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# Market Integration, Demand, and the Growth of Firms: Evidence From a Natural Experiment in India†

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*In many developing countries, the average firm is small, does not grow, and has low productivity. Lack of market integration and limited information on non-local products often leave consumers unaware of the prices and quality of non-local firms. They therefore mostly buy locally, limiting firms' potential market size (and competition). We explore this hypothesis using a natural experiment in the Kerala boat-building industry. As consumers learn more about non-local builders, high-quality builders gain market share and grow, while low-quality firms exit. Aggregate quality increases, as does labor specialization, and average production costs decrease. Finally, quality-adjusted consumer prices decline.* (*JEL* D22, D83, L15, L25, L62, O12, O14)

Why do good firms—whether low cost, high productivity, or high quality—sometimes fail to grow, even as bad firms persist? The growth and productivity of firms are likely to be key ingredients for income growth and economic development. Yet for developing countries, several observations reveal important challenges. First, the average firm in most developing countries is very small. For example, Hsieh and Klenow (2014) show that the typical manufacturing firm in India has only 2.6 employees, compared to 42 for the United States. And Hsieh and Olken (2014) show that 90 percent of manufacturing firms in Mexico, and almost 100 percent of firms in India and Indonesia, have fewer than 10 employees. Second, firms often do not grow significantly as they age. Hsieh and Klenow (2014) show that the average 40-year-old Indian firm is only 40 percent larger by employment than the average firm under 5 years old. By contrast, in the United States the older firms have seven times more employees than the younger ones. Thus, firms in developing countries

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generally start small and stay small.[1] Third, firms in low-income countries on average appear to have low productivity (Tybout 2000 and Bloom et al. 2010). Finally, there is often significant productivity dispersion across firms, despite the fact that competition should drive less productive firms out of the market.[2] For example, Hsieh and Klenow (2009) report that the ratio of the seventy-fifth percentile of the physical productivity (i.e., TFPQ) distribution of firms to the twenty-fifth percentile is 5.0 for India and 3.6 for China, compared to 3.2 for the United States.

There are many possible explanations for these facts (e.g., credit constraints, regulations, or poor managerial ability). In this paper, we focus on a lack of market integration, including that arising from information frictions. In particular, we argue that firms are often unable to sell beyond a fairly local market in part because it is difficult for consumers to learn about the existence and quality of different firms' output. As a result, consumers often buy exclusively from a local producer, and producers sell mostly to local customers.[3] The limited size of their potential customer base limits good firms' ability to grow and prevents them from exploiting economies of scale. The effective lack of competition also allows less productive firms to survive, lowering aggregate productivity and allowing cross-firm productivity dispersion to persist.

Limits to the market's ability to select good firms and drive out bad ones also arises in studies of consumer search (Stahl 1989), the industrial organization literature on market structure and product substitutability (Syverson 2004a, b), and studies of barriers to trade and intra-industry reallocations (Melitz 2003; Behrens, Mion, and Ottaviano 2011). Broadly speaking, in each case the problem is tied to some form of effective limit on the degree of market integration, whether due to high costs associated with finding and transacting with trading partners, lack of close substitutes, or tariffs and other barriers to trade that insulate firms from market forces. Correspondingly, removal of such barriers increases the market's ability to discipline the industry, reallocating profit and market share toward good firms and driving bad firms to exit.

In order to test this hypothesis, we use six years of semiannual censuses of boat builders and surveys of boat buyers (fishermen) to examine the artisanal fishing boat manufacturing industry in Kerala, India. We are particularly interested in the role that increasing integration in the downstream market for fish played in inducing greater integration and pro-competitive intra-industry reallocations in the upstream market for boats. At baseline, the industry featured a large number of very small firms, each largely serving a highly localized market. There was also significant variation across firms in the life-span of the boats produced (which we argue below is largely due to skill differences). This dispersion, combined with comparatively lower variation in sales prices, results in large cross-firm differences in prices per

[1] McCaig and Pavcnik (2016) document similar patterns using a large, nationally representative longitudinal survey of micro-enterprises in Vietnam that followed firms for four years.

[2] Productivity dispersion is also found in wealthier countries; see Syverson (2004a, b, 2011).

[3] Markets may be more prone to being localized in lower income countries for several reasons: people may travel less due to being more concentrated in dispersed, rural areas and having worse transportation infrastructure; it may be more difficult or costly for firms to advertise effectively; information aggregators (e.g., review sites) may be more limited; or contracting costs may be greater because civil courts and other dispute resolution mechanisms are not as accessible or developed.

year of boat life.[4] For example, despite charging similar prices and producing otherwise similar boats, the best builder in our data built boats lasting more than twice as long on average, thereby costing one-half as much per boat-year as those made by the worst builder. We also show that fishermen were initially poorly informed about these differences, and that nearly all fishermen bought their boats from the nearest builder, typically located in the same village.

We then consider a natural experiment, first documented by Jensen (2007), whereby the spread of mobile phones in Kerala led fishermen for the first time to begin selling their catch outside of their local markets. We show that as fishermen began traveling to different markets to sell their fish, they learned more about the quality of non-local builders and began buying boats non-locally. Thus, the arrival of mobile phones, by changing fishermen's behavior in the downstream market for fish, provided an exogenous shock to market integration and potential market size in the upstream market for boats.

We find that the increased integration in the fish market created large spillovers on the degree of integration in the boat market, inducing pro-competitive intra-industry reallocations, benefiting good firms and harming bad ones. The highest quality (longest boat life expectancy) builders gained market share and grew in size, while the lowest quality builders lost market share, with many ultimately exiting. As a result of these reallocations, average quality in the industry increased, and the industry transformed from a large number of very small firms to a much smaller number of much larger firms. By the end of our sample period, the number of firms had decreased by almost 60 percent, and the average surviving firm was larger than the biggest firm at baseline in terms of output, market share, and the number of employees.

In addition to cross-firm effects, we also find evidence of within-firm efficiency gains in the sector as growing firms exploited economies of scale. For example, after the introduction of mobile phones, the industry produced nearly the same number of boats with about 25 percent fewer labor hours and 37 percent less capital (with no change in material inputs). We also show that firm growth was associated with significant labor specialization, which is one potential micro-foundation for the observed decrease in average production cost. The average worker performed approximately 7–8 major job tasks (e.g., cutting wood, drilling, etc.) at baseline, but less than one-half as many by endline. Finally, we find evidence of gains for the industry's consumers (fishermen). Though the average raw sales price of boats increased slightly, the average estimated life-span of a boat purchased increased to an even greater extent (1.35 years), so the price per year of boat-life purchased declined by approximately 23 percent.

Although we only study a single industry in a single country, we believe that the key underlying features of this industry, i.e., small manufacturers serving mostly a highly localized market, are common to many industries in other developing

[4] Differences in the life-span of boats are the primary source of variation in productivity across firms. There is in fact very little variation in (pre-phone) labor, capital, and material inputs across builders. However, with the same inputs, some builders produce much longer lasting boats and are thus more productive in producing a year of boat life. Thus, in our context, the question of how productivity dispersion can persist in equilibrium (Syverson 2004a, b, 2011) is equivalent to asking why low-quality builders are not driven out of the market by high-quality builders.

countries.[5] In addition, the detailed, micro-level census data of firms (including detailed measures of the production process such as worker time allocation and specialization) in a single industry with highly comparable data and production processes, coupled with a natural experiment that exogenously shifts the potential market size and number of competitors for each firm, provide a complement to studies with a wider range of industries or countries.

As noted, our analysis and results relate to several different strands of literature. Due to its focus on entry and exit dynamics, the literature most closely related to our study considers the effects of removing trade barriers on productivity (e.g., Pack and Westphal 1986; Dollar and Sokoloff 1990; Hallward-Driemeier, Iarossi, and Sokoloff 2002; Pavcnik 2002; Melitz 2003; Melitz and Ottaviano 2008; Redding 2011; Topalova and Khandelwal 2011; Melitz and Redding 2014; de Loecker et al. 2016). The canonical model in this literature is Melitz (2003), which shows that removing barriers to trade between markets leads the most productive firms to expand sales and begin to export, while the least productive firms exit. The result is a reallocation of market share and profit toward the most productive firms, and an increase in aggregate productivity.[6]

Melitz (2003) discusses two possible channels through which these intra-industry reallocations may operate. The first operates through the labor market: lowering trade barriers leads firms to expand and increases demand for domestic labor, raising its price. In this costlier environment, only the most efficient firms can survive. The second channel is pro-competitive. The intuition underlying this mechanism follows from what Levinsohn (1993) refers to as the "imports-as-market-discipline" hypothesis, which he notes Helpman and Krugman (1989) refer to as "the oldest insight" in trade and imperfect competition. The core of the hypothesis is that opening a market to trade introduces foreign firms as additional competitors. Faced with tougher competition, domestic industries will no longer be able to enjoy secure rents arising from barriers to entry in the local market, and they will be forced to respond by becoming more competitive, i.e., lowering prices and markups. Although Levinsohn referred to oligopoly models, recent studies of monopolistically competitive industries yield similar results.[7] After presenting our results, we discuss their relationship to the Melitz (2003) model in Section V.

Our study also connects to the literature on productivity dispersion across firms within industries (see Syverson 2011 for a summary). Such dispersion may be

[5] Hsieh and Klenow (2014) and Hsieh and Olken (2014) give several examples of developing countries where average firm size is small. With respect to localized markets, Sri Lankan enterprise data from de Mel, McKenzie, and Woodruff (2008) show that the average percent of revenue coming from within 1 km of the business is 62 percent and the median is 75 percent. If we include customers coming from the same grama niladhari (G.N.) division but more than 1 km from the business, the mean is 76 percent and the median is 100 percent. A G.N. is slightly larger than a village, but still quite small; for example, in one of the sample districts, the average G.N. has a population of about 1,245 people (which would correspond to a below-average village in India) and an area of about 2 square km (about one-third smaller than the size of Central Park). Overall then, a large share of business seems to come from a fairly localized customer base.

[6] Qualitatively similar results appear in a number of other studies, including Pavcnik (2002), Melitz and Ottaviano (2008), Redding (2011), Topalova and Khandelwal (2011), Melitz and Redding (2014), De Loecker et al. (2016), and Goldberg and Pavcnik (2016).

[7] Melitz (2003) discusses this pro-competitive channel, while Melitz and Ottaviano (2008) present a formal model. Other channels have also been discussed, including increased labor market competition (Melitz 2003), exploiting increasing returns, reducing internal inefficiencies, and taking advantage of previously unavailable or more-expensive imports (Topalova and Khandelwal 2011).

particularly important for welfare. For example, Hsieh and Klenow (2009) estimate that reallocating capital across firms (to a level of efficiency achieved in the United States) would lead to dramatic gains in manufacturing productivity in China and India. Many explanations have been proposed for equilibrium cross-firm productivity dispersion (Syverson 2011); our paper suggests that in the present context, limited spatial competition due to barriers to trade likely played a key role. This proposed mechanism is related to previous studies. For example, Syverson (2004a, b) argue that the ability of consumers to substitute among different producers' output affects competition and can therefore impact minimum and average productivity, as well as productivity dispersion. These studies propose several potential barriers to substituting across firms' output, such as transportation costs, product differentiation, bundling, or branding and advertising. Syverson (2004a) tests this argument by considering variation in spatial substitutability in output across firms created by the difficulty of transporting ready-mix concrete over long distances, whereas Syverson (2004b) considers a range of barriers to substitutability and a broad collection of industries. Related, Hallward-Driemeier, Iarossi, and Sokoloff (2002) argue that transportation costs, along with product differentiation, in effect segment markets so that they are not integrated.

Third, our study also relates to the literature on consumer search, including the literature on the impact of mobile phones on markets in developing countries (Aker and Mbiti 2010). Although predictions are somewhat sensitive to modeling assumptions, a fairly general prediction in the sequential search literature is that reducing search costs leads to lower prices and decreased price dispersion (Reinganum 1979; Stahl 1989; Aker 2010; Aker and Mbiti 2010). While a number of studies have shown a positive link between mobile phone penetration and product-market performance (Jensen 2007; Aker 2010; Aker and Mbiti 2010), our study departs from this literature in showing how reduction of search cost in a downstream market can have beneficial effects on the upstream market.

Finally, our results contribute to the recent literature on constraints to firm growth in low-income countries (Fischer and Karlan 2015; Hsieh and Olken 2014). Among the factors explored are the possible lack of managerial capital and business training (Bruhn, Karlan, and Schoar 2010, 2018; Karlan and Valdivia 2011; Bloom et al. 2013; de Mel, McKenzie, and Woodruff 2014), access to credit and capital (de Mel, McKenzie, and Woodruff 2008, 2009, 2011, 2012; Fafchamps et al. 2014; McKenzie and Woodruff 2008, 2014, 2017; Karlan and Zinman 2011), and the quality of legal institutions (Laeven and Woodruff 2007). Using US data, Foster, Haltiwanger, and Syverson (2016) model and explore the role of limited demand for new firms' products in slowing their growth. While Foster, Haltiwanger, and Syverson (2016) also consider informational barriers as a constraint on firm growth, their focus is on the demand-side difference between new and old firms in a horizontally differentiated market where firms have idiosyncratic growth potential that accumulates over time. In contrast, our study focuses on supply-side differences, and on the way in which lifting market-wide barriers to trade (including informational barriers) differentially affects high- and low-quality firms in vertically differentiated markets.

The remainder of this paper proceeds as follows. Section I presents background information on the boat market in Kerala. Section II discusses the data and Section III presents the empirical strategy. Section IV presents the results and

Section V relates our results to the canonical Melitz (2003) model of intra-industry reallocation following trade liberalization. Section VI discusses alternative mechanisms and Section VII concludes.

## I. Informational Frictions and Market Fragmentation

Our analysis takes as its starting point the empirical observation, shown below, that despite large cross-firm differences in quality (and, correspondingly, price per year of boat life), fishermen initially bought their boats almost exclusively from a local producer, typically the one in their own village. Correspondingly, since there was a near one-to-one mapping between villages and builders, with every fishing village having one, and typically only one, builder, sellers sold almost exclusively to fishermen in their own village. There are many potential explanations for why the market would be highly localized in this way. We argue that barriers to trade arising from the high costs of acquiring information about and trading with non-local producers play a large role.

Consider the case of a fisherman purchasing a boat. He might be able to easily acquire price information from many producers, but estimating how long each producer's boats will last (and thus, price per year of boat life) is more challenging, and producers are unlikely to be able to credibly signal quality to potential buyers.[8] Though it might be easy to tell the difference between a very poorly-made boat and a well-made one just by sight, it is much more difficult to distinguish between a boat that will last on average four years and one that will last five. Boats are an experience good (Nelson 1970), where quality is revealed only after a number of years of use. If we assume that there is some random variation in boat durability even within a single builder, estimating average life expectancy would require experiencing a large number of boats from each builder, over a long period of time. If we start from an equilibrium where fishermen have repeatedly bought from a local builder, as have most of the other fishermen they know in the same village, each fisherman should be able to accurately estimate how long their local builder's boats last on average. However, they are likely to have significantly less information about the quality of non-local builders, for whom they may have few or no observations.[9]

As shown in Jensen (2007), most fishermen initially fish and sell their catch exclusively locally. This creates fewer opportunities to learn from fishermen in other

[8] There are also no warranties or guarantees in this market. There are informal agreements that builders will provide refunds or replacements if an obvious construction problem leads to a failure very shortly after purchase. However, extending warranties beyond a short period could create moral hazard and the difficulty in establishing whether failure was due to construction or use. For similar reasons, there is no private boat insurance available. A well-functioning civil court system or other dispute resolution mechanism could also solve this problem, since builders who promise a certain life expectancy could be sued if their boats do not meet that promise, but such systems are not generally available or easily accessible.

[9] Fishermen could experiment and purchase from a non-local builder to learn about quality. However, if there are search or other transactions costs in dealing with non-local producers, they would only do so if they have strong priors that quality differences across builders are significant. Further, boats are an expensive and infrequent purchase, which might limit the desire to experiment. It would take many observations and many years before an estimate could be formed. Fishermen could engage in collective action, such as subsidizing members of their group to experiment; however, in practice, we do not observe such behavior, perhaps due to the fact that learning would still require many fishermen to experiment and quality would only be observed over a long period of time, or the difficulty of sustaining such cooperation.

villages.[10] We argue that it was only when fishermen began traveling to other markets to sell their fish that they regularly interacted with non-local fishermen.[11] And indeed, it is common to see fishermen talking about their boats with people from different villages when they are in other markets selling their fish. This may occur while they are waiting side-by-side in their boats as their catch is being unloaded by a buyer or while they are awaiting payment.[12] In the course of this interaction they acquire information about non-local builders, allowing them to form better estimates of quality for a wider range of builders. This highlights an interesting feature of our setting: we argue that increased interactions in the market for *fish* has beneficial spillovers on the related market for *boats*.

As noted above, a common feature of models of market integration is the prediction that removing barriers to integration enhances the market's ability to discipline the industry. In our case, once fishermen have acquired information about the broader set of builders, demand should be reallocated toward the higher quality builders. This will result in increased market share and growth for high-quality producers, and reduced market share, and possibly exit, for low-quality producers. Rather than providing a formal model, we rely on this intuition, which, again, is common to models of search, product substitutability, and trade. In Section V, we provide discussion of the Melitz (2003) model to provide more details of the argument.

Though in our analysis, we will emphasize the role of information and learning, we note that there are other reasons why markets may be localized, including factors that mobile phones may also influence. For example, in our setting, before mobile phones, fishermen and builders would meet a few times in person prior to and during the course of boat construction. Mobile phones could reduce the number of in-person meetings required and thus lower the transaction costs of buying from a distant builder. However, we note that such costs (both time and travel costs) are very small relative to the cost of a boat, and many if not most of the visits cannot be eliminated by mobile phones (e.g., placing the order and making the initial deposit, examining progress or picking up the boat, and making final payment at the end). Thus, for the purposes of interpretation of our results, reductions in transaction costs due to mobile phones are unlikely to affect the market appreciably.

In addition, imperfect contract enforcement may also limit transactions to local buyers and sellers. Buyers typically provide a down payment averaging about 10–15 percent when they first order a boat. They may worry that a builder who they

[10] Problems such as this are the motivation for user review websites like Yelp or Angie's List, or expert review and testing companies like Consumer Reports or Zagat. No such resources exist for this market.

[11] To understand the difficulties in acquiring information on non-local firms, imagine you live in a town with one or two firms providing a particular service, such as an auto mechanic or a plumber. Interactions with mechanics or plumbers is not very frequent, but you might over time, and through talking with friends, learn how often their work is successful in fixing the problem or how long their work lasts before the problem recurs. If there is more than one mechanic in your town, you might even have a sense of which is better. But you might not know whether a mechanic in a town 45 minutes away is much better than your local mechanics. People in this other town however are likely to know how good their mechanic is. If you work with or know someone in this town, you might at some point exchange information. However, if you didn't, you might be reluctant to travel to the town, knock on a stranger's door, and ask for information on their mechanic. We argue that the increased interaction of fishermen from different towns once they begin selling their fish non-locally lowers the costs of acquiring such information.

[12] Most fishermen continue to fish near their home village even after mobile phones are introduced (Jensen 2007). Thus, there isn't much cross-village interaction while fishing.

don't know or have connections to will keep their money and not deliver the boat.[13] Phones themselves may not make enforcement easier, but the greater connections that fishermen form with non-local fishermen when they sell in other markets may either help them determine which sellers are trustworthy, or provide a means of contract enforcement through greater mutual social connections. Qualitative interviews and survey data did not reveal any such concerns as a reason why fishermen did not use non-local builders at baseline, but we cannot rule out some role for such effects.

Startz (2017) considers the role of face-to-face meetings in reducing both search and contracting costs. For example, a retailer may choose to travel to a manufacturer to learn more about different products and to collect any merchandise they purchase. In the present paper, the fact that fishermen are already traveling to different markets to sell their fish once they get mobile phones reduces the cost of then having such face-to-face meetings with builders in those markets.

We will show that mobile phones led to more accurate information about the quality of non-local builders. And although we found no evidence consistent with these other mechanisms, it won't be possible to formally test or completely rule them out. However, even if these other mechanisms were operative, the unifying interpretation would still be that the lack of market integration, limiting demand or effective market size, is a limitation to firm growth.

## II. Data and Setting

### A. *The Fisheries Sector in Kerala*

Fishing is a large industry in Kerala, employing over one million people and accounting for about 3 percent of the state's GDP. Discussions with builders, fishermen, and NGOs suggest that the boat building sector tended to be fairly stable over time prior to the introduction of mobile phones, with little to no entry or exit. Most businesses pass from father to son, and have been in the same family for several generations. Further, there are no schools or other resources such as books for learning boat building. This, plus high upfront capital costs, makes entry into the sector difficult, and may help account for the fact that most villages typically had just one builder.[14]

### B. *Survey Information*

We conducted our study in two districts of Kerala: Kannur and Kasaragod (see online Appendix Figure 1).[15] These districts were chosen because they are commercial fishing regions that did not have mobile phones at the time our survey began, but which we knew from interviews and licensing permits would soon be adding phones.

[13] The builder faces less risk because of the down payment and steady demand for boats. If a buyer doesn't return to pick up the boat and make the final payment, the builder can sell the boat to someone else.

[14] Most firms are based at the owner's home (typically in the same village they grew up in) and only two builders changed location during our sample period. We will therefore ignore the locational choice of firms.

[15] Jensen (2007) also examined a third district, Kozhikode. However, data collection for the present paper began after Kozhikode already had mobile phones, so we did not conduct our study there.

Because all of the firms in this industry were unregistered, there were no official data available. We instead worked with local knowledgeable officials and NGOs to identify all boat landing spots (places where fishermen dock their boats when not in use) in the two districts.[16] The mean number of boats per landing was 83, though there was considerable variation, with the smallest having only 28 boats and the largest having 151. We then visited each of these landings and conducted brief surveys with the owners of every boat at the landing, including asking about the boat's builder (name, location, and contact information). We also asked each boat owner the same information about the boat they owned prior to their current one, and whether they knew of any other builders. We used this information to create a complete list of all boat builders serving the study region. We cannot rule out that we missed some very small builders who sell just a few boats and may have been overlooked in our enumeration; however, any such builders would not constitute a large share of the market.

Using this list, we conducted a complete census of all boat building firms, repeated every six months for a six-year period from January 1998 to January 2004 (each census was proceeded by a survey at each landing, to capture any possible new builders, and to increase the chances of finding any builders that we may have previously missed). The census collected detailed information on the firm's activities, discussed in more detail below.

Finally, at each six-month interval we also surveyed a random sample of 15 fishermen in each of the landing spots/villages (we will use these terms interchangeably). This sample was drawn uniquely at each round, and is therefore not a panel. The survey gathered detailed information on boat purchase and use, and fishing behavior. Note that while at baseline the number of villages is the same as the number of builders, the fishermen's survey in a village continues even if the local builder has exited, so the two will deviate over time.

### C. *Descriptive Statistics*

In our baseline census, we identified 143 boat building firms in these two districts. Though there are no hard geographic boundaries, in general at baseline there is close to a one-to-one correspondence between landing spots and firms, with most buyers in one landing buying boats from one builder, and each builder selling mostly to fishermen at just one landing. Table 1 provides baseline descriptive statistics for these firms.[17] The average firm initially had only 2.1 workers. The largest firm in the industry had just four workers. Each firm is also small in terms of market share. If we consider the two districts combined as a single potential market, the average firm has a market share of 0.7 percent, and no firm supplies more than 1.3 percent

[16] Most fishing villages have a single, large landing spot. In some villages, an obstruction or geographic feature such as an inlet or a rock formation might split a landing spot into distinct clusters of boats, but for our purposes we will refer to them as a single landing spot. We also note that every fishing village has one wholesale beach market where fishermen sell their catch. So, in what follows, we think of each fishing village as having one corresponding landing spot and one corresponding fish market.

[17] We treat Round 2 as the baseline survey. One firm was not active in Round 1, having temporarily left for personal obligations. Thus, we were unable to collect data from this firm until Round 2.

Table 1—Summary Statistics For Key Variables at Baseline

| | Mean | Standard deviation | Min. | Max. |
|---|---|---|---|---|
| Number of employees | 2.1 | 0.52 | 1 | 4 |
| Boats produced per year | 14.1 | 6.3 | 4 | 27 |
| Market share (total market) | 0.007 | 0.003 | 0.002 | 0.013 |
| Life expectancy (years) | | | | |
| Previous boat | 4.76 | 0.99 | 3.25 | 7.57 |
| Auditor | 4.18 | 1.16 | 3.0 | 7.0 |
| Fishermen's perceptions | 4.51 | 0.79 | 3.53 | 7.08 |
| Quality residual | 0.00 | 0.97 | −1.66 | 2.63 |
| Price (rupees) | 3,932 | 365 | 3,226 | 4,967 |
| Price/year (rupees) | 861 | 186 | 503 | 1,357 |

*Notes:* Values for key variables in Round 2 (we treat Round 2 as the baseline due to the absence of one firm in Round 1). All data are from the boat builder survey. Market share (total market) refers to the number of boats sold by a firm in the past six months as a percent of the total boats sold across all firms in the sample. Prices are in 1999 rupees.

of the market.[18] By contrast, firms capture a very large share of their local market. On average, over 97 percent of boats in any given landing were purchased from the nearest builder at baseline. The sector as a whole therefore consists of something closer to a series of small, largely independent markets.[19]

## D. *Measuring Quality*

As noted above, as fishermen acquire greater information about different builders and markets become more integrated, we expect that high- and low-quality builders, i.e., firms with a high or low cost of producing a year of boat life, will be affected differently.[20] Therefore, understanding and measuring boat life expectancy will be critical to our empirical analysis.

At baseline, boats are manufactured using only hand tools, and with the same underlying raw materials. Based on interviews with builders, fishermen, NGOs, and a former insurance auditor, we argue that much of the variation in the life expectancy of boats built by different builders depends primarily on builder skill. Skill is particularly important in aspects of production such as treating and shaping/bending the wood prior to construction and weaving and fastening planks of wood together in the final construction.[21] In fact, as we discuss below, there is almost no variation in capital, material inputs (including quality), or labor hours per boat across builders at baseline. If quality were for example a choice variable, we might expect these

[18] It is difficult to define what constitutes a market, if such a boundary even exists. However, we show later that even with this broad geographic definition, there are detectable changes in market share.

[19] This is akin to the findings in Syverson (2011), where high transportation costs for ready-mix concrete means that most areas can be treated as separate markets.

[20] In focus groups with fishermen and builders, there was no suggestion that different builders' boats might vary by speed, fuel efficiency, or other dimensions relevant for a fisherman's productivity. Thus, we treat durability or life expectancy as the sole aspect of quality or differentiation among different builders' boats. In online Appendix A, we show that if there is any variation along other key dimensions, it does not appear to drive fishermen's boat buying behavior.

[21] For example, planks must be fastened together tightly enough that they don't come apart, yet also left with enough flexibility to absorb and transfer shocks when larger waves are hit. The degree of tightening is something that builders describe as a "feel" rather than a precise tightness that can be described or taught.

factors to differ across builders with high- and low-quality boats (i.e., builders with low-quality boats might use lower quality inputs or spend less time working on the boat to get it just right).

With quality variation largely driven by the skill of the builder, a natural definition of productivity is that higher productivity corresponds to producing more quality (boat-years) per dollar spent on inputs. This definition has been widely used in the literature (e.g., Melitz 2003). Since input expenditure does not vary across firms at baseline, higher productivity and higher quality are, essentially, synonymous in our context. Focusing on quality (longevity) as our measure of productivity also helps to address the additional complication that, as explained below, our builders' production technology exhibits increasing returns. Consequently, boat-years per dollar spent on inputs depends on the firm's scale of operation, while boat-years per boat (i.e., longevity) does not. To avoid conflating these two factors, we will avoid using the term productivity and instead focus on quality and cost directly.

We use four approaches to measuring boat quality or life expectancy. First, as noted, when we conducted our landing spot canvas, we asked all fishermen not just about their current boat, but their previous boat, including who built it, when they bought it, and when they replaced it. Data on previous boats allow us to directly estimate the average life expectancy of the boats built by each builder.[22] This measure potentially suffers from a few limitations, however. First, because it is based on previously owned boats that have already been replaced by a newer boat, it measures quality with a lag, and builder quality may change over time.[23] Second, for any newer entrants, there will not be a long enough track record to assess their boats in this way.[24] Third, the life expectancy of a boat may be affected by how it is used or the local fishing environment. For example, variation across areas in fishing intensity, the presence of biofouling organisms such as barnacles, the level of water salinity, or the presence of rocks and other hazards can result in variation in boat life that is independent of the underlying skill or quality with which it was constructed. To the extent that fishermen are able to "control" for such factors in comparing builders and making their purchasing decisions, our estimates of the relevant life expectancy differentials across builders will contain errors.

As a second method for estimating quality, we asked an independent auditor who had worked for a short-lived, government boat insurance program to assess the quality of newly-built boats for all of our builders, both on a scale of 1 to 5 and in terms of estimated life-span. This process involved inspecting the tension and spacing of fastenings (both visually and via calibrated stress tests) and checking for shape and defects or imperfections. We did this every six months alongside our landing canvas and builder census. This measure overcomes some of the challenges with the first approach. For example, by examining newly built boats, the measure is a better reflection of more recent quality and can also be applied to new entrants. It also provides an assessment of quality that is independent of use or fishing conditions

[22] Using data on previous boats to estimate builder fixed effects regressions that also include year-of-construction fixed effects to purge any estimates of year-specific common shocks yields similar results.

[23] Though fishermen may also only have the same data on duration of previous boats when inferring quality, so this may in fact be the correct measure for examining how they choose among builders.

[24] Ultimately, there was effectively no new entry during our sample, so this concern is not relevant (however, at the time we designed our study we did not want to ignore the possibility of entry).

(e.g., since we can examine new or very recently built boats). However, this measure is more subjective than the first approach.

Our third approach relies on the survey of fishermen, where we asked them to estimate how long boats built by their local builder and any other builders they knew lasted on average. This measure, like the previous one, is also subjective. However, in principle this is the information that fishermen will later use in choosing among builders, as well as the basis for what information they later share with other fishermen. And as discussed above, since most fishermen have bought from the same builder repeatedly, as have most of the other fishermen in their village, we expect they might have fairly accurate information about how long their local builder's boats last.

One remaining problem with all three measures is that quality may be a choice variable. For example, in areas where fishermen are poor or credit constrained, they may not be able to afford a higher quality boat that lasts longer but costs more upfront.[25] So some builders may intentionally build boats that don't last long, not because they lack the skill to produce better ones, but because of local demand conditions.[26] This would suggest that some builders that we label as low-quality may actually be able to build higher quality boats if their potential market size expands. Of course, it is possible that such builders will still be at a disadvantage when markets become less localized: if fishermen simply share raw, unadjusted information on life expectancy of different builders and are unable to control for (or are unaware of) endogenous quality, and if such builders are at least initially unable to credibly signal higher quality,[27] then this estimate should still be the relevant one for predicting changes in market share and other industry dynamics.

However, to at least account for the possibility of such mismeasurement, for our fourth measure we estimate a "skill residual." In particular, we regress estimated boat life expectancy at baseline (based on the fishermen's report of how long their previous boat lasted) on labor, material, and capital inputs.[28] The residual from this regression is the variation in builder life expectancy that cannot be explained by these factors; in other words, holding constant the number of hours worked on a boat and the materials (including quality) and capital used, which are the main elements through which quality can be influenced by production choices, it indicates which builders' boats last longer or shorter than expected.[29]

None of these measures is perfect. However, any imperfections or measurement error in classifying builders by quality should bias against finding our expected results for whether firms will gain market share, grow, or exit as a function of their

[25] Though below we show that average village income is uncorrelated with boat durability at baseline.

[26] Though we in fact see little variation in the quality of inputs used or the amount of time or capital used across various builders, including when comparing by quality. And if we regress estimated life expectancy on detailed capital, labor, and material inputs at baseline, none of the coefficients are statistically significant and the $R^2$ is 0.03. The fact that variation in inputs explains almost none of the variation in life expectancy across builders suggests that quality variation is more likely to be driven by variation in builder skill than demand or other factors that may make quality endogenous.

[27] For example, a builder previously facing a demand for low-quality boats would need to begin producing new boats and wait to show that they last five or six years rather than four years.

[28] Using the other measures of quality to generate residuals yields similar results in our regressions below.

[29] Results using the approach described in Levinsohn and Petrin (2003) are broadly similar to those obtained with the simple ordinary least squares residuals (we cannot use the Olley and Pakes 1996 approach because it can only be applied to observations where investment is nonzero, which causes us to drop many observations).

baseline quality, unless there is a systematic negative correlation between our four measures of quality and actual quality (either true quality or the quality perceived by buyers), which seems unlikely.

Table 1 shows that the average life expectancy of a boat based on estimates from previous boats is 4.8 years. However, there is considerable variation across builders.[30] The best builder's boats last on average 7.6 years, whereas the worst's last on average less than half as long (3.3 years). The auditor's assessment yields a lower estimate of average life expectancy, at just 4.2 years. Finally, estimates of life expectancy based on fishermen's perceptions of their local builder fall between the other two, with a mean of 4.5. Overall, all three measures suggest that there is considerable variation in boat life expectancy across builders.

The next-to-last row of the table shows that there is less variation in the raw price of boats, with about a 35 percent difference between the least and most expensive boats. However, given the large differences in life expectancy across builders, the price per year of boat life varies considerably, as shown in the last row of the table (note, the minimum and maximum prices do not correspond respectively to the shortest and longest lasting boats). For example, using life expectancy estimates from previous boats, the most expensive builder effectively charges 1,357 Rs per boat-year, whereas the least expensive builder charges less than half of that (502 Rs). These considerable quality or effective price differences are what we expect fishermen should respond to as they learn more about different builders.

## III. Empirical Strategy

### A. *Mobile Phones in Kerala*

Prior to the arrival of mobile phones, few businesses or homes had landline phones in Kerala. Ownership of landlines was expensive, and waiting times for service often lasted years. Mobile phones were first introduced in the state in 1997. Service expanded gradually throughout the state via cell towers, concentrating first on the most populous cities (see Figure 1). Each tower provides a service radius of approximately 25 km, though in practice range is more limited due to terrain, vegetation, and man-made structures.

In the two districts we study, Kannur and Kasaragod, there was no mobile phone service at baseline (January 1998). In late July 1998, two towers were put into service in Kannur district, which we call Region I. No new service was added in the area until May 2000, when two cities in Kasaragod district (Region II) received towers. New towers were added over the subsequent two years to fill in coverage gaps, so that by the end of 2002, most of the coast was covered. However, there are a number of fishing villages located inland or along major rivers that feed into the sea (Region III). Because they are further inland, and because of uneven terrain and dense tree cover, almost none of these villages had operational mobile phone

[30] There are also differences in the within-builder variance. However, there is a negative correlation between a builder's mean and their variance. The best builders (highest mean) also appear to be the most consistent (smallest variance) so buyers don't face a trade-off between, say, higher mean/higher variance builders and lower mean/lower variance builders.

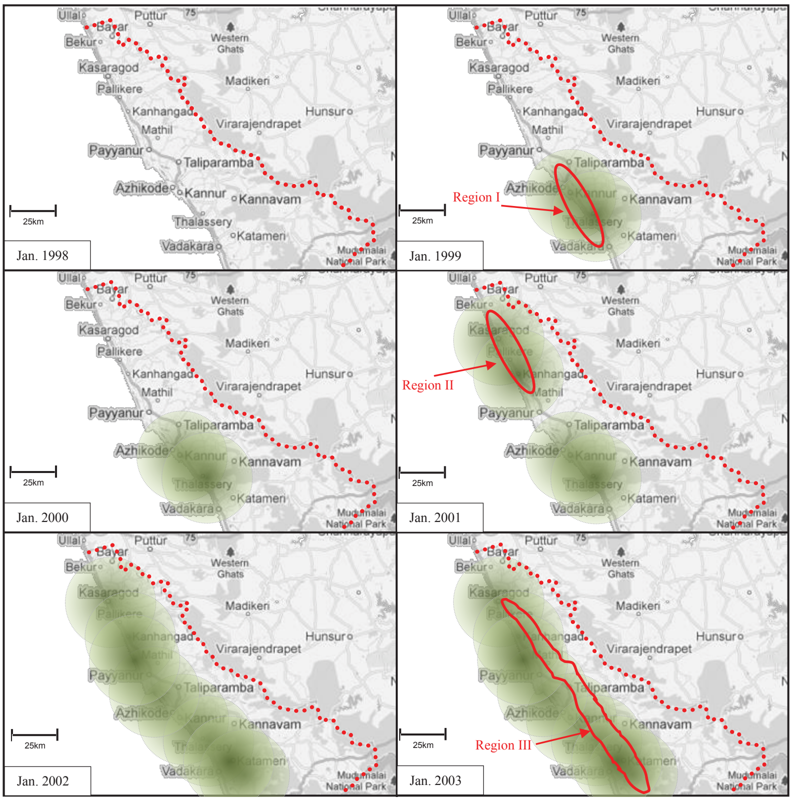


FIGURE 1. SPREAD OF MOBILE PHONES, JANUARY 1998–JANUARY 2003

*Notes:* Figure shows the spread of mobile phones in two districts of Kerala between 1998 and 2003. Circles represent mobile phone towers (center point) and their service radius. Region designations are created by the authors to reflect when various geographic areas received mobile phones and do not represent any actual administrative unit.

*Source:* Authors' calculations based on observed mobile phone tower locations

coverage during our sample period. Inland fishing villages are not as directly comparable to those along the coast. For example, many of them fish exclusively on lakes or rivers. Because they also keep their boats in these areas, it is much more costly for them to travel to distant areas to sell their catch, even if they had mobile phones. However, these villages can be used as an additional, if limited, comparison group in our analysis because they can at least capture any common effects on boat markets, such as changes in technology, prices, or regulations (provided such changes are equally distributed between coastal and more inland areas). Our results yield similar conclusions if we exclude this control group (see online Appendix Table 1).

The timing and location of mobile phone introduction was certainly not random. The primary concern of the mobile phone companies was the size of the potential customer base, so both timing and placement are highly correlated with an area's population size and wealth. In Section VI, we address the resulting empirical challenges for our study.

### B. *Empirical Specification*

The key predictions we will test are how changes in factors such as market share, probability of exit, and firm size are affected by the increase in market integration created by the introduction of mobile phones, as a function of baseline builder quality. In doing so, we take advantage of the staggered introduction of mobile phones across regions noted above. Thus, using builder-level data, we regress the outcomes of interest on indicators for whether the builder's region has mobile phones, the builder's baseline quality, and the interaction of the two,

$$(1)\quad Y_{b,t} \;=\; \alpha_0 + \alpha_1 Phone_{b,t} + \alpha_2 Quality_b + \alpha_3 Phone_{b,t} \times Quality_b + \varepsilon_{b,t},$$

where $Y_{b,t}$ is the outcome variable of interest for builder $b$ at time $t$, $Phone_{b,t}$ is a dummy variable equal to 1 for all periods where the builder's region has mobile phone coverage (regardless of whether they own a phone), and $Quality_b$ is one of the measures of the builder's quality, measured in Round 1 before any regions in our sample have phones. The results we present below also include region and round fixed effects (results are also robust to the inclusion of builder fixed effects; see online Appendix Table 2). All regressions are estimated via least squares. Our identifying assumption is that had it not been for the introduction of mobile phones, there would have been no differential change in these outcomes across builders. We discuss potential challenges below.

Our discussion so far suggests a proposed causal chain that runs as follows: mobile phone introduction → fishermen begin selling their catch non-locally → fishermen learn about the quality of non-local builders → fishermen start to buy their boats non-locally → high-quality builders gain market share and grow, and low-quality builders lose market share and possibly exit (possibly followed by changes in productivity). We will show the correlation between mobile phones and each of these subsequent links, but this analysis alone won't establish the full causal chain from start to finish, or rule out other factors affecting any one of the links in this chain. However, after establishing the correspondence in timing between mobile phones and each of these links, we will also show that the other links were not changing appreciably prior to mobile phone introduction, and attempt to rule out other explanations outside of the proposed causal chain.

## IV. Results

### A. *Changes in Fishermen's Behavior and Information*

We begin by providing some preliminary visual evidence. Panel A of Figure 2 provides data from our fisherman survey on the fraction of fishermen in each region who reported selling their catch exclusively in their local market during the week of the survey. The three panels of this figure correspond to the three regions in Figure 1, and the vertical lines represent the dates when mobile phones were introduced. Confirming the results of Jensen (2007), we find that the spread of mobile phones induced fishermen for the first time to sell outside of their local market, as they sought out the best price for their catch. Before mobile phones, over

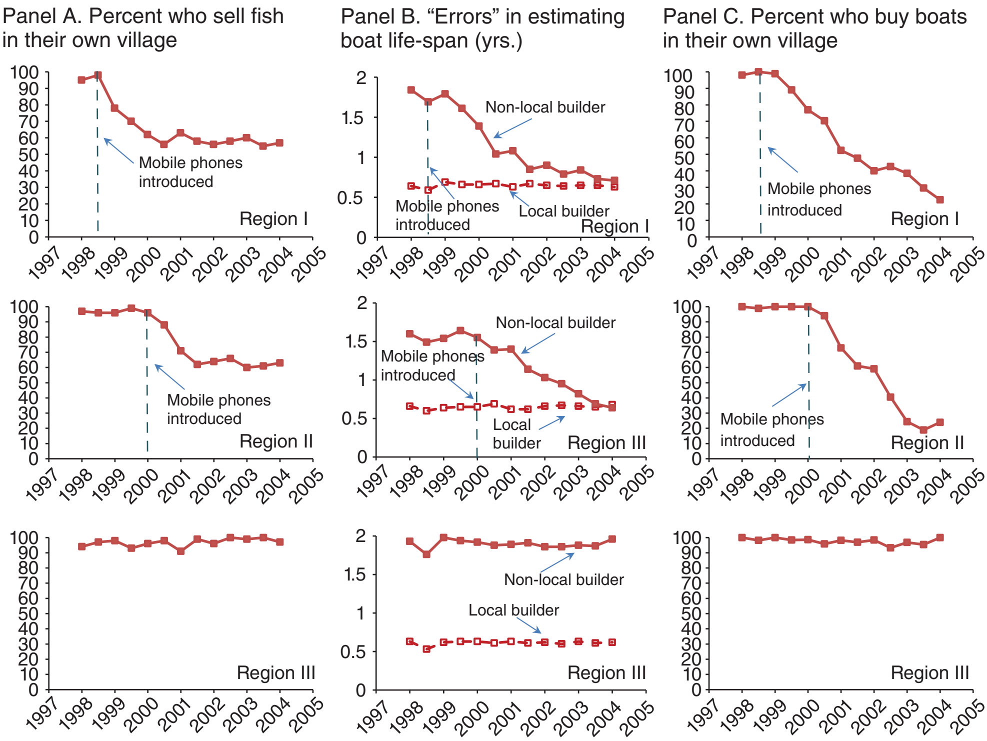


Figure 2. Mobile Phones and Fishermen's Behavior and Information

*Notes:* The left-hand panels represent the fraction of fishermen in each round of our fishermen survey who report selling their catch in their local market. The central panels represent the average of the absolute value of the difference between our estimates of life expectancy for boats (based on "previous boat" estimates) and fishermen's estimates, measured in years. "Local builder" refers to a builder in the fisherman's village, and "Non-local builder" is any other builder the fisherman is aware of. The right-hand panels represent the fraction of fishermen in each round of the landing canvas who report buying their boat from a local builder.

95 percent of fishermen in all three regions sold their catch in their local market. This rate declines in Regions I and II to between 60 and 70 percent when they get mobile phones, but is largely unchanged in Region III, which never received coverage.[31] Column 1 of online Appendix Table 3 confirms that the decline in selling fish locally associated with the introduction of mobile phones is statistically significant.[32]

We argue that this greater search by fishermen in the fish market leads to greater learning and integration in the market for boats. We provide evidence for this by examining data from our fisherman survey, which asked individuals to estimate how long on average they believed the boats built by their local builder lasted. The survey

[31] The share of fishermen who ever sell outside of their local market is much greater. About 90 percent of fisherman who own a cell phone report having sold in a non-local market at least once in the past month (and about 75 percent of fishermen own cell phones by the end of our survey). Even fishermen with cell phones may still end up selling in their local market regularly, either because their local price is the highest on a given day or because price differences are not sufficient to offset expected transportation costs.

[32] We estimate $SellLocal_{v,t} = \alpha_0 + \alpha_1 Phone_{b,t} + \varepsilon_{v,t}$, including region and round fixed effects. This specification corresponds to the pooled treatment regressions in Jensen (2007) designed to identify the reduced-form effects of phones on outcomes. We omit baseline builder quality and its interaction with phone as in the specification above because the predictions for fishing behavior should not depend on the quality of the builder in their village.

also asked if they knew of any other builders; if they said yes, we asked for the name and location of the one they were the most familiar with, and how long they believed that builder's boats lasted.[33] We can then match fishermen's estimates for each builder to our "previous boat" estimates for those builders. Panel B of Figure 2 graphs the absolute value of the "errors" (fishermen's estimates minus our estimates) for local versus non-local builders. In all three regions, before mobile phones are available, fishermen have much more accurate estimates (or estimates closer to ours) for local than non-local builders. Fishermen on average have estimates of the life-span of their local builder's boats that are within one-half year of our estimates. There is no evident trend in these estimates and the arrival of phones appears to have no effect. Regression results in column 2 of online Appendix Table 3 show that we cannot reject that the arrival of phones had no effect on fishermen's estimate of the quality of local builders.

By contrast, there is considerably more error and/or uncertainty regarding non-local builders. First (not shown in the figure), at baseline nearly one-third of fishermen reported that they didn't know of any non-local builders or reported "don't know" (or refused to answer) when asked to estimate the durability of any non-local builder's boats. Even among those who knew another builder, the average of the absolute value of the errors is about three to four times as large (1.5–2 years) as the estimates for local builders.[34] Notably, the figure shows that over time, the average error for non-local builders declines when mobile phones are introduced. In both Regions I and II, by the final round, the average error for non-local builders is very close to that for local builders. In other words, despite differing greatly at baseline, fishermen become nearly as good at estimating the life-span of builders outside their village as builders in their village. We also note that there are no changes in average errors in Region III, which never got phones, and that there was no evident trend in Region II prior to mobile phones being introduced (we do not have enough pre-phone data to assess any possible preexisting trend in Region I). Column 3 of online Appendix Table 3 shows that the decline in errors for non-local builders upon getting mobile phones is statistically significant. Thus, overall there is evidence of learning about the quality of non-local builders that corresponds to the timing of introduction of mobile phones and fish sales outside of local villages seen in Figure 2.[35]

Panel C of Figure 2 shows that the likelihood of buying boats from a local builder decreases in a corresponding pattern. We plot the fraction of boats purchased in the past six months that were built by a local builder. Before mobile phones, nearly all boats were purchased from the local builder. This share declines after mobile phones are introduced, and by the end of the sample period, approximately three-quarters of boats in both Regions I and II are bought from a builder outside the fisherman's

[33] For fishermen who report not knowing any other builders, we identified the nearest non-local builder and asked them to estimate how long they thought that builder's boats lasted. We exclude such cases here.

[34] The errors are systematic in one direction. Most fishermen estimate that the non-local builder's boats last the same as their local builder's, or slightly below. Almost no fishermen report estimates for a non-local builder that exceeds their local builder by more than half a year. This could account for the lack of search at baseline (though we should not interpret this result causally).

[35] The fact that fishermen's perceptions of life expectancy move closer to our estimates is also a crude validation of our estimates. Neither fishermen nor builders were given information about our estimates, so there is no reason otherwise to have expected the discrepancy between our estimates and theirs to decline.

village. Column 4 of online Appendix Table 3 shows that the decline in buying boats locally after mobile phones are introduced is statistically significant.

### B. *Changes in Exit*, *Market Share, and Firm Size*

As noted above, reallocation of demand across firms could lead to exit. Panel A of Figure 3 shows the number of firms over time in the three regions. The solid line in each panel plots the actual number of firms counted in each region in the semi-annual canvas. Focusing just on these lines, the figure shows a large reduction in the number of builders within a few periods of mobile phones entering. In Region I, the number of builders declines from 59 in the baseline survey to just 23 by the end. Region II sees a similar decline, from 48 to 19. Both regions thus experience a nearly 60 percent decline in the number of firms over this period.[36]

Our baseline qualitative discussions with builders, fishermen, and NGOs point to the boat building sector being very stable, with most businesses passing down through families from generation to generation, with little to no exit or entry in recent history. To provide support for this observation, and further visual evidence of just how unusual the decline in the number of firms around the time of mobile phone introduction was, we can construct a "pre-sample" time series of builders. For every boat that we find in our canvas of all boat landings at baseline in January 1998, we know who built it and when.[37] So we can for example look at all boats we find in January 1998 that were built around July 1997 and count up the number of unique builders of those boats. Provided there was no builder in the industry in July 1997 who had no boats surviving to January 1998, we should get a reasonable estimate of the number of builders who were building boats in the pre-sample period six months before our baseline survey. We can then do the same for all boats we find in our canvas that were built in January 1997, and further back.[38] In panel A of Figure 3, the dotted line traces back our estimates of the number of builders in the three years prior to our baseline.[39]

With these constructed pre-sample data, the evidence becomes more compelling, showing that in both regions there is no evidence of any changes at all before mobile phones are present.[40] In the case of Region II, this lack of any trend is evident even from the actual counts of firms from the canvas, but becomes even more striking

[36] These reductions are due to exit. None of the firms in our sample moved to different locations over this period. And follow up surveys reveal that all builders we code as exiting stop producing boats.

[37] Recall, this was a canvas of every boat landing throughout the two districts, and we gathered data on every boat at the landing, so we have what we believe to be an exhaustive canvas of every fishing boat in these two districts with which we should be able to identify every builder.

[38] We verify the accuracy of this method by using our final landing canvas in January 2004 to perform a similar "back-estimate" of the number of builders in the three years prior to that canvas, since for each of those years we also have a direct count of the actual number of firms. Despite this period featuring much more exit, we find a perfect correspondence between the actual and back-estimated number of firms.

[39] Aside from concerns about the accuracy of respondents' recall of purchase dates further in the past, going back more than three years might cause us to miss low-quality builders. For example, a builder whose boats last less than four years and who has since gone out of business would not have any surviving boats as of our baseline survey, so we would underestimate the number of active builders there were four years prior, which might bias us against finding a preexisting downward trend in the number of builders over time.

[40] The fact that the number of firms is stable over time of course does not suggest there was no entry or exit, only that the two were balanced. However, during our sample, all but three cases of entry or exit in Region III, or in Regions I and II prior to mobile phones, were firms that exited temporarily and returned later.

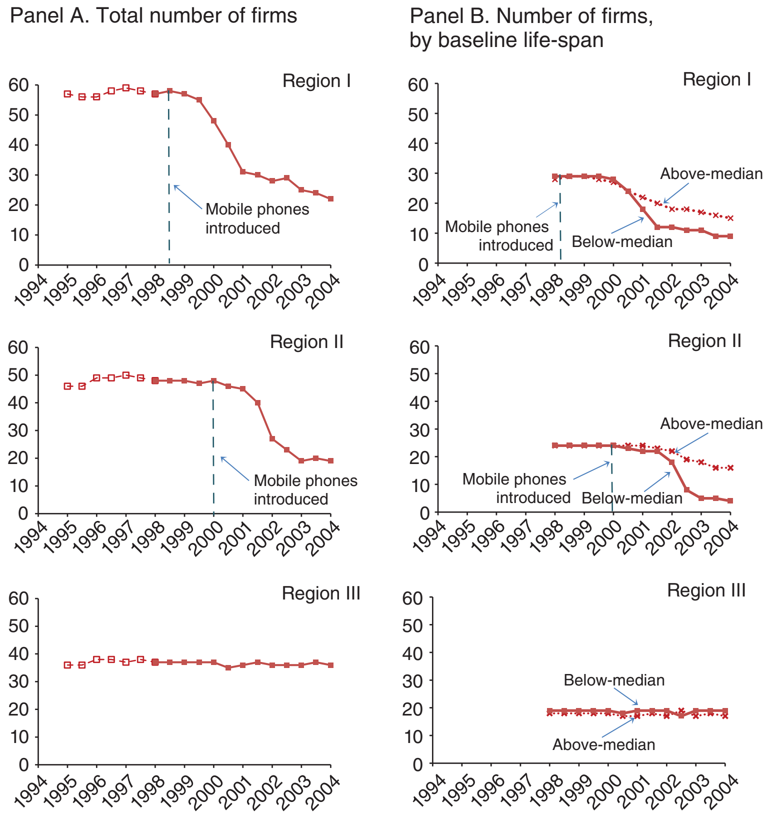


FIGURE 3. MOBILE PHONES AND THE NUMBER OF FIRMS

*Notes:* In the left-hand panels, the solid line is a count of the number of firms in each round obtained from our builder census. The dashed line is a "pre-sample" estimate of the number of firms, using the purchase dates and builder names from all boats observed in our canvas of landings. In the right-hand panels, the solid line is the number of firms with below-median life-span at baseline and the dotted lines with x-markers are the number of firms with above-median life-span at baseline.

when we also include the pre-sample estimates of the number of firms. And notably, in Region III, which did not receive phones, the number of firms is very stable over the whole survey period. Overall, the figures indicate that there was no evidence of any major changes in the number of firms other than when and where mobile phones are present.

Panel B of Figure 3 provides additional evidence to support our proposed interpretation by splitting the sample into firms above versus below the region-specific median life expectancy at baseline, using the previous-boat measure of life expectancy. The two top panels reveal that the decline in the number of firms seen in panel B of Figure 3 was heavily concentrated among those below the median baseline life expectancy (within their region). Some above-median firms do exit, and some below-median firms continue to produce, but overall it is clear that the decline is largest among lower quality builders. And, the longer pre-phone series available in Region II shows that prior to mobile phones, there was no evident differential trend in exit or entry for high- and low-quality builders.[41] Similarly, Region III, though again perhaps not as comparable, shows no differential trends in exit or entry by quality over this entire period. Overall, between the two figures we find that there was a large decline in the number of firms, which was much more pronounced among lower quality firms. These declines correspond in both regions to having received mobile phones (with about a 12–18-month lag), and there is otherwise no evidence of any decline in the number of firms, overall or by quality, before phones were available (or in Region III, which never received phones). Figures 2 and 3 together provide support for the first half of the proposed causal chain discussed above. Namely, that phones were associated with fishermen traveling to other markets to sell their catch, which improved information about non-local firm quality and the switch to non-local, high-quality builders and the exit of low-quality builders (though this does not rule out that mobile phones may have affected firms through other channels, which we explore below).

Table 2 provides the regression results for exit, market share, the number of employees, and the number of boats produced by each firm, using each measure of builder quality. Consistent with Figure 3, column 1 of panel A shows that getting phone coverage was associated with a large and statistically significant increase in the likelihood of exit. However, exit is a function of baseline quality when phones enter, as each additional year of baseline life expectancy reduces the likelihood of exit by 5 percentage points. Thus, low-quality builders are more likely to exit than high-quality ones. Panels B–D show that using the auditor's assessment, fishermen's estimates, or skill residuals for baseline quality yield very similar conclusions. The results are all statistically significant at the 1 percent level, and do not differ appreciably across the various quality measures.

Column 2 shows the effects of phones on market share, where the market is defined as the total number of boats sold in the prior six months across all three districts. The impact of phones on market share depends strongly and positively on baseline quality. In panel A, firms with previous-boat baseline quality less than 4.6 years' experience declines in market share, while those with greater quality grow. To give a sense of magnitudes, a firm at the seventy-fifth percentile of the baseline life-span distribution (5.5 years of life expectancy) gains on average about 0.43 percentage points in market share (averaged across all post-periods periods). By the final survey round, the average market share among all surviving firms in Regions I and II is 1.7 percent, which is greater than the largest market share at baseline (1.3 percent). And some firms have grown fairly large relative to the market; three firms each produce 5 percent or more of the total market. As with the regressions for exit, these results are robust to alternate measures of baseline quality, and all relevant coefficients are statistically significant at the one percent level.

Column 3 shows the results for firm size as measured by the number of employees, for consistency with the previous literature. We find that once mobile phones arrive, firms with the highest baseline quality hire additional workers. As above, the

[41] We do not provide pre-sample estimates of the number of firms based on baseline quality, since we would be unable to classify the few firms that exited (even if only temporarily) in the pre-sample period. However, if we just confine ourselves to firms that were in business at our baseline survey, we see no evidence of any preexisting differential trend in the number of firms based on baseline quality (since in general there was very little exit at all prior to the introduction of mobile phones).

TABLE 2—REGRESSION RESULTS: EXIT, MARKET SHARE, AND EMPLOYMENT

| | Exit (1) | Market share (2) | Workers (3) | Boats built (4) |
|---|---|---|---|---|
| *Panel A. "Previous boat" life expectancy (years)* | | | | |
| Phone × baseline quality | −0.0503 | 0.00464 | 0.551 | 9.177 |
| | (0.00870) | (0.000969) | (0.123) | (1.914) |
| Phone | 0.291 | −0.0212 | −2.489 | −41.96 |
| | (0.0448) | (0.00495) | (0.609) | (9.760) |
| Baseline quality | 0.00463 | −4.72e-05 | −0.00562 | −0.0991 |
| | (0.00371) | (0.000324) | (0.0358) | (0.644) |
| Observations | 1,524 | 1,524 | 1,524 | 1,524 |
| *Panel B. Auditor's assessment (years)* | | | | |
| Phone × baseline quality | −0.0270 | 0.00363 | 0.475 | 7.187 |
| | (0.00689) | (0.000867) | (0.110) | (1.713) |
| Phone | 0.162 | −0.0143 | −1.859 | −28.27 |
| | (0.0346) | (0.00404) | (0.489) | (7.970) |
| Baseline quality | −0.00173 | −0.000134 | −0.0286 | −0.269 |
| | (0.00270) | (0.000307) | (0.0242) | (0.608) |
| Observations | 1,524 | 1,524 | 1,524 | 1,524 |
| *Panel C. Fishermen's estimates (years)* | | | | |
| Phone × baseline quality | −0.0584 | 0.00556 | 0.699 | 11.01 |
| | (0.0105) | (0.00118) | (0.144) | (2.323) |
| Phone | 0.314 | −0.0242 | −3.017 | −47.82 |
| | (0.0497) | (0.00554) | (0.668) | (10.94) |
| Baseline quality | 0.00728 | −6.34e-05 | −0.0142 | −0.128 |
| | (0.00540) | (0.000414) | (0.0392) | (0.823) |
| Observations | 1,524 | 1,524 | 1,524 | 1,524 |
| *Panel D. TFP residuals* | | | | |
| Phone × baseline quality | −0.0487 | 0.00444 | 0.547 | 8.786 |
| | (0.00942) | (0.00101) | (0.125) | (1.985) |
| Phone | 0.0511 | 0.000871 | 0.135 | 1.745 |
| | (0.0148) | (0.00104) | (0.136) | (2.072) |
| Baseline quality | 0.00503 | 0.000309 | 0.00616 | 0.608 |
| | (0.00395) | (0.000305) | (0.0372) | (0.606) |
| Observations | 1,524 | 1,524 | 1,524 | 1,524 |

*Notes:* Dependent variable listed at the top of each column. Each panel represents the primary regression specification using a different measure of builder quality, indicated at the top of the panel. Regressions include region and round fixed effects. All data are from the boat builder survey. Units of observation are builder × round, with builders dropping from the sample once they have exited. Standard errors, clustered at the builder level, in parentheses.

results are all significant at the 1 percent level, and are consistent across the different measures of baseline quality. The firm at the seventy-fifth percentile of the baseline quality distribution would gain about 0.55 workers. By the end of the sample period, the mean number of employees per firm in both Regions I and II is greater than the largest firm at baseline.

Finally, column 4 approaches firm size from the perspective of output, measured in boats produced. We again find that the introduction of mobile phones increases firm size, with results consistent across the various quality measures. As above, in panel A, firms with previous-boat baseline quality below 4.6 years' experience reduced output, while those with greater quality grow. A firm at the seventy-fifth percentile of the baseline quality distribution gains around 8.5 boats (compared to a baseline average for the full sample of 14.1); further, the average surviving firm in Regions I and II produces 34 boats per year, which exceeds the largest firm at baseline, and several firms produce over 100 boats per year.

Together, the results reveal the broad changes to the industry over the period when mobile phones were added: namely, the industry moved from a large number of very small firms, to a much smaller number of larger firms.

### C. *Changes in Output and Quality*

We next turn to the impact of mobile phones and the ensuing increase in market integration on aggregate production. Before looking at the data, it is useful to differentiate between two possible interpretations of output. The simplest considers the number of boats produced. However, this measure ignores the fact that boats are durable goods, and that the life-span of the boats is a key aspect of quality. A more useful measure explicitly considers quality, or longevity, of the boats. In what follows, we focus primarily on the number of boat-years produced as our preferred measure of output. It is, however, often useful to track the impact on production of boats as an intermediate step. We use the auditor's assessment of longevity, because it can best capture any contemporaneous changes in quality over time; however, the conclusions below are robust to using the other estimates of longevity.

Since we are interested in the impact of phones on aggregate production, we begin our analysis at the regional level. Table 3 shows data on boats and boat-years produced, and measures of inputs and input costs per boat and per boat-year, aggregated across all firms within each region, drawn from our firm censuses (for ease of presentation, we present data from every other round). Many of these variables may be noisily measured or naturally fluctuate considerably from year to year. However, some clear patterns can be discerned.

The first rows of each panel of Table 3 show that the total number of boats produced in each region was fairly constant over time. While boat production is about 3–4 percent greater in the final rounds for Regions I and II compared to baseline, regression results presented in online Appendix Table 4 (column 1) show that, at the regional level, the introduction of mobile phones was not associated with a statistically significant increase in output. By contrast, the center row of each panel of Table 3 shows a clear increase in the total number of boat-years produced in both Regions I and II, with no corresponding increase in Region III. Online Appendix Table 4, column 7, confirms that the increase in the treated regions is statistically significant. Given that the number of boats essentially did not change, this implies that the boats produced after phones arrive are of higher average quality than those produced before. Indeed, in the next to last row in each panel, we see that the average life-span of a boat produced increased by 62 percent in Region I (4.2 years to 6.8 years) and 33 percent in Region II (4.4 years to 5.8 years), with no change in Region III. Figure 4 shows that this pattern holds across the entire quality distribution. There is a clear rightward shift in the distributions of life-span for Regions I and II between the first and last rounds of our sample, with little evident change for Region III.

TABLE 3—OUTPUT AND INPUTS OVER TIME: ALL FIRMS

| | Round 1 | Round 3 | Round 5 | Round 7 | Round 9 | Round 11 | Round 13 | % change (13–1) |
|---|---|---|---|---|---|---|---|---|
| *Panel A. Region I* | | | | | | | | |
| Boats produced | 696 | 726 | 703 | 671 | 685 | 711 | 720 | 3 |
| Value of capital/boat | 1.09 | 1.08 | 1.07 | 0.85 | 0.65 | 0.60 | 0.55 | −50 |
| Labor hours/boat | 391 | 388 | 339 | 293 | 288 | 290 | 249 | −36 |
| Labor value/boat | 1,236 | 1,225 | 1,082 | 924 | 911 | 913 | 780 | −37 |
| Materials value/boat | 198 | 206 | 202 | 205 | 210 | 201 | 199 | 0 |
| Variable costs/boat | 1,434 | 1,431 | 1,284 | 1,129 | 1,121 | 1,114 | 979 | −32 |
| Boat-years produced | 2,917 | 3,155 | 3,488 | 4,110 | 4,448 | 4,658 | 4,873 | 67 |
| Value of capital/boat-year | 0.26 | 0.25 | 0.22 | 0.14 | 0.10 | 0.09 | 0.08 | −69 |
| Labor hours/boat-year | 93 | 89 | 68 | 48 | 44 | 44 | 37 | −61 |
| Labor value/boat-year | 295 | 282 | 218 | 151 | 140 | 139 | 115 | −61 |
| Materials value/boat-year | 47 | 47 | 41 | 34 | 32 | 31 | 29 | −38 |
| Variable costs/boat-year | 342 | 329 | 259 | 184 | 173 | 170 | 145 | −58 |
| Average life-span of boats | 4.19 | 4.35 | 4.96 | 6.12 | 6.49 | 6.55 | 6.77 | 62 |
| Tasks per worker | 7.3 | 6.4 | 4.9 | 3.6 | 3.2 | 3.0 | 2.7 | 64 |
| *Panel B. Region II* | | | | | | | | |
| Boats produced | 752 | 727 | 722 | 720 | 745 | 759 | 782 | 4 |
| Value of capital/boat-year | 0.87 | 0.90 | 0.91 | 0.88 | 0.76 | 0.45 | 0.40 | −53 |
| Labor hours/boat-year | 390 | 394 | 394 | 373 | 320 | 286 | 252 | −35 |
| Labor value/boat-year | 1,219 | 1,236 | 1,231 | 1,168 | 1,006 | 896 | 787 | −35 |
| Materials value/boat-year | 203 | 207 | 199 | 199 | 193 | 195 | 190 | −6 |
| Variable costs/boat-year | 1,422 | 1,443 | 1,430 | 1,367 | 1,199 | 1,090 | 976 | −31 |
| Boat-years produced | 3,285 | 3,176 | 3,143 | 3,312 | 3,859 | 4,175 | 4,533 | 38 |
| Value of capital/boat-year | 0.20 | 0.21 | 0.21 | 0.19 | 0.15 | 0.08 | 0.07 | −65 |
| Labor hours/boat-year | 89 | 90 | 90 | 81 | 62 | 52 | 43 | −51 |
| Labor value/boat-year | 279 | 283 | 283 | 254 | 194 | 163 | 136 | −51 |
| Materials value/boat-year | 46 | 47 | 46 | 43 | 37 | 35 | 33 | −29 |
| Variable costs/boat-year | 326 | 330 | 328 | 297 | 231 | 198 | 168 | −48 |
| Average life-span of boats | 4.37 | 4.37 | 4.35 | 4.60 | 5.18 | 5.50 | 5.80 | 33 |
| Tasks per worker | 7.2 | 7.7 | 7.8 | 6.0 | 3.1 | 3.3 | 2.9 | 59 |
| *Panel C. Region III* | | | | | | | | |
| Boats produced | 535 | 567 | 530 | 529 | 512 | 530 | 541 | 1 |
| Value of capital/boat-year | 0.96 | 0.92 | 1.00 | 0.97 | 1.02 | 0.99 | 0.99 | 3 |
| Labor hours/boat-year | 396 | 395 | 392 | 391 | 395 | 390 | 388 | −2 |
| Labor value/boat-year | 1,241 | 1,236 | 1,230 | 1,221 | 1,233 | 1,221 | 1,210 | −3 |
| Materials value/boat-year | 196 | 199 | 196 | 198 | 198 | 201 | 199 | 1 |
| Variable costs/boat-year | 1,437 | 1,434 | 1,427 | 1,419 | 1,431 | 1,421 | 1,408 | −2 |
| Boat-years produced | 2,051 | 2,199 | 2,081 | 1,985 | 1,946 | 2,047 | 2,078 | 1 |
| Value of capital/boat-year | 0.25 | 0.24 | 0.25 | 0.26 | 0.27 | 0.26 | 0.26 | 3 |
| Labor hours/boat-year | 103 | 102 | 100 | 104 | 104 | 101 | 101 | −2 |
| Labor value/boat-year | 324 | 319 | 313 | 325 | 324 | 316 | 315 | −3 |
| Materials value/boat-year | 51 | 51 | 50 | 53 | 52 | 52 | 52 | 1 |
| Variable costs/boat-year | 375 | 370 | 363 | 378 | 377 | 368 | 367 | −2 |
| Average life-span of boats | 3.83 | 3.88 | 3.93 | 3.75 | 3.80 | 3.86 | 3.84 | 0 |
| Tasks per worker | 8.1 | 8.0 | 8.0 | 7.8 | 7.6 | 7.6 | 7.9 | 2 |

*Notes:* Value of capital, labor, and materials measured using constant, 1999 market prices in thousands of rupees. Tasks per worker for Round 1 are actually measured in Round 2.

There are two possible sources of this increase in the average quality of the boats produced in the treated regions: improvements in the quality of boats produced by a given firm, and reallocations of output to firms with higher baseline quality. Column 1 of Table 4 shows a builder-level regression of boat durability (again, using the auditor's assessment) on whether the builder's region has mobile phones. The regressions also contain builder fixed effects, so the coefficient on phones captures the effect of phones on longevity within builders. The estimated coefficients are small and not statistically significant. Thus, we cannot rule out that there was no change in quality within firms associated with the introduction of mobile phones

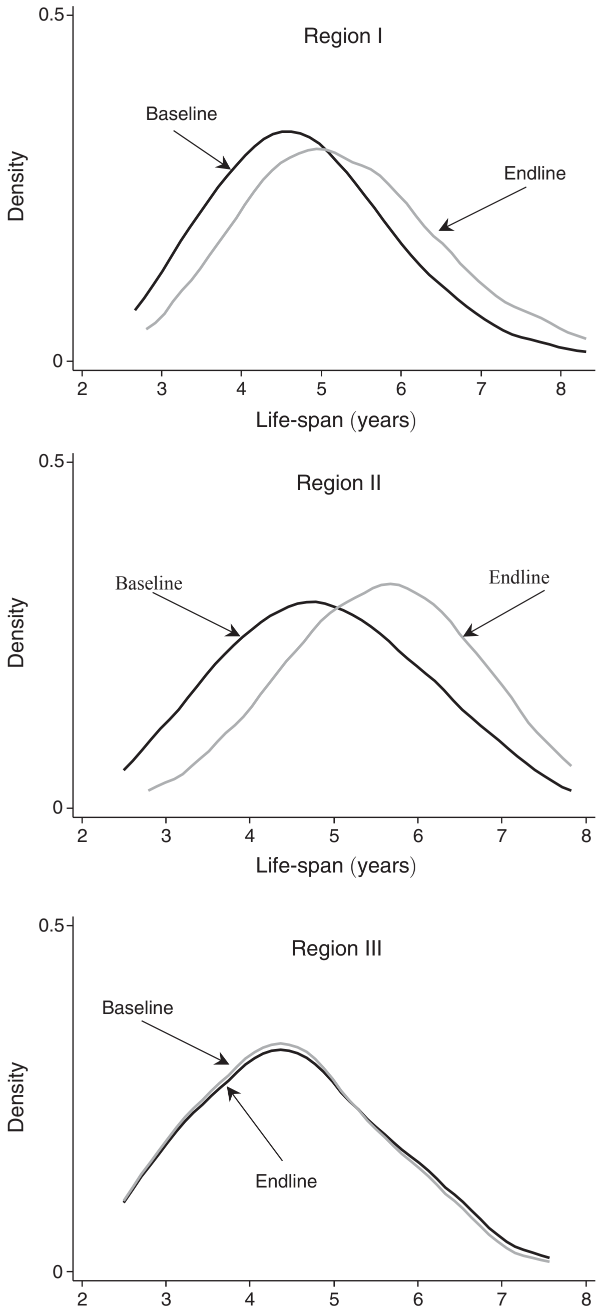


Figure 4. Distribution of Builder Quality

*Note:* Figures present kernel density estimates of the distribution of life-span for boats (based on "previous boat" estimates) in Rounds 2 (before mobile phones) and 13 (after Regions I and II have mobile phones).

Table 4—Inputs over Time: Within-Firm Estimates

| | Auditor assessment (1) | Labor value/boat (2) | Material value/boat (3) | Variable costs/boat (4) | Labor value/boat year (5) | Material value/boat year (6) | Variable costs/boat year (7) |
|---|---|---|---|---|---|---|---|
| Phone | 0.000896 | −38.89 | −0.232 | −39.17 | −6.490 | −0.0600 | −6.539 |
| | (0.0259) | (14.41) | (1.421) | (14.79) | (3.435) | (0.494) | (3.673) |
| Constant | 4.284 | 1,231 | 198.8 | 1,430 | 309.0 | 49.78 | 358.8 |
| | (0.0287) | (6.630) | (1.032) | (6.688) | (2.128) | (0.368) | (2.334) |
| Observations | 1,524 | 1,521 | 1,524 | 1,521 | 1,521 | 1,524 | 1,521 |

*Notes:* Dependent variable listed at the top of each column. All values (capital, labor, material, and variable costs) are measured in 1999 rupees. Units of observation are firm × round. Regressions include round and firm fixed effects. Standard errors, clustered at the builder level, in parentheses.

or the subsequent growth of firms.[42] This is consistent with the view that quality is largely determined by the builder's skill. The change in average quality instead comes primarily from the reallocation of market share toward better builders shown above.

### D. *Changes in Cost*

Next, we examine the impact of phones on production costs. There are three major components of cost: labor, materials, and tools or equipment (capital). Labor and materials are variable inputs and are measured in our data. For labor, we asked firms to report all workers and the number of hours they worked. To value labor, we collected data on locally prevailing wages from a separate community survey.[43] For material inputs, we asked firms about the amount of materials, the quality of the materials, and their prices.[44]

For capital, we took an inventory of every tool and piece of equipment used by the firm. Since tools and equipment are durable goods and they are largely fixed with respect to output (e.g., the number of hammers does not increase linearly with output), ideally we would include the rental price of these inputs, taking into account their current quality. However, while we observe current purchase prices for new goods, we do not have measures of the current quality or value of tools purchased in the past, and we cannot observe rental prices.[45] Consequently, our measure of a

[42] Effects could have been expected in either direction. There could be quality gains as workers specialize in tasks (as shown below). However, the newly hired workers are less experienced and less skilled than the original builder (though many of the tasks taken on by newer employers require less skill, and are also less likely to affect boat quality, such as purchasing inputs, cleaning up, or cutting wood).

[43] We also asked the builders in our survey for wage payments. However, at baseline many firms are just an owner and their son, and there are no formal wage payments.

[44] The primary inputs used are wood and coir. Boats are built using on average 19 linear meters of jackwood planks and 23 meters of coir rope. There are a few other smaller inputs used sporadically by some builders (such as home-made wood treatments, for example), but they are fairly uncommon and show up mostly as zeros when looking at means.

[45] In rounds 6, 8, 10, and 12, we collected data on the value of tools and equipment as reported by builders. The correlation between the value of tools from builders' estimates and from market price surveys is 0.63. More importantly, we don't find any systematic patterns whereby in regions that got phones, market price valuation

firm's capital stock involves valuing each tool at average market prices (collected from a separate survey), recognizing that doing so misses any quality variation in tools and equipment. And, since this index measures the value of the stock of capital rather than the flow of capital services the tools and equipment provide, we cannot simply add it to variable cost to create a measure of total cost. Consequently, in our analysis we will consider variable costs (labor and materials) and fixed costs (tools and equipment) separately.

Table 3 shows that the average variable cost (materials and labor) of producing a boat decreased by about one-third in both Regions I and II, with no appreciable change in Region III. Decomposing variable cost into labor and materials, we see slightly different patterns emerge. The arrival of phones had little effect on the materials cost per boat. This is to be expected, since the physical specifications of the boats do not change. With respect to labor, Regions I and II show respective declines in the labor cost of producing a boat of 37 and 35 percent, while labor cost per boat declined by only 3 percent in Region III. Thus, the decline in the variable cost of producing a boat is driven primarily by a decrease in labor costs. Regression results in columns 4–6 of online Appendix Table 4 confirm these findings.

The cost improvements are even larger when accounting for quality, with average variable cost per boat-year in Region I and Region II declining by 58 and 48 percent, respectively, while Region III declined by only 2 percent. Unlike in the case of the cost of producing a boat, both materials and labor contribute to the decline in the cost of producing a boat-year. Materials cost per boat-year declines by 38 percent in Region I and 29 percent in Region II, compared to almost no change in Region III. The improvements in labor cost are somewhat larger, with declines of 61 and 51 percent in Regions I and II, respectively, relative to a decline of around 3 percent in Region III. Regression results presented in columns 10–12 of online Appendix Table 4 confirm that the declines when phones are added are statistically significant.

There are several possible sources of the observed decrease in the average variable cost of producing a boat or boat-year. The first is a compositional effect. As we saw above, increased market integration via phones increased the exit probability of low-quality firms and reallocated market share toward high-quality firms (Table 2). However, the cost of labor and materials per boat did not vary significantly with quality at baseline,[46] and therefore there is a strong, negative correlation (−0.93) within firms between baseline life expectancy (using the auditor's assessment measure) and variable cost per boat-year. Thus, the arrival of phones also shifted market share toward low-cost firms and increased the exit probability of high-cost firms. Consequently, we expect that reallocation of market share across firms will play a role in the cost reduction.

In addition to this cross-firm effect, there is also the possibility for within-firm effects on average variable cost. The potential gains here could take two forms. A firm's average variable cost could decrease either because the quality of the boats

underestimates the (builder-reported) value of capital, or that any such underestimation is increasing over time. Thus, it seems unlikely that our approach to valuing tools causes us to systematically miss any tool quality upgrading that would cause us to overstate the extent of gains in productivity with respect to capital.

[46] If we regress variable cost per boat on the auditor's assessment of longevity, focusing just on the baseline round, the coefficient and standard error are 0.0004 and 0.001.

the firm produces increases, or because the firm is able to produce boats of a given quality while spending less on materials or labor. As discussed above, we can reject the hypothesis that the arrival of phones led to substantial quality improvements within builders. Consequently, any within-firm improvements we observe will be driven primarily by increases in efficiency, i.e., improvements in the cost of producing boats of a given quality.

As mentioned earlier, there is little scope to produce a boat of fixed specification using less materials (e.g., wood), and, as expected, we find no impact of phones on a builder's materials cost per boat. Firm-level regressions with builder fixed effects shown in Table 4 confirm this finding. Turning to labor, we find strong evidence in support of the hypothesis that the market changes caused by phones induced firms to produce boats of a given quality at lower labor cost. As shown in Table 4, phones lead to significant declines in labor cost per boat and per boat-year within builders. In the next subsection, we will argue that this decrease is due to firms exploiting returns to labor specialization as they increase their scale.

To give a sense of the relative importance of cross-firm reallocations and within-firm efficiency improvements in lowering costs, we can decompose the observed change in aggregate average variable cost as follows. Let $c_i^B$ be the average variable cost of a boat-year produced by firm $i$ at baseline and $c_i^E$ be the average variable cost of a boat-year produced by firm $i$ at endline. Let $m_i^B$ and $m_i^E$ denote market shares at baseline and endline, respectively, with the understanding that $m_i^E = 0$ for firms that exit.[47] Let $S$ denote the set of firms that survive to the final round of the survey. Average variable cost at baseline is therefore equal to $\sum_i m_i^B c_i^B$, and average variable cost at endline is $\sum_{i \in S} m_i^E c_i^E$. Subtracting the two and rearranging yields

$$(2) \qquad \sum_{i \in S} m_i^E c_i^E - \sum_i m_i^B c_i^B, \quad \text{or}$$

$$(3) \qquad \left\{ \sum_{i \in S} m_i^E c_i^E - \sum_{i \in S} m_i^E c_i^B \right\} + \left[ \sum_{i \in S} m_i^E c_i^B - \sum_i m_i^B c_i^B \right].$$

Here, the first difference in the second line (in curly brackets) is the change in variable cost per boat-year for firms that survive to the end of the survey, weighted by market share. The second difference (in square brackets) is the change due to market share reallocations and exit, computed using baseline costs. Computing these quantities for our data, we find that market-share weighted average variable cost decreased by 138 rupees/boat year overall, with nearly equal shares from both components: 70 rupees attributable to the decrease in the average variable cost of a boat-year produced by survivors, and 68 rupees coming from changes in market share and exit.[48]

For the sake of brevity we will not repeat the analysis above for capital, but we find a similar qualitative pattern in terms of the cost of capital. In Table 3, we

[47] This decomposition is similar in spirit to the type of decompositions performed in the productivity literature (e.g., Olley and Pakes 1996; Melitz and Polanec 2015).

[48] If we focus just on labor costs, the change is 127 rupees, 67 (53 percent) of which comes from changes within survivors, and 60 (47 percent) of which comes from changes in market share and exit.

see that the value of capital per boat declined by around 50 percent in Regions I and II but increased slightly (3 percent) in Region III, and the value of capital per boat-year declined by 65–70 percent in Regions I and II but increased by 3 percent in Region III. Once again, it is possible that either within-firm improvements or reallocations toward lower-cost firms could account for the decrease in capital cost per boat-year. However, unlike in the case of variable cost, we find that capital cost per boat-year is only weakly correlated (−0.34) with quality at baseline, leaving little scope for reallocation to play a role in the improvement in capital costs.[49] Performing a decomposition similar to the one described above for the variable cost of a boat-year, we find that the decrease in capital value per boat year is driven almost entirely by within firm improvements. Importantly, because both capital and variable input costs decrease, the improvements we observe in variable costs are not merely due to greater use of capital, and the improvements in the cost of capital are not merely due to greater use of variable inputs.

From our observation of these builders, a likely explanation for the within-firm improvements in the value of capital per boat-year is that tools often sit idle in small firms. For example, in a single person firm, the builder cannot simultaneously saw, drill, and weave together the wood planks.[50] However, as firms expand the number of workers they employ and the number of boats they build, idle capital time decreases, and firms can produce more output using the same amount of capital. More generally, tool utilization rates tend to increase with firms' scale, which reduces the value of capital per boat and boat-year.

One potential concern with this explanation is that if tools are used more intensively, depreciation may accelerate, which would confound our results. For example, if depreciation were perfectly linear in use, then capital requirements, properly accounted for, would vary only with the number of boats produced, with no resulting productivity gains.[51] However, since our survey collected information on both capital stock and new capital purchases at each round, we can provide some suggestive evidence that depreciation does not scale significantly with use. First, we exploit the fact that even at baseline, some firms produce more boats than others (as noted in Table 1). We find that new capital expenditures in the past year are less than 5 percent greater for firms in the top quartile of the distribution of baseline production compared to those in the bottom quartile, despite the fact that they produce 2.5 times as many boats per year (20 versus 8) and are using the same capital and nearly identical production processes. Second, we can examine annual capital purchases over time in Region III, where firms did not grow (in the other two regions, it is difficult to distinguish capital purchases over time designed to increase production

[49] Potential reasons for this weaker correlation include the lumpiness of capital expenditures and the difference between the stock value of capital that we measure and the flow value of capital into production, as discussed earlier.

[50] Imagine a simplified boat building process with three steps: the wood is first cut using a saw, then holes are drilled in the wood using a hand drill, and lastly, planks are mounted on stands and woven together. In a one-person firm, the builder does each of these steps in sequence. So while he is cutting the wood, the hand drill and stands are idle; while he is drilling the holes, the saw and stands are idle; and during weaving and final assembly, the saw and drill are idle. Adding workers to the firm can increase output without the need for more capital either by having workers operate separate production lines and sharing tools or by using a single assembly line where workers specialize in particular tasks associated with different tools. Of course, at some point greater scale would require some additional tools.

[51] In other words, we might see the capital stock appear to be almost constant over many periods, whereas in fact the increased intensity of use has caused capital to be replaced every few periods.

from purchases to replace depreciated capital). Overall, across the six years of data we collected, new spending on capital was on average only 18 percent of the value of firms' capital stock at baseline (and some of the implied depreciation may be due to age (rot or rust), accidental damage (e.g., dropping something on them), or loss or theft, rather than as a result of usage). The qualitative arguments above and both pieces of evidence suggest that depreciation will not increase dramatically as firms increase in scale, suggesting that the gains in output relative to capital will remain significant.

### E. *Economies of Scale and Returns to Labor Specialization*

The within-firm improvements in the variable cost of producing a boat identified in the previous subsection are of particular interest. As discussed, since the materials cost per boat does not change much, the improvement in variable cost is driven primarily by improvements in the labor cost of producing a boat. One possible explanation for decreased labor cost per boat following the arrival of phones is that the arrival of phones reallocated output to high-quality firms, and as these firms grew their average variable cost of production decreased, i.e., they experienced economies of scale. Using a locally-weighted regression smoother, panel A of Figure 5 plots, at the builder level, log variable cost of producing a boat as a function of the log of boats produced. The relationship between output and variable cost is fairly flat up to a log-output of about 2.5 (about 15 boats) and declines approximately linearly after that. The slope of this downward-sloping segment is around $-0.2$, suggesting that a 10 percent increase in output is associated with around a 2 percent decrease in average variable cost. Thus, we see evidence consistent with downward-sloping average cost (i.e., economies of scale) over a broad range of outputs.

Panel A of Figure 5 is largely unchanged if, instead of using all survey rounds, we focus only on the final rounds. This suggests that what we see is not evidence of a downward shift in the firms' cost function as would occur following an increase in total factor productivity. In other words, we do not see that individual firms are able to produce the same output using fewer inputs. Rather, as the firms increase their scale they are able to produce output at lower average cost.

One possible explanation of these economies of scale is that as firms grew they were able to exploit returns to labor specialization, as in the classic case of the pin factory described by Adam Smith (1776). The primary time-intensive tasks in these firms are: obtaining inputs, cutting, shaping, drilling, sanding, fastening, finishing/treating, customer relations, cleanup, and management and supervision. While some of these tasks, in particular the finishing and fastening of the boards, are highly skilled and related to quality, other tasks are unskilled and can be safely delegated without affecting quality.

We asked questions on the allocation of each worker's time to each of these tasks as part of our boat builder survey. The bottom rows of each panel of Table 3 reports the average number of tasks performed by each worker and shows that after the arrival of phones, labor specialization increased dramatically. Across all three regions, at baseline, the average worker in a firm performed about 7–8 of the measured tasks. In essence, in the small, two person firms common at baseline, both workers performed almost all tasks, with only a few exceptions (e.g., the owner

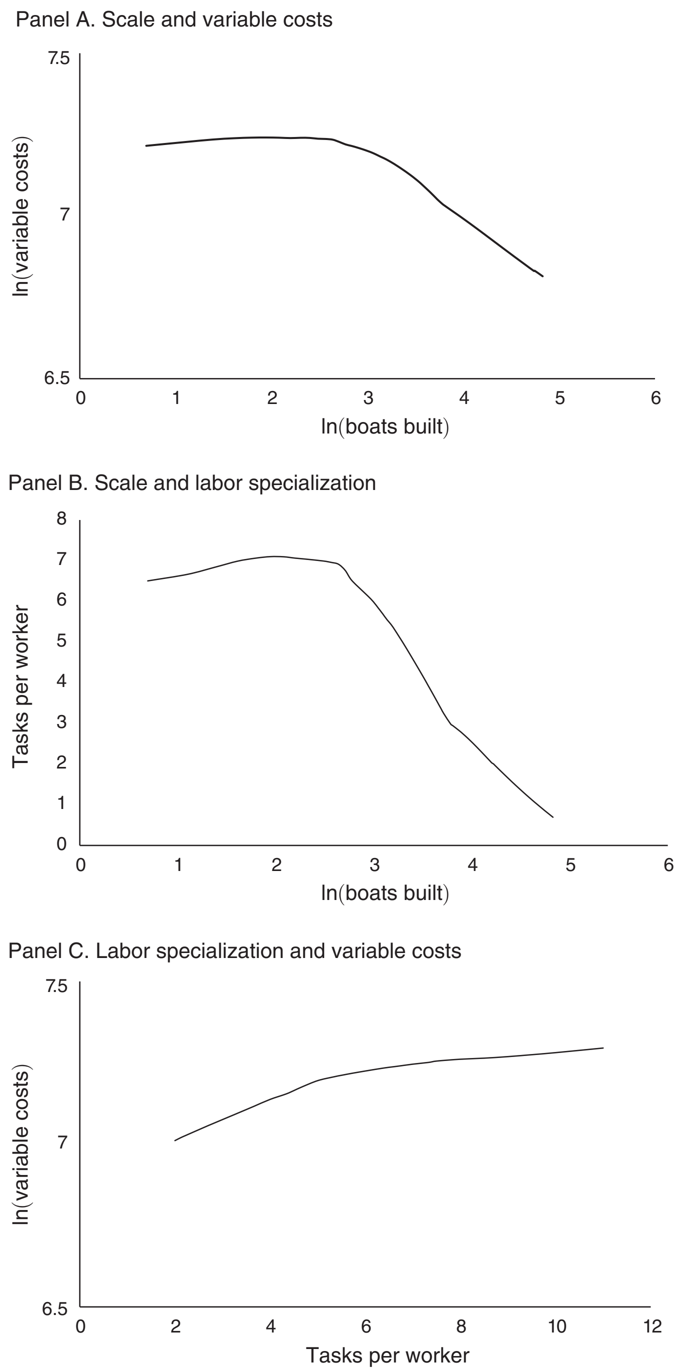


Figure 5. Economies of Scale and Returns to Labor Specialization

*Notes:* Data from the boat builder survey. *y*-axis of panels A and C show log of variable costs per boat produced. *y*-axis in panel B and *x*-axis in panel C show the average number of tasks per worker in the firm. *x*-axis in panels A and B are boats built in the past six months.

typically handled all customer relations, as well as management and supervision). However, in Region I, within two years of phones entering, the average worker performed only around three tasks, less than one-half of the baseline number. In Region II, again, because there is a longer period before phones are in place, we see more clearly that there was no change in the number of tasks performed by workers before mobiles phones were in place, but the decline is evident after mobile phones become available. By contrast, in Region III, there is essentially no change in the number of tasks performed per worker. Online Appendix Table 4, column 14, shows that the decline in tasks per worker (i.e., increase in specialization) associated with mobile phones is statistically significant.

We do not believe that phones affected specialization directly. Rather, phones increased the typical firm's scale, and firms increased specialization as they increased their scale. Panel B of Figure 5 plots the relationship between (log) output and tasks per worker. Although there is perhaps a slight upward trend in tasks per worker up to around 15–20 boats produced, there is a clear negative association as scale increases above that level. The relationship mirrors the relationship between log output and log variable cost depicted in panel A. Finally, panel C of Figure 5 plots the relationship between average tasks per worker and average labor cost (in logs) directly. As expected, we see that tasks per worker and average labor cost are positively related, i.e., that average labor cost decreases with specialization. Thus, although these figures do not establish causality, the data are consistent with the story that the arrival of phones shifted output toward higher-quality firms, which, as they expanded, were able to increase labor specialization and enjoy economies of scale in production.

As firms grow, owners generally tend to focus more on finishing and fastening, the two most skill-intensive tasks. For example, at endline, owners of the largest firms (those with 4 employees or more) devote almost 80 percent of their time to these two tasks alone. This compares to only 30–40 percent for those same owners at baseline, or owners of smaller firms at endline. Newer employees (typically, relatives) tend to specialize in less skilled tasks, particularly cutting the wood and cleaning up (24 percent of time in large firms at endline, compared to 10–15 percent at baseline and for small firms at endline). Given the skill intensity of some key aspects of boat production, this division of labor likely also helps the firm increase output, particularly in the short run when there is not enough time to find or train workers for skilled tasks. However, the ability of the firm to further grow may eventually hit limits; once the skilled builder is devoting all of their time to just the highest skill tasks, and is working at their maximum capacity, the firm will not be able to expand output without other workers also being able to perform the high skill tasks.

### F. *Gains for Consumers*

Table 5 shows estimates of changes for consumers (fishermen). For all fishermen who reported buying a new boat in the six months prior to the survey, we regress changes in price, life expectancy, and price per boat-year on a dummy variable equal to 1 in all periods in which the fisherman's region has mobile phones.

The first column shows that the introduction of mobile phones is associated with a statistically significant 173 Rs increase in the price of boats on average. This represents about a 4 percent increase over the baseline mean. However, the average life

Table 5—Pooled Treatment Regressions: Consumers

| | | | | With builder fixed effects | | |
|---|---|---|---|---|---|---|
| | Price (1) | Assessed life expectancy (2) | Price per boat-year (3) | Price (4) | Assessed life expectancy (5) | Price per boat-year (6) |
| Region has phone | 173.3 | 1.354 | −207.3 | 146.3 | −0.0325 | 34.56 |
| | (54.95) | (0.330) | (51.10) | (67.18) | (0.0345) | (17.85) |
| Constant | 4,034 | 4.039 | 1,062 | 4,098 | 4.753 | 950.9 |
| | (38.48) | (0.113) | (25.09) | (43.30) | (0.0277) | (11.62) |
| Builder fixed effects | No | No | No | Yes | Yes | Yes |
| Observations | 3,001 | 3,001 | 3,001 | 3,001 | 3,001 | 3,001 |

*Notes:* Dependent variable listed at the top of each column. Prices are in 1999 rupees, life expectancy measured in years. Data drawn from the fishermen survey. The sample is restricted fishermen who bought a boat in the six months prior to each round's survey. Regressions also include round fixed effects. Builder fixed effects in columns 4–6 are for the identity of the purchased boat's builder. Standard errors, clustered at the village level, in parentheses.

expectancy of a boat purchased (again using the auditor's assessment in order to capture any quality changes for newly built boats) increased by 1.35 years (column 2), which is a 32 percent improvement. As a result, the cost per boat-year dropped 207 Rs, or 20 percent. For fishermen, boats are by far the largest business expenditure, so this price decline is likely to represent a substantial welfare improvement. However, these are just the effects at most a few years after phones are introduced. As production grows more concentrated into fewer firms, firms may begin to exercise greater market power, potentially eroding consumer gains.

We can use builder fixed effects (which builder the boat was purchased from) to provide insight into how much of the changes above were driven by changes within surviving firms and how much is due to a reallocation in sales across firms. Column 4 of Table 5 shows that the coefficient on having phones is largely unchanged when we add builder fixed effects. Thus, the overall increase in price observed appears to be driven primarily by increases in prices within surviving firms rather than reallocation across firms with different prices initially. This is perhaps not surprising since, as noted, before mobile phones, there was no correlation between prices and builder quality.

By contrast, adding builder fixed effects to the regressions for life expectancy drives the coefficient on phones close to zero. In other words, the increase in life expectancy of boats purchased comes almost entirely from reallocation toward firms that were already higher quality, with little gain in quality for surviving firms.

Finally, in the last column, adding builder fixed effects actually reverses the sign of the effect of phones on price per boat-year. Column 3 shows that the average boat purchased has a lower price per year of boat life once phones are introduced, but column 6 suggests that this is largely the result of reallocation of sales toward higher quality firms. These firms increased their raw prices while providing largely the same quality boat as before. Thus, the price per year of boat life charged by these surviving firms has actually increased. This also demonstrates that fishermen who lived in villages with low-quality builders gained the most (much longer lasting boats at only somewhat higher raw prices), while those who lived in villages with high-quality builders actually lose: they buy boats that last just as long as the ones they bought before, but now they pay a higher price for those boats (about 3 percent per year of boat life).

## V. Relationship to the Melitz Model of Trade Liberalization

Although our analysis is not intended to be a formal test of the seminal Melitz (2003) model of intra-industry reallocation following trade liberalization, it does provide a detailed illustration of the kind of dynamics that model predicts. The Melitz model considers the steady-state equilibrium in a monopolistically competitive industry with heterogeneous firms that differ in productivity.[52] Although we will not reproduce the entire model here, a brief synopsis helps to motivate the model's empirical predictions.

In the model, there is a continuum of firms, each of which produces a different variant of a horizontally differentiated good. The firms differ in productivity (i.e., the marginal cost of producing output of a particular quality, or the quality of output produced by a given level of expenditure), produce output at constant, firm-specific marginal cost, and face an irreversible fixed cost of entering the market. Firms learn their productivity parameter only after entering the industry, at which time they may choose to remain in the industry or exit. Consumers have identical, constant elasticity of substitution (CES) demand. Under CES demand and profit-maximization, relevant firm-level variables of firms can be ranked in terms of the firms' productivity. Thus, CES demand allows the model to consider heterogeneous firms while remaining highly tractable. Relative to low-productivity firms, high-productivity firms exhibit larger profit-maximizing quantities, revenues, and profits, and lower prices.

Potential entrants into the industry face a fixed cost of entry, and existing firms operating within the industry face a constant probability of an exogenous shock causing them to exit. Thus, firms first decide whether to enter the market. If they choose to enter, they pay the fixed cost of entry and learn their (permanent) productivity. At this point, the firm can choose to operate, choosing a price and quantity, or exit.

Two conditions characterize the steady state equilibrium. First, the marginal (i.e., "cut-off") firm operating in the industry must earn zero profit in the steady state. Second, the marginal potential entrant into the industry must expect to earn zero profit. That is, the average profit of firms that operate in the industry must just equal the fixed cost of entry. These two conditions combine to determine the steady state equilibrium, characterized by (i) the cut-off productivity level such that firms with higher productivity operate in the steady state and firms with lower productivity do not, and (ii) the average profit of firms that operate in the steady state.

In the open economy equilibrium with a number of identical countries, firms are partitioned in terms of their productivity (provided the fixed cost of exporting is large enough relative to the fixed cost of entry). The most productive firms operate in both the domestic and export markets. A range of less productive firms operates

[52] The model expands on Hopenhayn's (1992a, b) work on endogenous selection with heterogeneous firms and Dixit and Stiglitz's (1977) model of monopolistic competition.

domestically but does not export, and the least productive firms exit the industry immediately upon learning their productivity parameter.

The main empirical predictions of the Melitz model concern the impact of opening the economy to trade when firms face a fixed cost of exporting, independent of export volume (in addition to any variable costs of exporting). Our paper differs from Melitz in that the increase in market integration is due to increased information about non-local builders and, possibly, decreased travel costs (since fishermen are traveling to non-local markets in order to sell fish anyway), rather than the removal of formal trade barriers. Nevertheless, our environment provides an opportunity to evaluate the full set of Melitz predictions.

In the Melitz (2003) model, opening the market to trade yields the following predictions:

(i) *Exit:* Exposure to trade leads the least productive firms to exit.

(ii) *Market Share and Profit:* The most productive firms (i.e., highest quality) increase market share and profit. The least productive firms decrease market share and profit.

(iii) *Productivity:* Exposure to trade increases average productivity (quality) and average profit per (operating) firm.

(iv) *Export Status:* After exposure to trade, firms that continue to operate are partitioned into two groups. The most productive (i.e., highest quality) firms sell both domestically and export, while a range of moderate productivity firms serve only their domestic markets.

(v) *Variety:* Product variety increases (i.e., within a market, consumers purchase from a greater range of producers).

Predictions (i)–(iii) on Exit, Market Share, and Productivity (quality) were verified in the previous section. Column 1 of Table 6 shows that the introduction of mobile phones increased overall monthly profits (panel A) but decreased profits for low-quality firms and increased profits for high-quality firms (as shown by the negative effect of phones but positive interaction of phones with baseline quality in panel B), completing Prediction (ii).

There is also evidence consistent with Prediction (iv). The model makes no specific predictions on a cut-off for how firms will be partitioned by quality. However, we note that for example in panel B of Figure 3, some firms in Regions I and II that were below the median for their region at baseline still remain in business by the end of our sample period. Even if we trace these firms back to the beginning of our sample period, we do not find a single fisherman from outside their village who reports having bought a boat from them. By contrast, by endline, all but four of the surviving above-median firms sell at least one-half of their output to fishermen from outside their village.

The issue of variety in Prediction (v) is slightly more complicated, since all buyers purchase a single boat and boats differ primarily in quality. However, if,

Table 6—Additional Results for Testing Melitz and Melitz-Ottaviano

| | Firm-level tests | | | | | Village/market-level tests | |
|---|---|---|---|---|---|---|---|
| | Profits (1) | Price (boat) (2) | Price (boat-year) (3) | Markup (boat) (4) | Markup (boat-year) (5) | Wages (6) | Product diversity (7) |
| *Panel A. Overall effect* | | | | | | | |
| Phone | 1,228 | 136.6 | 12.48 | 197.7 | 37.41 | −0.118 | 0.125 |
| | (694.5) | (47.63) | (17.22) | (59.45) | (14.71) | (0.318) | (0.0348) |
| Observations | 1,521 | 1,521 | 1,521 | 1,521 | 1,521 | 1,858 | 1,858 |
| *Panel B. Differential effect by quality* | | | | | | | |
| Phone × baseline quality | 2,652 | 12.97 | −27.55 | 60.41 | −17.79 | 0.342 | −0.114 |
| | (558.4) | (35.29) | (16.60) | (41.18) | (11.73) | (0.154) | (0.0178) |
| Phone | −11,903 | 70.81 | 165.8 | −103.9 | 135.2 | −1.783 | 0.683 |
| | (2,864) | (181.5) | (83.59) | (212.0) | (60.82) | (0.794) | (0.0954) |
| Baseline quality | −2.839 | 17.06 | −186.0 | 26.44 | −106.7 | −0.168 | 0.00388 |
| | (120.6) | (20.10) | (14.81) | (19.99) | (9.129) | (0.0962) | (0.00550) |
| Observations | 1,521 | 1,521 | 1,521 | 1,521 | 1,521 | 1,858 | 1,858 |

*Notes:* Dependent variable listed at the top of each column. Baseline quality is measured using our "previous boat" estimates of life expectancy. For the first five columns, observations are builder × round, using data from the builder survey. For the last two columns, observations are village × round, using data from the village survey. Regressions include region and round fixed effects. Standard errors, clustered at the builder level for columns 1–5 and at the village level in columns 6 and 7, in parentheses.

analogous to Melitz, we define the variety of products in a market to be equal to the number of sellers who sell boats in that market, then we do find an increase in variety after the introduction of phones. Using our main specification, column 7 of Table 6 takes the landing spot/village as the unit of observation rather than the firm, and examines the number of different builders associated with boat purchases in the past six months by fishermen in a given village. The introduction of mobile phones to a landing spot's region is associated with an increase in the number of different builders represented among recent purchases (upper panel) and that diversity increases more in villages that had a low-quality builder at baseline (lower panel). The overall increase in variety was small (from around 1 builder prior to mobile phones to 1.13 after), likely due to several factors: the fact that this is an average across all post-phone periods, and not all fishermen switch builders right away; the fact that fishermen from villages that already had high-quality builders won't see any benefit to switching, and will continue to purchase locally; and the fact that there is much less variation in the distribution of quality among remaining firms after low-quality firms have exited (see Figure 4), so fishermen from any particular village are likely to settle on the same builder, choosing one nearby rather than one that is more distant but of roughly similar quality.

Melitz (2003) proposes two possible channels for the intra-industry reallocation associated with exposure to trade. The first, which is explicitly modeled in Melitz (2003), operates through the labor market. Since labor supply is inelastic in this model, when firms expand output in order to export, this puts upward pressure on wages, and only the most productive firms can operate in the more competitive labor market. The least productive firms exit. The second channel echoes the imports-as-market-discipline hypothesis discussed in the introduction. Opening a market to trade introduces new competitors that are often more productive, on average, than domestic firms. This increase in competition induces firms to lower their prices, which, in turn, leads the least productive firms to exit as they cannot compete on price in this environment. Melitz (2003) notes that this pro-competitive channel cannot operate in that paper's model because the CES demand structure implies that the elasticity of the residual demand curve facing any firm does not depend on the number of competing firms or on the prices they charge. However, Melitz and Ottaviano (2008) consider a model with linear demand, which allows for endogenous markups, and shows that trade induces more aggressive competition, which in turn leads to pro-competitive intra-industry reallocations. In addition to the basic predictions of the Melitz model discussed above, Melitz and Ottaviano (2008) predict that this pro-competitive channel should lead to lower prices and markups among surviving firms.

Although the input market and pro-competitive channels need not be mutually exclusive, our data allow us to investigate the extent to which each seems to be operating. With respect to the labor-market channel, column 6 of Table 6 (top panel) shows that the introduction of mobile phones had no overall effect on market-level wages. This is, perhaps, not surprising in a setting where a significant amount of production tasks are unskilled and there is a large population of underemployed or unemployed labor. Indeed, the Melitz model assumes an inelastic supply of labor, which seems unlikely to apply in our case. The bottom panel adds an interaction for the quality of the local builder at baseline. The coefficient on phones is negative, suggesting an average decline in wages overall. The interaction term is positive, suggesting an increase in wages for villages with the highest quality builders. However, these effects are small. For the firm at the seventy-fifth percentile of the quality distribution, wages would increase by less than 0.1 Rs per day, from a base of around 34. For a firm at the twenty-fifth percentile, wages would decrease by 0.42 (about 1 percent).

With respect to pricing, column 2 of Table 6 shows that boat prices increase following the arrival of phones, consistent with the results from the previous section.[53] Column 4 shows that when measured in terms of raw boat prices, markups appear to have increased. When measured in terms of prices per year of boat life (column 5), the point estimates are much smaller. However, these regressions pool all periods after the arrival of phones in Regions I and II. As Melitz and Ottaviano (2008) note, the pro-competitive effects on prices and markups materialize only after exit and reallocation of market share occur. Returning to panel A of Figure 3, we see that exit does not begin until several rounds after phones arrive, and it takes a number of additional rounds after that before the number of firms in the industry stabilizes. Thus, a cleaner test of the pro-competitive channel would examine markups only after the market has had time to adjust.

Although this must be treated as only suggestive, online Appendix Table 5 breaks the post-phone period into early and late periods, where the late period is defined as

[53] The most appropriate comparison is to columns 4 and 6 of Table 5, which look at changes in prices within firms. However, the results will not match perfectly because Table 6 uses the firm as the unit of analysis. For Table 5, fishermen (boat buyers) are the unit of observation, and thus changes in firm pricing behavior are effectively weighted by firms' market shares.

the final three survey rounds (11–13). The effects on wages (column 6) remain small and not statistically significant in both the early and late post periods. However, in the late period, we now see negative effects on price (column 2), price per boat-year (column 3) and markup per boat-year (column 5) that is broadly consistent with pro-competitive forces driving the reallocations we observe after the arrival of phones (though only the price per boat-year effect is statistically significant). Thus, although our evidence on pricing and markups from the entire post-phone period does not directly support the pro-competitive channel, there is some suggestive evidence in support of this channel toward the end of our sample.

## VI. Alternative Explanations and Mechanisms

We argue that increased potential market size due to fishermen learning about heterogeneous builder quality led to the observed changes in the industry. In this section, we consider several potential empirical challenges and alternative mechanisms.

We start generally by noting again that Figure 3 shows that there were large declines in the number of firms after the introduction of mobile phones in Regions I and II, and that these changes occurred at two distinct points in time. In addition, there is no evidence of any changes or general trends prior to mobile phones being introduced in these two regions, nor any evident changes in Region III, which never received phones. Further, in Regions I and II, the changes disproportionately affected firms producing the lowest quality boats. Of course, any fixed differences across the regions, or any common or state-level changes (laws or regulations, input prices, new technologies, etc.) that affected all regions equally, could not explain the results. Challenges to our identifying assumption would have to come from factors that changed around the same two points in time as phones arrived in Regions I and II, and in a way that would differentially affect high- and low-quality firms, but that did not affect Region III and were not evident in any earlier periods. It is of course difficult to rule out every possible factor that might change. However, we will consider a few of the most significant possibilities. Additionally, we need to consider whether mobiles phones might have affected the sector through mechanisms other than those in our proposed causal chain. Some of the discussion that follows draws on Jensen (2007), which explored similar challenges because the same natural experiment was used.

*Other Infrastructure*.—Although the construction of mobile phone towers represented a major investment in telecommunications infrastructure, there is no evidence that this was accompanied by any other changes in infrastructure. Mobile phone towers were constructed entirely by private companies. And as discussed in Jensen (2007), the sequencing of when different towers were constructed was driven largely by licensing and technical factors (the availability of equipment and engineers). Further, the big cities where the towers were located already had adequate power supply for the towers, so there was no upgrading of the public electricity infrastructure. Finally, the boat builder and fishermen surveys asked about access to electricity. Column 1 of online Appendix Table 6 shows that there was no change in access to power associated with the timing of mobile phone introduction across the regions.

*Push versus Pull Factors*.—Another possibility to consider is whether other businesses became more attractive to boat builders, pulling them to other industries (as opposed to decreased demand for boats pushing some builders away from boat building). For example, Jensen (2007) shows that the profitability of fishing itself increased when mobile phones were introduced (by 8 percent), and perhaps this pulled in some builders. However, we believe that it is unlikely that exit was driven more by the increased attractiveness of outside opportunities. First, both at baseline and throughout the survey, boat building remains a profitable industry. For example, the average boat builder earns approximately 60 percent greater net income than the average fisherman. Further, in follow-up surveys tracking exited builders, the average ex-builder suffered an income loss of approximately 36 percent.[54] Further, we find no difference in profits at baseline between low- and high-quality builders (the point estimates suggest slightly greater profits for the low-quality builders, though the difference is not statistically significant); thus, it is not clear why the low-quality builders would have been more likely to choose to exit boat building (unless we assume that low-quality builders had higher expected profits in the alternative employment opportunity than high-quality builders, though there is no obvious reason why that might be the case).

*Income and the Demand for Boats and Boat Quality*.—As noted, over this time period fishing became more profitable. This in turn could have led to increased demand for boats. However, any such aggregate increase in total demand itself would perhaps be unlikely to lead to exit in the builder market; if anything, it might allow lower quality firms within a region to remain in business. A decrease in demand could lead to increased exit, which could occur for example if phones increased expected incomes from some other economic activity more than it increased them for fishing, causing some fishermen to exit. However, as shown in Table 3, there is no evidence that the total number of boats produced changed over this period (again, if anything there is perhaps a slight increase). This result is consistent with Jensen (2007), who finds no evidence of significant increases in entry or exit from fishing in response to the entry of mobile phones.[55] There is also no evidence of a spatial shift in demand that could explain our results, such as increased fishing in some areas (those with high-quality builders) and decreased fishing in others (those with low-quality builders), or fishermen moving from some villages to others. In column 2 of online Appendix Table 6, we present regressions like those above but where the dependent variable is the number of active fishing boats in each village (from our landing canvas), based on the baseline quality of the builder originally located in that village. The coefficient on the interaction of phone and baseline quality is small, and not statistically significant. Thus, there does not appear to have been any differential change in the demand for boats in villages with high- and low-quality builders; all that changed is where fishermen in those villages bought their boats.

[54] Though it is certainly possible that builders expected greater profits when making the decision to switch industries, or that the lower income is temporary and will soon catch up and overtake their previous earnings, or that there was some non-wage amenity to these alternative jobs that, perhaps in conjunction with a decreased income gap between the two jobs, was enough to induce some builders to switch.

[55] We might eventually expect a decrease in the demand flow for boats even with a stable number of fishermen due to the longer life-span of boats being sold once low-quality builders exit. However, any such effects would not yet have influenced boat demand during our sample period.

Another possibility is that the increased income from fishing led to an increase in the demand for higher quality boats (either making it easier to afford the costs of search, or by giving credit-constrained consumers the ability to purchase higher-quality, higher-priced boats). However, we believe this is unlikely to have played much of a role in the reallocation across builders. First, despite considerable variation in income across fishermen, both within and across villages (variation far in excess of the 8 percent increase in average profits associated with mobile phone introduction), at baseline essentially no one bought from non-local builders. If income itself drove search and a demand for higher quality boats, at least some of the wealthier fishermen should have been switching builders even before mobile phones. Second, higher quality boats were not more highly priced at baseline, so credit constraints (which might be alleviated with income growth) were not likely to have previously been limiting the demand for higher quality boats.

In addition, once fishermen start switching to non-local builders, income has no effect on whether someone buys their boat locally versus non-locally. For example, using our fisherman survey, we can take all periods when a village has mobile phone access and regress whether fisherman who recently bought a boat bought it from a local versus a non-local builder on their income. Online Appendix Table 7 shows that the effect of income is small and not statistically significant, with or without village fixed effects. Again, if income was important in search or the demand for quality, we should see wealthier fishermen switching at higher rates than poorer fishermen, but we don't.

Finally, from focus groups at the start of our study, we learned that the profitability of fishing had been increasing fairly significantly even well before our sample period. Yet no fisherman had switched to non-local buyers before this time. It seems unlikely that with year after year of increasing profitability of fishing around this time, this 8 percent increase in profits associated with mobile happened to be the exact marginal 8 percent increase in profitability that moved them to demand higher quality. It is certainly possible, but it would be a very knife-edge phenomenon, which moved them from no switching at all to widespread switching.

*Travel Distance and the Demand for Quality*.—A related possibility is that the demand for boat quality increased following mobile phone introduction due to the greater travel now involved in selling fish (and thus more rapid depreciation of boats). Figure 2 showed that fishermen had much less accurate information at baseline about the quality of non-local producers, so it can't be that fishermen already knew about quality differences but those differences were not important enough to them. However, quality might matter more when boats are being used more intensively, and this may have led fishermen to search for more information about builders.

We believe that it is unlikely that increased demand for quality drives our results. First, even before there was extensive travel for arbitrage, most fishermen should still have preferred to buy the boats that last longer, holding fixed the price of the boat. Second, even at baseline, fishermen from some villages traveled considerably longer on an average day than fishermen in other villages,[56] and within villages, some traveled more than others; yet, again, almost all fishermen bought their boats locally at baseline, suggesting those who traveled further for fishing were no more likely to buy their boats from a non-local producer before mobile phones.

Third, even after phones, there is considerable variation in how far fishermen travel on average. Again, some of this is within-village variation and some is across-village. However, online Appendix Table 7 shows that, again restricting to periods when the village has mobile phones, fishermen who travel further when fishing are no more likely to switch to non-local builders than fishermen who don't travel as far. If travel really made such a big difference on the demand for boat quality, we should see fishermen who travel more switching builders at a higher rate. Thus, it seems unlikely that greater travel distance alone affected the demand for boat quality or the likelihood of switching to non-local builders significantly.

*Input Markets*.—Another factor to consider is whether mobile phones might allow builders to search for and find better prices for inputs, in the same way that fishermen search for better prices for their catch or better builders. And if high-quality firms are better able to acquire inputs at lower prices (or to more easily secure a reliable supply of inputs), this could lead to differential exit by low-quality firms. However, perhaps because wood, the primary input, is nonperishable, in general there is very little price variation in input prices even in the absence of mobile phones. Further, in regressions like those above (column 3 of online Appendix Table 6) we find no statistically significant change in input prices paid by boat builders in response to adding mobile phones, much less for higher quality builders. Finally, our surveys asked builders whether they ever had to wait or were unable to find inputs, and there is no evidence that such problems are common, much less correlated with either the pattern of mobile phone introduction or the baseline quality of builders. In general, inputs appear to be readily available in the market throughout our sample period.[57]

*Credit Markets*.—If mobile phones increased access to credit for builders (e.g., by lowering search and transactions costs), this could have allowed some firms to expand and potentially push others out of business. However, even at the time of our final survey, we find that only three firms borrowed money or received formal or informal loans for their business from a bank, government program, friends, family, or any other source of credit. Most firms appear to grow via savings or retained earnings. The fact that firms were able to grow without access to credit is of interest in itself, given that credit access is often cited as a key limitation to firm growth.

*Advertising*, *Marketing, or Technical Knowledge*.—Finally, we believe that is it unlikely that phones had effects on the sector through their use in advertising

[56] Though most fishermen at baseline fish and sell their catch locally, there are still moderate differences in the average distance traveled by fishermen in different villages due to natural variation in coastline geography, fish density, and the distance between home landing spots and common fishing locations.

[57] We also did not observe any use of mobile phones in finding or recruiting workers. The vast majority of newly hired workers are relatives or friends who live nearby. However, as firms expand beyond the sizes observed at the end of our sample, they may need to expand to non-family/friend labor, in which case the question of where and how they get these workers may become more important.

or marketing. Since there was no directory or phone book of fishermen that firms could take advantage of, mobile phones were not a useful means for advertising or marketing their goods, and anecdotally, no builders reported doing so.[58] Similarly, phones would not have helped fishermen gain technical knowledge from others, since there were no resources available for learning about boat building through phones.[59]

## VII. Discussion and Conclusion

We find that the introduction of mobile phones in Kerala induced spillovers from the market for fish to the market for boats, increasing boat-buyers' information about non-local builders. The resulting increase in market integration caused consumers to switch from low-quality to high-quality producers, leading to increases in market share for high-quality/more productive firms, the exit of less productive or lower quality firms, and reductions in productivity/quality dispersion across firms. Aggregate productivity for the sector increased and consumer prices, per year of boat-life, decreased. We attribute this to mobile phones reducing barriers to trade across regions, increasing each builder's effective market size and the intensity of competition, as in the imports-as-market discipline hypothesis.

Though this sector is a small industry in a small region, we believe that the fundamental attributes of this industry (small firms largely serving a local customer base) are found in many other industries and in many other developing countries. The key insight we wish to emphasize is that factors such as imperfect information that limit the ability of businesses to get customers outside of their local area are an important constraint on firm growth. Further, in the present setting, once information on quality became available, firms were able to grow without greater access to credit, improved infrastructure, or changes in any of the other factors that are often thought to limit firm growth. Of course, we would not argue that these other factors are irrelevant for firm growth. In fact, credit constraints or managerial skill may become more important in our setting beyond an early stage of growth, since although firms in our sample grow considerably, they still remain fairly small by the last round of our survey (with no firm having more than ten employees). However, the results here demonstrate a clear role of limited effective market size as one potential constraint on growth and productivity.

## REFERENCES

**Aker, Jenny C.** 2010. "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger." *American Economic Journal: Applied Economics* 2 (3): 46–59.

[58] During our fieldwork, we didn't see builders going around to different landing spots to advertise. But builders could perhaps also have advertised by visiting non-local fishermen when they came to sell in the builder's market. When fishermen in our survey were asked if they knew any non-local builders, they were also asked how they learned about them. Unfortunately, the choices didn't include "directly from the builder" as an option, but there was a category for "other" that they could fill in. Once mobile phones become available, almost all fishermen report learning about non-local builders from other fishermen, either from other villages or their own village.

[59] Whether for the potential purposes of advertising and marketing or learning about boat building, access to the internet is not a relevant consideration during this period. Mobile phones were not internet capable and access to or use of the internet in general was very low in India, particularly among the poor.

**Aker, Jenny C., and Isaac M. Mbiti.** 2010. "Mobile Phones and Economic Development in Africa." *Journal of Economic Perspectives* 24 (3): 207–32.

**Behrens, Kristian, Giordano Mion, and Gianmarco I. P. Ottaviano.** 2011. "Economic Integration and Industry Reallocations: Some Theory with Numbers." In *International Handbook on the Economics of Integration: Competition, Spatial Location of Economic Activity and Financial Issues,* Vol. 2, edited by Miroslav N. Jovanovic, 148–68. Cheltenham: Edward Elgar.

**Bloom, Nicholas, Benn Eifert, Aprajit Mahajan, David McKenzie, and John Roberts.** 2013. "Does Management Matter? Evidence from India." *Quarterly Journal of Economics* 128 (1): 1–51.

**Bloom, Nicholas, Aprajit Mahajan, David McKenzie, and John Roberts.** 2010. "Why Do Firms in Developing Countries Have Low Productivity?" *American Economic Review* 100 (2): 619–23.

**Bruhn, Miriam, Dean Karlan, and Antoinette Schoar.** 2010. "What Capital Is Missing in Developing Countries?" *American Economic Review* 100 (2): 629–33.

**Bruhn, Miriam, Dean Karlan, and Antoinette Schoar.** 2018. "The Impact of Consulting Services on Small and Medium Enterprises: Evidence from a Randomized Trial in Mexico." *Journal of Political Economy* 126 (2): 635–87.

**de Loecker, Jan, Pinelopi K. Goldberg, Amit K. Khandelwal, and Nina Pavcnik.** 2016. "Prices, Markups, and Trade Reform." *Econometrica* 84 (2): 445–510.

**de Mel, Suresh, David McKenzie, and Christopher Woodruff.** 2008. "Returns to Capital in Microenterprises: Evidence from a Field Experiment." *Quarterly Journal of Economics* 123 (4): 1329–72.

**de Mel, Suresh, David McKenzie, and Christopher Woodruff.** 2009. "Are Women More Credit Constrained? Experimental Evidence on Gender and Microenterprise Returns." *American Economic Journal: Applied Economics* 1 (3): 1–32.

**de Mel, Suresh, David McKenzie, and Christopher Woodruff.** 2011. "Getting Credit to High Return Microentrepreneurs: The Results of an Information Intervention." *World Bank Economic Review* 25 (3): 456–85.

**de Mel, Suresh, David McKenzie, and Christopher Woodruff.** 2012. "One Time Transfers of Cash or Capital Have Long-Lasting Effects on Microenterprises in Sri Lanka." *Science* 335 (6071): 962–66.

**de Mel, Suresh, David McKenzie, and Christopher Woodruff.** 2014. "Business Training and Female Enterprise Start-Up, Growth, and Dynamics: Experimental Evidence from Sri Lanka." *Journal of Development Economics* 106: 199–210.

**Dixit, Avinash K., and Joseph E. Stiglitz.** 1977. "Monopolistic Competition and Optimum Product Diversity." *American Economic Review* 67 (3): 297–308.

**Dollar, David, and Kenneth Sokoloff.** 1990. "Patterns of Productivity Growth in South Korean Manufacturing Industries, 1963–1979." *Journal of Development Economics* 33 (2): 309–27.

**Fafchamps, Marcel, David McKenzie, Simon Quinn, and Christopher Woodruff.** 2014. "Microenterprise Growth and the Flypaper Effect: Evidence from a Randomized Experiment in Ghana." *Journal of Development Economics* 106: 211–26.

**Fischer, Greg, and Dean Karlan.** 2015. "The Catch-22 of External Validity in the Context of Constraints to Firm Growth." *American Economic Review* 105 (5): 295–99.

**Foster, Lucia, John Haltiwanger, and Chad Syverson.** 2016. "The Slow Growth of New Plants: Learning About Demand?" *Economica* 83 (329): 91–129.

**Goldberg, Pinelopi K., and Nina Pavcnik.** 2016. "The Effects of Trade Policy." In *Handbook of Commercial Policy*, Vol. 1A, edited by Kyle Bagwell and Robert W. Staiger, 161–206. Amsterdam: Elsevier.

**Hallward-Driemeier, Mary, Giuseppe Iarossi, and Kenneth L. Sokoloff.** 2002. "Exports and Manufacturing Productivity in East-Asia: A Comparative Analysis with Firm-Level Data." NBER Working Paper 8894.

**Helpman, Elhanan, and Paul Krugman.** 1989. *Trade Policy and Market Structure.* Cambridge, MA: MIT Press.

**Hopenhayn, Hugo A.** 1992a. "Entry, Exit, and Firm Dynamics in Long-Run Equilibrium." *Econometrica* 60 (5): 1127–50.

**Hopenhayn, Hugo A.** 1992b. "Exit, Selection, and the Value of Firms." *Journal of Economic Dynamics and Control* 16 (3–4): 621–53.

**Hsieh, Chang-Tai, and Peter J. Klenow.** 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics* 124 (4): 1403–48.

**Hsieh, Chang-Tai, and Peter Klenow.** 2014. "The Life Cycle of Plants in India and Mexico." *Quarterly Journal of Economics* 129 (3): 1035–84.

**Hsieh, Chang-Tai, and Benjamin A. Olken.** 2014. "The Missing 'Missing Middle.'" *Journal of Economic Perspectives* 28 (3): 89–108.

**Jensen, Robert.** 2007. "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics* 122 (3): 879–924.

**Jensen, Robert, and Nolan H. Miller.** 2018. "Market Integration, Demand, and the Growth of Firms: Evidence from a Natural Experiment in India: Dataset." *American Economic Review.* https://doi.org/10.1257/aer.20161965.

**Karlan, Dean, and Martin Valdivia.** 2011. "Teaching Entrepreneurship: Impact of Business Training on Microfinance Clients and Institutions." *Review of Economics and Statistics* 93 (2): 510–27.

**Karlan, Dean, and Jonathan Zinman.** 2011. "Microcredit in Theory and Practice: Using Randomized Credit Scoring for Impact Evaluation." *Science* 232 (6035): 1278–84.

**Laeven, Luc, and Christopher Woodruff.** 2007. "The Quality of the Legal System, Firm Ownership, and Firm Size." *Review of Economics and Statistics* 89 (4): 601–14.

**Levinsohn, James.** 1993. "Testing the Imports-as-Market-Discipline Hypothesis." *Journal of International Economics* 35 (1–2): 1–22.

**Levinsohn, James, and Amil Petrin.** 2003. "Estimating Production Functions Using Inputs to Control for Unobservables." *Review of Economic Studies* 70 (2): 317–41.

**McCraig, Brian, and Nina Pavcnik.** 2016. "Out with the Old Unproductive, In with the New and Similarly Unproductive: Microenterprise Dynamics in a Growing Low-Income Economy." Unpublished.

**McKenzie, David, and Christopher Woodruff.** 2008. "Experimental Evidence on Returns to Capital and Access to Finance in Mexico." *World Bank Economic Review* 22 (3): 457–82.

**McKenzie, David, and Christopher Woodruff.** 2014. "What Are We Learning from Business Training and Entrepreneurship Evaluations around the Developing World?" *The World Bank Research Observer* 29 (1): 48–82.

**McKenzie, David, and Christopher Woodruff.** 2017. "Business Practices in Small Firms in Developing Countries." *Management Science* 63 (9): 2967–81.

**Melitz, Marc J.** 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71 (6): 1695–725.

**Melitz, Marc J., and Gianmarco Ottaviano.** 2008. "Market Size, Trade, and Productivity." *The Review of Economic Studies* 75 (1): 295–316.

**Melitz, Marc J., and Saso Polanec.** 2015. "Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit." *RAND Journal of Economics* 46 (2): 362–75.

**Melitz, Marc J., and Stephen Redding.** 2014. "Heterogeneous Firms and Trade." In *Handbook of International Economics*, Vol. 4, edited by Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff, 1–54. Amsterdam: Elsevier.

**Nelson, Phillip.** 1970. "Information and Consumer Behavior." *Journal of Political Economy* 78 (2): 311–29.

**Olley, G. Steven, and Ariel Pakes.** 1996. "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica* 64 (6): 1263–97.

**Pack, Howard, and Larry E. Westphal.** 1986. "Industrial Strategy and Technological Change: Theory versus Reality." *Journal of Development Economics* 22 (1): 87–128.

**Pavcnik, Nina.** 2002. "Trade Liberalization, Exit, and Productivity Improvement: Evidence from Chilean Plants." *Review of Economic Studies* 69 (1): 245–76.

**Redding, Stephen J.** 2011. "Theories of Heterogeneous Firms and Trade." *Annual Review of Economics* 3: 77–105.

**Reinganum, Jennifer F.** 1979. "A Simple Model of Equilibrium Price Dispersion." *Journal of Political Economy* 87 (4): 851–58.

**Smith, Adam.** 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations.* London: Methuen & Co.

**Stahl, Dale O.** 1989. "Oligopolistic Pricing with Sequential Consumer Search." *American Economic Review* 79 (4): 700–712.

**Startz, Meredith.** 2017. "The Value of Face-to-Face: Search and Contracting Problems in Nigerian Trade." Unpublished.

**Syverson, Chad.** 2004a. "Market Structure and Productivity: A Concrete Example." *Journal of Political Economy* 112 (6): 1181–222.

**Syverson, Chad.** 2004b. "Product Substitutability and Productivity Dispersion." *Review of Economics and Statistics* 86 (2): 534–50.

**Syverson, Chad.** 2011. "What Determines Productivity?" *Journal of Economic Literature* 49 (2): 326–65.

**Topalova, Petia, and Amit Khandelwal.** 2011. "Trade Liberalization and Firm Productivity: The Case of India." *Review of Economics and Statistics* 93 (3): 995–1009.

**Tybout, James R.** 2000. "Manufacturing Firms in Developing Countries: How Well Do They Do, and Why?" *Journal of Economic Literature* 38 (1): 11–44.