Vertical Integration, Supplier Behavior, and Quality Upgrading among Exporters*

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Abstract

This paper studies the relationship between a firm's organizational structure and output quality. The setting is a large manufacturing sector in Peru where plants produce a vertically differentiated but otherwise homogeneous product for export: fishmeal. We link customs data to plant level data on each shipment's quality grade, transaction level data on supplies, and GPS measures of supplier (fishing boat) behavior. We start by documenting a robust association between the quality grade of a firm's exports and the share of its inputs that comes from vertically integrated suppliers at the time of production. To understand the source of this relationship, we first show that classical theories of the firm predict that, in incomplete contracts settings, owning productive assets upstream may help a subset of downstream manufacturers attempting to produce high quality output to incentivize quality-effort from the assets' operators. This explanation finds empirical support: in a given supplier-plant pair, the supplier delivers higher quality inputs (fresher fish) when integrated, and does so comparatively more during periods when (i) the plant aims to produce high quality output, and/or (ii) exogenous variation in upstream production (plankton) conditions makes quality-effort more costly. Finally, we show that firms source more of their inputs from integrated suppliers when faced with firm-specific shocks to demand for high quality exports. These results document an overlooked motivation for vertical integration and that strategic changes in organizational structure help manufacturers in developing countries achieve export success.

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1 Introduction

Why do so many of our economic transactions occur within firm boundaries (Antràs, 2003; Lafontaine & Slade, 2007)? Research on this question goes back to Ronald Coase's seminal contributions. The contracting issues emphasized in the body of theoretical work following Coase (1937) are especially prominent in environments where firms attempt to source *high quality* inputs (see Gibbons, 2005). This suggests that upgrading output quality – an essential element of export-driven economic development[1] – may be an overlooked motivation for vertical integration.

Sourcing of high quality inputs frequently entails three contracting challenges stressed in the literature. First, quality grade is notoriously difficult to contract upon (Williamson, 1971, 1975; Grossman & Hart, 1986; Hart & Moore, 1990), especially in developing countries (Nunn, 2007; Macchiavello & Miquel-Florensa, 2016). Second, the process of producing high quality inputs often involves the sort of complex multitasking studied in Holmstrom & Milgrom (1991); Holmstrom & Tirole (1991); Holmstrom (1999). Third, when different manufacturers demand different quality grades, a supplier's desire to improve her bargaining position with any given manufacturer may distort incentives (Baker *et al.* , 2002). Industries where downstream firms produce vertically differentiated products thus provide an unusual opportunity to directly test mechanisms at the core of classical theories of the firm.

In this paper we study the relationship between organizational structure and output quality empirically. We hypothesize that (i) vertical integration represents a strategy potential exporters in developing countries use to produce goods of high enough quality to sell to richer countries, and that (ii) this is because, when contracts are incomplete, owning the productive assets used by suppliers enables downstream firms to incentivize suppliers to deliver high quality inputs. We investigate this hypothesis in the context of one of Latin America's largest industries: fishmeal manufacturing in Peru.[2] We first explore how the quality grade and price of a firm's exports differ when more of its supply is coming from integrated suppliers. We then investigate *why* integration may enable quality upgrading, focusing on firms' ability to incentivize desired supplier actions and comparing integration also to other alternatives to the spot market such as repeated interactions. To guide the investigation, we adjust the Baker *et al.* (2002) model to allow for both quantity- and quality-oriented downstream firms, and supplier quantity-effort and quality-effort. We use "switchers" and exogenous variation in production conditions to compare a supplier's behavior before versus after integration. Finally, we construct an instrument for firm-specific foreign demand shocks to explore how Peruvian manufacturing firms adjust their input sourcing strategies when faced with higher demand for high quality grade goods.

Peru's fishmeal manufacturing sector is an ideal setting to study the relationship between vertical integration and output quality for several reasons. First, fishmeal is a vertically differentiated but otherwise homogeneous product. The quality of its primary input – fish – is difficult to contract upon. The presence of outside options – alternative downstream buyers who may value input quality less – gives suppliers (fishing boats) incentives that represent a challenge for plants trying to produce high quality fishmeal by buying inputs on the spot market.

[1] An existing body of literature documents that inputs of the desired specifications help downstream manufacturers in poor countries produce goods of the targeted output quality level and export to more profitable, richer countries (see, among others, Hallak, 2006; Verhoogen, 2008; Brambilla *et al.* , 2012; Kugler & Verhoogen, 2012; Manova & Zhang, 2012; Bastos *et al.* , 2016).

[2] Fishmeal is a brown powder made by burning or steaming fish, and often used as animal feed. Peru's fishmeal industry – the biggest in the world – accounts for around 3 percent of the country's GDP (Paredes & Gutierrez, 2008; De La Puente *et al.* , 2011).

Second, we directly observe output quality. Public inspectors verify manufacturing firms' monthly reports of each plant's output of both "fair average quality" (low protein content) and "prime" quality (high protein content) fishmeal. Furthermore, because we observe the price prevailing across the full range of protein content in a given week×export port in granular data from a fishmeal consulting firm, we are able to infer a continuous measure of each export shipment's quality grade.[3] We thus avoid relying on purely unit price-based quality measurement procedures that risk conflating quality with mark-ups and horizontal differentiation (see e.g. Khandelwal, 2010; Hallak & Schott, 2011).

Third, we observe all transactions between manufacturing plants and suppliers in administrative data from Peru's regulatory authorities. Domestic transactions data are rare in general; observing the transactions of an entire industry, including within-firm transactions, is especially rare. In combination with plant output and customs data, the supply transactions data allow us to track the flow of goods across three different stages of a global value chain. We observe who trades with whom at each stage and the outcome of the transaction.

Fourth, we observe the behavior of suppliers. The fishing boats that supply the fishmeal plants are required to transmit GPS signals to the regulatory authorities while at sea. We use GPS-based proxies for quantity- and quality-effort to explore how a supplier's behavior differs when integrated, exploiting independent-to-integrated and integrated-to-independent "switchers" for identification. We also use daily measures of plankton concentration across 10×10 kilometer grid-cells of the ocean constructed from satellite images to test how suppliers' behavioral response to exogenous variation in the opportunity cost of quantity- and quality-effort differs when integrated.

Fifth, the share of a firm's supply that comes from integrated suppliers, the quality grade of its output, and foreign demand for quality all vary with relatively high frequency in the context we study. This allows us to provide what to our knowledge is the first evidence on the extent to which, and how, firms vary their organizational structure in order to produce goods that correspond to the demand they face.

Finally, Peru's fishmeal manufacturing sector shares many features with other manufacturing industries in poor and middle-income countries – for example, highly variable demand and supply conditions, a weak institutional environment, and the processing of natural resources. As in rich countries (Atalay *et al.* , 2014; Hortacsu & Syverson, 2007), the observed degree of vertical integration is greatest among bigger downstream firms, but smaller firms also own suppliers.

Our results are as follows. Firms produce considerably higher quality output and are paid higher export prices when they own more suppliers. It is not just ownership that matters for output quality, but the actual share of a firm's inputs coming from integrated suppliers at the time of production, however. We find the same result at the plant level, and when controlling not only for firm/plant and time period fixed effects, but also for time-varying supplier and firm characteristics. While it is possible that other mechanisms also contribute to the relationship we establish, it is difficult to explain in the absence of a causal effect of the use of integrated suppliers on output quality.

To guide our investigation of *how* integration enables firms to produce higher quality output, we present a simple framework inspired by our conversations with industry insiders. We build on the seminal Baker *et al.* (2002) model, in which independent suppliers may devote effort to increasing the value of their assets (in our case, inputs produced) to alternative buyers. In particular, we assume that suppliers can take both quantity- and quality-increasing actions, and allow for two types of downstream firms: those focusing only

[3]The fair average quality versus prime classification is dichotomous and governed by a protein content (quality) ladder cut-off.

on producing quantity, and those who also put weight on the quality of their output. We take both input quantity and quality to be observable but non-contractible.[4] The framework highlights that it may be that quantity-oriented firms can achieve the first-best via "relational outsourcing" contracts with suppliers, but quality-oriented firms can do so only via "relational employment" contracts – i.e., vertically integrating.

We then show empirically that integrated suppliers put in greater quality-effort. Inputs *in a given supplier-plant relationship* on average come in smaller batches of higher quality (i.e., fresher) fish when the supplier is owned by the plant, and the difference is greater during periods (i) when the downstream firm is trying to produce high quality output, and (ii) when plankton scarcity tightens the supplier's trade-off between quantity- and quality-effort. These behavioral differences explain part of the correlation between the use of integrated suppliers and quality exported. We show that, in contrast, suppliers do not put in more quality-effort when they are engaged in repeated interactions with the firm/plant supplied.[5] Our findings are thus consistent with the idea that vertical integration enables downstream firms to incentivize specific supplier behaviors that other organizational structures may not.

In the final part of the paper we construct instruments for firm-specific shocks to foreign demand for quality.[6] We use these to show that downstream manufacturers significantly increase the share of their supply that is obtained from integrated suppliers when faced with greater demand for high quality output from abroad.

In sum, this paper shows that a greater ability to influence the behavior of integrated suppliers makes it possible, in settings with imperfect contracting, to produce products of higher quality when inputs are sourced internally. Firms are aware of and able to take advantage of this benefit of integration. In addition to documenting an overlooked motivation for vertical integration, our results demonstrate that strategic changes to organizational structure help manufacturers in developing countries achieve export success.

Our study bridges and advances the literatures on organizational structure and quality upgrading. Gibbons (2005); Lafontaine & Slade (2007); Bresnahan & Levin (2012) provide excellent overviews of existing research on the boundaries of the firm.[7] Theories of vertical integration have been difficult to take to the data. Our approach is most closely related to Baker & Hubbard (2003, 2004), Forbes & Lederman (2009, 2010), and Alfaro *et al.* (2016a), who study vertical integration in the U.S. trucking industry, the U.S. airline industry, and sectors producing homogeneous goods worldwide respectively.[8] Baker & Hubbard (2003, 2004) and Alfaro *et al.* (2016a) study potential drivers of integration (monitoring and prices) that vary over time. This makes it possible to pin down how firms' organizational choices respond to the specific drivers of interest. We also exploit such time variation, but focus on the nature of the demand firms' face as a potential

[4]The features of Peru's fishmeal manufacturing sector that lead us to make these assumptions are discussed in Section 2.

[5]If relational outsourcing contracts are used in the context studied, they likely address other firm needs (see e.g. an innovative study by Macchiavello & Miquel-Florensa, 2016). In that integrating appears to enable firms in the Peruvian fishmeal industry to "tell suppliers what to do", our findings resonate with Atalay *et al.* (2014)'s evidence of transfer of "intangible inputs" within firms, and with Arrow (1975)'s remark that the transfer of nonphysical knowledge inputs is difficult to achieve through formal firm-to-firm contracts. Our results indicate, however, that what non-integrated suppliers in the Peruvian fishmeal manufacturing industry lack is not the *knowledge* to produce high quality inputs, but rather the *incentives* to do so. We show, for example, that a given supplier puts in high quality-effort only when supplying its owner firm, and not when owned by one firm but supplying another.

[6]Specifically, we instrument for the demand a firm faces at a given point in time by interacting its initial export destinations with importer countries' total imports at that later point in time. We follow many fruitful applications of such a Bartik approach in the trade literature, including Park *et al.* (2009); Brambilla *et al.* (2012); Bastos *et al.* (2016). The methodology has been used to document e.g. that individual firms export higher quality products to richer destinations (see also Bastos & Silva, 2010).

[7]There is also an influential literature studying the relationship between integration and international trade (McLaren, 2000; Grossman & Helpman, 2002; Antràs, 2003; Nunn, 2007; Antràs & Staiger, 2012; Irarrazabal *et al.* , 2013; Antràs, 2014, 2016; Alfaro *et al.* , 2016b). Among other insights, this literature has shown that the incentives that govern firm decisions on where to locate different stages of production also affect organizational structure decisions in important ways.

[8]See also Hart *et al.* (1997) on quality and cost of service and a government's decision of whether or not to privatize prisons.

cause of integration.[9] We are able to do so because we can link downstream firms to export transactions, which makes it possible to take advantage of fluctuations in importing countries' demand.[10]

We are not aware of previous studies of the role vertical integration plays when downstream sectors are segmented and some firms aim to produce high quality output while others do not.[11] Our findings raise the possibility that output quality motives may be part of the reason why vertical integration is more common in developing countries (Acemoglu *et al.* , 2005; Macchiavello, 2011), especially in export-oriented production chains (Gibbon & Ponte, 2005; Bair, 2009).

We also are not aware of other work relating between- and within-firm supply and sales transactions over time to a dynamic model of organizational structure. What allows us to do so is (i) the close mapping between the context we study and the mechanisms emphasized in the classical theories of the firm that (our modified version of) Baker *et al.* (2002) builds on in combination with (ii) the granularity of the data we use.

Empirically, observing the same supplier-firm pair transacting under different organizational structures allows us to separate the consequences of organizational structure from other firm outcomes that correlate with the pair's characteristics (see also Atalay *et al.* , 2014).[12] With estimates of the benefits and drawbacks of each organizational structure for firm outcomes in hand, we relate these to direct measures of the underlying supplier behavior under each structure.[13] We also exploit shocks to the natural environment that generate a need for behavioral "adaptation" by the supplier (Williamson, 1975, 1985; Tadelis, 2002; Forbes & Lederman, 2009, 2010). Finally, we assess if firms choose an integrated structure in the situations in which our estimates suggest that they *should* do so given the objectives we observe them pursuing.[14]

The quality upgrading literature is newer, but it is now well-documented that producers of high quality goods use high quality inputs (Goldberg *et al.* , 2010; Kugler & Verhoogen, 2012; Manova & Zhang, 2012; Halpern *et al.* , 2015; Bastos *et al.* , 2016), more skilled workers (Verhoogen, 2008; Frías *et al.* , 2009; Brambilla *et al.* , 2012; Brambilla & Porto, 2016; Brambilla *et al.* , 2016), and export to richer destination countries

[9]Similarly to Forbes & Lederman (2009, 2010), Macchiavello & Miquel-Florensa (2016) relate differences in temptations to renege across organizational structures to ex ante choice of structure, but they generate ex post time variation in temptations from shocks to demand and supply conditions. Our demand results resonate with the findings of Alfaro *et al.* (2016a). They show that higher prices for homogeneous final products allow firms to overcome the costs of vertical integration (see also Legros & Newman, 2013). We show instead that vertical integration enables plants to incentivize suppliers to deliver inputs of the desired specifications, which in turn makes it possible for the downstream firm to produce a product of the targeted quality level.

[10]In studying how use of integrated and independent suppliers correlate with firms' objectives, we follow Baker & Hubbard (2003, 2004). They infer the firms' objective from the type of job contracted over. In our setting, firm outcomes are directly observed. Hortacsu & Syverson (2007); Forbes & Lederman (2009, 2010); Atalay *et al.* (2014); Hong & Li (2016); Macchiavello & Miquel-Florensa (2016) all use transaction level data to study vertical integration.

[11]In settings where product differentiation is multi-dimensional or prices are not observed, such an analysis would be difficult. Our focus on a vertically differentiated but horizontally homogeneous product is inspired by influential earlier papers that test market power theories of integration in sectors producing especially homogeneous products (Syverson, 2004; Hortacsu & Syverson, 2007; Foster *et al.* , 2008).

[12]We can assess the extent to which the benefits of integration can also be achieved through repeated interactions because we observe some supplier-firm pairs transacting both as independent and integrated entities, and others transacting as independent entities and when engaged in repeated transactions. See e.g. Macaulay (1963); Klein & Leffer (1981); Banerjee & Duflo (2000); MacLeod (2007); Macchiavello & Morjaria (2015) on relational contracts. Macchiavello & Miquel-Florensa (2016) show that, in the Costa Rican coffee industry, relational outsourcing contracts allow firms and their suppliers to overcome supply and demand assurance issues.

[13]Baker & Hubbard (2003, 2004) helped spark an empirical literature relating supplier multitasking to organizational structure (see also Woodruff (2002)). Baker and Hubbard infer driver behavior from fuel use and the downstream firm's objective from the type of job contracted over. In our setting we directly observe supplier behavior and firm outcomes. More importantly, supplier multitasking plays a different role in this paper than in Baker & Hubbard (2003, 2004). In their case, downstream firms want suppliers to multitask on some jobs, but not on others. In our case, some downstream firms want suppliers to put in effort in a particular dimension, but doing so may make the suppliers' product less desirable to alternative buyers.

[14]In relating evidence on the causes of integration to evidence on its consequences for firm performance, we follow the influential studies by Forbes & Lederman (2009, 2010). See also Mullainathan & Sharfstein (2001); Gil (2009); Novak & Stern (2008); Natividad (2014). We follow Natividad (2014) in studying vertical integration in the Peruvian fishmeal industry. However, his data comes from an earlier period in which the incentives for suppliers and plants generated by the regulatory regime overshadowed other forms of incentives and industry dynamics (see Hansman *et al.* (2016) and Section 2 of this paper).

(Hallak, 2006; Verhoogen, 2008; Manova & Zhang, 2012; Bastos *et al.* , 2016). Firms with such a profile tend on average to be bigger, more productive, and to be based in richer countries themselves (Schott, 2004; Hummels & Klenow, 2005; Baldwin & Harrigan, 2011; Johnson, 2012). We document how and why a new dimension of production – a firm's organizational structure – matters for output quality.

The rest of the paper is organized as follows. In Section 2 we provide background on the context, and in Section 3 we lay out the various datasets we use. In Section 4 we explore the association between output quality and vertical integration. In Section 5 we present the conceptual framework and show how the behavior of integrated suppliers differs from independent suppliers. In Section 6 we investigate how firms' use of integrated suppliers changes with demand for quality. Section 7 concludes.

2 Background on Peru's Fishmeal Manufacturing Sector

2.1 Technology and product differentiation

Peru is the world largest exporter of fishmeal, making up around 30 percent of the world's exports. The anchovy fishery that supplies its fishmeal manufacturing plants account for approximately 10 percent of global fish capture (Paredes & Gutierrez, 2008). During our data period, around 95 percent of Peru's total fishmeal production was exported. The three largest buyers are China, Germany, and Japan, but many other countries also import Peruvian fishmeal (see Appendix Table A1, discussed in Section 6). The product is primarily used as feed for agriculture and aquaculture.

Peru allows anchovy fishing for fishmeal production during two seasons each year.[15] The fish is processed as soon as possible after being offloaded as fishmeal is more valuable when made from fresh fish. Freshness at the time of delivery depends on several choices made by the boat's captain before and during a trip, such as the amount of ice brought on board, how tightly fish is packed, and the time spent in between a catch and delivery to a plant.

Because of the need for fresh fish, fishmeal plants operate only during the fishing seasons. In theory fishmeal can be stored for up to six or even 12 months, but we find that almost all is sold before the next production season begins, as shown in Appendix Figure A1 and discussed below.

Boats offload fish at a plant's docking station. The fish is then transported into the plant, normally via a conveyor belt. Inside the plant, the fish is weighed, cleaned, and then converted into fishmeal. Plants can use two different technologies to turn fish into fishmeal: steam drying (hereinafter "High technology"), and exposing the fish directly to heat (hereinafter "Low technology"). The High technology preserves the protein content of the fish through the production process better. As seen in Appendix Figure A2, firms and plants that use the High technology produce higher average quality fishmeal, though plant technology is far from the only factor influencing output quality, as reflected in the standard deviations shown (we discuss the data used in Section 3).

[15]Our period of analysis is 2009 to 2015, or the first 11 fishing and fishmeal production seasons after the introduction of "individual, transferable quotas" (ITQs) in the Peruvian anchovy fishery. Before the ITQ system, the sector operated under a shared, aggregate quota – or "race for the resource" – system wherein there was little scope for incentives that depend on the organizational structure of the production chain or other features of the economic environment to influence a boat's behavior (see e.g. Hansman *et al.* , 2016), other than possibly how fast the boat would "race". (Natividad (2014) uses data from a fishmeal company during the pre-ITQ period to show that its integrated boats fished higher quantities than its non-integrated suppliers, but does not find the same in the industry as a whole). Under the ITQ system, Peru's anchovy fishery is similar in many dimensions to other primary sectors that supply downstream factories, including the fact that the natural resources from which raw materials are extracted are privately owned.

The quality grade of a batch of fishmeal is denoted by its protein content, which in Peru typically ranges from 63 to 68 percent. In addition to the exact protein content, a dichotomous "prime" quality indicator for batches with protein content above a given level is sometimes used for Peruvian fishmeal, and batches below that cut-off labeled "fair average quality". Price differentials across transactions for Peruvian fishmeal of a given quality grade in a given time period are negligible.

2.2 Sector profile and firms' organizational structure

Around 22 towns along the coast of Peru have a port that is suitable for large fishing boats; all fishmeal plants are located in and around these ports. Table 1 shows summary statistics on the fishmeal sector for our sample period. In 2009 there were 89 active fishmeal plants. They were owned by 37 firms, but the seven largest firms account for approximately 78 percent of total production.

There are on average 766 active boats per fishing season, and significant heterogeneity in boat characteristics such as storage capacity, engine power, and average quantity caught per trip. Fishing trips last 21 hours (s.d. = 10 hours) and boats travel 76 kilometers to the port of delivery (s.d. = 46 kilometers) on average, underscoring the effort necessary to find and capture fish. Note that changes in installed technology are rare both for boats and plants during our data period.

There is heterogeneity also in processing capacity, technology, and the share of production that is of high quality grade across plants. Monthly average production is 3092 metric tons (s.d. = 3288 tons). Firms differ considerably in their average number of export transactions per season, and the size and value of their shipments. As seen in Appendix Figure A4, firm size correlates positively with average quality grade produced, consistent with Melitz (2003) style models in which unobserved firm heterogeneity governs firms' targeted output quality, other production choices, and size, and changes in demand- or supply-side factors can lead to changes in the targeted output quality (see, among others, Verhoogen, 2008; Khandelwal, 2010; Baldwin & Harrigan, 2011; Johnson, 2012; Kugler & Verhoogen, 2012). Such a perspective also appears consistent with a bird's-eye view of the evolution of the Peruvian fishmeal sector during our data period.

Regulations allow only steel boats to be owned by fishmeal firms in Peru. On average, 28 percent of the boats that are active in a given season are owned by a fishmeal firm, as seen in Table 1. During the last decade, downstream ownership of boats slowly increased.[16] Firms on average increase the share of inputs they obtain from integrated suppliers by 2.67 percent from season to season during our data period. Approximately 58 percent of this growth comes solely from increasing the amount of inputs coming from integrated suppliers.[17] This slow growth in use of integrated suppliers occurs in parallel with Peruvian

[16] See Appendix Figure A3. While the long-term trend in downstream ownership of boats has been positive, we also observe some sales of boats from fishmeal firms to independent co-ops or captains in the data. There was a bigger jump in downstream firms acquiring boats with the introduction of ITQs. As discussed above, we focus on the post-ITQ period. Steel boats that are not owned by fishmeal firms are generally owned by co-ops ("armadores"), while wooden boats are generally owned by individuals or families.

[17] The growth rate of "Share $\text{VI}_{i,t}$" – the share of the inputs sourced by firm i during production season t that comes from vertically integrated suppliers – can be decomposed as follows:

$$\text{Growth (Share VI)}_{i,t} \approx \log\left(\frac{\text{Share VI}_{i,t+1}}{\text{Share VI}_{i,t}}\right) = \log\left(\frac{\frac{\text{VI}_{i,t+1}}{\text{Total}_{i,t+1}}}{\frac{\text{VI}_{i,t}}{\text{Total}_{i,t}}}\right) = \underbrace{\log\left(\frac{\frac{\text{VI}_{i,t+1}}{\text{Total}_{t+1}}}{\frac{\text{VI}_{i,t}}{\text{Total}_{t}}}\right)}_{A} - \underbrace{\log\left(\frac{\frac{\text{Total}_{i,t+1}}{\text{Total}_{t+1}}}{\frac{\text{Total}_{i,t}}{\text{Total}_{t}}}\right)}_{B}$$

Here $\text{VI}_{i,t}$ and $\text{Total}_{i,t}$ is respectively the *amount* of inputs firm i sources from vertically integrated suppliers and in total during season t, and Total_t is the total amount of inputs sourced by the industry as a whole during season t. Term A can then be interpreted as the contribution to the growth rate of Share $\text{VI}_{i,t}$ that comes from increasing solely the (relative) amount of inputs coming from integrated suppliers. This term contributes approximately 58 percent of the 2.67 percent average (across all firms and all seasons) growth rate fishmeal firms (also slowly) increasing the share of their output that is of high quality grade.

The extent to which a given firm makes use of integrated versus independent suppliers varies considerably from month to month, however. During the period we study, the Peruvian fishmeal manufacturing industry was characterized by short-run fluctuations in (i) the composition of demand, (ii) firms' organizational structure, and (iii) average quality grade produced – the focus of our analysis – around the weakly positive longer-term trends in the industry-wide average quality level produced and degree of vertical integration discussed in this sub-section.

2.3 Contracting and supplier incentives

Peru's regulatory authorities allow a set of non-"artisan" boats - i.e., large wooden and steel boats - to supply fishmeal plants. There is no centralized spot market for fish purchases: plants are spread out along the coast, in part because of variation in the density of fish at any given part of the ocean. Because of the importance of fish freshness, independent boats typically decide which port to head towards through negotiations over the radio while returning from fishing and deliver their catch directly to a nearby plant. As noted in the introduction, the complex multitasking necessary to produce high quality fish, the difficulty of contracting over quality, and the presence of plants with heterogenous demands for quality mean that a spot market may not be the natural organizational structure for the industry as a whole. We explore these issues more in Section 5.2.

Fresher anchovies yield fishmeal with higher protein content on average. Though fish quality is not measurable at the time of delivery, informative signals exist: for example, the smell of the fish, and real-time information on boats' location made publicly available by the regulatory authories.[18] On the other hand, it is difficult to contract over fish quality. Many of the signals available are complicated to quantify and difficult to enforce, particularly given the limited capacity of Peru's courts and other law enforcement institutions. Furthermore, the quality of the final good – fishmeal – is only directly observed by the downstream firm itself, whose own actions also influence output quality. Additionally, the production technology makes it difficult to avoid using fish from multiple suppliers when making a given batch of fishmeal.

The size of a boat's catch is observable to the purchasing plant at the time of delivery, but nevertheless also difficult to contract on. Firms' desired quantity of inputs depends on many factors that are hard to verify ex post (e.g. fishing conditions, the timing of deliveries from other suppliers, variation in demand, etc) and costly to specify ex ante (see also Macchiavello & Miquel-Florensa, 2016).

We interviewed fishmeal industry associations, a major company's Chief Operating Officer, and others in the sector to gain a qualitative understanding of the characteristics of the contracts used and the incentives suppliers face. The interviewees reported that captains of boats owned by fishmeal firms generally are paid a fixed wage, often with a small bonus tied to some measure of performance. They also said that payments to independent suppliers generally are agreed upon case by case, but in most cases are calculated simply as quantity multiplied by a going price. We use internal data on payments to suppliers from a large firm to confirm this. These indicate that at a given point in time independent suppliers are paid a price per metric ton of fish delivered that is essentially fixed: port-date fixed effects explain 99 percent of the price variation

of Share $\text{VI}_{i,t}$ during our data period. Term B – the contribution of a firm decreasing the (relative) amount of inputs sourced from all suppliers – makes up the remaining 42 percent.

[18] As discussed in Section 3 below, the fishing boats transmit GPS signals to the regulatory authorities in real-time. The map that displays the last recorded location of each boat is periodically updated and is publicly accessible.

across transactions. Purchases from independent boats thus *do* appear to take place on a spot market.[19]

3 Data

Starting downstream and moving upstream, we use the following sources of data:

Export transactions. We use detailed data on the universe of fishmeal exports at the transaction level from Peru's customs authority. We observe the date of the transaction, the export port of transaction, the destination country, the weight of the fishmeal, the value of the transaction, and the exporting firm (though not the specific plant that made the fishmeal).

While we do not observe the quality grade directly in the customs data, we can approximate quality unusually well. This is because we observe quality grade-specific fishmeal prices in granular (week×export port×protein content level) data recorded by a fishmeal consulting company. By comparing the unit values of export shipments to this price data, we directly infer the protein content of a firm's exports at each point in time. In combination with the vertically differentiated but horizontally homogeneous nature of the product, this quality inference procedure allows us to avoid conflating product quality with mark-ups (see e.g. Khandelwal, 2010; Hallak & Schott, 2011). The inferred protein content of a firm's exports at a point in time is highly correlated with the "high quality share of production" directly observed for the firm's plants in production data (discussed below).[20]

We also report results using export unit prices as the dependent variable. Unit prices are highly correlated with protein content and important firm outcomes in their own right.

International trade flows. To construct our instruments for firm-specific shocks to foreign demand for fishmeal quality, we use BACI data. BACI is a consolidated version of COMTRADE (with less missingness) and provides information on the quantity of goods of each HS6 code exported from one country to another in a given year. We use the BACI data to measure the amount of fishmeal that Peru and other countries export and import in each year.[21]

Plant production. We also use administrative data on all plants' production from Peru's Ministry of Production, which regulates the fishmeal industry. Plants are required to submit information on how much high and low quality (protein content) fishmeal they produce every month. Quality grade is thus directly reported in the plant production data. As discussed in Sub-section 2.1, the distinction between high quality (prime) and low quality (fair average quality) fishmeal as reported by plants is based on a cut-off on the protein content ladder. The production data reported by plants is subject to auditing by government inspectors.

[19] More precisely, these observations suggest that if repeated interactions or other alternatives to integration are used in the Peruvian fishmeal industry to incentivize specific supplier behaviors, such arrangements are of a nature that does not require paying certain suppliers more than others.

[20] Unit values are uncorrelated with the size of the shipment, indicating that fishmeal firms do not offer bulk discounts. Aggregate data from the International Fishmeal and Fish Oil organization (IFFO), who obtain their information directly from fishmeal firms, indicate that the price of Peruvian fishmeal with protein content in the highest range ("super prime") is on average 13 percent higher than that of fishmeal with protein content in the low range (FAQ).

[21] A precise description of how the BACI data is constructed can be found in Gaulier & Zignago (2010). For 2015 we use COMTRADE data because BACI data is not yet available for that year. BACI data is only available at the year level while our measures of quality produced are at the season level, with some seasons spanning two years. We thus match a production season to the year in the BACI data that spans most of the season.

Plant registry. We link the production data with an administrative plant registry that contains information at the monthly level on each plant's technological production capacity and which firm owns the plant.[22] We also use this registry to link the export and production data. We can do so for almost all firms.[23]

Supply transactions. The Ministry of Production records all transactions between the fishmeal plants and their suppliers of raw materials, i.e. fishing boats. Information on the date of the transaction, the boat, the plant, and the amount of fish involved (though not the price), is included.

Boat registry. We merge the supply transactions data with an administrative boat registry that provides information on a boat's owner, the material the boat is made of, its storage capacity and engine power, and whether it has a cooling system installed.[24]

Boat GPS data. Peruvian fishing boats that supply fishmeal plants are required to have a GPS tracking system installed, and to continuously transmit their GPS signal to the Ministry of Production while at sea. The ministry stores the transmitted information – the boat's ID, latitude, longitude, speed, and direction – each hour on average, and shared the resulting dataset with us.

Since we do not directly observe when and where a boat has its nets out, we construct an algorithm to infer fishing location and -time. The algorithm exploits the fact that a boat's speed is lower when searching for fish or actively fishing than when traveling back to port.[25]

It is important to note that only about half of the observations in the Supply transactions dataset can be matched to a GPS recording, and the missing GPS observations are not "missing at random". Some boat owners, for example, disappear from the GPS data for a complete calendar year. However, such missingness is unlikely to be of concern for within-boat analysis, the level at which we use the GPS data.

Internal data from a large firm. One of the largest fishmeal firms in Peru shared its internal records on sales with us. The firm has been operating for more than a decade, and owns many plants throughout the coast. The sales records are detailed and include information on the shipment's type of packing, its free-on-board value, the price per metric ton, the buyer, destination country, date of the contract, and the terms. Most importantly for our purposes, the sales records include information on the specific plant that produced a given shipment of fishmeal.

Phytoplankton data. We use NASA chlorophyll concentration data from satellite images to predict fish abundance. This data allows scientists to measure how much phytoplankton is growing in the ocean by

[22] For firms the data contain information on the number of metric tons that can be produced per hour with respectively the installed Low and High technology, while for plants we observe an indicator for whether the plant has any of each type of technology installed. As very few firms in our sample only have the Low technology, we define a High technology firm as one for which the High technology share of total processing capacity is higher than the median (0.67).

[23] The smallest firms use intermediaries to export. We cannot link intermediated exports to a specific firm's production.

[24] Unfortunately, information on engine power is only available for 2004-2006 and so we do not observe any improvements in engine power from one year to another during our period of analysis. However, changes in engine power are very rare from 2004 to 2006 so we treat this boat characteristic as fixed.

[25] Specifically, we follow Natividad (2014) and assume that a boat has its nets out if speed is below 2.9 kilometers/hour. The industry association IFFO confirmed to us that the method should provide fairly accurate results. We have also used two alternative algorithms for inferring fishing location and -time; these yield similar results.

observing the color of the light reflected off the water. The data is available for each date and each 0.1°-latitude×0.1°-longitude (roughly 10 kilometer×10 kilometer) grid-cell.[26]

4 Vertical Integration and Output Quality

In this section, we document a robust relationship between vertical integration ("VI") and average quality grade produced. The association holds both within firms across time and across plants within a firm across time, and is found for each of the various ways we measure VI and quality produced. Taken together, the estimates we present point towards a direct effect of organizational structure on output quality.

We estimate regressions of the form:

$$\text{Quality}_{it} = \alpha + \beta_1 \text{VI}_{it} + \beta_2 \text{HighTech}_{it} + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

where Quality_{it} is a measure of the quality of the output produced by firm or plant i during production season or month t. As discussed in Section 3, at plant level, we measure output quality as the share of fishmeal produced that is of "prime" quality, while at the firm level we measure output quality using log export unit prices and protein content. The latter two measures are averaged across specific export transactions, weighting by quantity. (For the firm that provided internal data, we can use these two measures also at the plant level). The two firm level quality measures are complementary. Unit prices – the measure of output quality typically used in the existing literature – are important outcomes in and of themselves, but could partially reflect mark-ups and/or within-season fluctuations in the world price of fishmeal. Protein content instead provides a direct measure of output quality.

Our interest is in β_1, which measures the relationship between output quality and VI. The type of technology the firm or plant uses to convert fish into fishmeal is an important determinant of output quality (see Appendix Figure A2), and one that could plausibly correlate with VI (Acemoglu *et al.* , 2007, 2010). We thus control for installed HighTech_{it}, i.e., steam drying (High) technology.[27] As we include production season and firm or plant fixed effects, we estimate within-season changes in output quality for those firms or plants that see a change in VI within a given season, relative to other firms/plants that do not see a change in VI in the same season. Finally, ε_{it} is a heteroskedasticity robust error term.

A possible concern when matching sales transactions to input transactions is that fishmeal can be stored for several months so that firms might attempt to strategically time their export transactions based on time variation in the prevailing prices. In practice inventories are small – between +10 and -10 percent of total season production – as seen in Appendix Figure A1.[28] This is likely because many contracts are entered into before the production season starts, and because firms' ability to strategically "time" their sales is in

[26]Phytoplankton contain a photosynthetic pigment called chlorophyll that lends them a greenish color. In the rest of this paper, we use the term "plankton concentration" when referring to chlorophyll concentration. The data is no longer available at the date level on the NASA website (only at the week or month level), but was still available in late 2015 when we scraped the data. See http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA. Because some data points are missing, we interpolate the missing data by taking the average of date and geographical interpolations.

[27]As discussed in Section 3, at the firm level, HighTech_{it} is equal to the share of installed capacity that is of the high type, while at the plant level, where we observe whether any high technology is installed, HighTech_{it} is instead a dummy variable.

[28]Firms ramp up exporting towards the end of the production season, and have typically shipped all fishmeal before the next production season begins. Figure A2 shows the density of inventories defined as the difference between seasonal production and exports (during the production season and the months right after the production season) divided by total production (over the production season). As the graph illustrates, for the vast majority of observations in our sample, inventories are between +10 and -10 percent of total production, which confirms that storage of fishmeal is limited.

actuality limited. A related concern is that firms that are about to end operations and close down might sell off their fishmeal, in which case a lower unit price might not reflect lower quality but rather a "going-out-of-business" discount. To deal with this possibility, we exclude from our sample data from any firm×season observations that correspond to a firm's last season to produce and export fishmeal, but the results are robust to including these observations.

We begin by exploring the relationship between the number of suppliers owned and output quality at the firm level. In Table 2 we see that owning one more supplier is associated with the fishmeal exported commanding a 0.3 percent higher unit price, and having a protein content that is 0.027 percentage points higher. While vertical integration affecting output quality is one possible explanation for these patterns, it may also be that firms for example are able to purchase suppliers during periods when output quality is high for other reasons.

In Panel A of Table 3 we show that, rather than ownership of suppliers per se, what matters for output quality is *the share of a firm's supplies coming from integrated suppliers at the time of production*. The results imply that fishmeal a firm were to produce with inputs coming entirely from integrated suppliers would command 13 percent higher prices than fishmeal produced by the same firm with inputs coming entirely from independent suppliers. This price differential is roughly equal to the difference between the average unit price of the lowest quality category and highest quality category fishmeal as defined by a five-step quality ladder used by industry associations that report average prices. Similarly, the results imply that fishmeal produced with inputs from integrated suppliers would have a 1.3 percentage point higher protein content than fishmeal produced by the same firm with inputs from independent suppliers.

Of course, it is possible the relationship between output quality and the share of supply coming from integrated suppliers at the firm level is due to firm level shocks or changes in firm strategy that affect both. However, we find the same pattern across different plants *within the same firm*. In Panel B of Table 3 we repeat the analysis from Panel A, but now at the plant rather than the firm level. This is possible for the sample of plants belonging to the fishmeal firm that shared data, enabling us to link its export transactions with the specific plant that produced the fishmeal. We include plant fixed effects and thus focus on changes in the share of supply coming from VI suppliers over time within a production season and within a given plant. The magnitude and significance of the estimates are very similar to those in Panel A.

In Panel C of Table 3 we remain at the plant level, but now include all 89 plants observed in the full sample. This is possible when we use the dichotomous measure of output quality discussed in Section 3. This plant level quality measure is available at the month level. The results imply that the share of a plant's output that is of high quality would be seven percent higher if the plant were to obtain all of its input from VI suppliers, relative to when obtaining all of its input from independent suppliers. The magnitude of the association between integration and output quality we find when focusing on dichotomous output quality measured at the plant×month level is thus in line with the association we find with a continuous measure of quality grade, both at the firm level and at the plant level within a specific firm, across production seasons.[29]

In Table 4 we show that it is the integrated-versus-independent status of the boats supplying a fishmeal firm at the time of production itself, rather than other correlated observable supplier and manufacturer

[29]For completeness, we also run the firm level regressions in Table 2 using high quality share of production (i.e., we use these outcomes, measured at plant level, to construct the corresponding share for a firm as a whole) and the firm level analogue to Panel C of Table 3 (again aggreating up to firm level). The results are in Table A2 of the Appendix. The coefficient on the number of suppliers owned is not statistically significant in this case, but more importantly, the coefficient on the share of supply coming from integrated suppliers is similar in magnitude to that found in Table 3 and statistically significant.

characteristics, that matters for output quality. We return to the firm level. We repeat the regressions shown in Panel A of Table 3, but now include a series of additional controls. Controlling for the share of inputs coming from steel boats; high capacity boats; and boats with a cooling system leaves the magnitude and significance of the coefficient on share of inputs coming from VI suppliers essentially unchanged.[30]

Another possibility is that unobservable shocks to productivity induce firms to simultaneously acquire suppliers and increase output quality, without the former necessarily directly affecting the latter (as in, for example, Kugler & Verhoogen (2012)). However, adding a control for the firm's share of total industry production has little impact on the estimated VI supply coefficient, as seen in the last column of Table 4. This finding also suggests that a "foreclosure" story in which buying suppliers helps downstream firms increase their mark-ups by excluding competitors from the market cannot explain our results (see Ordover *et al.* , 1990; Hortacsu & Syverson, 2007).

We conclude that, while other mechanisms may also contribute to the association between vertical integration and output quality we have established in this section, the relationship is difficult to explain in the absence of a causal effect of the use of integrated suppliers on output quality.

5 Organizational Structure and Supplier Behavior

5.1 Supplier quantity-quality effort trade-off

In the previous section, we saw that manufacturers produce higher quality output when they source more of their inputs from integrated suppliers. In this section, we explore *how* the use of VI suppliers benefits downstream output quality. When the quality of inputs cannot be contracted upon, a firm's organizational structure may matter because the carrots and sticks that can be used to incentivize supplier effort to produce and deliver high quality inputs depend on the firm's structure.

What kind of supplier behavior is likely to improve the quality of inputs delivered? The industry insiders we talked to all reported that an important determinant of fishmeal quality is the freshness of the fish at the time of processing. The freshness of the fish depends on several factors. The first one is how the fish is stored while the boat is at sea. Some boats have an integrated cooling system on board, but the majority use ice to keep the catch fresh. Fish that has been stacked high vertically and heavily weighed down ("crushed") while stored on board will also be of lower quality when processed. The second factor that matters for freshness is how much time passes between when the fish is brought out of the water and when it is processed by a fishmeal plant. Boats' production technology thus implies a quantity-quality effort trade-off. Fishing close to port, bringing the catch to shore quickly, and not filling up the storage rooms with too much fish will increase the quality of the raw material delivered to the plants, but these same behaviors in general entail a smaller catch per trip.

In the next sub-section we develop a theoretical framework that captures the implications of suppliers' effort trade-off for downstream firms. We then use the framework's predictions to guide our investigation of how integration can allow firms to incentivize desired supplier quality-effort.

[30]We define "high capacity" as greater than the 75th percentile. Note that two of the supplier characteristics variables included – Share of inputs from high capacity boats and Share of inputs from boats with cooling system – are significantly correlated with output quality *in the cross-section* of firms. One reason why the coefficients on these characteristics are not significant in Table 4 is that we observe little change in these boat characteristics over time. In Table 4 we focus on the protein content as the measure of output quality; the corresponding results for unit prices, along with results at the plant level, are shown in Appendix Table A3. The results are very similar to those in Table 4.

5.2 Theoretical framework

In industries with vertically differentiated output quality, suppliers who are tasked with providing high quality inputs to high-end manufacturers have a natural alternative: they may simply sell their goods to lower-end manufacturers. Because the high-end manufacturers must consider the suppliers' incentive to maximize the inputs' value in the alternative (low-end) use, and because input quality is often thought to be partially observable but difficult to contract upon, the relationship between manufacturers and suppliers in such industries maps quite naturally into the classical Baker *et al.* (2002) model of organizational structure. We now sketch out a framework, slightly modifying Baker *et al.* (2002), to illustrate this intuition.

At a given point in time, there are two types of downstream firms. Quantity-oriented firms (P-firms) care only about (their share of) surplus that is due to the quantity of output that results from transactions with suppliers. We denote this surplus by P. Quality-oriented firms (Q-firms), however, care less about quantity, but also care about output quality. We denote the surplus associated with quality by Q. The total surplus generated from a transaction between a Q-firm and a supplier is $\alpha P + Q$, where $\alpha < 1$. There are several reasons why the market may be segmented in this way. Q-firms may for example be those with low marginal cost of producing quality, and/or those that have established relationships with buyers in importing countries that prefer high quality goods. We assume that suppliers who are serving Q-firms may also choose to supply P-firms, but that the reverse is not true.

A supplier chooses actions $a = \{a_1, a_2\}$ to produce inputs for downstream firms, where a_1 is the quantity-effort and a_2 is the quality-effort, and her cost of effort is $c(a) = \frac{1}{2}(a_1^2 + a_2^2)$.

The quantity surplus P is high (P_H) with probability $p(a) = a_1$ and low (P_L) with probability $1 - p(a)$, and we let $P_H = P_L + \Delta P$. Similarly, we let $Q = Q_H$ with probability $q(a) = a_2$ and $Q = Q_L$ with probability $1 - q(a)$, where $Q_H = Q_L + \Delta Q$.[31] The overall surplus S is then:

$$S = \begin{cases} P - \frac{1}{2}(a_1^2 + a_2^2) & \text{for } P\text{-firms} \\ \alpha P + Q - \frac{1}{2}(a_1^2 + a_2^2) & \text{for } Q\text{-firms} \end{cases} \tag{2}$$

We assume that effort a is unobservable to downstream firms, and that the realizations of Q and P are observable to both suppliers and downstream firms, but cannot be contracted upon. As in Baker *et al.* (2002), we consider four possible organizational structures:

1. Spot Outsourcing (Nonintegrated Asset Ownership, Spot Governance Environment)
2. Relational Outsourcing (Nonintegrated Asset Ownership, Relational Governance Environment)
3. Spot Employment (Integrated Asset Ownership, Spot Governance Environment)
4. Relational Employment (Integrated Asset Ownership, Relational Governance Environment)

The key distinction between outsourcing and employment is who owns the inputs produced. Under outsourcing, the supplier decides the use of the inputs. Under employment, the downstream firm determines the use of the inputs. In the spot market, suppliers get a share of the surplus generated. We assume that downstream firms and suppliers have equal bargaining power in both sectors so that suppliers get half of the surplus generated. Under relational contracts, the contract terms are given by $(s, b_{LL}, b_{LH}, b_{HL}, b_{HH})$

[31] We also assume $p(0) = q(0) = 0$ and $P_L < P_H < Q_L < Q_H$.

where salary s is paid by downstream firms to their suppliers at the beginning of each period and b_{ij} is a bonus paid when $Q = Q_i$ ($i = H, L$) and $P = P_j$ ($j = H, L$).

Proposition 1. *There exists an area of the parameter space in which the first-best is achievable in both the P-sector and the Q-sector, with the first-best in the P-sector realized only under Relational Outsourcing and the first-best in the Q-sector realized only under Relational Employment.*

Proof. See Appendix. □

The intuition for why quality-oriented downstream firms may need to own upstream productive assets and hire the suppliers operating the assets as employees is as follows. Under any sort of outsourcing, suppliers are free to allocate the inputs produced to their alternative use. This means that the returns to the supplier on the spot market in both the quantity- and quality-oriented sectors depend on the value of the inputs produced in the quantity sector. As a result, when the value of the input is high in the quantity sector, quality-oriented firms may be unable to prevent the suppliers they interact with from breaking their relationship and selling the goods on the spot market. Hence, the realization of market conditions plays an important role in determining whether suppliers will honor a Relational Outsourcing contract. In contrast, under Relational Employment, the downstream firm has control over the inputs, and will choose to allocate them efficiently regardless of the value in the quantity sector. Hence, when ΔP is too high (relative to ΔQ), Relational Outsourcing is not a feasible strategy for Q-firms as their suppliers' non-reneging conditions would not be satisfied.

This framework predicts that industries with vertically differentiated output quality may be in a situation in which the degree of vertical integration is greater amongst quality-oriented firms, and that we should expect integrated suppliers to put in lower quantity-effort than independent suppliers, but greater quality-effort.

5.3 Organizational structure and supplier average behavior

Guided by the version of the Baker *et al.* (2002) model with downstream quality differentiation presented above, we now explore how organizational structure matters for supplier behavior in the Peruvian fishmeal sector. We use the boat GPS data discussed in Section 3 to measure supplier behavior. We focus our analysis primarily on "switchers"; suppliers that are bought or sold by a fishmeal firm during our data period and observed delivering to the plants of the relevant firm both before and after the change in status. We thus compare the behavior of a specific supplier delivering inputs to a specific downstream firm during a specific production season when the supplier is owned by the firm versus when it is not. In the majority of "switches", the supplier goes from being independently owned to being owned by the fishmeal firm supplied, but there are also cases in which the supplier is sold from a downstream firm to an independent owner, or from one fishmeal firm to another.

As shown in Appendix Table A4, the characteristics of integrated suppliers unsurprisingly differ from the characteristics of independent suppliers. On observable features such as the size of the boat, the power of its engine, and whether or not it has a cooling system installed, the average switcher falls in between the average always-independent boat and the average always-integrated boat, but closer to the latter. More importantly,[32] we do not see any significant changes in suppliers' characteristics when switching in or out of integration with the plant supplied.

We proceed in three steps. In this sub-section, we show how a supplier's average behavior changes with being integrated with the firm supplied. In the next sub-section, we show how a supplier's behavioral response to a plant's need for input quality changes with integration. Finally, in Sub-section 5.5, we show how a supplier's behavioral response to an exogenous tightening of the trade-off between quantity- and quality-effort changes with integration.

We begin by estimating:

$$\mathrm{B}_{ijt} = \alpha + \beta \mathrm{I}[\mathrm{VI} \times \text{supplies owner firm}]_{ijt} + \gamma_{ij} + \delta_t + \varepsilon_{ijt} \quad (3)$$

where B_{ijt} is a measure of the behavior of supplier i, delivering to plant j, on date t. $[\mathrm{VI} \times \text{supplies owner firm}]_{ijt}$ is an indicator for the supplier being integrated with the plant it delivers to on date t. We include date fixed effects (δ_t) to control for potential date specific behaviors and Supplier×Plant fixed effects (γ_{ij}) so that we focus on how integration affects supplier behavior within a specific supplier-plant relationship.

We report results for four different behaviors that are closely related to suppliers' quantity-quality effort trade-off: (i) Total quantity fished on the trip, (ii) Maximum distance from the port of delivery at which we observe the boat during the trip, (iii) Total time at sea on the trip, and (iv) Time spent traveling back from the last fishing location to port. When prioritizing quality, we expect boats to bring back lower quantities per trip, stay closer to port, and return to port more quickly.

The results in Table 5 corroborate these predictions. The table demonstrates that suppliers devote greater effort to increasing the input quality of the plants they deliver to when integrated, at the cost of supplying a lower quantity per trip. Column 1 shows that, when integrated and supplying a parent plant, a boat delivers on average about six percent lower quantity per trip compared to when it supplies the same plant while independent.[33] We interpret this result as indicative that boats dedicate more of their storage capacity to ice in order to keep the catch fresher and less crushed under other fish, when integrated. Column 2 shows that boats fish approximately four percent closer to the port of delivery when integrated. In Column 3, we see that boats spend on average three percent less time at sea on a trip when integrated; however, we do not find a significant decrease in the time spent between the last fishing location and port, as seen in Column 4.

Integration may enable knowledge transfer from manufacturers to their suppliers (see e.g. Atalay *et al.* , 2014). In Appendix Table A5 we show auxiliary results that are difficult to reconcile with such a story being the primary explanation behind the change in supplier behavior when integrated. We re-estimate the regression reported in Table 5 separately for two different types of switchers: those suppliers who go from being independently owned to being owned by the fishmeal firm supplied or vice versa,[34] and those who go from being owned by another fishmeal firm to being owned by the fishmeal firm supplied or vice versa. The results are qualitatively similar in these two sub-samples, indicating that it is incentives that are due to the supplier's status *relative to the firm currently supplied* that matter for behavior.

[32]Differences in time-invariant supplier characteristics are controlled for in our analysis because we focus on *changes* in a supplier's behavior when it integrates with (or separates from) the plant supplied.

[33]We use the terms "independent" and "integrated" loosely in this section of the paper and do not always spell out that the terms refer to a supplier's status *relative to the specific firm that owns the plant supplied*.

[34]Note that the reason why we keep these two sub-groups as one sample rather than run the regression separately for each sub-group is that very few suppliers are sold from a fishmeal firm to an independent owner and observed supplying the initial owner both before and after the change in status.

In Appendix Table A6, we show that relational outsourcing contracts, unlike employment contracts, appear not to be used to incentivize supplier quality-effort in the Peruvian fishmeal industry, consisted with the framework in Sub-section 5.2. We show results for two different observable proxies for a supplier being engaged in a relational outsourcing contract with a downstream firm: (i) that the supplier delivers more than 80 percent of its fish to the same fishmeal firm (approximately the 75th percentile of the underlying distribution) for two consecutive production seasons, and (ii) that the supplier delivers to the same firm more than 10 times (approximately the 25th percentile of the underlying distribution) in a given production season and does so for three seasons in a row. The results show that a supplier supplying a given firm does not deliver fresher fish when engaged in repeated interactions with the plants in question, relative to more isolated instances of supplying the same plants. If anything, the supplier actually travels further from port during such periods.[35] It is worth noting that we also do not observe the positive relationship between output quality and relational outsourcing that we see for use of vertically integrated suppliers.[36]

The results in columns 1-4 of Table 5 are consistent with the hypothesis that vertically integrating enables fishmeal firms to induce supplier behaviors that improve the quality of their inputs. A potential alternative interpretation is that suppliers simply put in less quantity-effort when integrated (and not paid proportional to quantity). Since such a story allows for plants' output quality to benefit from integrated suppliers putting in less quantity-effort, it is difficult to separate from the incentives-for-quality-effort hypothesis we focus on. The results in Column 5 of Table 5, however, do not support an "accidental quality upgrading" view. There we show that boats go out on more fishing trips when integrated, perhaps to compensate for the fact that they bring less quantity per trip post-integration.

5.4 Organizational structure and supplier behavioral response to plant input quality needs

In the previous sub-section, we analyzed how a supplier's *average* behavior changes with integration. In this sub-section, we explore how the way a supplier *changes* its behavior in response to a change in the supplied plant's need for input quality differs when integrated. A change in the need for input quality arises when the plant aims to produce high quality fishmeal (for example because of a change in demand). As before, we compare periods when the supplier is integrated with the plant supplied and periods when the supplier is independent from but supplies the same plant. The marginal impact of the behavioral response of a single supplier on the output quality of the plant as a whole is likely to be limited. We thus interpret the coefficient of interest as the supplier's response to the plant's *intention* to produce higher quality output.

[35] Observable proxies for relational outsourcing contracts are by necessity somewhat arbitrary, but the quality-effort results are not sensitive to the exact definition used. The results for the second proxy show a decrease in quantity delivered when the supplier is engaged in a relational outsourcing contract with the plant, while the results for the first proxy do not. Note that we "turn on" the inferred contract at the start of the relevant period, not when the "cut-off" used in the proxy is reached.

[36] These results are shown in Appendix Table A7, which is analogous to Table 3, for completeness. There we relate output quality not only to the share of inputs coming from integrated suppliers, but also to the share coming from suppliers under relational outsourcing contracts (as defined by the proxies described above). The estimated coefficients on the share of inputs coming from integrated suppliers remain positive and highly significant, while the estimated coefficients on the share coming from suppliers under relational outsourcing contracts are very small and insignificant. Results analogous to those shown for integrated suppliers in sub-sections 5.4 and 5.5 for suppliers under relational outsourcing contracts are available from the authors upon request; these show that such suppliers do not adjust their behavior to the input quality needs of the plant supplied and production conditions in the output quality-beneficial way that integrated suppliers do.

We estimate the following equation:

$$
\begin{aligned}
\mathrm{B}_{ijt} = \alpha &+ \beta_1 \, \mathrm{I[VI \times supplies\ owner\ firm]}_{ijt} \times \mathrm{I[Low\ Quality]}_{jt} \\
&+ \beta_2 \, \mathrm{I[VI \times supplies\ owner\ firm]}_{ijt} \times \mathrm{I[High\ Quality]}_{jt} \qquad (4)\\
&+ \gamma_{ij} \times \mathrm{I[High\ Quality]}_{jt} + \gamma_{ij} \times \mathrm{I[Low\ Quality]}_{jt} + \delta_t + \varepsilon_{ijt} \qquad (5)
\end{aligned}
$$

where $\mathrm{I[Low\ Quality]}_{jt}$ is a dummy equal to 1 when plant j – i.e. the plant supplier i supplies at t – produces comparatively low quality fishmeal in the month date t falls within (and conversely for $\mathrm{I[High\ Quality]}_{jt}$).[37] We include Supplier×Plant×Quality level fixed effects (that is, $\gamma_{ij} \times \mathrm{I[High\ Quality]}_{jt}$ and $\gamma_{ij} \times \mathrm{I[Low\ Quality]}_{jt}$) to focus on the supplier's *differential* response to the plant's input needs when integrated. The other variables are as defined in equation (3).

The results in Table 6 suggest that integrated suppliers differentially adapt their quality-effort to the current needs of the downstream plant they supply. Column 1 shows that boats tend to deliver a lower quantity per trip when integrated with the plant supplied, regardless of whether the plant produces low or high quality at the time. However, columns 2, 3 and 4 show that, when integrated, boats adjust their behavior so as to deliver fresher fish when the plant supplied is producing high quality output. When integrated, boats fish about seven percent closer to port, spend about six percent less time at sea and five percent less time bringing the fish back to port, when the plant supplied is producing high quality output.[38]

In Panel A of Appendix Table A8, we show that the estimated behavioral response to the input quality needs of the plant supplied is very similar if instead of focusing on switchers, we take a difference in differences approach. That is, we now compare suppliers that are either integrated or non-integrated with the plant supplied, when the plant is producing low quality versus high quality fishmeal. Relative to non-integrated suppliers, integrated suppliers put in lower quantity-effort but higher quality-effort when the plant supplied is producing high quality fishmeal, as seen in respectively column 1 and columns 2-4 of the panel. We view these results as corroborating those in Table 6, although we ultimately put more weight on results from within-supplier comparisons.

5.5 Organizational structure and supplier behavioral response to variation in production conditions

We have analyzed a supplier's change in (i) average behavior and (ii) behavioral response to a downstream need for input quality when the supplier vertically integrates with (or separates from) the plant it supplies. The findings are consistent with the hypothesis that downstream firms that aim to produce high quality output can more easily incentivize integrated suppliers because the consequences such suppliers face if they do not deliver inputs of the desired quality differ. In theory it is possible that the findings in subsections 5.3 and 5.4 are explained by downstream firms acquiring or selling suppliers exactly at times when those suppliers would have changed their behavior even if they had not been bought/sold by the firm supplied. To go further, we now explore how a supplier's response to an exogenous tightening of the trade-

[37] We define this dummy variable using the measure of quality we observe at the plant level, namely the share of the plant's production that is of the high quality type of fishmeal. The dummy is equal to 1 if the share of the plant's production that is of high quality is higher than the median in our sample.

[38] The last row of Table 6 shows that, with the exception of the first column, the behavior of integrated suppliers is significantly different when the downstream plant produces higher quality.

off between quantity- and quality-effort, depends on whether the supplier is owned by the firm it supplies or not.

Plankton is the primary food source of Peruvian anchovies. Plankton concentration can thus be used to predict the amount of fish present in a specific location (see also Axbard, 2016; Fluckiger & Ludwig, 2015). In the map in Panel (a) of Figure 1, we depict variation in plankton concentrations along the coast of Peru on a randomly picked date. The variation shown means that fish density in the ocean outside of fishmeal plants located in different parts of Peru differed on the date shown. A dynamic version of the same map would show that the spatial distribution of plankton varies considerably across time. Panel (b) of Figure 1 shows a map of plankton concentrations on the same date around the cluster of fishmeal plants in the town of Paracas. We see that boats concentrate their fishing in areas where plankton concentrations are highest.

To exploit the plankton variation shown in Figure 1, we take a "split sample" approach. Specifically, we use 2015 data to identify the conditions that lead to availability of more and better fish, and thereafter exclude 2015 data from our regressions of interest. We first define good fishing conditions for a specific location. Geographically, the NASA plankton data is at the level of 0.1°-latitude×0.1°-longitude (roughly 10×10 kilometer) grid-cells×dates. We match the plankton data with information on how much fishing takes place in a given grid-cell, as inferred from GPS measures of boats' movements.

We first explore the likelihood that at least one boat fishes in a specific grid-cell on a specific date, as a function of the log plankton concentration.[39] The top panel of Figure 2 shows that the higher the log plankton concentration, the higher the likelihood that the location is chosen by at least one boat. The bottom panel of Figure 2 shows the total quantity fished by all boats in the grid-cell as a function of log plankton concentration, controlling for boat fixed effects. The graph shows a positive and approximately linear relationship. Overall, Figure 2 makes clear that a higher plankton concentration is associated with better fishing conditions. For the rest of this section, we define a grid-cell×date as *good for fishing* if the log plankton concentration is greater than the median as defined over all grid-cells where at least one boat fishes at some point in 2015.

Our objective is to define how good the fishing conditions in the area outside of a cluster of fishmeal plants (i.e., a fishmeal port) are on a specific date.[40] To do so, we must aggregate the grid-cells around each port to construct a port-specific measure. We first construct the share of fishing locations around a cluster of plants that are *good for fishing* on the date in question.[41] We then define a port×date as having *difficult conditions* if the share of the grid-cells surrounding the location that are *good for fishing* is lower than the 10th percentile in the distribution of port×dates in our sample. In this sense, our definition of *difficult conditions* corresponds to dates when it is challenging to find fish nearby a cluster of plants. Figure 3 shows that on the dates when upstream production conditions are *difficult*, supply of fish to plants is on average 90 percent lower.

With this measure in hand, we explore whether the benefits of vertical integration to firms attempting to produce high quality output are greater when suppliers' opportunity cost of delivering high quality inputs

[39] We take logs because the distribution of plankton concentration is fat-tailed.

[40] We do not focus on the conditions facing a specific boat at a specific location because the boat's choice of where to fish is likely to be endogenous to its objectives on the date in question.

[41] We use only the locations that are within 145 kilometers of the port, the 95th percentile of the maximum distance from the port of delivery at which boats are observed during fishing trips.

is high. We estimate the following equation:

$$\text{Quality}_{jt} = \alpha + \beta_1 \text{VI}_{jt} + \beta_2 \text{Difficult conditions}_{jt} + \beta_3 \text{VI}_{jt} \times \text{Difficult conditions}_{jt} + \beta_4 \text{HighTech}_{jt} + \gamma_j + \delta_t + \varepsilon_{jt} \quad (6)$$

where the firm×production season level continuous variable Difficult conditions$_{jt}$ is the average of port×date *difficult conditions* indicator variables for the locations where the firm's plants are located.

The results are presented in Table 7. The second row shows that if a downstream firm is subject to more *difficult conditions* upstream during a production season, the average quality grade of its fishmeal is significantly lower. We interpret this finding as evidence that when conditions are *difficult* according to our measure, it is more challenging for suppliers not only to deliver input quantity, but also quality.[42]

The third row of Table 7 shows that a firm can reduce the impact of *difficult conditions* on the quality of its output by sourcing more of its inputs from integrated suppliers. Since we normalize the *difficult conditions* variable to a mean of 0, the first row can be interpreted as the total correlation between the share of inputs coming from integrated suppliers and output quality. Comparing the first row of columns 1 and 2, and columns 3 and 4, we see that when we control for *difficult conditions* and its interaction with the VI share of inputs, the correlation between VI and output quality falls significantly.[43] This indicates that using integrated suppliers allows firms to partially overcome the challenges to producing high quality output that arise when upstream production conditions are difficult. This accounts for part of the correlation between integration and output quality we established in Section 4.

In Panel A of Appendix Table A10 we show that these results are not sensitive to how we define difficult production conditions. There we define a cluster of plants×date as having *difficult conditions* if the share of the grid-cells surrounding the location that are *good for fishing* is lower than the 20th percentile in the distribution of port×dates in our sample. The results are very similar to those in Table 7.

We next explore whether the ability of integrated suppliers to help downstream firms mitigate difficult production conditions upstream is explained by their behavior at such times. Since the focus is now on suppliers, we can again use Supplier×Plant×date level data and estimate the folowing equation:

$$\begin{aligned} \text{B}_{ijt} = \alpha &+ \beta_1 \text{I[VI} \times \text{supplies owner firm]}_{ijt} \times \text{I[Not difficult conditions]}_{ijt} \\ &+ \beta_2 \text{I[VI} \times \text{supplies owner firm]}_{ijt} \times \text{I[Difficult conditions]}_{ijt} \\ &+ \gamma_{ij} \times \text{I[Difficult conditions]}_{ijt} + \gamma_{ij} \times \text{I[Not Difficult conditions]}_{ijt} + \delta_t + \varepsilon_{ijt} \end{aligned} \quad (7)$$

where I[Difficult conditions]$_{ijt}$ indicates that the fishing conditions around plant j's location are *difficult* on date t as defined above (and vice versa for I[Not difficult conditions]$_{ijt}$). Similar to the approach in Subsection 5.4, we include Supplier×Plant×Difficult conditions fixed effects ($\gamma_{ij} \times$ I[Difficult conditions]$_{ijt}$ and $\gamma_{ij} \times$ I[Not Difficult conditions]$_{ijt}$) to focus on the supplier's differential response to production conditions

[42] Industry insiders explained to us that greater plankton availability improves the fish's fatty acid profile, which in turn results in a fishmeal of higher protein content.

[43] In Appendix Table A9, we present similar regressions at the plant (as opposed to firm) level (using the dichotomous measure of quality available at plant level), and also when restricting the sample to the plants belonging to the fishmeal firm that shared its data with us. The results are qualitatively very similar to those in Table 7. One difference is that, to the extent that integrated suppliers' behavioral response to difficult production conditions helps plants produce fishmeal that is of prime rather than FAQ quality (as measured by the dichotomous quality indicator) when upstream production conditions are difficult, this does not appear to explain the correlation between the use of integrated suppliers and the share of plants' production that is of prime quality.

when integrated. The other variables are as previously defined.

The results are in Table 8. Column 1 shows that a supplier tends to deliver a lower quantity of inputs on *difficult* production days when it is integrated with the plant supplied, relative to when it is not (though the coefficient is not significant). More importantly, boats fish 27 percent closer to port, spend 19 percent less time at sea, and bring the fish back to port in 21 percent less time on days when conditions are *difficult*, when integrated with the plant supplied relative to when not.[44] Such changes in supplier behavior are likely to significantly affect the quality of the inputs available to the downstream firm. How suppliers adjust their behavior in response to an exogenous increase in the opportunity cost of quality-effort thus helps explain why it appears especially important for downstream output quality to use integrated suppliers when upstream production conditions are *difficult* (see also Forbes & Lederman, 2009, 2010).

In Panel B of Appendix Table A10, where we define a port×date as having *difficult conditions* if the share of its fishing locations that are *good* is lower than the 20th percentile in the distribution, we show that these results are not sensitive to our definition of difficult production conditions.

In Panel B of Appendix Table A8 we show the estimated behavioral response to difficult production conditions is similar if instead of focusing on switchers we take a difference in differences approach. As in Panel A of the table (discussed above), we compare integrated (with the plant supplied) and non-inegrated suppliers, now when production conditions are difficult versus when they are not. Relative to non-integrated suppliers, integrated suppliers put in higher quality-effort when production conditions are difficult, as seen on columns 2-4 (although the estimated effects are attenuated relative to those in Table 8).[45] While we view the results in Panel B of Appendix Table A8 as corroborating those in Table 8, we ultimately put more weight on results from within-supplier comparisons.

In this sub-section we have shown that the boats that supply Peruvian fishmeal plants face a trade-off between taking quantity- and quality-increasing actions because of the technology they operate under. This trade-off is likely to be particularly pressing when production conditions are *difficult*. At such times, independent boats, whose pay depends directly on the quantity they deliver, put in less quality-effort. In contrast, integrated suppliers do not respond to difficult production conditions by lowering their quality-effort.

In sum, this section has shown that inputs *in a given supplier-plant relationship* on average come in smaller batches of higher quality fish when the supplier is owned by the plant, and that the difference is greater during periods (i) when the downstream firm is producing high quality output, and (ii) when plankton conditions increase the opportunity cost of quantity- and quality-effort. The evidence thus supports the intuition laid out in the framework in Sub-section 5.2 for *how* vertical integration enables firms to produce higher quality output. In the next section we explore if firms choose an integrated structure in the situations in which our estimates suggest that they *should* do so, given the objectives we observe them pursuing.

[44] The last row of Table 8 shows that the behavior of integrated boats is significantly different when conditions are *difficult*.

[45] As seen in Column 1, the quantity integrated suppliers deliver actually responds less to difficult production conditions than the quantity non-integrated suppliers deliver. Given that integrated suppliers deliver significantly lower quantities than integrated suppliers on "normal" (not *difficult*) production days, this is arguably unsurprising. More challenging conditions are likely to affect suppliers that generally put in high quantity-effort (i.e., non-integrated suppliers) more.

6 Variation in Foreign Demand for Quality and Vertical Integration

If an integrated organizational structure helps downstream firms source high quality inputs more efficiently, then profit maximizing manufacturers should make greater use of integrated suppliers when demand for high quality grade products is high. Empirical support for this prediction would, in addition to further increasing our confidence that integration causally affects output quality, demonstrate that manufacturers in Peru are aware of and able to act on the particular path to export success we study.[46]

To test how the relative use of integrated suppliers responds to the composition of final demand, we use quality-differentiated demand shocks to instrument for the observed quality grade of a firm's exports at a given point in time on the world market. Our approach relies on two important facts about the Peruvian fishmeal sector. First, firms export different quality grades to different destinations. This is apparent in the export transactions data, where some destination countries (e.g. Chile and Japan) consistently buy higher unit price and protein content fishmeal than other countries.[47] It is also clear in the sales records of the large firm that shared its data with us, where the quality column for exports to some destination countries is simply filled in with the name of the country (e.g. "Thailand quality"). An increase in demand from high quality importers should thus increase the quality content of Peruvian fishmeal exports.

The second important fact about the Peruvian fishmeal sector is that the timing of sales contracts relative to production is typically such that a firm can change its supply strategy in a given production season in response to high or low demand from particular importer countries. An industry association informed us that almost all contracts for a given season's production are negotiated either before the season starts, or early in the season.

To construct our demand shocks, we follow an approach similar to Bastos *et al.* (2016) (see also Park *et al.* (2009); Brambilla *et al.* (2012)). In the second stage, we investigate how the relative use of integrated suppliers responds to the quality grade produced:

$$\text{VI}_{it} = \alpha + \beta_1 \text{Quality}_{it} + \gamma_i + \delta_t + \varepsilon_{it} \tag{8}$$

We control for firm and production season fixed effects as in Section 4. In the first stage, quality grade produced is instrumented by demand shocks from specific destinations as follows:

$$\text{Quality}_{it} = \gamma_i + \delta_t + \sum_j \beta_j \ (\text{I}^j_{i2008} \ S^j_{-Peru,t}) + \varepsilon_{it} \tag{9}$$

where j is an export destination country, and $\text{I}^j_{i2008} \ S^j_{-Peru,t}$ are our excluded instruments. I^j_{i2008} is a dummy variable equal to one if firm i exported to destination j in 2008, the year prior to our analysis period. $S^j_{-Peru,t}$ is the leave-Peru-out share of world fishmeal imports from country j in season t. $S^j_{-Peru,t}$ is therefore a

[46] While evidence that firms "act as if" a particular strategy can lead to success is arguably strongly suggestive that the strategy in question *in fact* supports firm growth (see e.g. Bastos *et al.* , 2016; Park *et al.* , 2009; Brambilla *et al.* , 2012), the opposite is not necessarily true. That is, there are many examples in the recent literature of strategies that firms in developing countries *could* follow in order to grow faster, but do not (see e.g. McKenzie *et al.* , 2008; Bloom *et al.* , 2013; Hardy & McCasland, 2015). Among firms that maximize profits, this is presumably because of other constraints on the strategies' adoption. This paper is unusual in that the data and variation we exploit allow us to provide *separate* evidence on a strategy's effectiveness and the determinants of its use.

[47] See Appendix Table A1 for a list of the main importers of Peruvian fishmeal and the average quality imported. Some of the countries that import comparatively high quality grades of fishmeal are rich – for example Canada, Chile, and Japan – while others are middle-income. Note that, as for humans, quantity and quality of feed (the latter here defined by protein content) are highly imperfect substitutes for farm animals and farmed fish.

proxy for demand from destination j at a given point in time. Changes in j's demand should matter more for firms that previously exported to j, which we capture in the interaction between $S^j_{-Peru,t}$ and I^j_{i2008}.

In an alternative approach to instrumenting for high quality demand shocks, we replace $S^j_{-Peru,t}$ by S^j_{-it}, the leave-firm-i-out share of Peru's total exports to destination j in season t. This has little effect on the estimates (see Appendix Table A11).

To select a set of importer countries to include in the first stage, rather than select a set of arbitrary size, we take an agnostic approach. We use LASSO regressions to choose the importer countries whose demand fluctuations most affect overall quality exported: Japan and Canada.[48] Reassuringly, inspection of our data on quality grades shows that these are indeed countries whose imports of fishmeal differ considerably from other countries in average unit prices and protein content. In an alternative approach, we instead use the 20 biggest importer countries of fishmeal in the first stage; this gives very similar results to the LASSO approach (see Appendix Table A11).

Since the existing literature that uses destination country demand shocks for identification often struggles with weak instruments, we compute the Kleibergen-Paap Wald and Anderson-Rubin Wald test statistics. Comparing the statistics reported in Table 9 to the Stock-Yogo critical values,[49] we cannot reject the null hypothesis that our instruments are weak. However, we can reject the hypothesis that the coefficients on the excluded instruments are jointly zero when they are included in place of quality itself in the second stage regression using the Anderson-Rubin Wald test. It is important to note that weak instruments would bias the IV coefficients *downward*, i.e., towards the OLS coefficients, rather than upward. See Bastos *et al.* (2016) for a lengthier discussion of this issue in the context of Bartik instruments.

Another potential concern is that the liquidity that comes along with greater demand for quality (rather than the demand for quality itself) may affect firms' ability to integrate. That is, if firms' seasonal revenues are expected to be higher when demand for quality is high, they may be better able to access the capital necessary to vertically integrate, but actually integrate for other reasons than to satisfy the demand for high quality. While this is a priori unlikely since we focus on *use* of integrated suppliers rather than acquisitions, we address the concern by including controls for total seasonal sales. This has little effect on the estimated coefficients.

The OLS and the second stage IV results of interest are reported in Table 9. We find that firms respond to positive shocks to demand for high quality fishmeal by sourcing a higher share of their inputs from integrated suppliers.[50]

We conclude that Peruvian manufacturing firms are aware of, and act on, their greater ability to produce high quality grade output when integrated suppliers are used. The strategic changes in organizational structure in response to changes in the composition of demand we have shown evidence of in this section are consistent with the integration-quality relationship established in Section 4, the intuition of the model in Sub-section 5.2, and the corresponding evidence on how integration can help downstream manufacturers attempting to produce high quality output control supplier behavior in sub-sections 5.3, 5.4, and 5.5.

[48]LASSO (least absolute shrinkage and selection operator) is a regression analysis method that performs both variable selection and regularization in order to enhance the prediction accuracy and interpretability of the statistical model it produces, penalizing the model for including more regressors. In the leave-firm-i-out approach, LASSO selects Japan and Australia.

[49]Though Stock-Yogo's critical values are computed for the homoskedastic case, it is standard practice to compare the Kleibergen-Paap Wald test statistics to these critical values even when one reports standard errors that allow for heteroskedasticity.

[50]It is noteworthy that the IV coefficients in columns 3 and 4 are bigger than the OLS coefficients in columns 1 and 2. This corresponds with our conjecture that the relationship between the share of supply from integrated suppliers and output quality estimated in Section 4 *partly* reflects a causal relationship.

7 Conclusion

This paper identifies an overlooked motivation for vertical integration in incomplete contracts settings: downstream firms strategically integrate to be able to produce output of high enough quality to sell to higher-paying consumers in richer countries. Using integrated suppliers allows manufacturing plants to incentivize desired behavior upstream and better control input quality.

Using within- and across-firm transaction level data and direct measures of the quality grades produced by downstream firms in the Peruvian fishmeal manufacturing industry, we first show that an increase in the share of inputs coming from integrated suppliers is robustly associated with higher output quality. To understand this relationship, we present a modified version of the classical Baker *et al.* (2002) model in which we allow for both quality- and quantity-oriented downstream firms, and two types of supplier effort; quantity-effort and quality-effort. The model predicts that the subset of downstream firms that aim to produce high quality output may be able to achieve the desired supplier behavior only via employment contracts. When suppliers are independently owned, their incentive to renege on agreements with quality-oriented firms and shift to lower quality buyers may render the first-best effort levels unsustainable. Guided by the framework, we use "switchers" to explore how a supplier's behavior changes when integrated with the plant supplied. We find that fishing boats change their behavior consistently with the objective of delivering fresher fish – which allows their clients to produce higher quality fishmeal – when integrated. They do so more when the downstream plant is in need of high quality input, and when the fishing conditions increase the supplier's opportunity cost of quality-effort, consistent with the logic of the modified Baker *et al.* (2002) framework. Finally, we instrument for the quality grade produced with firm-specific, export destination demand shocks and show that, when firms face higher demand from importers of high quality, they source more of their inputs from integrated suppliers.

Overall this paper's results demonstrate a specific strategy that firms in incomplete contracts settings can and do adopt in order to upgrade the quality of their products and achieve export-driven growth, and why the vertical integration strategy works. Our findings raise the possibility that output quality motives may be part of the reason why vertical integration is more common in developing countries (Acemoglu *et al.* , 2005; Macchiavello, 2011). Quality upgrading, as well as other firm objectives that recent studies suggest can be achieved through organizational strategies (such as technology adoption and dealing with unforeseen contingencies (Forbes & Lederman, 2009, 2010; Atkin *et al.* , forthcoming)), are especially important for firms seeking to sell their products to richer consumers abroad. This suggests that creating scope for flexibility in firms' choice of organizational strategy is particularly important in the developing world, but also that improvements in contract enforcement can reduce the need for firms there to make organizational choices that may be second-best but not first-best optimal.

References

ACEMOGLU, D., AGHION, P., LELARGE, C., VAN REENEN, J., & ZILIBOTTI, F. 2007. Technology, Information and the Decentralization of the Firm. *Quarterly Journal of Economics*.

ACEMOGLU, D., AGHION, P., GRIFFITH, R., & ZILIBOTTI, F. 2010. Vertical Integration and Technology: Theory and Evidence. *Journal of European Economic Association*.

ACEMOGLU, DARON, JOHNSON, SIMON, & MITTON, TODD. 2005. *Determinants of Vertical Integration: Finance, Contracts, and Regulation*. NBER working paper.

ALFARO, LAURA, CONCONI, PAOLA, FADINGER, HARALD, & NEWMAN, ANDREW F. 2016a. Do Prices Determine Vertical Integration? *Review of Economic Studies*, **83**, 855–888.

ALFARO, LAURA, ANTRÀS, POL, CHOR, DAVIN, & CONCONI, PAOLA. 2016b. *Internalizing Global Value Chains: A Firm-Level Analysis*. NBER working paper.

ANTRÀS, P., & STAIGER, R. W. 2012. Offshoring and the Role of Trade Agreements. *American Economic Review*.

ANTRÀS, POL. 2003. Firms, Contracts, and Trade Structure. *Quarterly Journal of Economics*, **118**, 1375–1418.

ANTRÀS, POL. 2014. Grossman-Hart (1986) Goes Global: Incomplete Contracts, Property Rights, and the International Organization of Production. *Journal of Law, Economics, and Organization*.

ANTRÀS, POL. 2016. *Global Production: Firms, Contracts, and Trade Structure*. Princeton University Press.

ARROW, KENNETH J. 1975. Vertical Integration and Communication. *The Bell Journal of Economics*, **6**(1), 173–183.

ATALAY, ENGHIN, HORTACSU, ALI, & SYVERSON, CHAD. 2014. Vertical Integration and Input Flows. *American Economic Review*, **104**(4), 1120–48.

ATKIN, DAVID, CHAUDHRY, AZAM, CHAUDRY, SHAMYLA, KHANDELWAL, AMIT K., & VERHOOGEN, ERIC. forthcoming. Organizational Barriers to Technology Adoption: Evidence from Soccer-Ball Producers in Pakistan. *Quarterly Journal of Economics*.

AXBARD, SEBASTIAN. 2016. Income Opportunities and Sea Piracy in Indonesia: Evidence from Satellite Data. *American Economic Journal: Applied Economics*, **8**(2), 154–94.

BAIR, J. 2009. *Frontiers of commodity chain research*. Stanford University Press.

BAKER, G, & HUBBARD, T. 2003. Make Versus Buy in Trucking: Asset Ownership, Job Design and Information. *American Economic Review*.

BAKER, G, & HUBBARD, T. 2004. Contractibility and Asset Ownership: On-Board Computers and Governance in US Trucking. *Quarterly Journal of Economics*.

BAKER, GEORGE, GIBBONS, ROBERT, & MURPHY, KEVIN J. 2002. Relational Contracts and the Theory of the Firm. *The Quarterly Journal of Economics*, **117**(1), 39–84.

BALDWIN, R., & HARRIGAN, J. 2011. Zeros, Quality, and Space: Trade Theory and Trade Evidence. *American Economic Journal: Microeconomics*.

BANERJEE, A., & DUFLO, E. 2000. Reputation Effects and the Limits of Contracting: A Study of the Indian Software Industry. *Quarterly Journal of Economics*.

BASTOS, PAULO, & SILVA, JOANA. 2010. The quality of a firm's exports: Where you export to matters. *Journal of International Economics*.

BASTOS, PAULO, SILVA, JOANA, & VERHOOGEN, ERIC. 2016. *Export Destinations and Input Prices*. Unpub. paper.

BLOOM, NICHOLAS, EIFERT, BENN, MCKENZIE, DAVID, MAHAJAN, APRAJIT, & ROBERTS, JOHN. 2013. Does management matter: evidence from India. *Quarterly Journal of Economics*.

BRAMBILLA, IRENE, & PORTO, GUIDO. 2016. High-Income Export Destinations, Quality and Wages. *Journal of International Economics*.

BRAMBILLA, IRENE, LEDERMAN, DANIEL, & PORTO, GUIDO. 2012. Exports, Export Destinations, and Skills. *American Economic Review*, **102**(7), 3406–38.

BRAMBILLA, IRENE, LEDERMAN, DANIEL, & PORTO, GUIDO. 2016. *Exporting Firms and the Demand for Skilled Tasks*. mimeo, UNLP.

BRESNAHAN, TIMOTHY F., & LEVIN, JONATHAN D. 2012. Vertical integration and Market Structure. *In:* GIBBONS, R., & ROBERTS, D.J. (eds), *Handbook of Organizational Economics*.

COASE, R. 1937. The Nature of the Firm. *Economica*.

DE LA PUENTE, OSCAR, SUEIRO, JUAN CARLOS, HECK, CARMEN, SOLDI, GIULIANA, & PUENTE, SANTIAGO DE LA. 2011. *Evaluacion de los sistemas de gestion pesquera en el marco de la certificacion a cargo del marine. La pesqueria Peruana de anchoveta*. Stewardship Council, Cayetano Heredia University WP.

FLUCKIGER, MATTHIAS, & LUDWIG, MARKUS. 2015. Economic shocks in the fisheries sector and maritime piracy. *Journal of Development Economics*, **114**, 107 – 125.

FORBES, S. J., & LEDERMAN, M. 2009. Adaptation and Vertical Integration in the Airline Industry. *American Economic Review*.

FORBES, SILKE J., & LEDERMAN, MARA. 2010. Does vertical integration affect firm performance? Evidence from the airline industry. *The RAND Journal of Economics*, **41**(4), pp. 765–790.

FOSTER, LUCIA, HALTIWANGER, JOHN, & SYVERSON, CHAD. 2008. Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability? *American Economic Review*, **98**(1), 394–425.

FRÍAS, JUDITH A., KAPLAN, DAVID S., & VERHOOGEN, ERIC. 2009. *Exports and Wage Premia: Evidence from Mexican Employer-Employee Data.* mimeo Columbia University.

GAULIER, GUILLAUME, & ZIGNAGO, SOLEDAD. 2010 (Oct.). *BACI: International Trade Database at the Product-Level. The 1994-2007 Version*. Working Papers 2010-23. CEPII research center.

GIBBON, P., & PONTE, S. 2005. *Trading down: Africa, value chains, and the global economy*. Temple University Press.

GIBBONS, ROBERT. 2005. Four formal(izable) theories of the firm? *Journal of Economic Behavior and Organization*, **58**(2), 200 – 245.

GIL, R. 2009. Revenue sharing distortions and vertical integration in the movie industry. *Journal of Law, Economics, and Organization*.

GOLDBERG, PINELOPI KOUJIANOU, KHANDELWAL, AMIT KUMAR, PAVCNIK, NINA, & TOPALOVA, PETIA. 2010. Imported Intermediate Inputs and Domestic Product Growth: Evidence from India. *The Quarterly Journal of Economics*, **125**(4), 1727–1767.

GROSSMAN, G. M., & HELPMAN, E. 2002. Integration Versus Outsourcing In Industry Equilibrium. *Quarterly Journal of Economics*.

GROSSMAN, SANFORD J., & HART, OLIVER D. 1986. The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. *Journal of Political Economy*, **94**(4), pp. 691–719.

HALLAK, JUAN CARLOS. 2006. Product quality and the direction of trade. *Journal of International Economics*.

HALLAK, JUAN CARLOS, & SCHOTT, PETER. 2011. Estimating Cross-Country Differences in Product Quality. *Quarterly Journal of Economics*.

HALPERN, LASZLO, KOREN, MIKLOS, & SZEIDL, ADAM. 2015. Imported Inputs and Productivity. *American Economic Review*.

HANSMAN, CHRISTOPHER, HJORT, JONAS, & LEÓN, GIANMARCO. 2016. *Interlinked Firms and the Consequences of Piecemeal Regulation*. Unpub. paper.

HARDY, MORGAN, & MCCASLAND, JAMIE. 2015. *Are Small Firms Labor Constrained? Experimental Evidence from Ghana" with Morgan Hardy*. mimeo, University of British Columbia.

HART, OLIVER, & MOORE, JOHN. 1990. Property Rights and the Nature of the Firm. *Journal of Political Economy*, **98**(6), pp. 1119–1158.

HART, OLIVER, SHLEIFER, ANDREI, & VISHNY, ROBERT W. 1997. The proper scope of government: theory and an application to prisons. *The Quarterly Journal of Economics*, **112**(4), 1127–1161.

HOLMSTROM, B. 1999. The Firm as a Subeconomy. *Journal of Law, Economics, and Organization*.

HOLMSTROM, B., & TIROLE, J. 1991. Transfer pricing and organizational form. *Journal of Law, Economics, and Organization*.

HOLMSTROM, BENGT, & MILGROM, PAUL. 1991. Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design. *Journal of Law, Economics, & Organization*, 24–52.

HONG, GEE HEE, & LI, NICK. 2016. Market Structure and Cost Pass-Through in Retail. *Review of Economics and Statistics*.

HORTACSU, ALI, & SYVERSON, CHAD. 2007. Cementing Relationships: Vertical Integration, Foreclosure, Productivity, and Prices. *Journal of Political Economy*.

HUMMELS, D., & KLENOW, P. 2005. The variety and quality of a nation's exports. *American Economic Review*.

IRARRAZABAL, ALFONSO, MOXNES, ANDREAS, & OPROMOLLA, LUCA DAVID. 2013. The Margins of Multinational Production and the Role of Intrafirm Trade. *Journal of Political Economy*.

JOHNSON, ROBERT C. 2012. Trade and Prices with Heterogeneous Firms. *Journal of International Economics*.

KHANDELWAL, AMIT. 2010. The Long and Short (of) Quality Ladders. *The Review of Economic Studies*, **77**(4), 1450–1476.

KLEIN, B., & LEFFER, K. B. 1981. The role of market forces in assuring contractual performance. *Journal of Political Economy*.

KUGLER, MAURICE, & VERHOOGEN, ERIC. 2012. Prices, Plant Size, and Product Quality. *Review of Economic Studies*, **79**(1), 307–339.

LAFONTAINE, FRANCINE, & SLADE, MARGARET. 2007. Vertical Integration and Firm Boundaries: The Evidence. *Journal of Economic Literature*, **45**(3), 629–685.

LEGROS, PATRICK, & NEWMAN, ANDREW F. 2013. A Price Theory of Vertical and Lateral Integration. *Quarterly Journal of Economics*.

MACAULAY, S. 1963. Non-contractual relations in business: A preliminary study. *American Sociological Review*.

MACCHIAVELLO, ROCCO. 2011. Financial development and vertical integration: theory and evidence. *Journal of the European Economic Association*.

MACCHIAVELLO, ROCCO, & MIQUEL-FLORENSA, JOSEPA. 2016. *Vertical Integration and Relational Contracts: Evidence from Costa Rica's Coffee Chain*. Unpub. paper.

MACCHIAVELLO, ROCCO, & MORJARIA, AMEET. 2015. The Value of Relationships: Evidence from a Supply Shock to Kenya Rose Exports. *American Economic Review*.

MACLEOD, W. BENTLEY. 2007. Reputations, Relationships, and Contract Enforcement. *Journal of Economic Literature*, **45**(3), 595–628.

MANOVA, KALINA, & ZHANG, ZHIWEI. 2012. Export Prices Across Firms and Destinations. *The Quarterly Journal of Economics*, **127**(1), 379–436.

MCKENZIE, D., DE MEL, S., & WOODRUFF, C. 2008. Returns to Capital: Results from a Randomized Experiment. *Quarterly Journal of Economics*.

MCLAREN, J. 2000. Globalization and Vertical Structure. *American Economic Review*.

MELITZ, MARC J. 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, **71**(6), 1695–1725.

MULLAINATHAN, S., & SHARFSTEIN, D. 2001. Do firm boundaries matter? *American Economic Review*.

NATIVIDAD, GABRIEL. 2014. Integration and Productivity: Satellite-Tracked Evidence. *Management Science*, **60**(7), 1698–1718.

NOVAK, SHARON, & STERN, SCOTT. 2008. How Does Outsourcing Affect Performance Dynamics? Evidence from the Automobile Industry. *Management Science*, **54**(12), pp. 1963–1979.

NUNN, NATHAN. 2007. Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade. *The Quarterly Journal of Economics*, **122**(2), 569–600.

ORDOVER, JA, SALONER, G, & SALOP, SC. 1990. Equilibrium vertical foreclosure. *American Economic Review*.

PAREDES, E. CARLOS, & GUTIERREZ, MARIA E. 2008. *The Peruvian Anchovy Sector: Costs and Benefits. An analysis of recent behavior and future challenges*. IIFET 2008 Vietnam Proceedings.

PARK, ALBERT, YANG, DEAN, SHI, XINZHENG, & JIANG, YUAN. 2009. *Exporting and Firm Performance: Chinese Exporters and the Asian Financial Crisis*. NBER Working Papers 14632.

SCHOTT, P. 2004. Across-product versus within-product specialization in international trade. *Quarterly Journal of Economics*.

SYVERSON, CHAD. 2004. Product Substitutability and Productivity Dispersion. *The Review of Economics and Statistics*, **86**(2), 534–550.

TADELIS, STEVEN. 2002. Complexity, Flexibility, and the Make-or-Buy Decision. *American Economic Review*.

VERHOOGEN, ERIC A. 2008. Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sector. *The Quarterly Journal of Economics*, **123**(2), 489–530.

WILLIAMSON, OLIVER. 1971. The Vertical Integration of Production: Market Failure Considerations. *The American Economic Review*, **61**(2), pp. 112–123.

WILLIAMSON, OLIVER. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications, a Study in the Economics of Internal Organization*. Free Press.

WILLIAMSON, OLIVER. 1985. *The Economic Institutions of Capitalism*. Free Press.

WOODRUFF, C. 2002. Non-contractible Investments and Vertical Integration in the Mexican Footwear Industry. *International Journal of Industrial Organization*.

TABLE 1: SUMMARY STATISTICS

		Mean	Sd
Firms	Total number of firms in sample	37	
	Export shipment (metric tons)	384	(360)
	Export Price ($/metric ton)	1443	(312)
	Number of destinations per season	7.57	(5.45)
	Number of export transactions per season	89	(101)
Plants	Total number of plants in sample	89	
	Has high technology	0.82	(0.38)
	High quality share of production	0.82	(0.37)
	Monthly production (metric tons)	3092	(3288)
	Processing capacity (metric tons/hour)	102	(56)
Boats	Number of boats operating over a season	766	240
	Owned by a downstream firm	0.28	(0.45)
	Steel	0.44	(0.50)
	Storage capacity (m3)	187	(164)
	Power engine (hp)	430	(342)
	Number of fishing trips per season	24	(13)
	Number of delivery ports per season	3.47	(1.95)
	Offload weight (metric tons) per trip	114	(113)
	Time at sea per trip (hours)	20.84	(9.97)
	Max. distance from the plant's port (kms)	76	(46)

Notes: This table gives summary statistics averaged over our sample period. *Has high technology* is a dummy equal to 1 if the plant is equiped with the Stream Drying technology described in the Background section. Plants' *processing capacity* measures the total weight of fish that can be processed in an hour. *Steel* is a binary variable equal to 1 if a boat is a steel boat (they tend to be bigger, better suited for industrial fishing, and are subject to different regulations). *Offload weight per trip* is the amount fished and delivered to a downstream firm on each trip. *Time at sea per trip* is the total time spent at sea on a fishing trip. *Max. distance from the plant's port* is the maximum distance at which a boat is from the port on a trip.

TABLE 2: OUTPUT QUALITY AND VERTICALLY INTEGRATED SUPPLIERS

Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Number of suppliers owned	0.003^{**}	0.003^{**}	0.025^{**}	0.027^{**}
	(0.001)	(0.001)	(0.012)	(0.013)
High technology share of capacity	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.21	7.21	65.5	65.5
N	190	190	190	190

Notes: One observation is a firm during a production season. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 3: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS

	Panel A: Firm level			
Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.129**	0.129**	1.335***	1.336***
	(0.056)	(0.056)	(0.450)	(0.445)
High technology share of capacity	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.21	7.21	65.5	65.5
N	190	190	190	190

	Panel B: Plant level for a major firm			
Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.115***	0.107**	1.372**	1.340**
	(0.042)	(0.044)	(0.654)	(0.656)
Has high technology	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Plant FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.23	7.23	65.8	65.8
N	66	66	66	66

	Panel C: Plant level	
Dep. var:	High quality share of production	
	(1)	(2)
Share of inputs from VI suppliers	0.119***	0.068***
	(0.022)	(0.020)
Has high technology	No	Yes
Month FEs	Yes	Yes
Plant FEs	Yes	Yes
Mean of Dep. Var.	0.82	0.82
N	2146	2146

Notes: In Panel A, one observation is a firm during a production season. One major firm shared its sales records with us, which allowed us to link an export shipment to a specific plant in the firm. Results for plants from that firm are given in Panel B. Panel C uses data from all plants, at the month level, but uses a dichotomous variable for quality. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. *High quality share of production* is the ratio of the high quality production to all production for a plant on a given month. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). *Has high technology* controls for whether a plant is equiped or not with the high technology (for a plant, we can define whether it is equiped with the high technology or not, but for a firm, we define the share of its total processing capacity that is of the high technology). *Share of inputs from VI suppliers* is the share of a firm's (or plant's) inputs that come from VI suppliers during a season (or month). Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 4: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS, CONTROLLING FOR SUPPLIERS AND FIRM CHARACTERISTICS

Dep. var:	Protein content				
	(1)	(2)	(3)	(4)	(5)
Share of inputs from VI suppliers	1.336***	1.378***	1.308***	1.321***	1.376***
	(0.445)	(0.504)	(0.449)	(0.439)	(0.451)
Share of inputs from steel boats		−0.098			
		(0.539)			
Share of inputs from high capacity boats			0.184		
			(0.920)		
Share of inputs from boats with cooling system				0.754	
				(0.904)	
Share of industry's total production					2.472
					(3.612)
High technology share of capacity	Yes	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	65.5	65.5	65.5	65.5	65.5
N	190	190	190	190	190

Notes: One observation is a firm during a production season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. Results for our second dependent variable (*Log(unit price)*), along with similar results at the plant and for one major firm in the industry are given in Appendix Table A3. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). *Share of inputs from VI suppliers* is the share of a firm's (or plant's) inputs that come from VI suppliers during a season (or month). Steel boats tend to be bigger, better suited for industrial fishing, and are subject to different regulations. High capacity boats are boats from which the capacity is in the upper quartile of the distribution. Some boats have an integrated cooling system; the others boats use ice to keep the fish fresh. Column (1) reports the same coefficient as in Column (3) of Panel A of Table 3 for comparison. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 5: SUPPLIER BEHAVIOR AND VERTICAL INTEGRATION

Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)	I[Boat goes on trip]
	(1)	(2)	(3)	(4)	(5)
I[VI × supplies owner firm]	-0.055^{***}	-0.043^{**}	-0.034^{***}	-0.008	0.051^{***}
	(0.017)	(0.017)	(0.011)	(0.013)	(0.004)
Date FEs	Yes	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes	No
Supplier FEs	No	No	No	No	Yes
N	244 075	134 548	156 479	144 479	1 237 015

Notes: One observation is a supplier during a fishing trip. For Column (5), one observation is a supplier on a given production day. *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3.*I*Boat goes out at sea is the likelihood that the boat goes out fishing on a specific **day**. The number of observations varies from one column to the next as GPS variables for a given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 6: OUTPUT QUALITY, SUPPLIER BEHAVIOR AND VERTICAL INTEGRATION

Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[VI × supplies owner firm] ×I[Plant producing low quality]	-0.097^{***} (0.036)	0.056 (0.043)	0.006 (0.026)	0.061^{**} (0.032)
I[VI × supplies owner firm] ×I[Plant producing high quality]	-0.030 (0.023)	-0.083^{***} (0.024)	-0.056^{***} (0.015)	-0.047^{***} (0.017)
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant × High Quality FEs	Yes	Yes	Yes	Yes
N	239 717	131 168	152 715	140 778
p-val - Test: two coefficients equal	0.12	0.00	0.04	0.00

Notes: One observation is a supplier during a fishing trip. This table is similar to Table 5, but where I[VI × supplies owner firm] is interacted with the quality produced by the downstream plant. *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3. I[Plant producing high quality] is a dummy equal to one if the plant the supplier delivers to produces only high quality fishmeal. The number of observations varies from one column to the next as GPS variables for on given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 7: OUTPUT QUALITY, VERTICALLY INTEGRATED SHARE OF INPUTS, AND DIFFICULT UPSTREAM PRODUCTION CONDITIONS

Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.139^{**}	0.114^{**}	1.221^{***}	0.942^{**}
	(0.060)	(0.056)	(0.466)	(0.452)
Difficult conditions		-0.140^{**}		-1.542^{**}
		(0.062)		(0.727)
Share VI $\times$ Difficult conditions		0.185^{**}		1.660^{**}
		(0.072)		(0.789)
High technology share of capacity	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.20	7.20	65.4	65.4
N	178	178	178	178

Notes: One observation is a firm during a production season. The number of observations is lower than in Table 3 as the year 2015 is excluded from the sample. (This year is used to define the plankton concentration threshold at which the production conditions can be considered as difficult). *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). I[*Difficult conditions*] is a dummy equal to 1 when the share of good fishing locations $\left[\text{Log(plankton concentration)}>0.5\right]$ around a specific plant on a specific day is less than 10 percent (this corresponds to the bottom 20th percentile in the distribution of share of good fishing locations in our sample). This dummy is defined at the port-day level, while the regressions are at the firm-season level, so the dummy variable is averaged by firm-season to construct *Difficult conditions*. It can then be interpreted as the share of days when the conditions are difficult for a specific firm during a production season. The variable is normalized to a mean equal to 0 in our sample so that the first row of this table can be interpreted as the correlation between the *Share of inputs from VI suppliers* and quality. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Supplier behavior, vertical integration and difficult upstream production conditions

Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[VI × supplies owner firm] ×I[Not difficult conditions]	-0.061^{***}	-0.029	-0.026^{**}	-0.004
	(0.019)	(0.019)	(0.012)	(0.014)
I[VI × supplies owner firm] ×I[Difficult conditions]	-0.071	-0.267^{***}	-0.190^{***}	-0.213^{***}
	(0.071)	(0.081)	(0.052)	(0.068)
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant × Difficult conditions FEs	Yes	Yes	Yes	Yes
N	216 079	116 416	135 489	125 037
p-val - Test: 2 coefficients equal	0.88	0.00	0.00	0.00

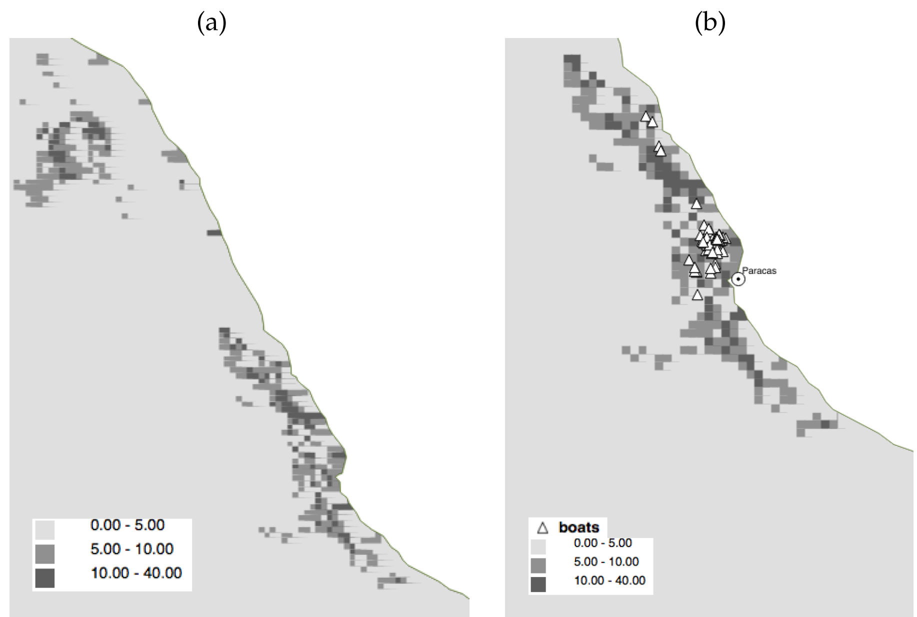
Notes: One observation is a supplier during a fishing trip. The number of observations is lower than in Table 5 as the year 2015 is excluded from the sample. (This year is used to define the plankton concentration threshold at which the production conditions can be considered as difficult). *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3. I[*Difficult conditions*] is a dummy equal to 1 when the share of good fishing locations [Log(plankton concentration)>0.5] around a specific plant on a specific day is less than 10 percent (this corresponds to the bottom 20th percentile in the distribution of share of good fishing locations in our sample). The number of observations varies from one column to the next as GPS variables for on given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 9: VERTICALLY INTEGRATED SHARE OF INPUTS AND OUTPUT QUALITY PRODUCED - INSTRUMENTING WITH FIRM-SPECIFIC DEMAND SHOCKS

	OLS	OLS	IV	IV
Dep. var:	Share of inputs from VI suppliers			
	(1)	(2)	(3)	(4)
Protein content	0.025**	0.024**	0.092**	0.097*
	(0.010)	(0.011)	(0.042)	(0.052)
Log(Sales)		0.003		−0.036
		(0.013)		(0.031)
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.43	0.43	0.43	0.43
N	190	190	190	190
First stage				
Dep. var:	Protein content			
	(1)	(2)	(3)	(4)
Japan			4.749**	2.877
			(2.341)	(2.559)
Canada			18.479***	16.092***
			(6.996)	(6.466)
Kleibergen-Paap LM p-value (Under-id)			0.00	0.01
Kleibergen-Paap Wald F statistic (Weak inst)			6.56	4.56
Anderson-Rubin Wald test p-value			0.05	0.05

Notes: One observation is a firm during a production season. *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. The instruments are interactions of indicators for positive exports to destination country in 2008 and leave-Peru-out share of fishmeal exports towards the destination in the relevant year. The destination countries selected for the construction of these instruments by LASSO are Japan and Canada. In Appendix Table A11, we include the top 20 destinations in the first stage as a robustness check. Robust standard errors in parenthesis * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

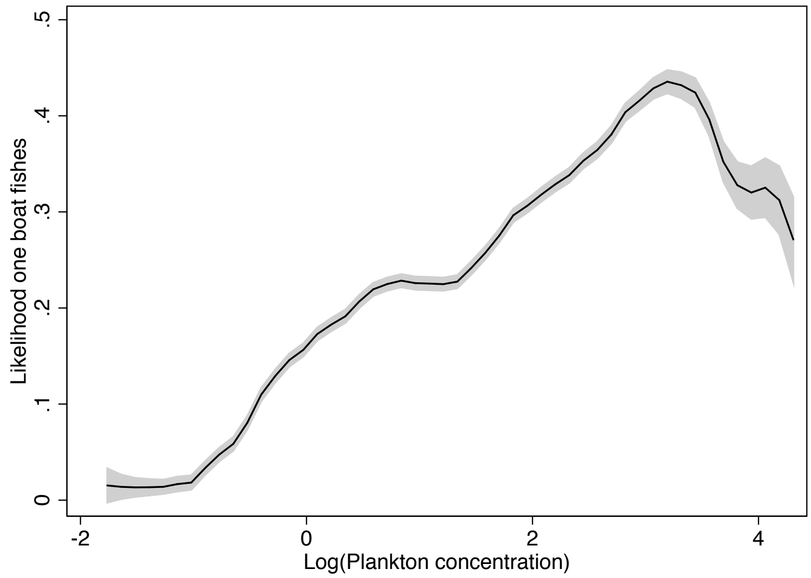
FIGURE 1: MAP OF PHYTOPLANKTON CONCENTRATION ALONG THE COAST OF PERU



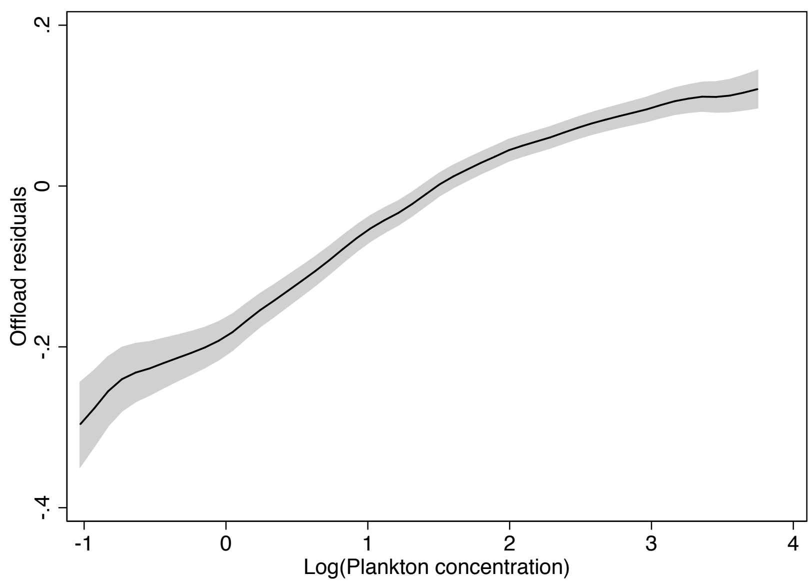
Notes: Panel (a) of this figure shows the distribution of plankton along the coast of Peru on December 10, 2012, as an example. A darker grey indicates a higher phytoplankton concentration (in mg/m^3). Panel (b) shows the same map zoomed around the port of Paracas, and the white triangles show where the boats offloading in Paracas last fished on a given trip. Fishing activity is proxied by the boat having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3.

Figure 2: Plankton concentration, fishing locations, and quantity supplied

(a)

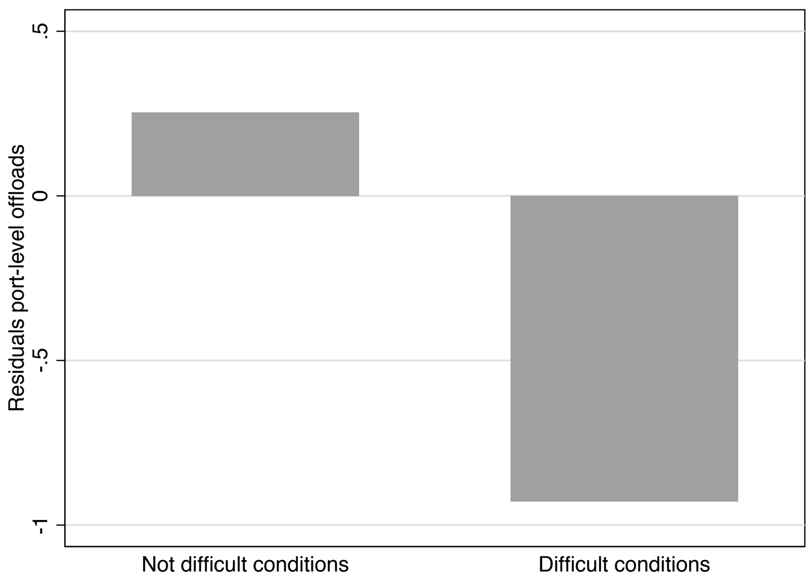


(b)



Notes: Panel (a) of this figure shows the likelihood that a boat fishes in a specific 0.1 degree$\times$0.1 degree (roughly 10 kilometer$\times$10 kilometer) grid-cell as a function of Log(phytoplankton concentration) at that location. Only locations were a boat fishes at least once during our data period and only the days when at least one boat goes out fishing are included. Panel (b) shows the residuals of a regression of quantity of fish caught in the grid-cell on boat fixed effects as a function of the Log(phytoplankton concentration). Catches are proxied by the boat having a speed lower than 2.9 kilometers/hour maintained for at least half an hour as discussed in Section 3.

FIGURE 3: DIFFICULT UPSTREAM PRODUCTION CONDITIONS AND QUANTITY SUPPLIED



Notes: This graph shows how port residualized log fish offloads vary with fishing conditions. *Difficult conditions* is defined in Section 5.5

Appendix

The P-sector

The first best in the P-sector maximizes

$$P - \frac{1}{2}(a_1^2 + a_2^2).$$

The first best actions are then $a_1 = \Delta P$ and $a_2 = 0$ and the first best surplus is $S = P_L + \frac{1}{2}(\Delta P)^2$. We now consider the actions taken under four possible organizational structures:

Spot Employment

Under spot employment, $a_1 = a_2 = 0$ and the surplus is $S = P_L$. The supplier provides no effort as the downstream party can simply take the output without paying the upstream party (see Baker *et al.* , 2002) .

Spot Outsourcing

Under spot outsourcing, firms and suppliers bargain over the surplus generated by the firm, with bargaining weights equal to $\frac{1}{2}$. More formally, the supplier chooses a_1, a_2 to maximize:

$$\frac{1}{2}P - \frac{1}{2}(a_1^2 + a_2^2).$$

The supplier chooses $a_1 = \frac{1}{2}\Delta P$ and $a_2 = 0$, hence the surplus is $S = P_L + \frac{3}{8}(\Delta P)^2$.

Relational Employment

Under both relational outsourcing and relational employment, we assume that firms provide bonuses to suppliers that depend on the realization of Q and P. Following Baker *et al.* (2002), we assume with some loss of generality that these bonuses take the form:

$$b_{ij} = b_i + \beta_j$$

where b_i is the surplus associated with the realization of Q, taking value b_L if $Q = Q_L$ and value $b_H = b_L + \Delta b$ if $Q = Q_H$. Similarly, β_j is the surplus associated with the realization of P, and can take values β_L if $P = P_L$ and $\beta_H = \beta_L + \Delta\beta$ if $P = P_L$. In the P sector, the supplier takes the first best level of effort if $\Delta\beta = \Delta P$, $\beta_L = P_L$ and $b_L = \Delta b = 0$.

Under relational employment, the firm owns the good. By reneging, the firm avoids making bonus payment b_j, but loses out on the dynamic value of the relationship, purchasing on the spot market in perpetuity. Letting π be the cost of the boat, a relational contract is sustainable under relational employment if the following no-reneging conditions hold:

- Firm: $-b_j + \frac{1}{r}D^{RE} \geq \frac{1}{r}D^{SO} + \pi$
- Supplier: $b_j + \frac{1}{r}U^{RE} \geq \frac{1}{r}U^{SO} - \pi$

Under the first best contract, these two conditions are equivalent to:

$$\max \beta_j - \min \beta_j = \Delta P \leq \frac{1}{r}[S^{FB} - S^{SO}] = \frac{1}{8r}(\Delta P)^2$$
$$\Rightarrow \Delta P \geq 8r$$

Relational Outsourcing

Under relational outsourcing, the supplier owns the good. By reneging, the firm avoids making bonus payment b_j, but also loses out on both the dynamic value of the relationship and the firm share of the current period surplus $\frac{1}{2}P_j$. By reneging, the supplier gains the spot market value of the good $\frac{1}{2}P_j$, but loses out on both the dynamic value of the relationship and the bonus payment this period. Given this, a relational contract is sustainable under relational outsourcing if the following no-reneging conditions hold:

- Firm: $-\beta_j + \frac{1}{r}D^{RO} \geq -\frac{1}{2}P_j + \frac{1}{r}D^{SO}$
- Supplier: $\beta_j + \frac{1}{r}U^{RO} \geq \frac{1}{2}P_j + \frac{1}{r}U^{SO}$

Under the first best contract, these two conditions are equivalent to:

$$\max\{b_j - \frac{1}{2}P_j\} - \min\{b_j - \frac{1}{2}P_j\} = \frac{1}{2}\Delta P \leq \frac{1}{r}[S^{RE} - S^{SO}] = \frac{1}{8r}(\Delta P)^2$$

$$\Rightarrow \Delta P \geq 4r.$$

The Q-sector

The first best in the Q-sector maximizes

$$\alpha P + Q - \frac{1}{2}(a_1^2 + a_2^2).$$

The first best actions are then $a_1 = \alpha \Delta P$ and $a_2 = \Delta Q$. The first best surplus is:

$$\alpha P_L + Q_L + \frac{1}{2}\alpha^2 \Delta P^2 + \frac{1}{2}\Delta Q^2$$

Spot Employment

Just as in the P sector, under spot employment $a_1 = a_2 = 0$. The surplus is $S = \alpha P_L + Q_L$.

Spot Outsourcing

A crucial difference between the Q and P sectors is the presence of an outside option for the supplier. In particular, the supplier may always go to the spot market in the P sector, and obtain $\frac{1}{2}P$. As a result, firms and suppliers bargain over the difference between the outside option to the supplier and the surplus to the firm. Hence, the supplier chooses a_1, a_2 to maximize:

$$\frac{1}{2}(\alpha P + Q - \frac{1}{2}P) + \frac{1}{2}P - \frac{1}{2}(a_1^2 + a_2^2).$$

The suppliers actions are given by: $a_1 = (\frac{1}{2}\alpha + \frac{1}{4})\Delta P$, and $a_2 = \frac{1}{2}\Delta Q$. The surplus is then:

$$\begin{aligned} S =& \alpha P + Q - \frac{1}{2}\left(a_1^2 + a_2^2\right) \\ =& \alpha P_L + Q_L + \alpha \Delta P a_1 + \Delta Q a_2 - \frac{1}{2}\left(a_1^2 + a_2^2\right) \\ =& \alpha P_L + Q_L + (\frac{1}{2}\alpha^2 + \frac{1}{4}\alpha)\Delta P^2 + \frac{1}{2}\Delta Q^2 - \frac{1}{2}\left(\left[\frac{1}{4}\alpha^2 + \frac{1}{16} + \frac{1}{4}\alpha\right]\Delta P^2 + \frac{1}{4}\Delta Q^2\right) \\ =& \alpha P_L + Q_L + \left(\frac{3}{8}\alpha^2 + \frac{1}{8}\alpha - \frac{1}{32}\right)\Delta P^2 + \frac{3}{8}\Delta Q^2 \end{aligned}$$

Relational Employment

Under relational employment or relational outsourcing, the first best will be realized if $\Delta b = \Delta Q$ and $\Delta \beta = \alpha \Delta P$. Similarly to the P sector, the no-reneging conditions under **relational employment** are given by (assuming spot outsourcing is more efficient than spot employment):

- Downstream: $-b_{ij} + \frac{1}{r}D^{RE} \geq \frac{1}{r}D^{SO} + \pi$
- Upstream: $b_{ij} + \frac{1}{r}U^{RE} \geq \frac{1}{r}U^{SO} + \pi$

Under the first best contract, these two conditions are equivalent to:

$$\begin{aligned} \max b_{ij} - \min b_{ij} &= \Delta b + \Delta \beta = \alpha \Delta P + \Delta Q \\ &\leq \frac{1}{r}[S^{RE} - S^{SO}] \\ &= \frac{1}{r}\left(\left[\frac{1}{8}\alpha^2 - \frac{1}{8}\alpha + \frac{1}{32}\right]\Delta P^2 + \frac{1}{8}\Delta Q^2\right). \end{aligned}$$ [51]

Relational Outsourcing

The no-reneging conditions under relational outsourcing (again assuming spot employment is more efficient than spot outsourcing) are given by:

- Downstream: $b_{ij} - \frac{1}{2}[(\alpha + \frac{1}{2})P_j + Q_i] \leq \frac{1}{r}(D^{RO} - D^{SO})$
- Upstream: $b_{ij} - \frac{1}{2}[(\alpha + \frac{1}{2})P_j + Q_i] \geq \frac{1}{r}(U^{RO} - U^{SO})$

[51] In general, this condition may be written as $\alpha \Delta P + \Delta Q \leq \frac{1}{r}[S^{RE} - \max\{S^{SE}, S^{SO}\}]$

Under the first best contract, these two conditions are equivalent to :

$$\begin{aligned}
&\max\{b_{ij} - \frac{1}{2}[(\alpha + \frac{1}{2})P_j + Q_i]\} - \min\{b_{ij} - \frac{1}{2}[(\alpha + \frac{1}{2})P_j + Q_i]\} \\
&= |\Delta b - \frac{1}{2}\Delta Q| + |\Delta\beta - \frac{1}{2}(\alpha + \frac{1}{2})\Delta P| \\
&\leq \frac{1}{r}[S^{RE} - S^{SO}] = \frac{1}{r}[S^{FB} - S^{SO}] \\
&= \frac{1}{r}\left(\left[\frac{1}{8}\alpha^2 - \frac{1}{8}\alpha + \frac{1}{32}\right]\Delta P^2 + \frac{1}{8}\Delta Q^2\right)
\end{aligned}$$

Note that when $\alpha < \frac{1}{2}$ the lefthand side of the inequality may be written as:

$$|\Delta b - \frac{1}{2}\Delta Q| + |\Delta\beta - \frac{1}{2}(\alpha + \frac{1}{2})\Delta P| = \frac{1}{2}\Delta Q + \left(\frac{1}{4} - \frac{1}{2}\alpha\right)\Delta P.$$

Proof of Proposition 1

To prove the proposition, we simply need to show that there exist some parameter values for which the first best may be achieved under relational outsourcing but not relational employment in the P sector, and under relational employment but not relational outsourcing in the Q sector. First, consider a set of parameter values in which $\alpha < \frac{1}{2}$ and the surplus is greater in the Q sector under spot outsourcing as compared to spot employment.

In the P sector, first best may be achieved in under relational outsourcing but not relational employment if

$$\frac{\Delta P}{4} \geq r > \frac{\Delta P}{8}.$$

In the Q sector, first best may be achieved in under relational employment but not relational outsourcing if the following set of inequalities hold:

$$\frac{1}{2}\Delta Q + \left(\frac{1}{4} - \frac{1}{2}\alpha\right)\Delta P > \frac{1}{r}\left(\left[\frac{1}{8}\alpha^2 - \frac{1}{8}\alpha + \frac{1}{32}\right]\Delta P^2 + \frac{1}{8}\Delta Q^2\right) > \alpha\Delta P + \Delta Q.$$

To satisfy the condition in the P-Sector, consider the case where $r = \frac{2\Delta P}{15}$. To further simplify, let $\Delta Q = \gamma\Delta P$. We can then rewrite the above set of inequalities as:

$$\left(\frac{1}{2}\gamma + \frac{1}{4} - \frac{1}{2}\alpha\right)\Delta P > \frac{15}{2}\left[\frac{1}{8}\alpha^2 - \frac{1}{8}\alpha + \frac{1}{32} + \frac{\gamma^2}{8}\right]\Delta P > (\alpha + \gamma)\Delta P.$$

This set of inequalities holds, for example, when $\alpha = 0$ and $\gamma = \frac{1}{3}$, which reduces the above to:

$$\frac{10}{24}\Delta P > \left[\frac{195}{576}\right]\Delta P > \frac{1}{3}\Delta P.$$

Given that all aspects of the inequality are continuous, note that this also must hold for some $\alpha > 0$. Finally, note that the assumptions that $\alpha < \frac{1}{2}$ and that the surplus is higher under relational outsourcing as compared to relational employment are sustained when $\alpha = 0$, $\gamma = \frac{1}{3}$ and $r = \frac{2\Delta P}{15}$.

Appendix tables

TABLE A1: MAIN IMPORTERS OF PERUVIAN FISHMEAL AND AVERAGE QUALITY IMPORTED

	Total Weight (1000 metric tons)	Average Protein content	Sd(Protein content)
CHINA	3944	65.93	1.65
GERMANY	923	65.36	1.63
JAPAN	535	66.06	1.69
CHILE	289	66.57	1.51
VIETNAM	261	65.79	1.60
TAIWAN	238	65.97	1.73
UNITED KINGDOM	150	65.23	1.61
TURKEY	130	64.90	1.50
SPAIN	89	65.41	1.62
INDONESIA	89	66.09	1.64
AUSTRALIA	81	65.82	1.82
CANADA	62	65.74	1.53
FRANCE	46	65.53	1.68
GREECE	42	66.02	1.49
SOUTH KOREA	22	66.51	1.46
ITALY	21	64.97	1.52
BULGARIA	16	65.39	1.73
HONG KONG	15	65.89	1.61
VENEZUELA	13	66.62	1.65
BELGIUM	12	64.93	1.70
PHILIPPINES	11	64.88	1.46
ECUADOR	10	65.89	1.55
INDIA	10	65.16	2.02
RUSSIA	9	66.68	1.67
NETHERLANDS	9	65.00	1.51

Notes: This table reports the top 25 importers of Peruvian fishmeal, the total quantity imported over the whole period of our sample, the average quality imported and the standard deviation of the quality imported across all transactions.

TABLE A2: OUTPUT QUALITY AND VERTICALLY INTEGRATED SUPPLIERS (CONT'D)

Dep. var:	High quality share of production			
	(1)	(2)	(3)	(4)
Number of suppliers owned	-0.000	0.001		
	(0.004)	(0.004)		
Share of inputs from VI suppliers			0.324^{*}	0.325^{**}
			(0.166)	(0.149)
High technology share of capacity	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.73	0.73	0.73	0.73
N	190	190	190	190

Notes: One observation is a firm during a production season. The regressions here are similar to the ones in Table 6 and Table 3 but the dependent variable is our dichotomous measure of quality (the ratio of the high quality production to all production). *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season (or month). *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A3: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS, CONTROLLING FOR SUPPLIERS AND FIRM CHARACTERISTICS (CONT'D)

	Panel A: Firm level				
Dep. var:	Log(unit price)				
	(1)	(2)	(3)	(4)	(5)
Share of inputs from VI suppliers	0.129**	0.142**	0.144**	0.129**	0.130**
	(0.056)	(0.058)	(0.058)	(0.056)	(0.056)
Share of inputs from steel boats		-0.032			
		(0.041)			
Share of inputs from high capacity boats			-0.104		
			(0.070)		
Share of inputs from boats with cooling system				-0.006	
				(0.075)	
Share of industry's total production					0.076
					(0.236)
High technology share of capacity	Yes	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.21	7.21	7.21	7.21	7.21
N	190	190	190	190	190

	Panel B: Plant level for a major firm									
Dep. var:	Log(unit price)					Protein content				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Share of inputs from VI suppliers	0.107**	0.141*	0.147*	0.155*	0.106**	1.340**	1.569	1.599	2.411	1.306**
	(0.044)	(0.070)	(0.080)	(0.078)	(0.044)	(0.656)	(1.203)	(1.249)	(1.497)	(0.631)
Share of inputs from steel boats		−0.051					−0.348			
		(0.095)					(1.150)			
Share of inputs from high capacity boats			−0.051					−0.333		
			(0.094)					(1.082)		
Share of inputs from boats with cooling system				−0.066					−1.482	
				(0.088)					(1.519)	
Share of firm's total production					0.030					0.918
					(0.073)					(1.087)
Has high technology	0.031	0.025	0.027	0.028	0.031	0.124	0.088	0.104	0.076	0.136
	(0.027)	(0.028)	(0.027)	(0.027)	(0.027)	(0.378)	(0.394)	(0.385)	(0.379)	(0.379)
Has high technology	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plant FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.23	7.23	7.23	7.23	7.23	65.8	65.8	65.8	65.8	65.8
N	66	66	66	66	66	66	66	66	66	66

	Panel C: Plant level				
Dep. var:	High quality share of production				
	(1)	(2)	(3)	(4)	(5)
Share of inputs from VI suppliers	0.068***	0.046*	0.052*	0.045**	0.068***
	(0.020)	(0.027)	(0.031)	(0.022)	(0.020)
Share of inputs from steel boats		0.039			
		(0.031)			
Share of inputs from high capacity boats			0.025		
			(0.034)		
Share of inputs from boats with cooling system				0.069**	
				(0.027)	
Share of industry's total production					0.068
					(0.143)
Has high technology	Yes	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes	Yes
Plant FEs	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.82	0.82	0.82	0.82	0.82
N	2146	2146	2146	2146	2146

Notes: This Table is similar to Table 4 but includes all levels of observation available. In Panel A, one observation is a firm during a production season. One major firm shared its sales records with us, which allowed us to link an export shipment to a specific plant in the firm. Results for plants from that firm are given in Panel B. Panel C uses data from all plants, at the month level, but uses a dichotomous variable for quality. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality.*High quality share of production* is the ratio of the high quality production to all production for a plant on a given month. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). *Has high technology* controls for whether a plant is equiped or not with the high technology (for a plant, we can define whether it is equiped with the high technology or not, but for a firm, we define the share of its total processing capacity that is of the high technology). High capacity boats are boats from which the capacity is in the upper quartile of the distribution. Some boats have an integrated cooling system; the others boats use ice to keep the fish fresh. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A4: SUPPLIER CHARACTERISTICS

	Offload weight per trip (metric tons)	Cooling system	Capacity (m3)	Power engine (hp)	Max. Distance from the plant's port (kms)
Wooden	42.27	0.00	65.47	215.57	56.33
	(17.46)	(0.06)	(27.16)	(94.45)	(7.98)
Steel - Independent	107.85	0.08	212.11	401.94	79.93
	(45.15)	(0.28)	(88.02)	(190.38)	(14.70)
Steel - Switchers	169.02	0.30	322.00	655.28	94.87
	(72.21)	(0.46)	(122.27)	(326.73)	(15.25)
Steel - VI	188.28	0.34	378.55	769.99	97.11
	(70.63)	(0.47)	(131.13)	(352.44)	(13.27)

Notes: *Offload weight* is the amount fished on a trip. *Maximum distance to Port on a trip* is the maximum distance at which a boat is from the port on a fishing trip. Steel boats are different from wooden boats in that they are bigger and more suited from industrial fishing. They are also subject to a different regulation; wooden boats cannot be owned by fishmeal firms. *Independent* boats are owned by an individual or a company that is not a fishmeal company. *Switchers* are boats that move from VI to Independent or from Independent to VI at some point in our data. *VI* are boats that remain Vertically Integrated during the whole sample of our data.

TABLE A5: SUPPLIER BEHAVIOR AND VERTICAL INTEGRATION

Panel A: Switchers only (Independent to VI or VI to Independent)				
Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[VI × supplies owner firm]	-0.067^{***}	-0.034^{*}	-0.000	-0.001
	(0.020)	(0.020)	(0.013)	(0.015)
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes
N	240 654	131 847	153 465	141 483

Panel B: Changing ownership (VI to VI)				
Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[VI × supplies owner firm]	-0.030	-0.059^{*}	-0.107^{***}	-0.024
	(0.029)	(0.034)	(0.020)	(0.023)
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes
N	240 654	131 847	153 465	141 483

Notes: One observation is a supplier during a fishing trip. This Table is similar to Table 5 but in Panel A, identification only comes from switchers - suppliers that were independent and are acquired at some point by a fishmeal company or by suppliers that were integrated and are sold by a fishmeal company and become independent. In Panel B, identification only comes from integrated suppliers that are sold by a fishmeal company and bought by another fishmeal company. *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3. The number of observations varies from one column to the next as GPS variables for on given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A6: SUPPLIER BEHAVIOR AND RELATIONAL OUTSOURCING

Panel A: Relational outsourcing = 80% of offloads to the same firm for 2 consecutive production seasons				
Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[Relational × supplies relational firm]	0.006	0.017^{***}	-0.000	0.008
	(0.006)	(0.006)	(0.004)	(0.005)
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes
N	244 075	134 548	156 479	144 479

Panel B: Relational Outsourcing = more than 10 interactions with the same firm for at least 3 consecutive production seasons				
Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[Relational × supplies relational firm]	-0.043^{***}	0.018	0.001	-0.016
	(0.014)	(0.015)	(0.010)	(0.012)
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes
N	244 075	134 548	156 479	144 479

Notes: One observation is a supplier during a fishing trip. *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3. The number of observations varies from one column to the next as GPS variables for on given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. In Panel A, we define an independant boat as being under a relational contract if the boat delivers more than 80% of its offloads (75th percentile) to the same fishmeal firm for 2 consecutive fising seasons. In Panel B, we define an independant boat as being under a relational contract if the boat interacts more than 10 times (25th percentile) with the same firm during a fishing season and so, for at least 3 consecutive fishing seasons. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A7: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS AND SUPPLIERS UNDER A RELATIONAL OUTSOURCING CONTRACT

Panel A: First definition of relational outsourcing

Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.128**	0.130**	1.322***	1.356***
	(0.059)	(0.058)	(0.461)	(0.453)
Share of inputs from relational suppliers	−0.005	0.009	−0.075	0.108
	(0.039)	(0.035)	(0.545)	(0.480)
High technology share of capacity	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.21	7.21	65.5	65.5
N	190	190	190	190

Panel B: Second definition of relational outsourcing

Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.134**	0.133**	1.362***	1.347***
	(0.055)	(0.054)	(0.449)	(0.441)
Share of inputs from relational suppliers	−0.098	−0.076	−0.508	−0.213
	(0.183)	(0.178)	(1.828)	(1.757)
High technology share of capacity	No	Yes	No	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.21	7.21	65.5	65.5
N	190	190	190	190

Notes: One observation is a firm during a production season. The regressions are similar to the ones in Table 3 but control for the share of inputs from independent suppliers under a relational contract with the downstream firm. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). *Share of inputs from relational suppliers* is the share of a firm's inputs that come from suppliers under a relational contract during a season. Each observation is a firm over one fishing season. In Panel A, we define an independant boat as being under a relational contract if the boat delivers more than 80% of its offloads (75th percentile) to the same fishmeal firm for 2 consecutive fising seasons. In Panel B, we define an independant boat as being under a relational contract if the boat interacts more than 20 times (median) with the same firm during a fishing season and so, for at least 3 consecutive fishing seasons. Robust standard errors in parenthesis * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A8: SUPPLIER BEHAVIOR AND VERTICAL INTEGRATION - ROBUSTNESS CHECKS

Panel A: Output quality, supplier behavior and vertical integration

Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[VI × supplies owner firm × Plant producing high quality]	-0.032^{***}	-0.143^{***}	-0.041^{***}	-0.034^{***}
	(0.012)	(0.013)	(0.009)	(0.010)
I[VI × supplies owner firm]	Yes	Yes	Yes	Yes
I[Plant producing high quality]	Yes	Yes	Yes	Yes
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes
N	239 717	131 168	152 715	140 778

Panel B: Output quality, vertically integrated share of inputs, and difficult upstream production conditions

Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)	Log(Time between last fishing location and port)
	(1)	(2)	(3)	(4)
I[VI × supplies owner firm × Difficult conditions]	0.032^{***}	-0.052^{***}	0.006	0.003
	(0.009)	(0.012)	(0.008)	(0.009)
I[VI × supplies owner firm]	Yes	Yes	Yes	Yes
I[Difficult conditions]	Yes	Yes	Yes	Yes
Date FEs	Yes	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes	Yes
N	216 679	116 834	135 874	125 427

Notes: *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour as discussed in Section 3. I[Plant producing high quality] is a dummy equal to one if the plant the supplier delivers to produces only high quality fishmeal. I[*Difficult conditions*] is a dummy equal to 1 when the share of good fishing locations [Log(plankton concentration)>0.5] around a specific plant on a specific day is less than 10 percent (this corresponds to the bottom 20th percentile in the distribution of share of good fishing locations in our sample) The number of observations varies from one column to the next as GPS variables for on given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A9: OUTPUT QUALITY, VERTICALLY INTEGRATED SHARE OF INPUTS, AND DIFFICULT UPSTREAM PRODUCTION CONDITIONS - ROBUSTNESS CHECKS

	Panel A: Plant level for a major firm			
Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.107^{**}	0.066	1.338^{**}	0.693
	(0.044)	(0.042)	(0.656)	(0.536)
Difficult conditions		-0.146^{*}		-2.327^{***}
		(0.077)		(0.771)
Share VI × Difficult conditions		0.192^{***}		3.043^{***}
		(0.063)		(0.594)
Has high technology	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes
Plant FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.23	7.23	65.8	65.8
N	66	66	66	66

	Panel B: Plant level	
Dep. var:	High quality share of production	
	(1)	(2)
Share of inputs from VI suppliers	0.071***	0.072***
	(0.023)	(0.023)
Difficult conditions		-0.058
		(0.036)
Share VI × Difficult conditions		0.051
		(0.045)
Has high technology	No	Yes
Month FEs	Yes	Yes
Plant FEs	Yes	Yes
Mean of Dep. Var.	0.80	0.80
N	1907	1907

Notes: This table is similar to Table 7 but focuses the unit of observation is different. One major firm shared its sales records with us, which allowed us to link an export shipment to a specific plant in the firm. Results for that firm, at the plant-season level are given in Panel A. Panel B uses data from all plants, at the month level, but uses a dichotomous variable for quality. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. *High quality share of production* is the ratio of the high quality production to all production for a plant on a given month. *Has high technology* controls for whether a plant is equiped or not with the high technology (steam drying technology as defined in the backrgound section). *Share of inputs from VI suppliers* is the share of a plant's inputs that come from VI suppliers during a season (or month). I[*Difficult conditions*] is a dummy equal to 1 when the share of good fishing locations $[\text{Log(plankton concentration)}>0.5]$ around a specific plant on a specific day is less than 10 percent (this corresponds to the bottom 20th percentile in the distribution of share of good fishing locations in our sample). This dummy is defined at the port-day level, while the regressions are at the firm-season level, so the dummy variable is averaged by firm-season to construct *Difficult conditions*. It can then be interpreted as the share of days when the conditions are difficult for a specific firm during a production season. The variable is normalized to a mean equal to 0 in our sample so that the first row of this table can be interpreted as the correlation between the *Share of inputs from VI suppliers* and quality. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A10: DIFFICULT UPSTREAM PRODUCTION CONDITIONS - ROBUSTNESS CHECKS 2

Panel A: Output quality, vertically integrated share of inputs, and difficult upstream production conditions

Dep. var:	Log(unit price)		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.139^{**}	0.113^{**}	1.221^{***}	1.017^{**}
	(0.060)	(0.055)	(0.466)	(0.465)
Difficult conditions		-0.260^{***}		-2.089^{***}
		(0.064)		(0.741)
Share VI $\times$ Difficult conditions		0.297^{***}		2.111^{*}
		(0.106)		(1.085)
High technology share of capacity	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes
Mean of Dep. Var.	7.20	7.20	65.4	65.4
N	178	178	178	178

Panel B: Supplier behavior, vertical integration and difficult upstream production conditions

Dep. var:	Log(Quantity fished)	Log(Maximum Distance from the Port)	Log(Total time spent at sea)	Log(Time between last fishing location and Port)
	(1)	(2)	(3)	(4)
I[VI $\times$ supplies owner firm] $\times$I[Not difficult conditions]	-0.051^{***}	-0.020	-0.025^{**}	-0.001
	(0.018)	(0.017)	(0.012)	(0.013)
I[VI $\times$ supplies owner firm] $\times$I[Difficult conditions]	-0.011	-0.732^{***}	-0.413^{***}	-0.727^{***}
	(0.159)	(0.158)	(0.121)	(0.140)
Date FEs	Yes	Yes	Yes	Yes
Supplier $\times$ Plant $\times$ Difficult conditions FEs	Yes	Yes	Yes	Yes
N	220 821	120 061	139 447	128 932

Notes: This Table is similar to Table **??** and Table **??** but uses another definition of *difficult production conditions.* I[*Difficult conditions*] is here a dummy equal to 1 when the share of good fishing locations [Log(plankton concentration)>0] around a specific plant on a specific day is less than the bottom 10th percentile in the distribution of share of good fishing locations in our sample. This dummy is defined at the port-day level, while the regressions are at the firm-season level, so the dummy variable is averaged by firm-season to construct *Difficult conditions* in Panel A. It can then be interpreted as the share of days when the conditions are difficult for a specific firm during a production season. The variable is normalized to a mean equal to 0 in our sample so that the first row of this table can be interpreted as the correlation between the *Share of inputs from VI suppliers* and quality. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season. *High technology share of capacity* controls for the share of the firm's total processing capacity (measured in metric tons per hour and averaged across all active plants within the firm) that is of the high technology (steam drying technology as defined in the backrgound section). In Panel B, *Quantity supplied* is the amount of fish the supplier delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed from port during a trip. *Total time at sea* is the amount of time the supplier is away from port per trip. *Time between last fishing location and port* is the time it takes the boat to travel back to the port from the last fishing activity location on a given trip. Fishing activity is proxied by the supplier having a speed lower than than 2.9kms/hour maintained for at least half an hour (Natividad, 2014). The number of observations varies from one column to the next as GPS variables for on given trip are sometimes missing. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

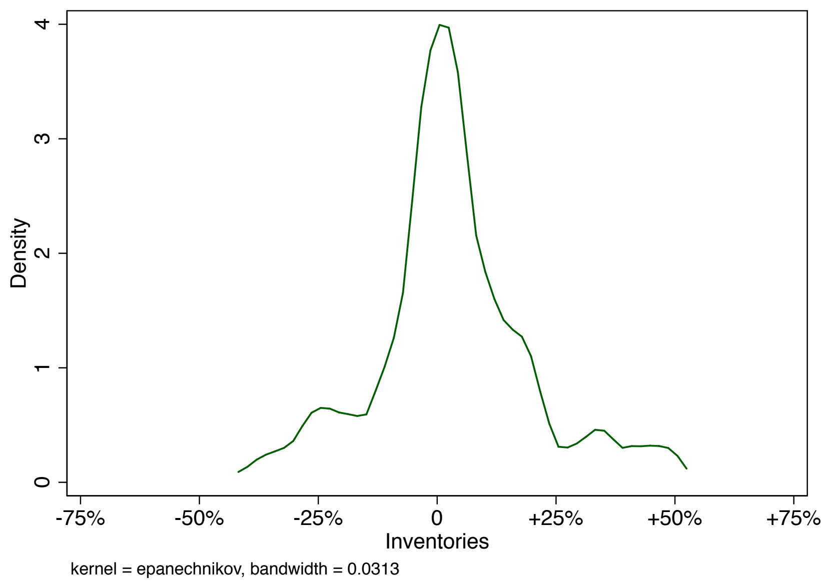
TABLE A11: VERTICALLY INTEGRATED SHARE OF INPUTS AND OUTPUT QUALITY PRODUCED – INSTRUMENTING WITH FIRM-SPECIFIC DEMAND SHOCKS - ROBUSTNESS CHECKS

	OLS	OLS	IV - Method 1 *Leave-Peru-out*	IV - Method 1 *Leave-Peru-out*	IV - Method 2 *Leave-firm i-out*	IV - Method 2 *Leave-firm i-out*
Dep. var:	Share of inputs from VI suppliers					
	(1)	(2)	(3)	(4)	(5)	(6)
Protein content	0.025^{**}	0.024^{**}	0.085^{***}	0.053^{**}	0.072	0.073
	(0.010)	(0.011)	(0.027)	(0.026)	(0.045)	(0.053)
Log(Sales)		0.003		−0.012		−0.023
		(0.013)		(0.018)		(0.031)
Season FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.43	0.43	0.43	0.43	0.43	0.43
N	190	190	190	190	190	190
First stage						
Dep. var:	Protein content					
	(1)	(2)	(3)	(4)	(5)	(6)
China			-2.109^{*}	0.351		
			(1.177)	(1.342)		
Germany			−4.276	−4.916		
			(4.330)	(4.538)		
Japan			2.181	4.528^{**}	3.977	2.699
			(2.504)	(2.278)	(2.591)	(2.698)
Chile			60.866^{*}	54.307		
			(36.759)	(39.385)		
Vietnam			2.553	3.968		
			(5.314)	(5.343)		
Taiwan			2.164	2.927		
			(4.793)	(4.692)		
United Kingdom			1.753	0.347		
			(4.297)	(4.776)		
Turkey			−12.781	−12.168		
			(8.803)	(9.179)		
Spain			11.143	14.903		
			(11.347)	(13.028)		
Indonesia			−4.462	−4.838		
			(4.986)	(5.560)		
Australia			15.975	13.322	-4.740^{***}	-4.067^{***}
			(13.113)	(13.932)	(1.637)	(1.555)
Canada			15.569^{**}	18.301^{**}		
			(6.561)	(7.054)		
France			−4.690	−8.492		
			(15.352)	(16.839)		
Korea, Rep.			−7.388	−5.800		
			(13.705)	(14.889)		
Italy			3.687	4.011		
			(10.986)	(12.156)		
Bulgaria			230.925	250.196		
			(234.269)	(257.455)		
Venezuela			229.520	290.568		
			(256.967)	(285.363)		
Belgium			−184.737	−179.659		
			(125.058)	(134.605)		
Philippines			1.529	−1.868		
			(31.306)	(28.860)		
India			111.072	101.055		
			(97.785)	(101.222)		
Kleibergen-Paap LM p-value (Under-id)			0.08	0.04	0.01	0.03
Kleibergen-Paap Wald F statistic (Weak inst)			1.06	1.19	4.49	3.48
Anderson-Rubin Wald test p-value			0.00	0.01	0.13	0.14

Notes: *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season. *Protein content* is the quantity weighted average of a measure of quality infered with a database that provides weekly prices by quality. The instruments for columns (3) and (4) are interactions of indicators for positive exports to destination country in 2008 and *leave-Peru-out* share of fishmeal exports towards the destination in the relevant year. All top 20 destinations are included. In Columns (5) and (6), the instruments are interactions of indicators for positive exports to destination country in 2008 and *leave-firm-i-out* share of fishmeal exports towards the destination in the relevant year. The destination countries selected for the construction of these instruments by LASSO are Japan and Australia. Each observation is a firm-production season. Robust standard errors in parenthesis * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix figures

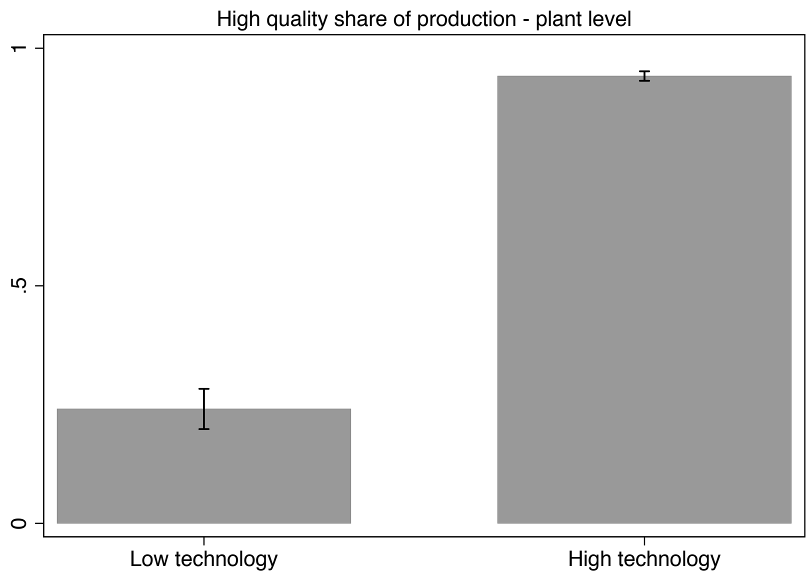
FIGURE A1: DENSITY OF INVENTORIES



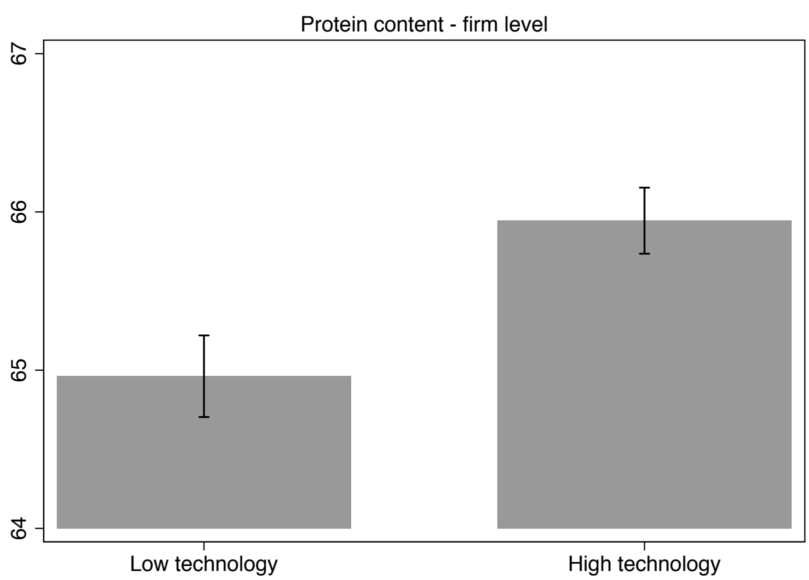
Notes: Kernel density of estimated inventories. Inventories are defined as the ratio of (Total Production - Total Exports) to Total Production, where Total Production is a firm's production during a given production season and Total Exports are the sum of exports that are shipped during the production season and the period directly following the relevant production season (before the next production season starts).

FIGURE A2: PLANT TECHNOLOGY AND OUTPUT QUALITY

(a)

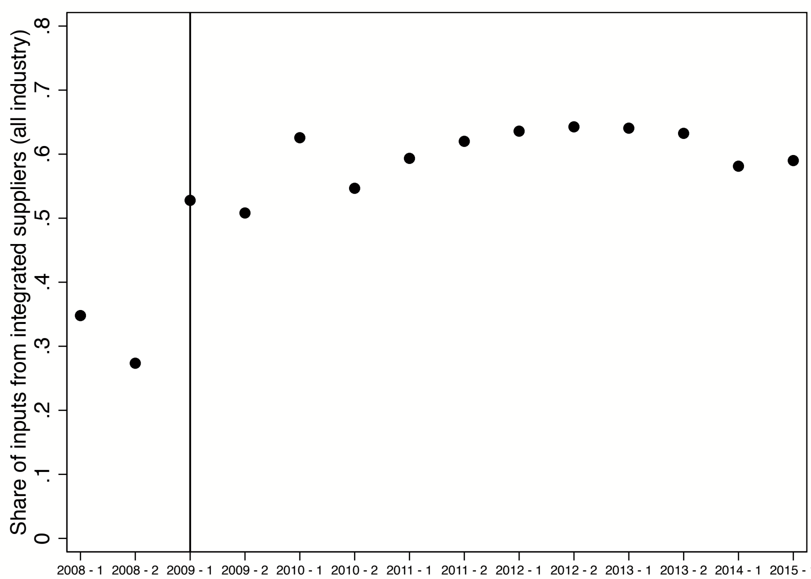


(b)



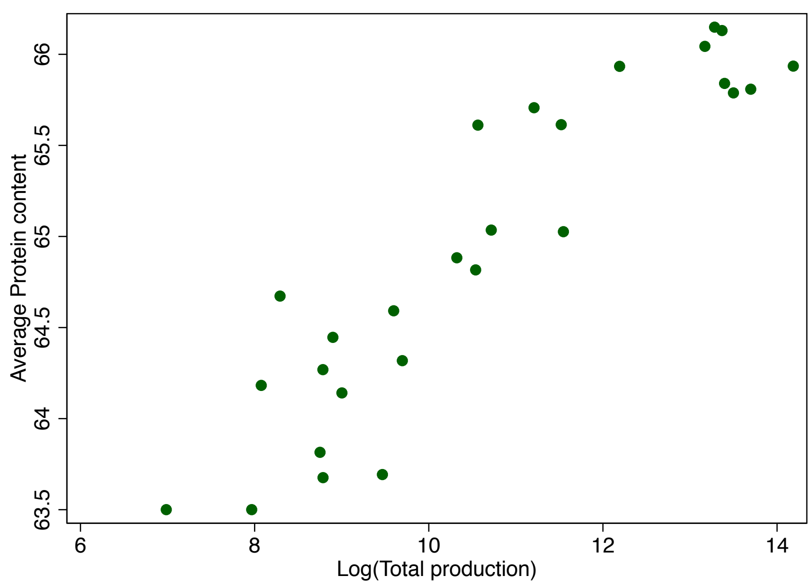
Notes: Panel (a) shows the high quality share of production for plants with high technology (as defined in Section 2) and plants that only have low technology. Panel (b) shows the average protein content (quality grade) for high and low technology firms. High technology firms are firms for which the high technology share of total capacity is above the sample median.

FIGURE A3: EVOLUTION OF THE VERTICALLY INTEGRATED SHARE OF INPUTS INDUSTRY-WIDE



Notes: This graph shoes the evolution of the Peruvian fishmeal industry's share of inputs from integrated suppliers by production season. For every year, -1 is the first production season in the calendar year, in general from April to July, and -2 is the second production season, in general from November to January.

FIGURE A4: AVERAGE OUTPUT QUALITY AND FIRM SIZE



Notes: Each dot represents one fishmeal firm in our sample. Total production is the total weight of fishmeal the firm produced during our data period and average protein content is the quantity weighted average protein content of the firm's fishmeal exports.