Appendix A Additional Tables and Figures

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

	Total Weight (1000 metric tons)	Average Protein content	Sd(Protein content)
CHINA	4315	66.07	1.60
GERMANY	972	65.42	1.62
JAPAN	545	66.12	1.69
CHILE	308	66.60	1.51
VIETNAM	281	65.91	1.59
TAIWAN	250	66.02	1.71
UNITED KINGDOM	147	65.26	1.62
TURKEY	128	64.91	1.52
INDONESIA	94	66.16	1.64
SPAIN	90	65.44	1.61
AUSTRALIA	85	66.06	1.80
CANADA	67	65.76	1.52
FRANCE	55	65.59	1.72
SOUTH KOREA	25	66.56	1.46
ITALY	21	64.97	1.52
BULGARIA	16	65.42	1.75
VENEZUELA	13	66.67	1.64
PHILIPPINES	12	64.92	1.47
BELGIUM	11	65.08	1.69
INDIA	10	65.17	2.03

Notes: This table reports the top 20 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: SUPPLIER CHARACTERISTICS

	Offload weight per trip (metric tons)	Cooling system	Capacity (m3)	Power engine (hp)	Max. Distance from the plant's port (kms)
Wooden	41.00	0.00	65.73	215.40	56.11
	(16.24)	(0.06)	(27.34)	(94.78)	(7.74)
Steel - Independent	104.03	0.09	219.30	412.31	81.12
	(40.77)	(0.28)	(84.35)	(189.82)	(13.42)
Steel - Switchers	148.24	0.26	301.37	620.14	92.03
	(71.00)	(0.444)	(131.23)	(331.29)	(15.42)
Steel - VI	181.62	0.34	381.67	768.79	97.38
	(68.01)	(0.47)	(136.97)	(352.40)	(12.67)

Notes: *Offload weight* is the amount fished on a trip. *Maximum distance from port* is the maximum distance at which a boat is from the port on a fishing trip. Steel boats are generally bigger, better suited for industrial fishing, and are subject to different regulations. 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 A3: VERTICAL INTEGRATION AND THE QUALITY PRICE PREMIUM – ROBUSTNESS CHECKS

Dep. var:	Share VI (t) - Share VI (t-1)		Share of inputs from VI suppliers							
	IV	IV	OLS	OLS	OLS	OLS	OLS	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Upgradable share of production (t-1) × Quality premium	2.475***	2.591***					0.530	0.430	0.408	0.486
	(0.599)	(0.500)					(0.500)	(0.479)	(0.430)	(0.493)
Log(production) (t) - Log(production) (t-1)	0.001									
	(0.007)									
Quality premium			0.884**		0.214					
			(0.373)		(0.233)					
Quality premium is high				0.471***						
				(0.069)						
Quality premium is low				0.390***						
				(0.073)						
Log(average price)						0.094				
						(0.089)				
Upgradable share of production (t-1)	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.00	0.00	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
N	191	191	205	205	205	205	205	205	205	205
R^2	0.24	0.24	0.02	0.63	0.89	0.89	0.90	0.90	0.90	0.90
Quality prem. is high = Quality prem. is low (p-val)				0.04						
First stage										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Upgradable share of production (t-1) × Log(Quota Chile) (t-1)	−1.083**	−0.982***						−1.627***	−1.260***	
	(0.436)	(0.297)						(0.168)	(0.163)	
Upgradable share of production (t-1) × Log(Quota Denmark) (t-1)	−5.646**	−1.620						−8.968***	−3.009	
	(2.644)	(1.879)						(1.124)	(1.773)	
Upgradable share of production (t-1) × Log(Quota Iceland) (t-1)	−1.419**	−0.444						−2.267***	−0.799*	
	(0.666)	(0.472)						(0.281)	(0.439)	
Upgradable share of production (t-1) × Log(Qty exp. by Thailand) (t-1)		0.081***							0.085***	
		(0.021)							(0.016)	
Upgradable share of production (t-1) × Log(Chile Price)										1.179***
										(0.023)
Upgradable share of production (t-1) × Log(Denmark Price)										−3.292***
										(0.406)
Upgradable share of production (t-1) × Log(Iceland Price)										1.680***
										(0.358)
Log(production) (t) - Log(production) (t-1)	0.002									
	(0.001)									
Kleibergen-Paap LM p-value (under-id)	0.01	0.02						0.01	0.01	0.00
Kleibergen-Paap Wald F statistic (weak inst)	22.2	44.7						431.6	806.9	1674.2

Notes: One observation is a firm during a production season. This Table provide robutness checks for Table 4. See notes at the bottom of Table 4 for the description of all variables. In columns 1 and 2, we control for changes in scale, with *Log(production) (t) - Log(production) (t-1)*, with is the change in the Log of total production between season t-1 and season t. In columns 3 and 4, the instruments are interactions between Low quality producer$(t-1)$ or Upgradable share of production$(t-1)$ and the price of fishmeal from the top high quality fishmeal exporters. Standard errors clustered at the firm level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A4: VERTICAL INTEGRATION AND THE QUALITY PRICE PREMIUM – LOGIT TRANSFORMATION

Dep. var:	Log(Share VI$_t$/[1-(Share VI$_t$)])- Log(Share VI$_{t-1}$/[1-(Share VI$_{t-1}$)])									
	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Quality premium	0.533		0.382							
	(0.805)		(0.829)							
Quality premium is high		0.092**								
		(0.034)								
Quality premium is low		−0.019								
		(0.092)								
Log(average price)				0.062						
				(0.459)						
Upgradable share of production (t-1) × Quality premium					11.228***		14.329***		11.734***	
					(3.791)		(4.776)		(2.940)	
Low quality producer (t-1) × Quality premium						3.821*		6.218		4.580**
						(2.149)		(4.413)		(2.051)
Upgradable share of production (t-1)	No	No	No	No	Yes	No	Yes	No	Yes	No
Low quality producer (t-1)	No	No	No	No	No	Yes	No	Yes	No	Yes
Season FEs	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
N	191	191	191	191	191	191	191	191	191	191
R^2	0.00	0.01	0.07	0.07	0.14	0.13	0.14	0.01	0.03	0.02

Notes: One observation is a firm during a production season. *Share VI$_t$* is the share of inputs sourced from integrated suppliers in season t. To compute Log(Share VI$_t$/[1-(Share VI$_t$)] for all observations, we add 0.01 to firm-seasons with Share VI equal to 0, and subtract 0.01 from firm-seasons with Share VI equal to 1. *Quality premium* is equal to Log(High Quality) − Log(Low Quality) where High and Low Quality are the average price of "Prime" and "FAQ" fishmeal in the month preceding the current fishing season. We choose to take the month preceding the fishing season rather than the fishing season itself as integration decisions are typically decided in the month preceding the season and integration within a season is extremely rare in the data. *High Quality premium* (*Low Quality premium*) is equal to 1 if the Quality Premium is above (below) the sample average value. Log(average price) is the Log of the average price of Peruvian fishmeal, again computed in the month preceding the current fishing season. Low quality producer$(t-1)$ is equal to 1 if a firm's share of low quality output in the preceding season was at least 1 percent. Upgradable share of production$(t-1)$ is the share of a firm's production that was of low quality in the previous season. A firm that produces almost only low quality output has more potential to upgrade than a firm already producing almost only high quality output. In Columns 7 and 8, the instruments are interactions between Low quality producer$(t-1)$ or Upgradable share of production$(t-1)$ and the fishing quota of top high quality fishmeal exporters. Standard errors clustered at the firm level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A5: INDIVIDUAL INSTRUMENTS FIRST STAGE FROM COLUMNS 9 AND 10 IN TABLE 4 AND COLUMN 10 OF TABLE A3

Dep. var:	Upgradable share of production (t-1) × Quality premium			Low quality producer (t-1) × Quality premium		
	(1)	(2)	(3)	(4)	(5)	(6)
Upgradable share of production (t-1) × Log(Chile Price)	0.299***					
	(0.033)					
Upgradable share of production (t-1) × Log(Denmark Price)		0.150***				
		(0.057)				
Upgradable share of production (t-1) × Log(Iceland Price)			0.128**			
			(0.050)			
Low quality producer (t-1) × Log(Chile Price)				0.377***		
				(0.063)		
Low quality producer (t-1) × Log(Denmark Price)					0.314**	
					(0.124)	
Low quality producer (t-1) × Log(Iceland Price)						0.266**
						(0.108)
Upgradable share of production (t-1)	Yes	Yes	Yes	No	No	No
Low quality producer (t-1)	No	No	No	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
N	205	205	205	205	205	205

Notes: One observation is a firm during a production season. This Table shows regressions equivalent to the first stage in column 9 and 10 of Table 4, except that each instrument is taken individually in each regression. See the table notes of Table 4 for more details on each variable. Standard errors clustered at the firm level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A6: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS—ROBUSTNESS USING A SINGLE LARGE FIRM

	Impact of Share of VI Inputs on Quality			
Dep. var:	Protein Content			
	OLS		IV: Ind. Boats	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	1.369**	1.338**	1.469*	1.390
	(0.654)	(0.656)	(0.807)	(0.918)
Has high technology	No	Yes	No	Yes
Month FEs	Yes	Yes	Yes	Yes
Plant FEs	Yes	Yes	Yes	Yes
Mean of Dep Var.	65.8	65.8	65.8	65.8
N	66	66	66	66
R^2	0.82	0.82	0.82	0.82
	First Stage			
Dep. var:	Share of Inputs from VI Suppliers			
	(1)	(2)	(3)	(4)
Number of Independent Boats in Port (Leave-Out)			−0.000	−0.000
			(0.000)	(0.000)
Share of Independent Boats in Port (Leave-Out)			−0.412**	−0.398*
			(0.200)	(0.207)
Kleibergen-Paap LM p-value (Under-id)			0.005	0.006
Kleibergen-Paap Wald F statistic (Weak inst)			3.61	3.06

Notes: This table presents robustness checks for Table 6 using a major firm's internal data that allows us to link export sales to a specific plant. *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season. *Has high technology* is a dummy variable equal to one if the plant in question has any steam drying technologies installed. *Share of inputs from VI suppliers* is instrumented by (a) the number of independent boats present in the plant's port in the season in question, excluding those that interact directly with the plant itself, and (b) the ratio of the number of boats in (a) to the total number of boats in the plant's port in that season that do not interact with the plant itself. Robust standard errors are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A7: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS—FIRST STAGE

	First Stage			
Dep. var:	Share of Inputs from VI Suppliers			
	IV: Ind. Boats		IV: Wooden Boats	
	(1)	(2)	(3)	(4)
Number of Independent Boats in Port (Leave-Out)	-0.001^{***}	-0.001^{***}		
	(0.000)	(0.000)		
Number of Wooden Boats in Port (Leave-Out)			-0.002^{***}	-0.002^{***}
			(0.000)	(0.000)
Kleibergen-Paap LM p-value (Under-id)	0.009	0.009	0.010	0.009
Kleibergen-Paap Wald F statistic (Weak inst)	33.1	33.7	27.7	28.7

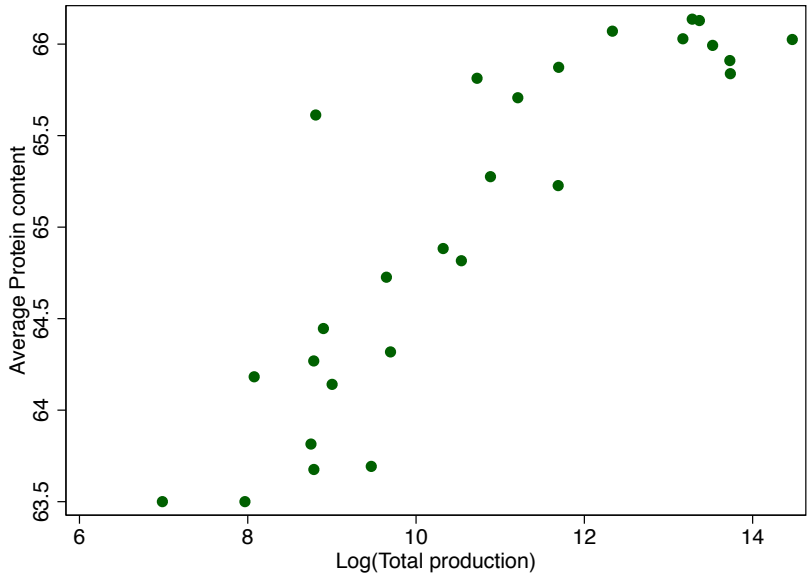
Notes: This table shows first stage results for columns 3-6 from Table 6. One observation is a plant in a particular month. *Share of inputs from VI suppliers* is the share of a plant's inputs that come from VI suppliers during a season. Columns 1 and 2 show the first stage instrumenting for *Share of inputs from VI suppliers* with the number of independent boats present locally (in the plant's port) in the season in question, excluding those that interact directly with the plant itself. Columns 3 and 4 show the first stage instrumenting for *Share of inputs from VI suppliers* with the number of wooden boats present locally (in the plant's port) in the season in question, excluding those that interact directly with the plant itself. Columns 2 and 4 include controls for *Has high technology*, a dummy variable equal to one if the plant in question has any steam drying technologies installed. Standard errors are clustered at the port level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE A8: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS—ROBUSTNESS

	Impact of Share of VI Inputs on Quality				
Dep. var:	High Quality Share of Production				
	IV: Ind. Boats (t-1)	IV: Wooden Boats (t-1)	IV: Windspeed	IV: Cloudiness	IV: Windspeed and Cloudiness
	(1)	(2)	(3)	(4)	(5)
Share of Inputs from VI Suppliers	0.197	0.210	0.071	0.204	0.214
	(0.141)	(0.140)	(0.334)	(0.209)	(0.162)
Has high technology	Yes	Yes	Yes	Yes	Yes
Month FEs	Yes	Yes	Yes	Yes	Yes
Plant FEs	Yes	Yes	Yes	Yes	Yes
Mean of Dep Var.	0.84	0.84	0.84	0.83	0.83
N	2,545	2,545	1,487	1,502	1,413
R^2	0.66	0.66	0.65	0.65	0.65
	First Stage				
Dep. var:	Share of Inputs from VI Suppliers				
	(1)	(2)	(3)	(4)	(5)
Independent Boats in Port (End of Month t-1)	−0.001***				
	(0.000)				
Wooden Boats in Port (End of Month t-1)		−0.001***			
		(0.000)			
Wind Speed (Mean)			−0.134**		−0.087
			(0.060)		(0.078)
Wind Speed (Median)			0.021		−0.006
			(0.022)		(0.030)
Wind Speed (Bottom Sextile)			0.072***		0.043
			(0.027)		(0.034)
Wind Speed (Top Sextile)			0.029		0.044*
			(0.025)		(0.027)
Wind Speed (Std. Dev.)			0.016		−0.015
			(0.018)		(0.021)
Cloudiness (Mean)				0.151*	0.186*
				(0.080)	(0.097)
Cloudiness (Median)				−0.051*	−0.071**
				(0.030)	(0.035)
Cloudiness (Bottom Sextile)				0.004	−0.001
				(0.027)	(0.030)
Cloudiness (Top Sextile)				−0.109***	−0.118***
				(0.033)	(0.042)
Cloudiness (Std. Dev.)				0.074***	0.083***
				(0.021)	(0.026)
Kleibergen-Paap LM p-value (Under-id)	0.028	0.034	0.212	0.197	0.492
Kleibergen-Paap Wald F statistic (Weak inst)	9.05	8.26	2.71	5.38	4.41

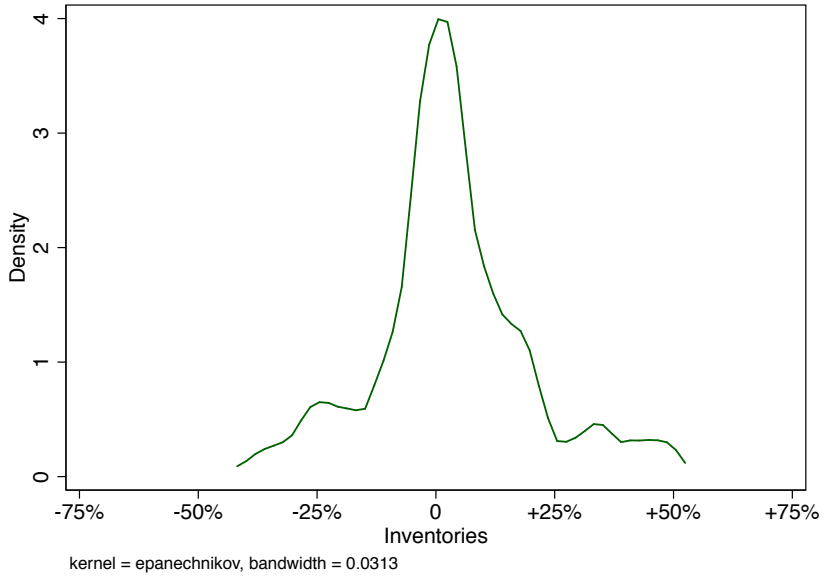
Notes: One observation is a plant in a particular month. *High Quality share of production* is the share of a plant's total production during a fishing season that is reported as high quality "prime" output. *Share of inputs from VI suppliers* is the share of a plant's inputs that come from VI suppliers during a season. *Has high technology* is a dummy variable equal to one if the plant in question has any steam drying technologies installed. Column 1 instruments for *Share of inputs from VI suppliers* with the number of independent boats present in the port at the end of the previous month. To construct this measure, each boat is assigned to the port of its last delivery in month $t-1$. In the first month of the season, boats are assigned to the port of their first delivery. Column 2 instruments for *Share of inputs from VI suppliers* with the number of wooden boats present in the port at the end of the previous month. Column 3 instruments for *Share of inputs from VI suppliers* with the mean, median, 1st and 5th quintiles and standard deviation of monthly port level windspeed. Column 4 instruments for *Share of inputs from VI suppliers* with the mean, median, 1st and 5th quintiles and standard deviation of monthly port level cloudiness. Column 5 instruments for *Share of inputs from VI suppliers* with the mean, median, 1st and 5th quintiles and standard deviation of monthly port level windspeed and cloudiness. Standard errors are clustered at the port level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

FIGURE A1: AVERAGE OUTPUT QUALITY AND FIRM SIZE



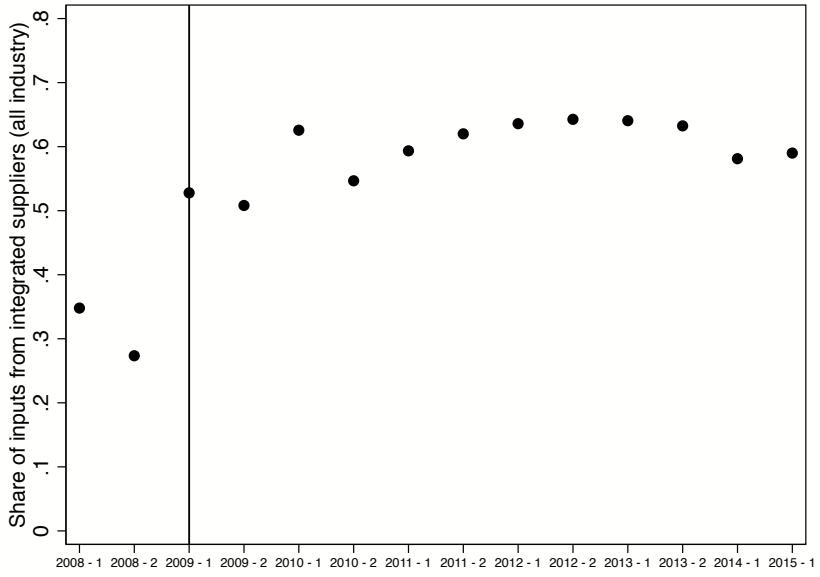
Notes: Each dot represents one fishmeal firm in our sample. Total production is the total weight of fishmeal the firm produced during our data period and average protein content is the quantity weighted average protein content of the firm's fishmeal exports.

FIGURE A2: DENSITY OF INVENTORIES



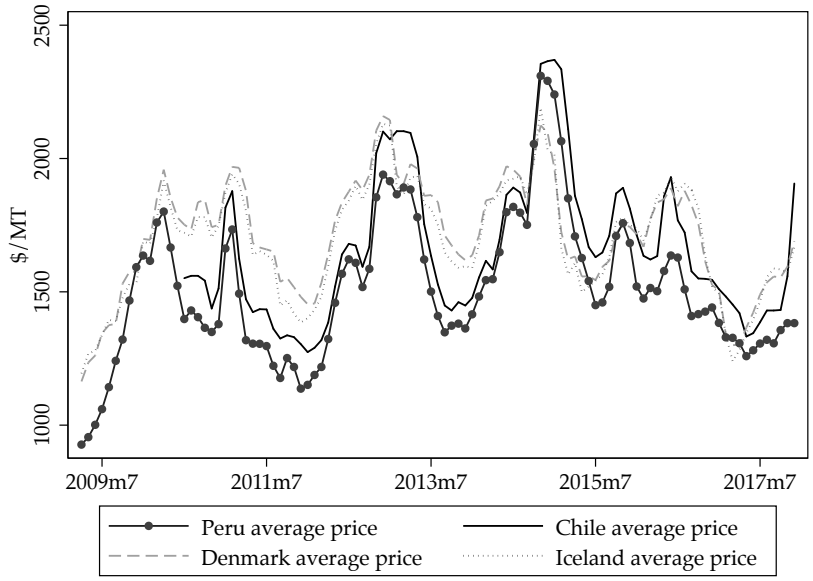
Notes: Kernel density of estimated inventories. Inventories are defined as the ratio of (Total Production - Total Exports) to Total Production, where Total Production is a firm's production during a given production season and Total Exports are the sum of exports that are shipped during the production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

FIGURE 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: FISHMEAL PRICES IN PERU AND OTHER COUNTRIES

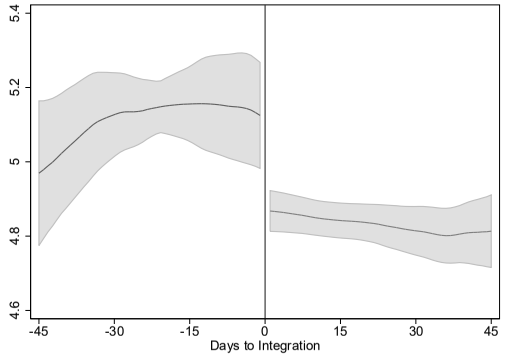


Notes: This figure shows the evolution of the average fishmeal price in other fishmeal exporting countries. Denmark and Iceland export mostly "Super Prime" fishmeal grade while Peru exports mostly "Prime" grade fishmeal.

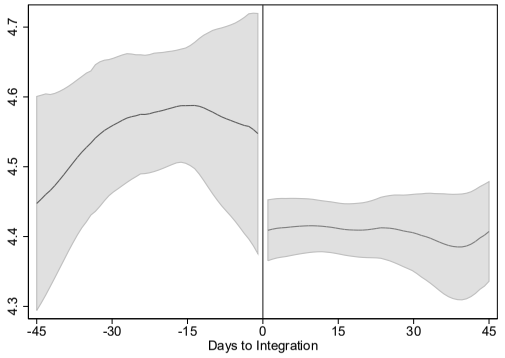
FIGURE A5: EVENT STUDIES OF BOAT BEHAVIOR

PANEL A: 45 DAYS BEFORE AND AFTER INTEGRATION

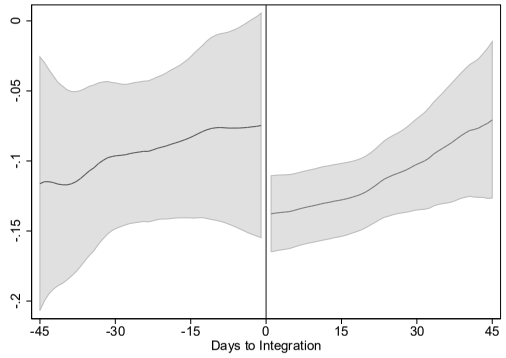
(a) Log(Quantity Supplied)



(b) Log(Max. Distance From Port)

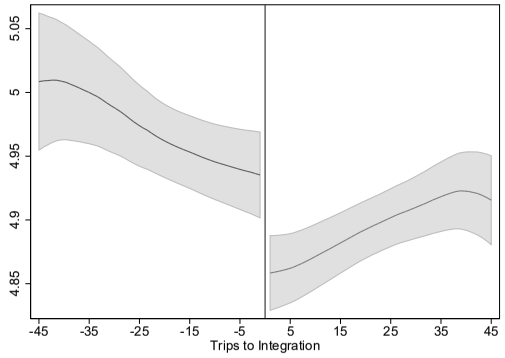


(c) Log(Total Time Spent at Sea)

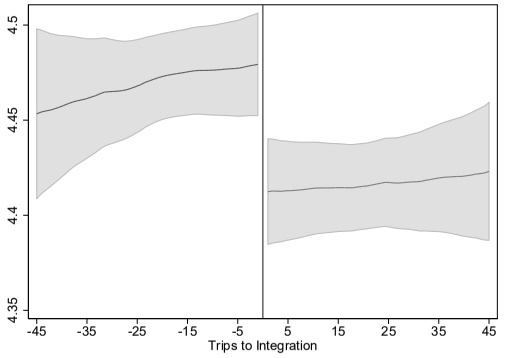


PANEL B: 45 TRIPS BEFORE AND AFTER INTEGRATION

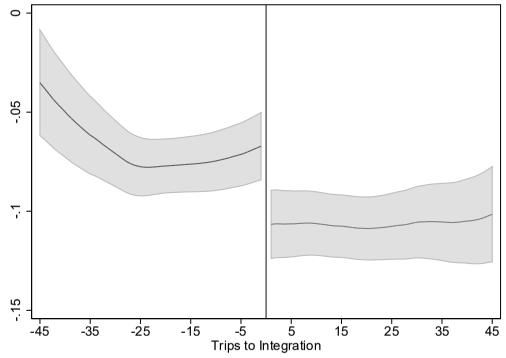
(d) Log(Quantity Supplied)



(e) Log(Max. Distance From Port)



(f) Log(Total Time Spent at Sea)



Notes: Lines show local linear fits with 95 percent confidence intervals in gray. One observation is a boat during a fishing trip. *Quantity supplied* is the amount of fish the boat delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed away from port. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. *Total time at sea* is the amount of time the boat is away from port per trip. We include only observations from boat×plant pairs which were at initially not integrated and later became integrated. In panel A we include any observations in the 45 days before and after integration. In panel B we include the 45 trips before and after integration for each boat×plant pair if available.

Appendix B Details of Decomposition Shown in Table 2

This appendix describes the variance decomposition performed in Table 2 in detail. The goal of the decomposition is to attribute realized changes in the share of inputs firms receive from vertically integrated suppliers (Share VI) to three relevant margins of adjustment. These margins are:

(1) The *VI intensive margin*: firms may increase *Share VI* by increasing the share of inputs they receive from integrated suppliers holding the quantity of those suppliers constant. As integrated suppliers deliver some of their catch to non-owner firms (see Figure 1 for more detail) a firm may direct integrated suppliers to deliver a larger fraction of their quota to the owner firm.

(2) The *VI extensive margin*: firms may increase *Share VI* by purchasing new suppliers while holding the share of inputs they source from each integrated supplier constant.

(3) The *Independent Margin*: firms may increase *Share VI* by purchasing less from independent boats, holding all else constant.

To aid in our decomposition, we next define a series of useful variables:

Definition of variables

- $Total_t$ is the total quantity of inputs bought by all firms in the industry during season t.
- $VI_{i,t}$ is the total quantity of inputs sourced from VI suppliers by firm i during season t.
- *Total* $VI_{i,t}$ is the total quantity of inputs produced by the suppliers owned by firm i during season t. Some boats owned by firm i may deliver their inputs to another firm so, by definition, $\text{VI}_{i,t} \leq \text{Total VI}_{i,t}$. Total $\text{VI}_{i,t}$ is determined by the total quota allocated to each VI supplier as boats typically fish their entire quotas on a given season.
- $Indep_{i,t}$ is the total quantity of inputs sourced from independent suppliers by firm i during season t (suppliers not integrated with downstream firm i in season t).
- *Share* $VI_{i,t}$ is the share of inputs sourced from VI suppliers in season t for firm i. Note that

$$\text{Share VI}_{i,t} = \frac{\text{VI}_{i,t}}{\text{VI}_{i,t} + \text{Indep}_{i,t}}.$$

Decomposing changes in Share VI

We now show how the change in *Share VI* for firm i between season $t-1$ and t can be decomposed into these three margins:

$$\begin{aligned}
\text{Share VI}_{i,t} - \text{Share VI}_{i,t-1} &= \frac{\text{VI}_{i,t}}{\text{VI}_{i,t} + \text{Indep}_{i,t}} - \frac{\text{VI}_{i,t-1}}{\text{VI}_{i,t-1} + \text{Indep}_{i,t-1}} \\
&= \frac{\frac{\text{VI}_{i,t}}{\text{Total}_t}}{\frac{\text{VI}_{i,t}}{\text{Total}_t} + \frac{\text{Indep}_{i,t}}{\text{Total}_t}} - \frac{\frac{\text{VI}_{i,t-1}}{\text{Total}_{t-1}}}{\frac{\text{VI}_{i,t-1}}{\text{Total}_{t-1}} + \frac{\text{Indep}_{i,t-1}}{\text{Total}_{t-1}}}
\end{aligned}$$

$$= \underbrace{\frac{\frac{\text{VI}_{i,t}}{\text{Total VI}_{i,t}}\frac{\text{Total VI}_{i,t}}{\text{Total}_t}}{\frac{\text{VI}_{i,t}}{\text{Total VI}_{i,t}}\frac{\text{Total VI}_{i,t}}{\text{Total}_t}+\frac{\text{Indep}_{i,t}}{\text{Total}_t}} - \frac{\frac{\text{VI}_{i,t-1}}{\text{Total VI}_{i,t-1}}\frac{\text{Total VI}_{i,t}}{\text{Total}_t}}{\frac{\text{VI}_{i,t-1}}{\text{Total VI}_{i,t-1}}\frac{\text{Total VI}_{i,t}}{\text{Total}_t}+\frac{\text{Indep}_{i,t}}{\text{Total}_t}}}_{\text{VI Intensive (Intensity of own use of VI suppliers inputs)}} +$$

$$\underbrace{\frac{\frac{\text{VI}_{i,t-1}}{\text{Total VI}_{i,t-1}}\frac{\text{Total VI}_{i,t}}{\text{Total}_t}}{\frac{\text{VI}_{i,t-1}}{\text{Total VI}_{i,t-1}}\frac{\text{Total VI}_{i,t}}{\text{Total}_t}+\frac{\text{Indep}_{i,t}}{\text{Total}_t}} - \frac{\frac{\text{VI}_{i,t-1}}{\text{Total VI}_{i,t-1}}\frac{\text{Total VI}_{i,t-1}}{\text{Total}_{t-1}}}{\frac{\text{VI}_{i,t-1}}{\text{Total VI}_{i,t-1}}\frac{\text{Total VI}_{i,t-1}}{\text{Total}_{t-1}}+\frac{\text{Indep}_{i,t}}{\text{Total}_t}}}_{\text{VI Extensive (Integration - boat purchases or sales)}} +$$

$$\underbrace{\frac{\frac{\text{VI}_{i,t-1}}{\text{Total}_{t-1}}}{\frac{\text{VI}_{i,t-1}}{\text{Total}_{t-1}}+\frac{\text{Indep}_{i,t}}{\text{Total}_t}} - \frac{\frac{\text{VI}_{i,t-1}}{\text{Total}_{t-1}}}{\frac{\text{VI}_{i,t-1}}{\text{Total}_{t-1}}+\frac{\text{Indep}_{i,t-1}}{\text{Total}_{t-1}}}}_{\text{Indep margin (Buying more/less from independent suppliers)}}$$

Variance decomposition

With this equation in hand, we can then decompose the within firm variation in firm sales using a procedure commonly used in the trade literature. Specifically, the variance decomposition presented in Table 2 is conducted by conducting regressions each of the the three components in the equation above on Share $\text{VI}_{i,t}$ − Share $\text{VI}_{i,t-1}$ controlling for firm fixed effects. The results are available in Table B1 below. The coefficients for the three regressions sum up to one and so each coefficient is the contribution of the corresponding margin to the variance of the right-had side variable.

Using the decomposition to quantify the impact of each margin in Table 4

While the variation in changes in *Share VI* as a whole can be decomposed into to the three margins above in the proportions presented in Table 2, the changes in the quality premium displayed in Table 4 may reflect adjustments along these margins in ways that differ from average. That is, firms may rely particularly on certain margins of adjustment when responding to the quality premium. To see if this is the case, we repeat the analysis shown in columns 5 and 7 of Table 4—a main result of the paper—but replace the dependent variable with each of the three terms defined in the equation above. As for the variation decomposition, the coefficients for each margin sum up to the corresponding coefficients in in column 5 (for OLS) and 7 (for IV) of Table 4. The *VI extensive margin* is by far the largest contributor to our observed effect, that is, much of the effect is driven by firms acquiring more boats when the quality premium is high. The second largest contributor is the *VI intensive margin*, suggesting that firms also shift towards the suppliers they already own when the premium is high. Interestingly, the coefficient on the independent margin is negative and insignificant, suggesting that this margin plays little role in our observed effect.

TABLE B1: VARIANCE DECOMPOSITION OF CHANGES IN SHARE VI

Dep. var:	VI extensive margin (Boats purchases or sales)	VI intensive margin (Intensity of own use of VI suppliers)	Indep. margin (Buying less/more from Indep.)
	(1)	(2)	(3)
Share $VI_{i,t}$ − Share $VI_{i,t-1}$	0.350^{***}	0.156^{***}	0.495^{***}
	(0.037)	(0.038)	(0.048)
Firm FEs	Yes	Yes	Yes

Notes: One observation is a firm during a production season. The *VI extensive margin* corresponds to the change in the variable due to the firm buying or selling boats. The *VI intensive margin* corresponds to changes in the own use share of all the inputs produced by VI suppliers. VI suppliers sometimes supply other firms (around 10% of the time - see Figure 1) so a firm could decide to take in more or less of its VI suppliers inputs. The last contribution is the *Indep. margin* which corresponds to the firm buying more or less from independent boats than in the previous season which mechanically impacts the share of inputs from VI suppliers. The beginning of this Appendix B provides the computational details of the decomposition. Standard errors are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE B2: QUANTIFYING THE IMPACT OF EACH MARGIN IN TABLE 4

	OLS			IV		
Dep. var:	VI Extensive margin	VI Intensive margin	Indep. margin	VI Extensive margin	VI Intensive margin	Indep. margin
	(1)	(2)	(3)	(4)	(5)	(6)
Upgradable share of production (t-1) × Quality premium	2.582^{***}	0.328^{***}	-0.201	2.674^{***}	0.401^{***}	-0.539
	(0.613)	(0.084)	(0.392)	(0.542)	(0.137)	(0.333)
Upgradable share of production (t-1)	Yes	Yes	Yes	Yes	Yes	Yes
Season FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.00	-0.00	0.00	0.00	-0.00	0.00
N	191	191	191	191	191	191
R^2	0.38	0.17	0.09	0.38	0.17	0.09

Notes: One observation is a firm during a production season. This Table replicates exactly the regressions in Table 4 where the dependent variable is replaced by each of the margin presented above. The OLS specific is the same as column 5 of 4 while the IV is similar to column 7. The *VI extensive margin* corresponds to the change in the variable due to the firm buying or selling boats. The *VI intensive margin* corresponds to changes in the own use share of all the inputs produced by VI suppliers. VI suppliers sometimes supply other firms (around 10% of the time - see Figure 1) so a firm could decide to take in more or less of its VI suppliers inputs. The last contribution is the *Indep. margin* which corresponds to the firm buying more or less from independent boats than in the previous season which mechanically impacts the share of inputs from VI suppliers. The beginning of this Appendix B provides the computational details of the decomposition. Standard errors clustered at the firm level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix C Dynamic Theoretical Framework and Relational Contracts

Dynamic theoretical framework

The model presented in the main body of the paper assumes that all transactions are done on the spot market. This stylized version of the model results in the upstream party not taking any action when integrated and the absence of incentives to take a quality-increasing action ($a_2 = 0$). In this version of the model, we follow closely Baker *et al.* (2001, 2002) in allowing the downstream party to use relational contracts to incentivize the quality action.

We make the same assumptions for Q as before, but add a shock to the alternative use P:

$$P = a_1 + \epsilon$$
$$Q = Q_0 - \gamma a_1 + \delta a_2$$

where ϵ is orthogonal to any action taken by the upstream party[48]. We assume that $\epsilon = \bar{\epsilon}$ with probability $\frac{1}{2}$ and $\epsilon = -\bar{\epsilon}$ with probability $\frac{1}{2}$ and that ϵ is known by the upstream party at the time of delivery of the inputs. [49]

As in the main text model, we assume that both P and Q are not contractible. P -the quantity focused alternative use- is perfectly observable at the time of delivery of the inputs, but Q -the quality surplus- is only observed to the downstream party with some delay (e.g. once the inputs are processed).[50] To incentivize the quality-increasing action, the downstream party can offer a payment contingent on the realization of the surplus Q to the upstream party. However, since this payment can only be made after the inputs are delivered, the downstream party can only credibly promise to make this delayed payment through repeated interactions with the upstream party.[51] Note again that at the time of delivery of the inputs, since all parties know the value of Q_0, and because $P = a_1 + \epsilon$ is observable, Q has an observable portion (in expectation) at the time of delivery of the inputs: $\tilde{Q} = Q_0 - \gamma \mathbb{E}(a_1|P) = Q_0 - \gamma P$. Hence, a payment on the spot, proportional to $\tilde{Q}$ is still feasible.

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)

[48] We could also assume uncertainty over the realization of the Q surplus, but it would not change the intuition of the result below.

[49] As in the main text model, we assume that $0 \leq \delta \leq 1$ and $0 \leq \gamma \leq 1 - \alpha$. Also, note again that P could itself be the result of a bargaining process between the boat and a quantity focused firm.

[50] In our context, fish quality can hardly be assessed when the fish is offloaded at the factory. However, once the fish is processed in the factory, fishmeal quality can be measured.

[51] In the model, we suppose that this delay is shorter than a full time period, so the surplus Q is observed before the next period starts and the next transaction occurs. Thus, the downstream party does not discount the payment.

We write the relational compensation contract as $\{b(Q)\}$, where $b(Q)$ is a payment contingent on the observation of Q[52].

First Best

The first-best actions $\{a_1^*, a_2^*\}$ maximize the expected value of Q minus the cost of actions $c(a_1, a_2) = \frac{1}{2}a_1^2 + \frac{1}{2}a_2^2$. This gives $a_1^* = 0$ and $a_2^* = \delta$ and total surplus:

$$S^* = Q(a_1^*, a_2^*) - c(a_1^*, a_2^*) = Q_0 + \frac{1}{2}\delta^2$$

Spot Market

On the Spot Market, the supplier does not take the first best actions. In particular, under both Spot Employment and Spot Outsourcing $a_2 = 0$, because the downstream firm cannot credibly commit to rewarding the supplier's quality-focused actions.

Relational Contracts

Whether the upstream party is integrated with the downstream party or not, if she accepts the relational contract, she will choose actions a_1 and a_2 to solve:

$$\max_{a_1, a_2} = b\big(Q(a_1, a_2)\big) - c(a_1, a_2)$$

It is straightforward to see that the first best can only be achieved if the contract is of the form $b\big(Q(a_1, a_2)\big) = Q(a_1, a_2) - t$, where t is a transfer independant of the surplus Q. In the remainder of this section, we assume that the relational contract is written in such a way and that under relational employment (when the downstream party owns the supplier) or under relational outsourcing (when the supplier is independent), the suppliers take the first best actions $\{a_1^*, a_2^*\}$ [53].

This relational contract is self-enforcing if both parties choose to honor it for all possible realizations of P. We next explore the feasibility of the first best contract under employment and outsourcing and show that if the shock to the alternative use P is high enough, the first best contract is only self-enforceable under Relational Employment. We use superscripts {RE, SE, RO, SO} to indicate Relational Employment, Spot Employment, Relational Outsourcing and Spot Outsourcing and {U, D, S} to denote the upstream party, downstream party and overall surplus respectively.

Relational Employment

Since $S^{SE} > S^{SO}$, [54] if one of the two party reneges, the downstream party will retain ownership and earn D^{SE} in perpetuity, while the upstream party will earn U^{SE} in perpetuity. The upstream party reneges if

[52] Alternatively, we could consider a more general relational compensation contract of the form $\{s, b(Q)\}$ as in Baker *et al.* (2002), where salary s is paid by downstream to upstream at the beginning of each period and $b(Q)$ is a payment contingent on the realization of Q. Such an assumption would not change our results below.

[53] In particular, t must be such that $t \leq Q(a_1^*, a_2^*) - c(a_1^*, a_2^*) = Q_0 + \frac{1}{2}\delta^2$ so that the downstream party would accept the contract

[54] See the proof in the main text model.

she refuses to accept the promised payment $b(Q)$. Thus, the upstream party does not renege as long as:

$$b(Q) + \frac{1}{r}U^{RE} \geq \frac{1}{r}U^{SE} \tag{7}$$

Similary, the downstream party reneges if she takes the inputs and refuses to pay the bonus to the upstream party. The downstream party honors the contract as long as:

$$\frac{1}{r}D^{RE} \geq b(Q) + \frac{1}{r}D^{SE} \tag{8}$$

Summing (7) and (8), and noting that $S^X = U^X + D^X$, we get the following necessary condition:

$$S^{RE} \geq S^{SE} \tag{9}$$

(9) is actually sufficient as well as necessary, because a transfer t can always be chosen so that when (9) is statisfied, (7) and (8) are also satisfied [55].

As $S^{RE} = S^* = Q_0 + \frac{1}{2}\delta^2$ and $S^{SE} = S^* = Q_0$, (9) is satisfied, and so **the first best can always be enforced under Relational Employment**.

Relational Outsourcing

Since $S^{SE} > S^{SO}$, if one of the two party reneges, the upstream party will purchase the ownership right from the downstream party for some price π, after which the upstream and downstream parties will earn U^{SE} and D^{SE}, respectively, in perpetuity. If the upstream party reneges on the relational-outsourcing contract, she negotiates to sell the good for the spot-outsourcing price of $(1-\alpha)P + \alpha\tilde{Q}$, where α is the supplier's bargaining coefficient and $\tilde{Q}$ is the observable portion of the surplus Q as in the main text model. Thus, the upstream party honors the contract as long as:

$$b(Q) + \frac{1}{r}U^{RO} \geq (1-\alpha)P + \alpha\tilde{Q} + \frac{1}{r}U^{SE} + \pi \tag{10}$$

The timing of reneging is slightly different for the downstream party. She has no incentives to renege at the time of delivery of the inputs as Q is unobservable. Instead, the downstream party reneges if she takes the inputs and refuses to pay the bonus to the upstream party. The downstream party does not renege as long as:

$$\frac{1}{r}D^{RO} \geq b(Q) + \frac{1}{r}D^{SE} - \pi \tag{11}$$

If (10) holds for all P and $\tilde{Q}$, then it must hold for the maximum value of $(1-\alpha)P + \alpha\tilde{Q}$. Summing (10) and (11) we get the following necessary condition:

$$\frac{1}{r}S^{RO} \geq \frac{1}{r}S^{SE} + \max\{(1-\alpha)P + \alpha\tilde{Q}\} \tag{12}$$

Evaluated at $\{a_1^*, a_2^*\}$, (12) is equivalent to:

[55] For both (7) and (8) to be satisfied and the supplier to accept the contract, it must be that $Q_0 + \frac{1}{2}\frac{r}{1+r}\delta^2 \leq t \leq Q_0 + \frac{1}{2}\delta^2$

$$(1-\alpha\gamma-\alpha)\bar{\epsilon} \leq \frac{1}{2r}\delta^2 - \alpha Q_0 \tag{13}$$

Thus, if $\bar{\epsilon}$ is high enough, **the first best contract cannot be enforced under Relational Outsourcing**.

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. As a result, when the value of the input is high in its alternative use (e.g. if the supplier happens to get more fish or if there is less competition on a specific day in the quantity-focused sector), quality-oriented firms may be unable to prevent the suppliers they interact with from breaking their relationship and selling the goods for its alternative use. In contrast, under Relational Employment, the downstream firm has control over the inputs, and will choose to allocate them efficiently regardless of the value of the inputs in their alternative use.

A key testable prediction of this model in our context is that (1) independent suppliers under a relational contract should not adopt a behavior consistent with delivering higher quality inputs and (2) downstream firms should not produce higher quality output when they source more of their inputs from non-integrated suppliers with whom they have a relational contract.

Empirical evidence on relational contracts in the Peruvian fishmeal industry

We now test these predictions. We show results for two different, frequency-of-interacting based observable proxies for a supplier being engaged in a relational outsourcing contract with a downstream firm: specifically, (i) that the supplier delivers more than 80 percent of its fish to the same fishmeal firm (approx. 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 (approx. the 25th percentile of the underlying distribution) in a given production season and does so for three seasons in a row. We "turn on" the inferred contract at the start of the relevant period, not when the "cut-off" used in the proxy is reached.

In Appendix Table C1, which is analogous to Table 5, we show that relational outsourcing contracts appear not to be used to incentivize supplier quality-increasing actions in the Peruvian fishmeal industry, consistent with the dynamic version of our theoretical framework above. The results show that a supplier supplying a given plant does not deliver fresher fish when engaged in repeated interactions with the firm in question, relative to more isolated instances of supplying the same plant.

In Appendix Table C2, which is analogous to Table 6, 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. These results indicate that repeated interactions are not used to incentivize the delivery of high quality inputs in the Peruvian fishmeal sector, as the model above predicts.

In combination with the results in the body of the paper, the findings in tables 5 and 6 provide support for the idea that vertical integration enables downstream firms to incentivize specific supplier behaviors—and consequently the types of output associated with those behaviors—that other organizational structures do not.

Organizational structure and supplier behavioral response to plant input quality needs

The dynamic model with relational contracts presented above also predicts the following result. When the return on the quality surplus Q of the quality-increasing action is higher (when δ increases), integrated suppliers will choose a higher level of that action ($a_2^* = \delta$ increases). We test this prediction below.

A change in the need for input quality arises when the plant aims to produce fishmeal of the high quality type (for example because of a change in demand). As in Section 6, 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, but now differentially when the downstream plant produces low or high quality output.

We first estimate the following equation:

$$\begin{aligned} \text{B}_{ijt} = \alpha &+ \beta_1 \text{ I[VI} \times \text{supplies owner firm]}_{ijt} \times \text{I[Low Quality]}_{jt} \\ &+ \beta_2 \text{ I[VI} \times \text{supplies owner firm]}_{ijt} \times \text{I[High Quality]}_{jt} \\ &+ \gamma_{ij} \times \text{I[High Quality]}_{jt} + \gamma_{ij} \times \text{I[Low Quality]}_{jt} + \delta_t + \varepsilon_{ijt} \end{aligned} \tag{14}$$

where $\text{I[Low Quality]}_{jt}$ 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 $\text{I[High Quality]}_{jt}$).[56] We include Supplier $\times$ Plant $\times$ Quality level fixed effects (that is, $\gamma_{ij} \times \text{I[High Quality]}_{jt}$ and $\gamma_{ij} \times \text{I[Low Quality]}_{jt}$) to focus on the supplier's *differential* response to the plant's input needs when integrated. The other variables are as defined in equation (5).

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.

The results in Appendix Table C3 suggest that suppliers differentially adapt their quality behavior to the current needs of the downstream plant they supply when integrated. 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.[57] However, columns 2 and 3 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 and spend about six percent less time at sea, when the plant supplied is producing fishmeal of the high quality type. Overall, the evidence confirms the prediction from the relational model that integrated suppliers will provide more of the quality focused action when its return to the quality surplus is higher.

[56] We define this dummy variable using our directly observed measure of quality at plant level. The dummy is equal to 1 if the share of the plant's production that is of high quality type is higher than the median in our sample.

[57] The estimated decrease in quantity per trip when integrating with the plant being supplied is bigger when the plant is producing low quality fishmeal. This is surprising in light of our results in sections 7 and 5. A possible explanation is that independent suppliers face strong incentives to deliver high input quantities when the plant being supplied is attempting to produce high output quantities (and prioritizing output quality less) and that integrated suppliers do not.

TABLE C1: 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)
	(1)	(2)	(3)
I[Relational × supplies relational firm]	0.010	0.016*	−0.000
	(0.007)	(0.009)	(0.006)
Date FEs	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes
N	319,827	140,365	163,165
N distinct suppliers	1,149	1,081	1,081
R^2	0.62	0.42	0.34
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)
	(1)	(2)	(3)
I[Relational × supplies relational firm]	−0.009	0.026	0.002
	(0.020)	(0.022)	(0.015)
Date FEs	Yes	Yes	Yes
Supplier × Plant FEs	Yes	Yes	Yes
N	319,827	140,365	163,165
N distinct suppliers	1,149	1,081	1,081
R^2	0.62	0.42	0.34

Notes: For panel A and B, one observation is a boat during a fishing trip. For panel C, one observation is a boat during a fishing season. *Quantity supplied* is the amount of fish the boat delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed away from port. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. *Total time at sea* is the amount of time the boat is away from port per trip. The number of observations varies across columns as GPS variables for a given trip are sometimes missing. We define I[Relational ×supplies relational firm] to be equal to one if the supplier is (i) currently under a relational contract (ii) currently delivering to the firm it is under a relational contract with. In Panel A, we define an independent 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 two consecutive fishing seasons. In Panel B, we define an independent 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 three consecutive fishing seasons. For both definitions, wooden and steel boats can be in a relational contract. (Only allowing steel boats to be under a relational contract does not change the magnitude nor significance of these results). Because we include Boat × Plant FEs, I[Relational ×supplies relational firm] is identified from boats moving in and out of a relational contract. Standard errors clustered at the boat level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

TABLE C2: OUTPUT QUALITY AND SHARE OF INPUTS FROM VERTICALLY INTEGRATED SUPPLIERS AND SUPPLIERS UNDER A RELATIONAL OUTSOURCING CONTRACT

Panel A: Relational outsourcing = 80% of offloads to the same firm for 2 consecutive production seasons

Dep. var:	High Quality share of prod.		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.278**	0.285**	1.089***	1.120***
	(0.114)	(0.119)	(0.376)	(0.369)
Share of inputs from relational suppliers	−0.084	0.004	−0.260	−0.127
	(0.079)	(0.060)	(0.515)	(0.429)
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.	0.75	0.75	65.7	65.7
N	275	275	208	208
R^2	0.76	0.81	0.79	0.80

Panel B: Relational Outsourcing = more than 10 interactions with the same firm for at least 3 consecutive production seasons

Dep. var:	High Quality share of prod.		Protein content	
	(1)	(2)	(3)	(4)
Share of inputs from VI suppliers	0.316**	0.289**	1.145***	1.134***
	(0.119)	(0.113)	(0.262)	(0.268)
Share of inputs from relational suppliers	−0.381***	−0.427***	0.373	0.608
	(0.131)	(0.144)	(1.833)	(1.699)
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.	0.75	0.75	65.7	65.7
N	275	275	208	208
R^2	0.76	0.82	0.79	0.80

Notes: One observation is a firm during a production season. *Protein content* is the quantity weighted average of a measure of quality inferred from a database that provides weekly prices by quality. *Log(unit price)* is the log of the quantity weighted average unit price of exports during a season. *Share of inputs from VI suppliers* is the share of a firm's inputs that come from VI suppliers during a season. *Share of inputs from relational suppliers* is the share of a firm's inputs that come from VI suppliers during a season. In Panel A, we define an independent 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 two consecutive fishing seasons. In Panel B, we define an independent 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, for at least three consecutive fishing seasons. For both definitions, wooden and steel boats can be in a relational contract. (Only allowing steel boats to be under a relational contract does not change the magnitude nor significance of these results). *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 uses steam drying technology. Standard errors clustered at the firm level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE C3: SUPPLIER BEHAVIOR, VERTICAL INTEGRATION AND OUTPUT QUALITY

	Panel A		
Dep. var:	Log(Quantity supplied)	Log(Max. distance from the plant's port)	Log(Total time spent at sea)
	(1)	(2)	(3)
I[VI × supplies owner firm] × I[Plant producing low quality]	-0.133^{***}	0.019	-0.013
	(0.043)	(0.046)	(0.031)
I[VI × supplies owner firm] × I[Plant producing high quality]	-0.066^{**}	-0.065^{**}	-0.042^{**}
	(0.029)	(0.026)	(0.019)
Date FEs	Yes	Yes	Yes
Supplier × Plant × High Quality FEs FEs	Yes	Yes	Yes
N	319,827	140,365	163,165
N distinct suppliers	1,149	1,081	1,081
R^2	0.62	0.44	0.35
Two coefficients equal (p-val)	0.0012	0.028	0.089

Notes: One observation is a supplier during a fishing trip. This table is similar to Table 5, but with I[VI × supplies owner firm] interacted with the quality produced by the downstream plant. *Quantity supplied* is the amount of fish the boat delivers to the plant per trip. *Max. distance from the plant's port* is maximum distance a specific boat is observed away from port. *Max. distance from the plant's port* can only be measured if the boat leaves from and arrives at the same port. *Total time at sea* is the amount of time the boat is away from port per trip. 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. Standard errors clustered at the boat level are included in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix D How Demand for Output Quality Affects Vertical Integration

In this section, we develop an alternative strategy to the one presented in section 5 to show that firms choose to integrate their suppliers when they face increased demand for high quality fishmeal. To do so, we develop an IV strategy that exploits quality-differentiated firm-specific demand shocks. We find that these shocks cause firms to increase their Share VI.

D.1 Empirical strategy

The logic behind our instruments for the quality grade of a firm's exports at a given point in time relies on two important facts about the Peruvian fishmeal sector. First, there is an exceptionally tight link between quality grade and export destination. 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.[58] Sales records provided by a large firm drive home this connection. Country names are frequently used as a shorthand to represent different qualities—the quality column for exports is often simply filled in with the name of a 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 integrate or sell suppliers in a given production season in response to high or low demand from particular importer countries.

In the second stage, we estimate how acquisitions/sales of suppliers and firms' input mix respond to the quality grade produced:

$$\text{VI}_{it} = \alpha + \beta_1 \text{Quality}_{it} + \gamma_i + \delta_t + \varepsilon_{it} \tag{15}$$

We control for firm and production season fixed effects and cluster the standard errors at firm level as in Section 7.

To construct our demand shocks, we follow an approach similar to Bastos *et al.* (2018) (see also Park *et al.* (2010); Brambilla *et al.* (2012)). In the first stage, quality grade produced is instrumented by demand shocks from specific destinations as follows:

$$\text{Quality}_{it} = \gamma_i + \delta_t + \sum_j \beta_j \ (\text{I}^j_{i,\bar{t}} \ S^j_{-i,t}) + \varepsilon_{it} \tag{16}$$

where j is an export destination country, and $\text{I}^j_{i,\bar{t}} \ S^j_{-i,t}$ are our excluded instruments. $\text{I}^j_{i,\bar{t}}$ is a dummy variable equal to one if firm i exports to destination j at least once during our analysis period. $S^j_{-i,t}$ is the leave-firm-out share of Peru's fishmeal exports going to country j in season t, a proxy for the relative demand for firm i coming 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 $S^j_{-i,t}$ and $\text{I}^j_{i,\bar{t}}$. A high β_j should represent a high quality importer country. We present the results of this specification in columns 3 and 4 of Appendix Table D1).

[58] See Appendix Table A1 for a list of the main importers of Peruvian fishmeal and the average quality imported. Note that, as for humans, quantity and quality of feed (the latter here defined by protein content) are highly imperfect substitutes for the animals that consume fishmeal.

In an alternative approach (presented in columns 5 and 5 of Appendix Table D1), we replace $S^{j}_{-i,t}$ by $Quality^{j}_{-i,t}$, the leave-firm-out average quality of Peru's fishmeal exports going to country j in season t. In that case, a positive and high β_j represents a high willingness of Peruvian firms to respond to the higher demand for quality expressed by other countries. Conversely, a negative β_j represents a substitution effect: if an importer country starts buying higher quality output from other exporters, that same country would start buying low quality from other firms.

D.2 Results

We find that firms respond to positive shocks to demand for high quality fishmeal by sourcing a higher share of their inputs from suppliers that have been integrated.[59]

The OLS and the second stage IV results are reported in Appendix Table D1. The estimates indicate that a one percentage point increase in the average protein content demanded—about 20 percent of approx. 63-68 percent range observed in Peru—induces the firm to source between 4 and 6 percent more of its inputs from integrated suppliers. As presented in Table 2, most of the variation in the share of inputs sourced from integrated suppliers comes from acquiring and selling suppliers.

Our interpretation of the results in Appendix Table D1 is that firms vertically integrate *in order to be able to produce high quality output*. A potential alternative is that the liquidity that comes along with greater demand (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 relative 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. We address the concern by including controls for total seasonal sales. This has little effect on the estimated coefficients.

In the first stage, we use the 20 countries that import the most fishmeal from Peru (see Appendix Table A1). Since China represents about 50 percent of total exports, we split China into 4 sub-countries, and we do so by using the destination port within China of each specific shipment. Our results are very similar if instead we use the 10 biggest importer countries or we use LASSO regressions to choose the importer countries whose demand fluctuations most affect quality grade exported.[60] The first stage results are reported in Appendix Table D1 [61].

Since the existing literature that uses destination country demand shocks for identification often struggles with weak instruments, we compute the Kleibergen-Paap test statistics. Comparing the statistics reported in Table 4 to the Stock-Yogo critical values[62], while we do not pass the Kleibergen-Paap underidentification test, we reject the null hypothesis that our instruments are weak (as the F-statistic surpasses the 10 percent critical value). We also reject the hypothesis that the coefficients on the excluded instruments

[59] The IV coefficients in columns 3 to 6 are bigger than the OLS coefficients in columns 1 and 2. We believe this is in part to be expected because the relationship between output quality and vertical integration *at firm level* estimated in Table 3 partly reflects a causal effect of organizational structure on output quality and partly other mechanisms. If the OLS estimates in that table are biased upwards, we would expect the OLS estimates here to be biased downwards, as we study the inverse relationship.

[60] 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. LASSO selects eight importer countries.

[61] The sign of the coefficients for each instrument in column 3 and 4 are broadly consistent with the relative average quality imported by each country (See Appendix Table A1). It is more difficult to interpret the sign of the first stage in column 5 and 6 as the sign reflects the strength of the tie between a specific destinations and Peruvian exporters.

[62] 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.

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 additionally 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.* (2018) for a lengthier discussion of this issue in the context of "demand pull" instruments.

The strategic changes in organizational structure in response to changes in the composition of demand are consistent with the integration→quality relationship shown in Section 7 and confirm the results shown in section 5 that firms integrate when they face incentives to quality upgrade. We conclude that Peruvian manufacturing firms are aware of, and act on, their greater ability to produce high quality grade output when their suppliers have been integrated.

TABLE D1: VERTICALLY INTEGRATED SHARE OF INPUTS AND OUTPUT QUALITY - INSTRUMENTING WITH FIRM-SPECIFIC DEMAND SHOCKS

Dep. var:	Share of inputs from VI suppliers					
	OLS	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Protein content	0.036***	0.037***	0.078*	0.079*	0.055**	0.057**
	(0.012)	(0.011)	(0.043)	(0.042)	(0.026)	(0.027)
Log(Sales)		−0.004		−0.028		−0.016
		(0.013)		(0.025)		(0.018)
Season FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dep. Var.	0.45	0.45	0.45	0.45	0.45	0.45
N	192	192	192	192	192	192
R^2	0.92	0.92	0.92	0.92	0.92	0.92
Dep. var:	First Stage Protein Content					
	(1)	(2)	(3)	(4)	(5)	(6)
China - HUANGPU			−2.029	−1.152	−5.563***	−5.125***
China - SHANGHAI			0.380	0.801	−1.705**	−1.843**
Germany			−0.219***	−0.214***	−0.037***	−0.040***
China - other			−1.791**	−1.922***	−0.406	−0.155
Japan			−0.175	−0.454	−0.166	−0.207
China - DALIAN			−0.168	0.298	0.024	0.008
Chile			0.392***	0.405***	0.078***	0.078***
Vietnam			0.124	0.111	0.321***	0.253**
Turkey			−0.004	−0.016	−0.001	−0.002
Indonesia			0.435*	0.357*	0.191	0.101
Spain			0.310*	0.295	−0.064	−0.014
Australia			0.048	0.056*	0.002	0.000
Canada			−0.135	−0.239	0.015	0.012
France			−0.600*	−0.498*	−0.232	−0.145*
Greece			0.000	−0.001	0.002	0.001
Italy			−0.007	−0.003	0.004	0.004
Bulgaria			0.020	0.015	0.001	0.001
Kleibergen-Paap LM p-value (under-id)			0.53	0.46	0.53	0.45
Kleibergen-Paap Wald F statistic (weak inst)			625.5	598.6	1141.9	797.7

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 inferred with a database that provides weekly prices by quality. The instruments are interactions of indicators for at least one export in our analysis period to each of the top 20 destination countries with leave-firm-out share of Peru's fishmeal exports towards the destination in the relevant season (columns 3 and 4) or leave-firm-out average protein content exported towards the destinatiion in the relevant season (columns 5 and 6). Standard errors clustered at the firm level are included in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.