros and Newman 2013). Postcompetition, contracts between manufacturers and retailers were remarkably stable: all retailer sales continued on a commission basis, with new manufacturers adopting the existing commission amount in all but one case noted below.

¹⁴The total volume of individual orders reported by fishermen correlates closely to the aggregate sales volumes reported separately by manufacturers.

¹⁵Retailers are unable to identify occasional fishermen customers who are not based in one of three wharves—primarily seasonal fishermen from neighboring Guinea. 347 out of 5,281 orders (6.6 percent) in our transaction data are unidentified, and we include them in the analysis with a common fisherman identifier.

TABLE 1—BASELINE SUMMARY STATISTICS

	All	By Wharf			Min	Max
		W1	W2	W3		
Age	40.23 (9.35)	39.11 (9.71)	41.68 (11.48)	40.20 (8.42)	24.00	82.00
Years fishing experience	17.31 (8.70)	15.70 (11.19)	18.06 (8.82)	17.73 (7.34)	1.00	47.00
Own fishing boat (= 1)	0.61 (0.49)	0.68 (0.47)	0.90 (0.30)	0.48 (0.50)	0.00	1.00
Captain fishing boat (= 1)	0.81 (0.39)	0.65 (0.48)	0.90 (0.30)	0.85 (0.36)	0.00	1.00
Fishing trips per month	9.57 (10.61)	15.22 (17.03)	7.42 (6.19)	7.96 (7.06)	2.00	86.00
Fishing assets (\$)	9,107.34 (7,492.56)	11,646.70 (8,901.26)	8,130.65 (8,539.43)	8,318.85 (6,109.30)	1,035	45,195
Standard trip expenses (\$)	375.76 (167.83)	311.74 (132.68)	382.30 (198.94)	402.26 (163.93)	54.42	941.39
Ice as share of trip expenses	0.26 (0.12)	0.26 (0.07)	0.33 (0.07)	0.24 (0.14)	0.00	0.76
Retailer survey: Relationship years	3.99 (2.71)	4.84 (2.02)	3.35 (2.24)	3.85 (3.05)	0.00	13.00
Retailer survey: Loyal (= 1)	0.73 (0.45)	0.68 (0.47)	0.90 (0.30)	0.68 (0.47)	0.00	1.00
Retailer survey: Close friend (= 1)	0.73 (0.45)	0.76 (0.43)	0.55 (0.51)	0.78 (0.42)	0.00	1.00
Retailer survey: Coethnic (= 1)	0.33 (0.47)	0.73 (0.45)	0.65 (0.49)	0.04 (0.19)	0.00	1.00
Observations (firms)	153	37	31	85		

Notes: Standard deviations are reported in parentheses. W1 refers to Tombo, W2 refers to Aberdeen, and W3 refers to Goderich.

that addressed their fishing trips over the past two weeks including the use of ice, the selection of retailers, and fishing trip outcomes. In September 2013, immediately following the entry of Manufacturer 2 into Tombo but prior to entry by other manufacturers, we surveyed all five incumbent retailers to assess perceptions of whether the customer is loyal, using the definition in the introduction, and documented other potential indicators of relationship strength including friendship or common ethnicity.

The sample of 153 fishermen customers included in the transaction data is summarized in Table 1. With an average age of 40 years and over 17 years of fishing experience, about 60 percent of the fishermen respondents owned their own fishing boat and over 80 percent served as boat captain for regular trips.¹⁶ A typical month during the dry season involved almost ten trips, and fishermen have been buying from their ice retailers for an average of four years. In our retailer survey data, 73 percent of fishermen are identified by their primary retailer as loyal using the

¹⁶The transaction data are a sample of retail customers, rather than of the owners or captains of boats. These are not mutually exclusive groups. The sample includes 29 owners who are not captains and 59 captains who are not owners, with the remainder fitting into both categories.

definition in the introduction.¹⁷ The same fraction, 73 percent, are identified as a close friend by their retailer, and only one-third are identified as sharing the same ethnicity as their retailer. The fishing trip data are summarized in online Appendix Table B1, where we observe that the average planned trip length is almost three days, with one-quarter of trips not involving ice. The average ice purchase was 464 kilograms (\sim \$75, using the ice prices before entry), though this rises to 611 kilograms (\sim \$85) conditional on making an ice purchase. The average trip gross profit margin, defined as total trip revenues minus total trip expenses (including labor costs), was approximately \$109, with a large standard deviation of about \$150.¹⁸ These profit margins emphasize that, relative to the per capita income of Sierra Leone, these fishing firms are relatively large operations.

Finally, in addition to our original data sources, we rely on external sources for three pieces of data. Weather data, used as controls in transaction level regressions, are collected by a nearby weather station at Lungi airport and made available by the commercial service MeteoBlue (MeteoBlue 2014). Retail fish price data, used in Appendix A, are from the microdata of the local consumer price index (Statistics Sierra Leone 2014). Finally, data on GDP and population, used above in our welfare calculations, are from the World Development Indicators (World Bank 2014). None of these three external sources currently offer the ability to store or reference custom extracts, but they do allow for redistribution for the purpose of replication of research findings. Variables are included in the replication package of Ghani and Reed (2020).

III. Results

A. Empirical Strategy

A standard approach in the empirical literature on relational contracting (e.g., McMillan and Woodruff 1999; Antràs and Foley 2015; Macchiavello and Morjaria 2015) is to relate service provision (e.g., supply assurance and trade credit) between a pair of agents to the history of the relationship between them—for instance, the number of past interactions. Our empirical strategy follows in this vein by tracing how service provision evolves between fishermen-retailer pairs, conditional upon the retailer's *ex ante* stated expectation that (exclusive) repeated trade between the two will continue. We measure this expectation with the retailer's agreement in a baseline survey with the statement that the fisherman “will wait for his agent to come even if he has another way of getting ice earlier.” Ice retailers are known colloquially as “agents.”¹⁹

¹⁷In Tombo (W1) and Aberdeen (W2), R1 and R2 designated 68 percent and 90 percent, respectively, of their fishermen customers as loyal, suggesting that even monopolistic retailers acknowledge the threat of new entrants stealing their customers. In Goderich (W3), the corresponding figures were 61 percent for R3, 94 percent for R4, and 33 percent for R5, for an average of 68 percent of loyal fishermen customers across the wharf. No fisherman was designated as loyal by more than one retailer.

¹⁸About 14 percent of trips had negative profits, reflecting the risky production process of fishing.

¹⁹One question is how to interpret the “loyal” variable in wharves that begin with only one active retailer: Tombo (W1) and Aberdeen (W2). Loyalty is not necessarily automatic in these markets. Historically, there have been other retailers operating in these wharves, indicating a threat of entry, which may shape expectations about

TABLE 2—CORRELATES OF EX ANTE LOYALTY

	Loyal (= 1)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Relationship Years	0.173 (0.042)							-0.005 (0.057)
Relationship Years squared	-0.013 (0.004)							0.000 (0.005)
Close Friend (= 1)		0.490 (0.077)						0.269 (0.089)
Coethnic (= 1)			0.284 (0.098)					0.089 (0.104)
More Ice (= 1)				0.118 (0.070)				0.094 (0.064)
Order Size (z-score)					0.123 (0.031)			0.090 (0.031)
Fishing Assets (\$1,000)						0.006 (0.005)		0.003 (0.004)
Fishing Risk Tolerance							0.134 (0.180)	0.124 (0.150)
Observations (firms)	149	149	149	149	141	145	145	137
R ²	0.24	0.35	0.19	0.15	0.27	0.16	0.16	0.36
Retailer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Loyal (= 1) is an indicator variable that equals one if the retailer reported that this fisherman customer would only buy from him even if other ice supply was available, using the primary retailer from the baseline data. "Relationship Years" is the length of a fisherman's retailer relationship. "Close Friend (= 1)" is a indicator that equals one if a retailer indicated this buyer was a close friend. "Coethnic (= 1)" is a indicator that equals one if a retailer indicated the buyer shared his ethnicity. "More Ice (= 1)" is a indicator of whether that fisherman was in the top tercile of self-reported ice expenditures as a share of trip expenses. "Order Size" is the standardized z-score of fishermen's average order sizes during the first six months of transaction data. "Fishing Assets (\$1,000)" is the value of key fishing assets in thousands of US dollars. "Fishing Risk Tolerance" is the average of three risk tolerance questions about dangerous fishing practices rescaled on a 0–1 continuous scale. Robust standard errors are in parentheses.

To provide a qualitative understanding of what may cause beliefs about loyalty to emerge, Table 2 shows how the variable "Loyal" correlates with factors that previous literature has emphasized can sustain repeated trade, including relationship length, friendship, shared ethnicity, and relationship value. Column 1 of Table 2 shows a quadratic positive relationship between perceived loyalty and the number of years a fisherman has purchased from that retailer, suggesting that experience with one another matters. In columns 2 and 3, we find positive correlations ($p < 0.01$) with both the "Close Friend" and "Coethnic" indicator variables also collected in the retailer survey, suggesting that interpersonal closeness may support relational contracts. Loyalty also correlates with fishermen who are higher-value buyers. In column 4, we find a significant positive correlation ($p < 0.1$) with an indicator variable, "More Ice (=1)," which indicates whether the fisherman is in the top tercile of self-reported ice expenditure

loyalty. Further, fishermen retain the option to buy ice directly from the manufacturer, cutting out the retailer. Retailers are aware of these factors and, as a result, still view the market as contestable. The "loyal" variable may therefore be interpreted similarly across markets, regardless of the baseline number of retailers.

as a share of total trip expenditure. This suggests that fishermen who are more reliant on ice as part of their costs, and for whom special treatment from retailers may be more valuable, are more likely to be loyal. In column 5, we find a positive correlation ($p < 0.01$) with the z -score of fishermen's order sizes during the first six months of transaction data, indicating that retailers are focused on serving fishermen who buy at greater volume. In column 6, we find no significant correlation with asset wealth. In column 7, we find no significant correlation with a composite measure of fisherman risk tolerance, composed of the average of three binary questions about readiness to participate in risky fishing behavior when experiencing an unproductive fishing trip (i.e., staying out to sea longer than planned, traveling further than planned, or fishing in prohibited areas).

Our approach is to use "Loyal" as the first difference in a triple-differences framework, with service provision as the key outcome. The second difference is before and after the shock of upstream manufacturer entry. This difference allows us to ask how service provision changes *within* pairs of buyers and sellers with the same history when outside options available for the buyer improve. The third difference, across wharves, allows us to test whether the effect of this shock on service provision also varies with the competitive environment. Specifically, we compare the "Loyal" and "Entry" interaction in one wharf, Goderich (W3), with the same interaction in the other two wharves, Tombo (W1) and Aberdeen (W2). Goderich is the only wharf with multiple retailers at baseline, presumably due to its size and proximity to M1's factory. This final comparison identifies the subset of relationships in which repeated trade is likely to be most valuable to retailers, due to the greater competition they face. Ultimately, by closely tracking the pattern of transactions across these groups, we observe how the nature of relational contracts may evolve—initially supporting supply assurance, and later trade credit—in buyer-seller pairs with similar histories.

The following discussion is organized around three sequential results. First, at the start, fishermen buyers perceived as loyal receive priority deliveries from retailers—a form of informal insurance against volatile supply. This is the baseline relational contract. Second, the entry of new manufacturers weakens this contract by reducing the risk of supply shortages and lowering prices, thus inducing a move down the demand curve. Third, after manufacturer entry, retailers establish a new relational contract in which they expand trade credit disproportionately to the *same* buyers previously identified as loyal, especially in the market where the value of contracts to sellers is likely highest in terms of the competitive defense they may provide. Together, these results show how loyalty—the expectation of reciprocal repeated trade—predicts the allocation of services in non-price competition.

B. Loyal Fishermen Receive Supply Assurance from Retailers

Initially, fishermen perceived as loyal receive priority deliveries on days when retailers experience more difficulty procuring ice from M1. At the beginning of our data, prior to the entry of M2, approximately 18 percent of orders are delivered late. The prevalence and extreme day-to-day variability of late deliveries prior to M2's entry is shown in Figure 2. In focus group discussions at baseline, fishermen indicated that the late deliveries were extremely costly, indicating the potential value

of priority deliveries, or insurance against lateness. To illustrate this, it is helpful to quote one fisherman in full:

Whenever we get ice late, it disrupts all our plans. Of all the things we need before we make a trip, ice is the only thing we have to wait for. When we need fuel, we just go to the fuel station and get it, but for ice they [the retailers] must come with it. And any time we do get our ice late it costs us money. When you have put a crew together for a trip, their feeding becomes your responsibility, which means even if you don't get to leave early, or not leave at all on that day because you couldn't get ice on time, you still get to feed the crew. That is an extra and unnecessary cost we can avoid if we get the ice on time. It dampens the morale of the crew, it makes us lose valuable time, and we miss the ideal time to set out for fishing, which might in turn affect our catch, fuel consumption, and our duration at sea.

Before the entry of additional manufacturers, delays in ice delivery from M1 lasting half a day or more were common due to capacity constraints and competing demand. M1's production capacity is essentially stochastic, with a number of factors constraining its ability to produce fishermen's orders overnight. Despite substantial investment, mechanical problems with the ice machines, generators, and delivery vehicles occurred almost daily. Employees regularly showed up late or reported sick, and electricity outages—as well as shortages of diesel for the backup generator—were common. Finally, even if ice is produced, the truck to deliver it may break down, run out of fuel, or lack a driver. Equally important, however, is that fishermen's orders must compete with other higher-margin customer segments. Restaurants, bars, supermarkets, party planners, and others frequently place large orders without advance notice, and have a substantially higher willingness to pay for immediate service.²⁰ M1 frequently prioritizes these high-value buyers when supply is scarce, thus delaying fishermen's deliveries to each wharf.

Finally, we note that retailers have discretion over which fishermen are served on time, given the details of the delivery process. In our transaction data, a fisherman's ice order constituted, on average, approximately 23 30-kilogram bags, or a total weight of approximately 690 kg per order (about two-thirds of a cubic meter in volume). Given capacity constraints, M1's ice delivery trucks could only bring a maximum weight per trip (approximately 5 tons, or 6 average orders) and they would visit each wharf repeatedly until the full set of fishermen's orders for that day had been fulfilled. Importantly, retailers had full discretion over how these bags were allocated across fishermen customers when they arrived. When ice supply was scarce and M1 rationed supply to the fishermen at the wharves, this often resulted in M1 making some ice truck deliveries on time and others late, providing retailers with an opportunity to provide supply assurance to selected customers.

²⁰The average price per kilogram for this segment is about twice as high as the fisherman retail price. Online Appendix Figure B1 shows the separate time series for the incumbent's sales to fishermen and non-fishermen buyers. The two are positively correlated ($\rho = 0.12$) due to seasonal patterns—e.g., during the rainy season, from July to September, demand drops for both sources—but both contain a high degree of daily variation.

We establish the existence of an original relational contract supporting supply assurance by showing that those fishermen considered loyal are less likely to receive late deliveries on days on which retailers, due to demand from the higher-margin segment, were more likely to deliver ice late to some of their customers. Formally, we estimate the following linear probability model using daily data on factory sales with retailer records of each order by fisherman j from retailer k on date t :

$$(1) \quad \mathbf{1}(\text{Late})_{jkt} = \theta_1 \text{Outside_Sales}_t + \theta_2 \text{Outside_Sales}_t \times \mathbf{1}(\text{Loyal})_{jk} \\ + \theta_3 \mathbf{1}(\text{Loyal})_{jk} + \mu_j + \eta_k + \tau_{m(t)} + X_t' \beta + \epsilon_{jkt},$$

where $\mathbf{1}(\text{Late})_{jkt}$ is an indicator variable that equals 1 if that order was not delivered on time to a fishing wharf, and Outside_Sales_t is the daily sales by M1 to non-fishing sources of demand, transformed into a z -score by subtracting the mean and dividing by the standard deviation.²¹ The specification includes time-varying weather controls for daily temperature, rainfall, and wind speed included in the vector X_t and monthly fixed effects, $\tau_{m(t)}$, for each calendar month m , which may affect demand for timely ice deliveries on a given day due to the seasonality of fishing. Finally, the regression includes fisherman-fixed effects, μ_j , to control for time-invariant characteristics such as wealth, and retailer-fixed effects, η_k , to control for time-invariant characteristics such as the distance of a retailer's market to M1's factory, which may affect his ability to deliver ice on time in the pre-entry period. If the coefficient θ_1 is positive, this will confirm that outside demand is a driver of lateness. If the coefficient on the interaction term, θ_2 , is negative, that will suggest that loyal buyers are prioritized on days when ice is more difficult for retailers to deliver on time.

Table 3 reports the results of this regression, with standard errors that are two-way clustered by delivery date (t) and fisherman buyer (j) to address serial correlation in the timing of supply and demand shocks across orders on the same day and in the time-invariant characteristics of fishermen.²² In column 1, we confirm that a one standard deviation increase in outside sales is associated with a 11 percentage point increase in the likelihood of a late delivery. Adding weather controls and fixed effects for fishermen, retailers, and month in column 2 attenuates the magnitude to 6 percentage points, but the results remain statistically significant at 5 percent. In column 3, we find that the coefficient on the interaction term of "Outside Sales \times Loyal" is indeed negative and significant, with a magnitude of 3 percentage point reduction in lateness, a 17 percent decrease from the mean value, for a one standard deviation increase in outside demand. Using variation from fishermen who purchase from more than one retailer, we also estimate the direct effect of loyalty on lateness, θ_3 : while the sign is negative, we fail to reject the null hypothesis of zero. Finally, we test whether the results in column 3 are heterogeneous across wharves with different retailer market structures. If relational contracts are offered by sellers as a defense against competition, we would expect loyal buyers to be prioritized more often under

²¹ While we do not directly observe non-fishing demand, interviews confirm sales to non-fishing sources are a reasonable proxy for non-fishing demand given M1's constant willingness to prioritize non-fishing orders.

²² Our results are robust to clustering only by delivery date or by fisherman buyer.

TABLE 3—OUTSIDE ICE SALES, LATENESS, AND LOYALTY

	Late Ice Delivery (= 1)			
	(1)	(2)	(3)	(4)
Outside Sales (<i>z</i> -score)	0.111 (0.014)	0.062 (0.024)	0.093 (0.028)	0.078 (0.031)
Outside Sales × Loyal (= 1)			-0.034 (0.016)	-0.022 (0.024)
Loyal (= 1)			-0.003 (0.064)	-0.003 (0.065)
Outside Sales × Goderich (= 1)				0.026 (0.043)
Outside Sales × Goderich × Loyal (= 1)				-0.021 (0.043)
Time period		Pre-entry		
Mean dependent variable	0.182	0.182	0.182	0.182
Number of firms	142	141	141	141
Observations	2,649	2,648	2,648	2,648
<i>R</i> ²	0.09	0.24	0.24	0.24
Weather controls	No	Yes	Yes	Yes
Month fixed effects	No	Yes	Yes	Yes
Retailer fixed effects	No	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes

Notes: “Late Ice Delivery (= 1)” is an indicator variable for whether an order was delivered late, and an observation is an order. Data include purchases from the original five retailers serving the incumbent manufacturer. “Outside Sales” is the standardized *z*-score of total kilograms of all non-fishing ice sales made by the incumbent manufacturer (M1) on that day. “Loyal (= 1)” is an indicator variable that equals one if the retailer reported this buyer would only buy from him even if other ice supply was available. “Goderich (= 1)” is an indicator variable for an order in Goderich Wharf. Weather controls include average daily temperature, hours of rain, and average windspeed. “Pre-entry” time period is prior to the entry of the first competitor manufacturer in each wharf. Regressions include weather controls, retailer fixed effects, fishing firm fixed effects, and month fixed effects as noted; “Goderich (= 1)” is colinear with the retailer fixed effects and thus dropped.

the relational contract in the market with competition between retailers. To test this hypothesis, we add an interaction term for “Outside Sales” with a “Goderich (= 1)” indicator variable and a triple-interaction term for “Outside Sales × Goderich × Loyal” in column 4. We find a negative coefficient on the triple-interaction term, as predicted. Comparing the coefficients on the interactions of “Outside Sales × Loyal” to the triple interaction, it appears that retailers also prioritize loyal buyers in Goderich more intensively in the presence of outside sales, but we lack the statistical power required to test this conclusively.²³

An important question about these results is whether the “Loyal” interaction simply proxies for other determinants of demand for supply assurance. For instance, in Table 2 we saw that fishermen who were considered loyal also ordered more ice, on average. Online Appendix Table B2 demonstrates that the result from column 3 of Table 3 is robust to controls for the other variables that could sustain repeated trade from Table 2, such as relationship length, friendship, coethnicity, and proxies for willingness to pay such as share of trip expenses spent on ice, average order

²³Note that this variation exists pre-entry only in Goderich and not in the other two wharves, which have a single incumbent retailer, so we cannot estimate a “Loyal × Goderich” interaction term.

size, and whether the fisherman bought more ice, on average. None of these variables substantially reduce the effect of “Loyal” on which fishermen are prioritized during ice shortages, supporting the case that “Loyal” is a meaningful predictor of a baseline relational contract.

Overall, these results confirm the existence of a relational contract where loyal fishermen are assured of supply in times when ice is scarce. This empirical pattern reinforces what retailers reported in interviews: loyal buyers who refuse to buy from other retailers provided more stable demand for retailers and, in return, received supply assurance. Non-price competition, through the provision of supply assurance services, appears to be determined in part by sellers’ expectations of buyers’ reciprocal behavior.

C. Manufacturer Entry Reduces Supply Shortages and Disrupts Repeated Retail Trade

To show how relational contracting may evolve between two parties, we require a shock that removes individuals from the original relational contract, but which is not related to their demand for such a contract. We have argued in Section I that the entry of new ice manufacturers was such a shock, for three reasons: first, entry was triggered by the emergence of entrepreneurs with cash for investment and the lowering of procurement and financing barriers for industrial ice machines; second, the exact timing when each manufacturer entered a market was determined by idiosyncratic delays involving equipment, staff, and production processes; and third, the incumbent manufacturer did not anticipate entry by its competitors.

In the retail market, entry into ice manufacturing had two effects. First, the direct effect was to reduce the frequency of late deliveries due to supply shortages, which provided the basis for the relational contract based on informal insurance. Second, entry induced fishermen to switch retailers, which is consistent with the value of supply assurance falling with the reduction in uncertainty and with the observation that retailers increasingly had access to lower manufacturer prices, allowing them to price compete. The resulting reduction in lateness is shown in Figure 2: late deliveries fall as sales by manufacturers other than the incumbent M1 expand.²⁴ The shifts in customer-retailer switching can be seen in Figure 8, which plots the weekly instances of these switches—that is, when a fisherman orders from a different retailer than the one that fulfilled their previous order—and the cumulative share of fishermen who have made at least one switch in our data. The visual results are stark: before new manufacturer entry, about 5 percent of fishing firms completed less than 20 switches; after entry, 50 percent of fishing firms made over 200 switches.

²⁴While there is a major decrease in lateness during the rainy season from July to September, when overall production volume decreases at the factory, lateness returns again as orders pick up after the rainy season. Late orders then drop dramatically following manufacturer entry and competition and do not return to their previous levels when comparing January 2014–July 2014 to the same half of the prior year. Retailers report this decline occurred because they diversified their sourcing of ice from new manufacturers to ensure a reliable supply for their fishermen buyers. In practice, retailers did not cancel or switch orders at the last minute, but instead split the sourcing of their daily orders between multiple manufacturers and used the credible threat of reallocating future orders to a competing manufacturer to discipline against late deliveries. As manufacturers now had excess capacity relative to current total demand, this threat primarily ensured that they did not reduce the effort required to ensure timely delivery.

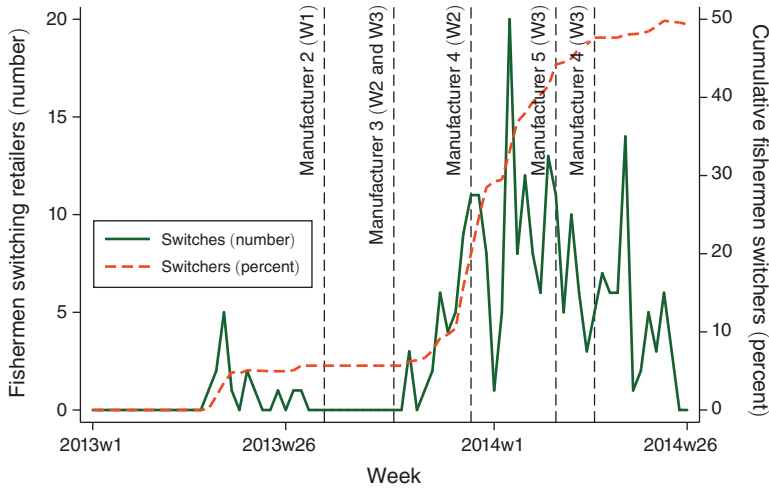


FIGURE 8. CUSTOMER-RETAILER SWITCHING

Notes: This figure presents the count of weekly customer-retailer switches and the cumulative percentage of fishing customers who are observed switching retailers across all wharves during the 18-month data collection period with the 5 incumbent retailers. Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

The cumulative probability of switches rises sharply after manufacturer entry into Goderich (W3), where multiple agents compete directly for buyers at baseline.²⁵ We only observe 13 new fishermen (a 9 percent increase) in the transaction data after the entry of new manufacturers, so the increase in switching cannot be attributed primarily to the entry of new buyers without pre-existing retailer relationships.

We quantify these results using the following econometric specification:

$$(2) \quad Y_{jkt} = \theta_4 \mathbf{1}(\text{Entry})_{w(k)t} + \mu_j + \eta_k + \tau_m(t) + X_t' \beta + \epsilon_{jkt},$$

where, as above, the data are retailer records of each order by fisherman j from retailer k on date t . The outcome Y_{jkt} is either an indicator for whether the order was delivered late, $\mathbf{1}(\text{Late})_{jkt}$, or an indicator for whether a buyer switched to a new retailer from their last recorded purchase, $\mathbf{1}(\text{Switch})_{jkt}$. The function $\mathbf{1}(\text{Manufacturer_Entry})_{w(k)t}$ equals 1 following the entry of the first new manufacturer into wharf w on day t , and 0 otherwise. As above, we include time-varying weather controls, fishermen fixed effects, retailer fixed effects, and calendar month fixed effects. The inclusion of fishermen fixed effects helps address potential concerns about changes in the composition of buyers over time, which might otherwise contribute to an increase in observed switching.

Table 4 reports the results. Following manufacturer entry, we find significant decreases in the frequency of late deliveries. Lateness falls, on average, by

²⁵Online Appendix Figure B2 shows switching for Goderich only, where 80 percent of fishermen switched retailers.

TABLE 4—EFFECT OF COMPETITION ON LATENESS AND SWITCHING

	Late Ice Delivery (= 1)				Switch Retailer (= 1)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Manufacturer Entry (= 1)	-0.162 (0.020)	-0.161 (0.028)	-0.069 (0.031)	-0.071 (0.032)	0.090 (0.013)	0.025 (0.010)	0.001 (0.008)	-0.006 (0.008)
Entry × Goderich (= 1)		-0.000 (0.029)	-0.162 (0.038)	-0.163 (0.037)		0.116 (0.016)	0.152 (0.044)	0.151 (0.044)
Entry × Loyal (= 1)			-0.106 (0.025)	-0.104 (0.025)			0.019 (0.010)	0.015 (0.009)
Loyal (= 1)			0.089 (0.034)	0.088 (0.034)			-0.504 (0.232)	-0.478 (0.233)
Goderich × Loyal (= 1)			-0.158 (0.032)	-0.154 (0.032)			0.408 (0.237)	0.376 (0.239)
Entry × Goderich × Loyal (= 1)			0.198 (0.032)				-0.080 (0.045)	
Entry × Goderich × Loyal × 2013:IV (= 1)				0.209 (0.036)				-0.134 (0.046)
Entry × Goderich × Loyal × 2014:I (= 1)				0.098 (0.038)				0.023 (0.055)
Entry × Goderich × Loyal × 2014:II (= 1)				0.260 (0.035)				-0.091 (0.050)
Time period	All months							
Mean dependent variable	0.106	0.106	0.106	0.106	0.051	0.051	0.051	0.051
Number of firms	154	154	154	154	153	153	153	153
Observations	5,280	5,280	5,280	5,280	4,933	4,933	4,933	4,933
R ²	0.19	0.19	0.19	0.20	0.18	0.19	0.22	0.23
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month, retailer, and firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: “Late Ice Delivery (= 1)” is an indicator variable for whether an order was delivered late, “Switch Ice Retailer (= 1)” is a dummy variable for whether a buyer switched to a new retailer relative to their last recorded purchase, and an observation is an order. “Switch Ice Retailer (= 1)” is undefined for 347 out of 5,281 orders (6.6 percent) where the retailer could not identify the fisherman customer. Data include purchases from the original five retailers serving the incumbent manufacturer, including sales by these retailers on behalf of other manufacturers. “Time period” covers January 2013 to June 2014. All regressions include weather controls, retailer fixed effects, fishing firm fixed effects, and calendar month fixed effects; “Goderich (= 1)” is collinear with the retailer fixed effects and thus dropped. Robust standard errors, two-way clustered by fishing firm and delivery date, are in parentheses.

16 percentage points in column 1.²⁶ In column 5, we see that this coincided with a 9 percentage point increase in the likelihood that a fisherman had recently switched or purchased from another retailer, indicating a breakdown in loyalty. In columns 2 and 6, we interact the entry dummy with an indicator variable for Goderich (W3).²⁷ This shows that while late deliveries fell after entry in all wharves equally, an increase in switching was concentrated in Goderich. These interaction effects suggest that the original relational contract had the most power to reduce switching in the market where switching was also easiest, given the presence of other retailers. In Tombo

²⁶By using the full 18 months of data, which include the less active rainy season from July to September, these results understate the magnitude of the decrease in year-on-year terms. The share of orders delivered late falls from 21.7 percent in the first half of 2013 to 1.4 percent of orders during the first half of 2014.

²⁷The indicator variable for Goderich is collinear with the retailer fixed effects and thus is not estimated separately in this specification.

and Aberdeen, except for a brief period when an additional retailer enters, the alternative is buying from another wharf or directly from a manufacturer, which requires more effort. Columns 3 and 7 add an additional triple interaction term for whether the buyer had previously been identified as “Loyal.” Loyal buyers in Goderich are 8 percentage points less likely to switch than their non-loyal counterparts ($p < 0.1$), indicating that relationships do not completely break down in this market.

In columns 4 and 8, we saturate the triple interaction term with indicators for the quarter of the year, allowing us to trace the timing of these effects. In particular, while loyal buyers in Goderich were 13 percentage points less likely to switch in 2013:IV ($p < 0.01$), this difference disappears in 2014:I and then returns at a reduced magnitude of 9 percentage points in 2014:II ($p < 0.1$). We note that the coefficient on the “Loyal” fixed effect is significant. Given the use of fishermen and retailer fixed effects, this coefficient is identified by pre-entry variation in the behavior of the same fisherman transacting with two different retailers, who have differing assessments of that fisherman’s loyalty. Though significant, the coefficient is identified based on a very small number of fishermen: only 8 fishermen (~5 percent of total) are identified switching retailers prior to entry, of which only 5 are identified as loyal buyers by at least one retailer. For this reason, we do not emphasize this result.

Overall, we have shown that after entry, loyal buyers are more likely to receive ice on time and are also more likely to start switching retailers, consistent with a breakdown in their reciprocal contract due to an improvement in their outside options. This affect is attenuated in the most competitive market, Goderich, where loyal buyers experience less of an improvement in lateness and also less switching.

D. Retailers Expand Trade Credit Disproportionately to Previously Loyal Buyers, Especially in the Most Competitive Market

Having established that manufacturer entry induces the breakdown of the original relational contract within fishermen-retailer pairs, we now establish that, in the same pairs, a new relational contract emerges in which retailers offer trade credit to previously loyal fishermen. Trade credit is offered at 0 percent interest. This service is attractive, as informal lenders (i.e., “susu” accounts) charge a weekly interest rate of 2 to 3 percent. Retailers self-finance their trade credit out of their current balance of margin due from M1 and their own capital reserves, and are responsible for collection, making them resistant to meeting all demands for trade credit.²⁸ We also show that this new contract is concentrated in the wharf, Goderich, that is the most competitive market.

We interpret this finding as evidence that retailers work to reestablish relational contracts in which they can extract loyalty from fishermen whom they already know can maintain a reciprocal relationship, and that relational contracts may be

²⁸For clarity, we note that this is not a setting of interlinked transactions in which the price of output and the interest rate are codetermined (Bardhan 1980; Bell 1988). Here, the retail price is controlled entirely by the manufacturer, so only credit supply is determined by the relational contract.

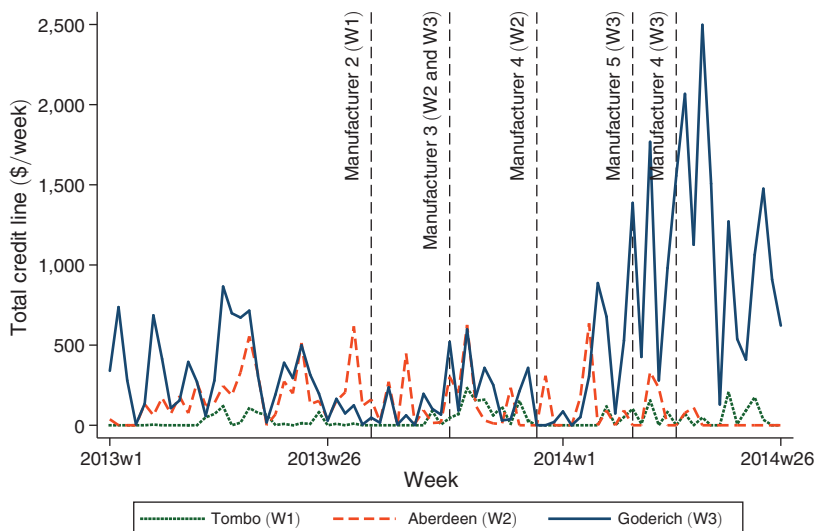


FIGURE 9. TOTAL CREDIT PROVISION

Notes: This figure presents the aggregate weekly credit provision by the five incumbent retailers in each of the three wharves during the 18-month data collection period. We convert credit totals to US dollars using the average exchange rate of 4,200 leones during this period. Vertical lines mark the first date of ice sales by a competitor manufacturer in one or more wharves.

established to deter competition and protect market share. This idea is summarized by a retailer in an interview conducted at the end of data collection:

Providing credit does not tie a customer to an agent [retailer]. But not providing credit will make a customer leave you. What ties a customer to an agent is the relationship—the confidence and trust he has in you the agent that you can give him ice when he orders and in times of financial troubles he can depend on you to provide credit. So providing credit helps build a better relationship with a fisherman.

The onset of the new contract supporting trade credit is visible graphically. Figure 9 shows that the aggregate credit supply in Goderich spikes after new manufacturer entry, but not in the other two wharves, where retailers face less competitive pressure. Expansion is concentrated in the most competitive market. This is consistent with the idea that, because the retailers in Aberdeen and Tombo were legacy monopolists and served smaller markets, they faced fewer threats from new retailers and did not need to compete as vigorously to maintain relationships with fishermen. If the model of credit summarized by the retailer is correct, then we would expect trade credit increases to be concentrated in Goderich, because this is where fishermen will find it easiest to switch to other retailers, and it should be hardest to “tie” a fisherman to a retailer.

Several facts are not consistent with alternative explanations for this credit increase after entry. First, after new manufacturers entered, M1 did not expand its existing credit facilities, through which retailers could borrow against their unclaimed

margin. Given fears of retailer default, M2, M3, M4, and M5 did not provide either existing or new retailers with the same credit facilities. Instead, they required retailers to pay in full up front for all ice sales. Together, these facts indicate that these results do not arise because of increased credit supply from manufacturers. Second, while retailers are richer after entry (given that margins were fixed, and quantity grew) and thus can better self-finance credit, any wealth effect should occur across all wharves, but the credit increase is only observed in Goderich. Third, the timing of the credit increase in Goderich starts not with manufacturer entry in October 2013, but after fishermen-retailer switches started to rise in early 2014. It peaks in the second quarter of 2014 (April–June), when switches begin to fall, suggesting that credit provision and switching are closely linked in time. Fourth, fishermen complete roughly 20 percent more trips per week, implying roughly a 20 percent increase in profits (holding fixed costs constant), but the total credit increase in Goderich is over 100 percent in magnitude. The difference in the magnitudes of these effects makes it difficult to imagine all of the credit increase is driven by improved fishermen credit worthiness. Finally, fishermen in Goderich were more financially constrained than their counterparts in Aberdeen and Tombo. Having more demand for credit, we would expect to observe retailers extending more credit in the cross-section, but this is not the case, suggesting that pre-existing differences in fishermen's creditworthiness do not explain the effects observed.

In Table 5, we quantify the effects of manufacturer entry on increased credit provision using the same regression as in equation (2), where the dependent variable is an indicator for whether the order involved trade credit, $\mathbf{1}(\text{Credit_Order})_{jkt}$, for each order by fisherman j from retailer k on date t . As before, the specification includes fishermen fixed effects, retailer fixed effects, calendar-month fixed effects, and time-varying weather controls. Reviewing the table, column 1 shows a 9 percentage point increase in the likelihood of credit provision after entry, and column 2 demonstrates that the effect is higher among previously loyal buyers, though we lack statistical power to confirm this at conventional significance levels. The next columns explore heterogeneity across wharves by adding interaction terms. Column 3 includes only the interaction "Entry \times Goderich (=1)." The coefficient on this term is positive and significant, indicating that the overall credit effect is strongest in Goderich, whether among previously loyal buyers or not. In column 4 we add in a triple interaction term, "Entry \times Goderich \times Loyal," and its coefficient is positive, suggesting that, on average, loyal buyers in Goderich may have received more credit than their non-loyal counterparts in the same wharf after the competition shock.

However, in column 5, once we saturate the triple interaction with indicator variables for the quarter of year, we identify a significant and positive effect of the triple difference concentrated in 2014:II. This is also the same period in which switching—which indicated instability in relationships—began to decline, as shown in Figure 8. In this period, we find that the likelihood of receiving credit increased significantly, by 20 percentage points, for loyal buyers in Goderich during 2014:II ($p < 0.01$), more than doubling the 15 percent of loyal buyer orders that received credit pre-competition in Goderich. We interpret this heterogeneity as evidence that after manufacturer entry, retailers continued to invest in fishermen about whom they

TABLE 5—EFFECT OF COMPETITION ON CREDIT PROVISION

	Ice Credit Order (= 1)				
	(1)	(2)	(3)	(4)	(5)
Manufacturer Entry (=1)	0.087 (0.023)	0.055 (0.029)	0.032 (0.021)	0.020 (0.026)	-0.016 (0.026)
Entry × Loyal (= 1)		0.036 (0.029)		0.015 (0.030)	0.020 (0.032)
Loyal (= 1)		-0.050 (0.036)		0.017 (0.062)	0.016 (0.059)
Entry × Goderich (= 1)			0.095 (0.029)	0.051 (0.046)	0.060 (0.051)
Goderich × Loyal (= 1)				-0.076 (0.075)	-0.079 (0.075)
Entry × Goderich × Loyal (= 1)				0.058 (0.053)	
Entry × Goderich × Loyal × 2013:IV (= 1)					-0.087 (0.054)
Entry × Goderich × Loyal × 2014:I (= 1)					0.047 (0.075)
Entry × Goderich × Loyal × 2014:II (= 1)					0.200 (0.069)
Time period			All months		
Mean dependent variable	0.158	0.158	0.158	0.158	0.158
Number of firms	154	154	154	154	154
Observations	5,280	5,280	5,280	5,280	5,280
R^2	0.10	0.10	0.10	0.10	0.11
Weather controls	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Retailer fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes

Notes: “Ice Credit Order (= 1)” is a dummy that equals one if a buyer paid less than the full cost for their order up front, and an observation is an order. Data include purchases from the original five retailers serving the incumbent manufacturer including sales by these retailers on behalf of other manufacturers. “Time period” covers January 2013 to June 2014. All regressions include weather controls, retailer fixed effects, fishing firm fixed effects, and month fixed effects; “Goderich (= 1)” is colinear with the retailer fixed effects and thus dropped. Robust standard errors, two-way clustered by fishing firm and delivery date, are in parentheses.

had information but changed the service provided from supply assurance to trade credit. Once the rent that retailers were able to charge for insuring against supply uncertainty disappeared, they were forced to compete for loyalty by providing trade credit. To summarize, contracts appear to evolve so that relationships may persist.

As with our study of supply assurance, a question is whether our “Loyal” variable simply proxies for other determinants of demand for trade credit. As a robustness test, online Appendix Table B3 replicates equation (5) of Table 5, including interactions of “Entry” with other correlates of the “Loyal” variable, including—importantly—the value of assets, which may reduce demand for credit (given a greater capital endowment) or, alternatively, increase supply of credit (because the buyer has more collateral). In all of these specifications, the interaction of “Entry × Goderich × Loyal × 2014:II” remains significant at 1 percent, suggesting that the result is not driven by any of these omitted variables.

Selection into Relational Contracts.—We have argued that the trade credit increase was concentrated among previously loyal buyers because the retailers had more information about the creditworthiness of these buyers and so found it easier to extend credit to them. This form of seller lock-in may have a reciprocal effect with buyers. With credit, a fisherman who wants to switch retailers now faces an adverse selection problem in that he may appear as a worse credit risk to a new retailer who does not know him.²⁹

Explaining why the effects were concentrated among loyal buyers specifically in Goderich requires identifying an additional factor, which increased the value of trade credit, particularly in this market. A candidate explanation is that buyers in Goderich simply have relatively more elastic demand. If that is the case, with the retailer margin held fixed by resale price maintenance, retailer profit per customer should increase *more* in this market now that prices have fallen. This effect would increase the value of each buyer in Goderich to the retailer, and, equivalently, make the loss of a buyer to a competing retailer more costly.

It is possible to test for a difference in demand elasticity across wharves by studying how orders respond to entry when aggregated at the retailer level. Formally, we aggregate transaction records for each retailer k on date t to construct the logarithm of their daily revenue (in terms of commission), or $\log \text{Revenue}_{kt}$. This variable is the sum of $\log \text{Orders}_{kt}$, the logarithm of total number of orders received; $\log \text{Order_Size}_{kt}$, the logarithm of the average order size on that date; and the commission margin received per order. Note that the effect of lower prices on these variables is ambiguous, as it depends on fishing technology. More abundant ice may lead to fewer but larger orders as fishermen take longer trips; alternatively, they may make trips with ice more frequently, increasing the number of orders, with an ambiguous effect on order size.

Table 6 presents the results of running the same regression as in equation (2) on these dependent variables, including retailer fixed effects, calendar-month fixed effects, and time-varying weather controls. We only consider days on which a retailer records sales, thus making all results conditional on the retailer's daily presence in the market. First, consider the average effect of entry across wharves. Column 1 shows a 13 percent increase in retailer daily revenues, with no corresponding increase in the number of orders in column 3 and a 15 percent increase in average order size in column 5. Larger orders support an interpretation that greater reliability and lower prices for ice increased the per-trip demand for ice but, if anything, slightly decreased the average number of trips being taken, as each trip could now be longer.³⁰ In columns 2, 4, and 6, we add an interaction term for "Entry \times Goderich" to test whether these patterns vary when multiple incumbent retailers serve a market. The interaction coefficient in column 2 is positive, consistent with a higher demand elasticity in Goderich, but we lack the statistical power to reject

²⁹ We cannot empirically document the persistence of this credit increase as the Ebola virus reached Freetown in July 2014, ending data collection. However, qualitative reports from retailers and fishermen over the next year indicate that trade credit levels in Goderich gradually decreased over time but remained above previous levels, and that buyer switching correspondingly decreased as a subset of stable relationships reemerged.

³⁰ Online Appendix Table B1 provides evidence that fishermen in all wharves increase the fraction of trips involving ice, resulting in longer trips after manufacturer entry.

TABLE 6—EFFECT OF COMPETITION ON RETAILER REVENUE

	log revenue		log orders		log order size	
	(1)	(2)	(3)	(4)	(5)	(6)
Manufacturer Entry (= 1)	0.133 (0.042)	0.076 (0.059)	-0.057 (0.041)	-0.184 (0.050)	0.147 (0.030)	0.169 (0.041)
Entry × Goderich (= 1)		0.092 (0.068)		0.207 (0.057)		-0.037 (0.049)
Time period	All months					
Mean dependent variable	10.962	10.962	0.903	0.903	3.138	3.138
Number of days	525	525	525	525	525	525
Observations	1,701	1,701	1,701	1,701	1,701	1,701
R ²	0.19	0.19	0.19	0.19	0.13	0.13
Weather controls	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Retailer fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: “log revenue” is the logarithm of daily retailer revenues from fishermen ice sales, “log order size” is the logarithm of the daily average order size for each retailer, and an observation is a retailer-day. Note that the coefficient in column 1 does not equal the sum of coefficients in columns 3 and 5 as retailer R2 received a 50 percent higher margin per sale for a subset of 124 orders processed through M4. No observations are included on days in which a retailer did not have completed sales. Data include purchases from the original five retailers serving the incumbent manufacturer including sales by these retailers on behalf of other manufacturers. “Time period” covers January 2013 to June 2014. All regressions include weather controls, retailer fixed effects, and month fixed effects. Robust standard errors are clustered by delivery date in parentheses.

the null hypothesis that the overall revenue response is identical across markets. Interestingly, however, when looking only at number of orders rather than revenues, in column 4, we find that while the order number falls in Tombo and Aberdeen, it actually increases in Goderich. In column 6, we do not find evidence that order size changed differentially in Goderich. It appears that fishermen in Goderich order more frequently but with orders of the same size, consistent with more elastic demand.

While we cannot say so definitively, the higher (order number) demand elasticity in Goderich may be an endogenous response to increased retailer credit supply in this wharf, which made ice purchases accessible to a wider range of fishermen. Overall, these results are consistent with Goderich having more retailers at baseline and a greater persistence of relational contracting after entry because this wharf has customers with relatively more elastic demand.

IV. Conclusion

Relational contracts use repeated trade to support supply assurance and trade credit in the absence of formal contract enforcement. While previous literature has documented how existing relational contracts affect behavior within a given market structure, our analysis highlights how contracts themselves change in response to market conditions.

We highlight two less commonly discussed features of relational contracts. First, repeated trade can outlast a specific relational contract, as firms establish new agreements when outside options improve, causing the previous agreement to break down. Contracts evolve, as agents with a history of repeated interactions exploit the information they have about one another to establish new informal terms.

Second, when strategically deployed, relational contracts may serve to establish barriers to entry, protecting incumbents from the threat of increased competition. This suggests that relationships may be more likely to emerge in more competitive environments (which, in equilibrium, may also be those with more valuable customers). Asymmetric information may play an important role here as well, allowing incumbent retailers to better manage risks—in this case, around credit defaults by fishermen—where entrants are uninformed.

Together, these findings suggest a broader role for relational contracts than currently defined in economic theory. Relational contracts—specifically, a history of good behavior under such a contract—may guide which customers benefit from non-price competition, particularly in settings where price competition is constrained. Further, well-functioning markets are not necessarily the enemy of relational contracting. Here, while improved outside options for buyers destroyed the original agreement, in which supply assurance was exchanged for loyalty, relational contracts nonetheless reemerged to support trade credit provision—in part, we argue, because of their value as a competitive defense. This may help explain why trade credit is so prevalent even in developed markets, where working capital finance from banks is readily available.

Beyond relational contracting, our case study provides evidence of the benefits of market competition in developing economies. Our evidence that the indirect costs of monopoly in one sector (ice) may be incurred in another (fish) addresses an old question of whether competition provides benefits for economic development (Rodrik 1988; Stiglitz 1989). That question is especially relevant in Africa, where production in many industrial sectors is concentrated in a few large firms (see, i.e., Sutton and Kellow 2010; Sutton and Kpentey 2012; Sutton and Olomi 2012; and Sutton and Langmead 2013 on Ghana, Ethiopia, Tanzania, and Zambia). In Sierra Leone, moving from one to five competitors in the market for a homogeneous input not only lowered prices substantially but raised the quantity and lowered the prices of the final good, generating consumer benefits of 0.3 percent of GDP annually, suggesting substantial externalities from entry into a monopolistic market. While there is uncertainty over the optimal level of entry (Mankiw and Whinston 1986; Bresnahan and Reiss 1991), it is almost surely greater than one.

This case is also instructive for investors attempting to measure the impact, or externalities, generated by their investments—a question that is relevant here, given that the British government was an indirect investor in M1 via its CDC development finance institution, which invested in Manocap, M1's owner. In this market, we documented that the second through fifth entrants had substantial impact by lowering the price of fish. As for M1, by establishing the initial retail market that succeeded in serving fishermen, the firm effectively built the distribution channel that would be used by subsequent entrants. On this basis, M1's ultimate impact on consumers may have been at least as large as the benefits from subsequent entrants.

APPENDIX A

This Appendix documents how the entry of four firms into a monopolistic market for ice manufacturing reduced the price of ice and, ultimately, the price of fish.

TABLE A1—TOTAL ICE SALES TO FISHERMEN AND PERCENT CHANGES

	M1 only Pre-entry	M1 only Post-entry	All Post-entry	M1 only Percent change	All Percent change
Wharf 1 sales (thousand kg)	286.77	201.87	348.18	-29.61	21.41
Wharf 2 sales (thousand kg)	369.90	61.68	199.59	-83.33	-46.04
Wharf 3 sales (thousand kg)	749.19	814.44	906.93	8.71	21.05
Wharves total (thousand kg)	1,405.86	1,077.99	1,454.70	-23.32	3.47
All fishing total (thousand kg)	1,436.37	1,123.95	1,659.96	-21.75	15.57
Wharf 1 sales (million leones)	172.06	109.23	203.78	-36.52	18.44
Wharf 2 sales (million leones)	221.94	34.61	112.51	-84.41	-49.31
Wharf 3 sales (million leones)	449.48	450.55	498.72	0.24	10.95
Wharves total (million leones)	843.48	594.39	815.00	-29.53	-3.38
All fishing total (million leones)	860.88	621.41	948.78	-27.82	10.21

Notes: Total ice sales to fishing firms in thousand-kilogram or million-leone units, where the exchange rate during this period was 4,200 leones to the US dollar. Pre- and post-entry time periods are restricted to January–June 2013 and January–June 2014 to allow for direct comparisons. M1 refers only to sales by the original manufacturer, while “All” refers to sales by the collection of all five manufacturers. Wharf 1 refers to Tombo Wharf, Wharf 2 refers to Aberdeen Wharf, and Wharf 3 refers to Goderich Wharf. “Wharves total” includes all sales made at the three original wharves, and “Fishing total” includes sales to fishing buyers at these three wharves, at other wharves, and directly at the factory locations.

Following manufacturer entry, the price of ice falls and fishermen in all wharves increase the fraction of their trips involving ice, resulting in longer trips and more total fish caught per week. As a result, the price of fish caught with ice falls, as well, while the price of fish caught without ice remains unchanged. This case provides an example of how positive externalities may be generated by entry into a monopolized market for a homogeneous intermediate good.

First, we document effects of entry on the quantity and price of ice. Table A1 reports changes in the quantity of ice sold (and revenue) for each wharf and the totals before and after entry. Aggregate ice quantity sold to fishing firms across all manufacturers—including sales by retailers and those directly from the factory—increased by about 15 percent year-on-year when comparing the first half of 2013 to the first half of 2014. Table A2 reports regression estimates of the effect of entry on ice prices using the fisherman-retailer transaction data. We run the same specification as equation (2), except we use the retail ice price paid for each transaction as an outcome variable. The baseline specification in column 1 documents that prices fall, on average, by 8 percent after manufacturer entry. In column 2, we replace the Manufacturer Entry (= 1) indicator variable with the number of active manufacturers serving a wharf, showing a per manufacturer decrease of roughly 4 percent. Column 3 shows that the price effect is larger in Goderich, where more manufacturers entered. In column 4, we find no evidence that loyal customers receive greater price decreases, which makes sense, as retailers do not control price in this setting.

Second, we turn to effects of entry on the fish market. We use a difference-in-differences approach to identify the downstream effects of ice manufacturer entry on the quantities and prices of fish. Specifically, we compare differences in quantities of fish caught and the prices of fish sold before and after manufacturer entry across two types of fish: “Ice fish,” which are caught far from shore, and “Non-ice fish,” which are caught closer to shore.

TABLE A2—EFFECT OF COMPETITION ON PRICES

	log Ice Price (leones)			
	(1)	(2)	(3)	(4)
Manufacturer Entry (= 1)	-0.082 (0.003)		-0.072 (0.004)	-0.071 (0.005)
Number of manufacturers		-0.039 (0.001)		
Entry × Goderich (= 1)			-0.017 (0.003)	-0.017 (0.006)
Entry × Loyal (= 1)				-0.001 (0.005)
Loyal (= 1)				-0.000 (0.004)
Goderich × Loyal (= 1)				0.003 (0.005)
Entry × Goderich × Loyal (= 1)				0.000 (0.006)
Time period		All months		
Mean dependent variable	9.766	9.766	9.766	9.766
Number of firms	154	154	154	154
Observations	5,280	5,280	5,280	5,280
R ²	0.68	0.69	0.68	0.68
Weather controls	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes
Retailer fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes

Notes: “log Ice Price (leones)” is the natural logarithm of the average price paid for a 30-kg bag of ice, and an observation is an order. “Manufacturer Entry (= 1)” is an indicator that equals 1 after the entry of the first new ice manufacturer in a wharf. “Number of manufacturers” is the count of ice manufacturers serving a wharf. Data include purchases from the original five retailers serving the incumbent manufacturer, including sales by these retailers on behalf of other manufacturers. “Time period” covers January 2013 to June 2014. All regressions include weather controls, retailer fixed effects, firm fixed effects, and calendar month fixed effects; “Goderich (= 1)” is collinear with the retailer fixed effects and thus dropped. Robust standard errors, two-way clustered by fishing firm and delivery date, are in parentheses.

To measure fish quantity, we use data from 22 high-frequency waves of survey data in which we asked fishermen to report their total catch for each trip in the previous two weeks. For ice fish and non-ice fish, we average the number of fish caught across each month, and we estimate the following regression:

$$(3) \text{Average_Fish_Caught}_{fwt} = \theta_5 \mathbf{1}(\text{Manufacturer_Entry})_{wt} + \mu_f + \eta_w + \tau_{m(t)} + \epsilon_{fwt}$$

where μ_f is a fixed effect indicating whether the fish is ice fish or not, η_w is a fixed effect for each wharf, and $\tau_{m(t)}$ is a fixed effect for the calendar month, to account for seasonal shifts in demand and cost. The results are presented in panel A of Table A3. Column 1, which omits fixed effects, shows an estimated increase of $\theta_5 = 102.81$ in the average number of fish caught (45 percent of the mean value) following manufacturer entry. This estimate increases in column 2, to 116.81 (51 percent of the mean value), when including all fixed effects. The difference in differences may be seen by subtracting column 3 from column 4. Each column shows the regression

TABLE A3—EFFECT OF COMPETITION ON FISH QUANTITY AND PRICES

	Average fish caught (number)			
	(1)	(2)	(3)	(4)
<i>Panel A. Fish quantity</i>				
Manufacturer Entry (= 1)	102.81 (36.18)	116.81 (23.78)	23.68 (11.00)	209.93 (46.71)
Fish sample	All fish	All fish	Non-ice fish	Ice fish
Mean dependent variable	227.24	227.24	39.84	414.64
Number of survey waves	22	22	22	22
Observations	132	132	66	66
R ²	0.02	0.55	0.49	0.68
Wharf fixed effects	No	Yes	Yes	Yes
Ice fish fixed effects	No	Yes	—	—
Month fixed effects	No	Yes	Yes	Yes
<i>Panel B. Fish price</i>				
log fish price per kilogram				
Manufacturer Entry (= 1)	-0.055 (0.025)	-0.054 (0.013)	-0.009 (0.027)	-0.099 (0.034)
Fish sample	All fish	All fish	Non-ice fish	Ice fish
Mean dependent variable	9.249	9.249	8.916	9.583
Number of months	24	24	24	24
Observations	1,728	1,728	864	864
R ²	0.00	0.67	0.61	0.17
Market fixed effects	No	Yes	Yes	Yes
Fish type fixed effects	No	Yes	Yes	Yes
Month fixed effects	No	Yes	Yes	Yes

Notes: The dependent variable in panel A is the number of fish reported caught per fisherman surveyed from May 2013 to July 2014, where quantity is aggregated over all trips in the last two weeks by each wharf, survey wave, and whether the fish type is caught with ice or not. The dependent variable in panel B is the log price of different types of fish per kilogram, as measured in monthly microdata collected for Sierra Leone's Consumer Price Index at six markets in Freetown from January 2013 until December 2014. "Manufacturer Entry (= 1)" is an indicator variable that equals 1 after the entry of the first new ice manufacturer in the Aberdeen and Goderich markets near Freetown.

estimated on the subsample of non-ice fish and ice fish, respectively. Comparing the two, clearly the increase in the number of fish caught was greater for ice fish.

We measure fish prices using microdata from the monthly consumer price index (CPI), which collects data on 12 types of fish across 6 markets. Panel B of Table A3 reports estimates of a similar regression,

$$(4) \quad \log Price_Fish_{fxt} = \theta_6 \mathbf{1}(Manufacturer_Entry)_t + \mu_f + \eta_x + \tau_{m(t)} + \epsilon_{fxt},$$

where μ_f are fixed effects for all 12 fish types, η_x are fixed effects for each of the 6 markets, and $\tau_{m(t)}$ are fixed effects for month of the CPI.³¹ In column 1 of panel B, we find a 5 percent average decrease in the price of 12 different varieties of fish sold in the Freetown markets following manufacturer entry. This result is robust to

³¹ Because CPI data are only collected in Freetown and not in Tombo, we use the month of the first new manufacturer entry into the Goderich and Aberdeen wharves to define $\mathbf{1}(Manufacturer_Entry)_t$.

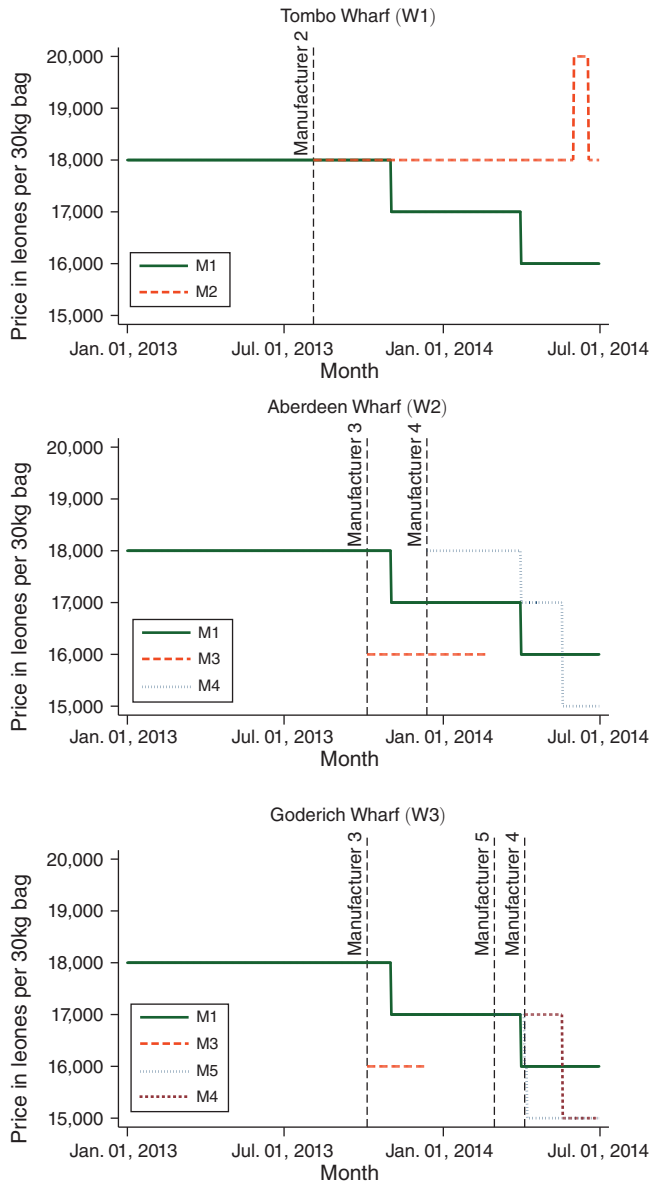


FIGURE A1. ENTRY AND PRICE COMPETITION, PARTITIONED BY WHARF

Notes: The y-axis shows the retail price per 30-kilogram bag of ice. Vertical lines mark the first date of ice sales by a competitor manufacturer in that wharf.

including fixed effects for market, fish type and month in column 2. In columns 3 and 4, we split our sample into “Ice fish” and “Non-ice fish.” Those fish that do not require ice show no significant price decrease in column 3, while those that do require ice show a 10 percent price decrease in column 4. This result is consistent with increased supply of fish requiring ice because of the increased fishermen productivity observed in panel A.

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