Discontinuous Investment and Productivity in Multibusiness Firms*

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Abstract

In multibusiness capital budgeting, a negative shock to the investment opportunities of a firm's business segment increases the attractiveness of investment opportunities of other business segments of the same firm. A regression discontinuity model exploiting government production bans on a regulated business segment ("fishmeal") shows that the increased investment in the *non*-fishmeal segment due to the bans is substantial (over 35% of the mean value). This discontinuous investment reduces productivity, and it is only found among financially constrained firms and among firms with more attention-demanding operations.

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The pursuit of value-creating investment opportunities in the multibusiness firm plays a prominent role in modern theories of corporate scope and internal capital markets (Gertner, Scharfstein, and Stein 1994, Stein 1997, Bernardo, Cai, and Luo 2004). Several recent empirical studies tie multibusiness scope with internal capital allocation (Shin and Stulz 1998, Seru 2010). Other studies connect multibusiness scope with productivity outcomes (Schoar 2002, Maksimovic and Phillips 2008). It is reasonable to hypothesize, therefore, that multibusiness scope may influence the capital allocation process and, subsequently, changes in productivity. However, while this connection has been clear in theory (Mitchell 2000, Gomes and Livdan 2004), empirically analyzing the nature, causes, and consequences of multibusiness investment in a unified framework has proven to be difficult. Business segment data are typically coarse, exogenous events shifting a segment's investment environment are hard to find, and the causal chain linking scope and value is often long and opaque. As a result, despite its importance in theory and practice, the multibusiness investment process remains largely mysterious to date.

This paper provides an empirical analysis of working-capital investments in multibusiness firms through a study of the population of firms in the Peruvian fishing industry, the second largest in the world. Firms have two different investment opportunities: fishmeal production and non-fishmeal production. (Fishmeal is a flour-like substance used as high-protein feed in livestock production and aquaculture; non-fishmeal products include canned, cured, and frozen seafood, all for human consumption). My central strategy is to analyze sharply discontinuous rules in the *daily* activities of fish-processing firms in the form of recurrent government bans on fishmeal production. As shown in Figure 1 for the case of one port, fishmeal can be produced only during government-determined seasons, in quantities up to completing a preestablished industry-wide quota. The conditions upon which the government bans on fishmeal are determined allow me to implement a regression discontinuity model that assesses the causal impact of fishmeal bans on the investment activity of *non-fishmeal* units of the same firms in the short window before and after their sister fishmeal divisions enter the ban period. I first show that government bans completely paralyze fishmeal activity. In this sense, the sharp fishmeal rules may be viewed as exogenous shocks to the scope of investment opportunities of multibusiness firms.

Aside from its simplicity, the fish-processing setting is particularly well suited to generate substantially new knowledge about the investment channel inside multibusiness firms for several reasons. First, granular information on the productive operations of all plants in high frequency allows me to focus on short-term investments in working capital and production processes; this large segment of the real economy is not only understudied (Bresnahan and Ramey 1994, Carpenter, Fazzari, and Petersen 1998, Wen 2005) but it is also particularly helpful to connect firm boundaries, the investment process, and productivity outcomes directly rather than through a long causal chain. Second, the investment opportunities available to fish-processing firms are largely driven by biological factors that obviate concerns about asymmetric information or moral hazard typically hindering the study of multibusiness capital allocation. Hence, viewing fish as an investment opportunity that will lose value if not processed immediately shifts the locus of frictions to mechanisms existent regardless of the intentions of managers (Maksimovic and Phillips (2002), (2006)). Third, the emphasis on the cross-subsidization of cash flows following Lamont's (1997) influential work has diverted attention from the conceptual and statistical mechanisms linking the scope of investment opportunities and value creation. Specifically, recent theories of multibusiness investment suggest that the reduction of value in multibusiness firms may actually reflect a neoclassical relationship between productivity and scope (Mitchell 2000, Gomes and Livdan 2004). In fish-processing, government bans on fishmeal production offer unusual and specific shocks to the scope of investment opportunities which, in combination with high-frequency data on productivity and financing, allow for an integrated study of the nature, causes, and consequences of multibusiness investment.

Government bans on anchovy extraction, the only species used for fishmeal, prohibit the production of fishmeal for certain periods. These prohibitions result in long shutdown periods covering the reproductive cycles of anchovy (two seasons per year) or shorter within-season moratoriums that allow juvenile fish to grow further before continuing extraction. At the beginning of a season, the regulatory authority announces a total anchovy quota that becomes the universe of what firms can catch and process in their fishmeal segment. My empirical approach is to measure the discontinuous investments of each multibusiness firm in the *non-fishmeal* segment precisely as the firm crosses the limit of what is a permissible period to produce fishmeal. I essentially contrast the non-fishmeal investment behavior of a fish-processing firm as it just crosses a fishmeal-allowed period with the same firm as it just falls out of the fishmeal-allowed period. Certainly, I view the fishmeal bans as directly related to the collective activity of all fishmeal producers (i.e., the "assignment variable" is global rather than individual), and possibly correlated with unobserved natural factors. However, the power of my empirical tests is based on the identifying assumption that the biological function relating the investment opportunities in non-fishmeal operations with those in fishmeal operations is not discontinuous. Specifically, investment opportunities in the non-fishmeal business have no biological reason to make a discrete jump at the level of an end-of-season anchovy ban. Government rules have jumps: nature doesn't.

Using this regression discontinuity approach, I find that crossing into the ban-on-fishmeal period significantly increases the investment in the non-fishmeal segment of multibusiness firms, with point estimates above 35% of the unconditional mean value. This boost in investment is measured in terms of the quantity of fish processed by the non-fishmeal business units as well as the dollar value of fish. Because all models control flexibly for the productivity of each firm in the fishmeal business, I cannot attribute the jump in non-fishmeal investment to the fact that good firms differ from bad firms. Moreover, several physical friction arguments such as mothballing are found insufficient to generate the discontinuous investment pattern observed in the non-fishmeal segment given the shock to investment opportunities. Because this jumpy investment due to the cease of fishmeal operations is only found in multibusiness firms and not in focused non-fishmeal firms, I rule out an industry-wide explanation for the intermittence of investment layouts: fishmeal bans spur non-fishmeal investments through mechanisms binding only in multibusiness firms.

I therefore investigate the causal mechanisms for discontinuous investment in the non-fishmeal segment of multibusiness firms. First, I find evidence of a *financial constraint* mechanism: the ban-on-fishmeal effect on non-fishmeal investments is only significant for firms with more costly access to bank loans, the most important source of external finance in this setting. The regression discontinuity models allow me to see that firms with a small share of troubled bank loans or a small requirement of mortgage collateral for bank loans do not increase their investment in non-fishmeal when they enter the ban-on-fishmeal period. By contrast, firms with a higher cost of financing show sharp increases in their non-fishmeal investments when crossing into the ban periods. I also find evidence that financially constrained firms depend heavily on their internal cash for operations during the fishmeal season, thus leaving little room for non-fishmeal production, a result broadly consistent with the existence of financial constraints in multibusiness firms.

Second, I find suggestive evidence of a *managerial attention* mechanism consistent with the conscientious approach of attention-constrained managers rather than with careless neglect. The jump in non-fishmeal investment triggered by fishmeal bans is only found among those firms with more attention-demanding non-fishmeal operations — firms with larger non-fishmeal volume, firms with a broader variety of non-fishmeal products, and firms with more countries of destination for their exports. The results suggest that managerial attention is too scarce for non-fishmeal investments during the fishmeal season, thus being reallocated to non-fishmeal right after the end of active fishmeal season and leading to larger investments. Because the most affected firms are those with large non-fishmeal divisions, the results also go against the conventional story that internal capital markets favor the strong and powerful.

The *consequences* of investment discontinuities may be substantial. I find that multibusiness firms affected by the fishmeal bans have lower productivity in their non-fishmeal segment; because these firms spike their investments during fishmeal-banned periods, they go beyond their optimal scale, suffering from a significant productivity drop, a result consistent with theory (Mitchell 2000, Gomes and Livdan 2004). Discontinuous investment thus provides a new explanation for capital misallocation (Hsieh and Klenow 2009). To my knowledge, this study is one of the first to present an integrated framework in which the *nature* of discontinuous investment behavior and the *causes* of this behavior, such as financial constraints and managerial inattention, have important value *consequences* for multibusiness firms.

The central result of an influential theoretical literature connecting multibusiness scope, investment and value has been elusive to empirical research. Two conceptual reasons for this difficulty are the interrelation between cash flows of different divisions (e.g., Lamont 1997, Shin and Stulz 1998) and the asymmetric information and moral hazard problems in capital allocation (e.g., Stein 1997, Rajan, Servaes, and Zingales 2000, Marino and Matsusaka 2003, Bernardo, Cai, and Luo 2004, Ozbas 2005). Methodologically, Whited's (2001) warning that endogeneity and measurement error may complicate the interpretation of multibusiness investment patterns and Maksimovic and Phillips's (2002) observation that much of the variation in multibusiness investment may be neoclassical have raised the stakes of investigating the underlying mechanisms linking the scope of investment opportunities and multibusiness investment. The relatively straightforward investment and financing model of fish-processing firms allows me to do this with clarity in the context of shocks to divisional investment opportunities, equivalent to high-frequency shocks to focus that are difficult to model empirically even if they capture a broad class of managerial problems in many markets.[1]

The results linking corporate scope, discontinuous investment, financial constraints and managerial attention give a new perspective to the current understanding of multibusiness capital budgeting. First, multibusiness scope has been associated with the alleviation of financial constraints (Billett and Mauer 2003, Dimitrov and Tice 2006); my analysis helps underscore the heterogeneity of financial even among very similar multibusiness firms. Second, financial constraints have been found to influence the timing of large investment projects (Whited 2006); my findings suggest a prominent role of financial frictions in the *daily* timing of working capital investments in multibusiness firms. Third, managerial attention has been advanced as a potential advantage of recently-diversified firms through a 'new toy' mechanism (Schoar 2002); by contrast, the results here suggest that the *ongoing* operation of diversified firms imposes an attention burden on managers that results in distorting capital allocation. Fourth, capital budgeting policies have been shown to respond to the exogenous evolution of demand-side investment opportunities in the long run (Della Vigna and Pollet 2011); this paper indicates that *supply-side* shocks to investment opportunities affect *multibusiness* firms' capital allocations in a matter of *days*. Finally, the intensity of capital allocation activity has been associated with firm performance (Guedj, Huang, and Sulaeman 2009); my study is among the first to find a discontinuous capital allocation process with direct mechanisms linking firm scope and productivity.

[1]See Bernard, Redding, and Schott (2010) for a study of the multi-product firm's decision to co-produce; Wolfram (1999) for evidence of production patterns in real time; and Graham, Harvey, and Puri (2010) for survey results on the practical importance of capital budgeting in multibusiness firms.

1 Data

1.1 Institutional background

Fish Processing

The Peruvian industrial fishing sector is defined as the extraction and processing of wild fish from the ocean.[2] In this study, I focus on *processing* firms and define them by their products: fishmeal or non-fishmeal. Fishmeal is a flour-like substance used as high-protein feed in livestock production and aquaculture, and fish oil is a by-product of the fishmeal production process also used as a protein supplement for livestock and aquaculture. (Hereafter, both fishmeal and fish oil are labeled under the common term 'fishmeal.') The human consumption segment, labeled here as 'non-fishmeal,' includes canned seafood, frozen seafood, and cured seafood. The main input of both segments is raw fish, which must be processed in a matter of hours; the extraction of raw fish is performed on the sea and its processing is done on land. There are no firm-specific property rights over fish or fishing grounds; hence, in the case of fishmeal each firm with a permit can extract or produce as much as it wants up to a global industry-level season quota. (The regulatory environment is described in more detail below). There is an active raw fish market on which extracting firms and processing firms transact; in the case of vertically integrated firms that own both ships and plants, these exchanges take the form of vertical transfers.

The fish-processing activities of the fishmeal and non-fishmeal segments show important similarities and differences. On the one hand, both segments depend on wild fish, a resource in the form of species following different biological cycles. Hence, some key operational practices such as the management of peaks and lows in the resource stock generally apply to both segments. On the other hand, fishmeal depends solely on anchovy, whereas canned, cured, and frozen seafood producers rely little on anchovy and use instead a wide variety of fish and marine species typically available in much smaller quantities.[3] Moreover, downstream production processes do not overlap

[2] The marine ecosystem of the Peruvian sea is known as the world's champion producer, by far, of exploitable fish biomass, yielding more than 20 times the tonnage of fishery landings produced by comparable ecosystems. See Bakun and Weeks (2008) for a review.

[3] Anchovy is also edible by humans; recent government efforts have shifted more attention to a potentially growing segment of human-consumption anchovy but as of 2011, it still remains a small niche.

across segments: fishmeal is an animal-feed commodity produced in largely automatized plants; seafood production, by contrast, relies more intensively on labor and requires a different kind of sanitary controls to comply with consumer market requirements.

Investment and Financing

The focus of this paper is on working capital, the main investment item in the industry. Every day, fish-processing firms decide whether to purchase (or transfer) raw fish to be processed in their plants. In the case of multibusiness firms, the main focus of this study, investment in the two different segments is therefore tied to biodynamics across different marine species: anchovy for fishmeal vs. other species for non-fishmeal. Results from marine biology research[4] suggest that some non-fishmeal species such as mackerel feed on anchovy, and that the sharpest changes in the relation between these non-fishmeal species and anchovy are due to macro regime shifts in the sea (e.g., El Niño oscillations every seven years) rather than micro differences of days around a seasonal ban. Therefore, while the cyclicality between fishmeal and non-fishmeal species should be reflected in some kind of alternation in extraction, in principle each business segment pursues different investment opportunities that are not mechanically tied by a biological mechanism.

Other kinds of investment such as capital equipment are theoretically possible but not studied here. First, the fishmeal segment is capped by regulation due to environmental reasons; thus, the total extracting and processing capacity cannot be increased.[5] Second, while non-fishmeal capacity is not capped, the size of the non-fishmeal segment (measured in volume of fish) has not increased substantially over the period studied. Hence, the empirical approach takes fixed capital investments as given to focus on the daily productive investments of *all active new and old plants* in the industry resulting in finished products ready for sale — an investment in inventories decision.[6] Focusing on daily investments is also an advantage over coarser long-horizon investments that are subject to the criticism that firms endogenize

[4]See Muck and Sanchez (1987), Alheit and Niquen (2004), Bertrand et al. (2004), and Guénette, Christensen, and Pauly (2008) for relevant pieces in a vast marine biology literature focused on the Peruvian sea.

[5]Not only are fishmeal firms prohibited from building additional plants: they cannot enlarge the processing capacity of their existing plants. Firms are allowed to scrap their existing plants if they want to build a new plant, though in practice few firms do it.

[6]See Dimitrov and Tice (2006) for a study of segment investments proxied by sales and inventory data from Compustat.

investment opportunities through entry and exit.

To finance their investments, firms rely largely on bank financing, as there are only a handful of publicly-traded fish-processing firms. However, firms finance their segments' operations differently. Specifically, fishmeal operations are financed with working capital loans against warrants, self-liquidating guarantees that automatically convert into international trade loans covering the export cycle. (Over 95% of fishmeal production is exported). By contrast, non-fishmeal operations are more difficult to fund with bank instruments; seafood is not a commodity and it is not accepted as a self-liquidating guarantee for bank loans. Multibusiness firms typically use their internal cash for non-fishmeal operations.

Regulatory Environment: Fishmeal Production Bans and Quotas

Fish is a national good; hence, the industrial fishing sector is regulated by the government.[7] Specifically, fishing for fishmeal is the primary object of regulation, given the tendency to overfish fueled by the ever-growing demand for fishmeal. The explicit goal of government regulation is to protect the marine resources of the country for future generations, while at the same time to allow for private initiative that creates wealth, jobs, and trade surplus.[8] The government regulates fish extraction and processing through the Ministry of Production. In the period of interest, three regulatory instruments are used to pursue these goals: a cap on total extractive capacity, equivalent to an entry restriction applied to both ships and plants; a quota on fish extraction at the industry level for each season, enforced by an end-of-active-season ban; and temporary localized days-long moratoriums to protect the growth of juvenile fish. Most bans are on anchovy and white anchovy (hereafter pooled as anchovy for brevity), the only species allowed for fishmeal production.

The fishmeal season is defined here to include both the *active season* and the *post-season*. During the active season, typically announced two weeks in advance by the regulatory authority, fishing anchovy for fishmeal is allowed; during the post-season, which starts automatically when the industry-wide quota is reached regardless of the date, no anchovy for fishmeal can be caught and fishmeal plants are paralyzed. The end-of-active-season bans, typically going from January

[7]See Aranda (2008) for a detailed description of the regulatory framework.

[8]These goals are detailed in the General Fishing Law (D.L. N° 25977), available at www.produce.gob.pe.

to April and from August to October, are meant to cover the reproductive period of anchovy, whereas short-term moratoriums are mandated within an active season in cases when the fish being caught are still too young to be extracted without endangering future catches. Most bans apply to the northern and central regions of the Peruvian sea above parallel 16°S, while the south has few bans. Regulatory enforcement is conducted in a centralized way through satellite surveillance, as well as on the field through a wide network of government officials.

Figure 2 depicts the time series of cumulative anchovy catches for fishmeal during all the seasons studied. Point A falls on a day during the active season; the dotted line between points A and B depicts the date when the industry-wide quota of anchovy is reached, thus starting the post-season ban; point B falls on a day of the post-season in the same season of point A. Finally, point C falls in a different season, around a date when the government mandates a short-term moratorium (in some or all the latitudes of the coastline). The empirical design of this paper asks how and why the discontinuous rules in the fishmeal segment depicted in Figure 1 for the case of one port and Figure 2 for the whole industry influence investment in the *non*-fishmeal segment of multibusiness firms.

1.2 Data sources and sample

The primary data source is the Ministry of Production's Fishing System database.[9] This database includes daily reports on each fish purchase transaction or vertical transfer from each vessel to each plant in the country, and a historical ownership registry of all plants and ships. Information on each banking loan received by fish-processing firms each month is obtained from the Banking Superintendency's credit registry. Information on firm exports are collected by the Customs authority and available at the Tax Authority's public database. Data on all fishing quotas and fishing bans are hand-collected from the government's daily legal gazette *El Peruano*. The geographical location of each plant is matched with the ban regulations using latitude indicators. Weekly world prices for fishmeal are obtained from the International Fishmeal and Fish Oil Organization in London. Daily diesel oil prices after local taxes are obtained from a large fish-

[9]Although part of this database is publicly available, I accessed the complete system through a research agreement that includes a confidentiality clause.

processing firm.

The sample period for the study is 6 September 2002 to 31 July 2008, a date range chosen to reflect a uniform industry environment.[10] The sample firms for the main tests are all firms with processing capabilities *both* in the fishmeal and non-fishmeal segments; that is, my primary interest is in the scope of investment opportunities *across* segments within multibusiness firms, a possibility that does not exist for focused firms. For completeness, the empirical design does incorporate information on all firms regardless of whether they are focused on fishmeal, focused on non-fishmeal, or multibusiness. Table 1 reports summary statistics on the main variables of the study.

2 Empirical Strategy

I seek to understand how multibusiness firms invest in their *non-fishmeal* business units. Under the null hypothesis that different segments follow different dynamics in pursuit of their own value-creating prospects, changes in the investment opportunities in the fishmeal segment should not affect non-fishmeal investments. Because the fishmeal segment is subject to government-mandated bans leading to alternating periods of voluntary production and mandatory shutdown, the empirical strategy focuses on whether fishmeal bans affect non-fishmeal investments.

2.1 Baseline specification

Consider firm i's decision to invest in non-fishmeal in its plant at port p on day t:

$$INF_{i,p,t} = \alpha + \beta * Ban_{p,t} + \nu * X_{i,p,t} + \delta_i + \gamma_{p\times s} + \epsilon_{i,p,t} \quad (1)$$

where $INF_{i,p,t}$ is investment in non-fishmeal, $Ban_{p,t}$ is a dummy for whether there is a fishmeal ban in the latitudes including port p on day t, $X_{i,p,t}$ is a set of controls, δ_i is a firm fixed effect,

[10] On 5 September 2002, the day before the initial date in the sample, the regulatory authorities decreed that mackerel, an alternative species previously used for fishmeal and non-fishmeal, would be permanently banned for the fishmeal industry, so that the only species useable for fishmeal would be anchovy.

$\gamma_{p\times s}$ is a port-season interaction fixed effect; and $\epsilon_{i,p,t}$ is the error term. $INF_{i,p,t}$ is zero when the firm does not purchase or transfer fish to a plant on that day.

The inclusion of port-season interaction fixed effects $\gamma_{p\times s}$ controls for any unobserved changes occurring over time at a plant's geographical location: any changes in local productive conditions, fish abundance, workforce availability, or economic conditions. Moreover, the inclusion of firm fixed effects controls for any time-fixed heterogeneity at the level of each non-fishmeal processing company. The errors from the regression are likely to be correlated across observations, so I cluster standard errors by firm.

Because each port along the coastline hosts multiple firms, and because $Ban_{p,t}$ is determined by all firms' fishmeal activity rather than by firm i's non-fishmeal activity, specification (1) is a reasonable baseline specification to assess the causal impact of $Ban_{p,t}$. In other words, the coefficient β is a proper estimate of how shocks to investment opportunities in the fishmeal segment affect investment in the non-fishmeal segment.

However, specification (1) may be considered insufficient given the possibility that the post-season period could differ significantly from the active-season environment. Specifically, investment opportunities in non-fishmeal may change drastically as the post-season evolves farther away from the date when a fishmeal ban is enacted. To disentangle the effect of fishmeal bans from changes in non-fishmeal investment opportunities that would have otherwise occurred, I estimate the impact of bans by focusing only on discontinuous changes in non-fishmeal investments around the threshold of a banned period. I turn to this specification next.

2.2 Regression discontinuity design

My main estimation approach expands equation (1) to exploit the discontinuity of $Ban_{p,t}$, including as right-hand side variables high-order polynomials of the *assignment variable* on which fishmeal bans are determined. With the inclusion of these functions, the point estimate on the ban indicator variable is identified under the assumption that managerial preferences over how much to invest in the non-fishmeal segment are not discontinuous exactly at the ban threshold.

In this section, I detail the design following Lee and Lemieux (2010) closely. I also validate my discontinuity approach following the methodological suggestions of Bakke and Whited (2010) by estimating equation (1) exclusively on a small sample around the threshold events.

A. Setup

Because the investment opportunity function of the non-fishmeal segment is continuous in calendar time and in the conditions of the fishmeal business (in the absence of fishmeal bans), then any jump in the investment behavior of non-fishmeal business units precisely at the fishmeal-permissible boundaries may be attributed to the causal impact of the bans. As in a standard regression discontinuity design, this allows for consistent estimation of the effect of bans (Hahn, Todd, and Klaauw 2001). My setting differs in that there are multiple relevant discontinuities over time, as fishmeal bans are recurrent. I exploit the panel nature of the data to capture firm-specific differences using firm fixed effects and port-season interaction fixed effects. As noted by Cellini, Ferreira, and Rothstein (2010), moreover, investment behavior may entail substantial lags, making regression discontinuity designs more complicated due to dynamic effects. By focusing on daily working-capital decisions, however, I get around this problem and ask how firms react to daily conditions in their investment opportunity set within a given season.

Formally, the criteria used by the regulatory authority to determine the end-of-active-season bans converge into one single continuous metric: the cumulative sum of anchovy tons extracted for fishmeal. If this cumulative sum is less than the industry-wide quota $\bar{Q}$ determined by the regulatory authority, firms can continue processing fishmeal:

$$\text{Continue fishmeal?}_{i,t} = \begin{cases} 1 & \text{if } \sum_{\forall i} \sum_{0}^{t-1} Q_i < \bar{Q} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

where Q_i is the amount of anchovy caught by each firm on a given day. Note that at any point throughout the permissible period, the life-cycle of anchovy may be ending while the life-cycle of non-fishmeal species may be developing in the opposite direction;[11] however, as demonstrated

[11] In additional tests described below, I also make sure that the link between investment opportunities across the two segments is not explained by the adjustment in the marginal cost of each investment opportunity reflected in the price of different fish species.

by marine biology research described in Section 1.1, the biodynamics of these investment opportunities do not map directly, if at all, onto the jump triggered by the discontinuity when the decision rule in expression (2) switches from 1 to 0.

To exploit this discontinuity empirically, I define the assignment variable *Distance to Quota*, $D_{t,s}$, as the difference between the cumulative amount of anchovy caught by all firms up to the previous day and the government quota for a given season s:

$$D_{t,s} = \bar{Q}_s - \sum_{\forall i} \sum_{0}^{t-1 \in s} Q_i \tag{3}$$

Hence, employing data on all fishing seasons, I estimate:

$$INF_{i,p,t} = \alpha + \beta * Ban_{p,t} + \nu * X_{i,p,t} + \sum_{j=1}^{5} \omega_j * D_{t,s}^j + \delta_i + \gamma_{p \times s} + \epsilon_{i,p,t} \tag{4}$$

where $D_{t,s}$ is the assignment variable of the regression discontinuity design and enters the equation as polynomials of degree five. Note that in specification (1) and (4), $Ban_{p,t}$ is coded as one whenever there is an end-of-active-season ban as well as any short-term moratorium, which may be particular to some locations. Moreover, a season encompasses the periods before and after completing $\bar{Q}$ (i.e., periods of $D_t > 0$ and $D_t = 0$).

B. Graphical Explanation of the Setup

Figure 2 helps to understand the regression discontinuity setup. (A graphical analysis of the results is reported separately in Section 3.1). Consider points A and B in the plot. Because the industry-wide quota is known by all participants ex ante, and because *Distance to Quota* is also published daily and known by all firms, the end-of-active-season is somehow expected by fishmeal processing firms. However, within a small window between points A and B, the business conditions and investment opportunities in the *non-fishmeal* segment are essentially the same. Therefore, the shock modeled in specification (4) consists in the exogenous shift in the *relative importance* of investment opportunities from the fishmeal segment to the non-fishmeal segment of multibusiness firms in the narrow window around the end-of-active-season bans.

The timing of the shutdown and corresponding shift in investment opportunities may be anticipated by firms, and long-run planners may incorporate these changes in their allocation decisions across fishmeal and non-fishmeal activities. By analogy, this anticipation is analogous to students knowing that passing an exam exonerates them from summer school while failing an exam forces them to attend summer school, the classical example of regression discontinuity research. This knowledge, however, is not relevant for identification: the plausible identifying assumption here is that treatment is random for observations just before and after the (anticipated) shutdown of investment opportunities in fishmeal.

C. Observability and Manipulation of Threshold

Because the regulatory authority publishes daily the industry-wide progress of anchovy catches, the assignment variable is known by all firms in real time. Moreover, to the extent that the assignment variable is collective rather than individual, manipulation should not be feasible in practice. Additional institutional details guarantee that assignment is indeed accurate. First, regulation mandates that all fishing ships send satellite signals with the real-time position to the fishing authority (Bertrand, Díaz, and Lengaigne 2008); this feature makes monitoring effective and inexpensive. Second, the centralized fishing authority sends a daily list of ships with irregular behavior to its decentralized network of officials throughout the coast, facilitating local enforcement. Third, the weight of each fishing-for-fishmeal transaction is recorded by government-approved electronic scales at each of the firms' unloading stations, thus ensuring that the figures reported are truthful. Overall, Figure 2 shows that the government end-of-active-season bans effectively paralyze fishmeal plants: the trends after the kink when the industry reaches a quota are flat rather than upward sloping.

D. Validation in Points near Threshold

As discussed by Bakke and Whited (2010), one risk for identification in regression discontinuity models is that the effects may be driven by points far away from the threshold — so much so that those points seemingly increase the significance of coefficients even if they violate the local continuity of the assignment variable. To validate my empirical strategy, I fit equation (1) also using only a small sample in the vicinity of points where distance-to-quota approaches zero. Specifically, I consider days for which the cumulative catches of anchovy are above 75% of the global quota; the post-season days for the bandwidth are kept symmetric to the number of days in the active-season that meet this bandwidth criterion.

2.3 Controlling for size and efficiency

Crucial to estimating how shocks to investment opportunities in one segment affect investment in the other segment is the accurate measurement of the efficiency or "ability" of firms. In closely related work, Whited (2001) finds that measurement error in divisional investment opportunities may lead to inaccurate conclusions about investment efficiency, and Maksimovic and Phillips (2002) propose a neoclassical model that accounts for much of what otherwise would be considered inefficient diversification. Although my design exploits shocks to the relative investment opportunities of two well-defined segments at a granular level, it is also important to rule out the obvious case in which good firms behave differently from bad firms.[12] In essence, my question is: After controlling for the efficiency of multibusiness firms, do we see that negative shocks to investment opportunities in one segment lead to greater investments in the other segment? An affirmative answer to this question would lead to the search for causal mechanisms that cannot be trivially explained by a high-quality parameter.

To obtain a credible proxy for firm efficiency, I delve into micro data of the fishmeal production process itself: physical inputs and outputs[13] of *all* fishmeal producing plants, regardless of whether they are multibusiness or focused. Consider the output per input yield of firm i's plant at port p in month m:

$$Yield_{i,p,m} = \gamma + \beta_0 VI_{i,p,m} + \beta_1 SPP_{i,m} + \beta_2 VIShips\%_{i,p,m} + \beta_3 HI_{i,m} + \beta_4 d_{i,p,m} + \alpha_m + \gamma_p + \nu_{i,p,m} \quad (5)$$

[12] Recall that my empirical setting gets around the issues of whether asymmetric information, agency and power struggles account for inefficient investment typically highlighted in the conglomerate investment literature. In this sense, my approach is akin to Maksimovic and Phillips's (2002), who propose that their study is not inconsistent with agency features though it is not set out to test for them.

[13] See Foster, Haltiwanger, and Syverson (2008) for recent work on the advantages of physical productivity measures to determine firm efficiency.

where $Yield_{i,p,m}$ is the tons of fishmeal produced by firm i at port p in month m divided by the total amount of anchovy tons that entered the plant as inputs; $VI_{i,p,m}$ is a dummy for whether the plant belongs to a vertically integrated firm; $SPP_{i,m}$ is the total number of fishmeal ships owned by firm i in month m, if any, divided by the number of active fishmeal plants of i in that month; $VIShips\%_{i,p,m}$ is the fraction of distinct ships landing at the plant that are vertical ships; $HI_{i,m}$ is a dummy for whether i has more than one fishmeal plant across the coastline; $d_{i,p,m}$ is a count of the different product lines installed at that location of firm i in month m; α_m is a monthly fixed effect; γ_p is a port fixed effect; $\nu_{i,p,m}$ is the error term.

In essence, equation (5) is a productivity regression at the plant-month level. The unique advantage of this estimation is that the residual $e_{i,p,m} = Yield_{i,p,m} - \widehat{Yield}_{i,p,m}$ becomes an extremely accurate proxy for whether firm i is more productive than other firms at location p in month m, after controlling for many factors that may account for a higher yield. Based on this residual variable, I create *monthly productivity quartiles*, so that a given plant in a given month may only belong to one of four different quartiles that month. I introduce these productivity quartile dummies in the main estimation equations (1) and (4) as flexible controls, thus allowing different productivity quartiles to exert a different influence on investment.[14]

Similarly, to account for the effect of firm size in the investment regressions of interest, I introduce firm size quartiles based on the previous calendar year's total use of inputs in the non-fishmeal segment across all firms regardless of whether they are multibusiness or focused. These size quartile dummies are introduced in equations (1) and (4) to capture the flexible effect of size on investment. Overall, controlling for size and efficiency on the right-hand side assuages the concern that investment behavior follows these variables instead of investment opportunities in the non-fishmeal segment; however, there might be a concern that these micro controls may instead be adding noise into the sharp regression discontinuity design. When estimating every model without size or efficiency controls, the untabulated results remain unchanged.

[14]Whenever a plant has not produced fishmeal in a given month, I use its latest productivity quartile in the estimation.

2.4 Causes and consequences of discontinuous investment

Finding that a shock to the relative investment opportunities across segments drives investment behavior after controlling for efficiency is of inherent interest but begs the question of what are the economic causes and consequences of such pattern. I address these issues separately. First, I propose tests to rule out mechanical connections between fishmeal and non-fishmeal operations, which would amount to physical processes such as mothballing or technological constraints that force firms to alternate their investments. Next, to study the causal mechanisms for the influence of fishmeal bans on non-fishmeal investment, I estimate the regression discontinuity equation (4) across split samples using proxies that directly reveal the specific channels leading to jumps in non-fishmeal investment behavior. The two candidate explanations advanced here are (i) firm-level financial constraints, measured at the monthly level using banking data and (ii) the attention required by non-fishmeal operations, measured using operational variables. Although split-sample regressions are reported, the models are also run as full samples with interaction terms (with the proxy for the mechanism both in levels and in interactions) in order to determine the differential statistical significance of the bans across groups.

Tests of the *consequences* of the discontinuous behavior generated by shocks to investment opportunities are a little coarser in this setting for a couple of reasons. First, product output data are available in monthly frequency, not daily. Second, productivity in the non-fishmeal segment is hard to assess given the wide variety of seafood products. Because it is important to assess whether intermittent investment behavior has value consequences, I implement tests using monthly output-per-input data on the non-fishmeal segment of each multibusiness firm.

3 Results

3.1 Graphical evidence

It is not surprising that fishmeal bans paralyze fishmeal investment — but do they affect *non-fishmeal* investment? Figure 3 plots the end-of-active-season fishmeal bans and the daily investment in non-fishmeal expressed in tons of fish (Panel I) or their market value in thousands of dollars using average monthly market prices (Panel II) for all multibusiness firms in the industry during all days in the sample period. (The scatter dots represent mean investments per day). The pattern revealed is essentially the same in both panels: there is a significant boost in non-fishmeal investment when fishmeal activities are banned as the active season ends. The figure also provides evidence on the symmetric effect: how non-fishmeal investment is *reduced* when a new active fishmeal season *starts*. Hence, from a graphical standpoint, a noticeable discontinuity in non-fishmeal investment in the vicinity of fishmeal bans is confirmed: negative shocks to fishmeal investment opportunities increase investment in the non-fishmeal segment.

Though the empirical design is primarily centered on the scope of investment opportunities across segments within multibusiness firms, it is also important to analyze what happens to *focused* non-fishmeal firms given the industry-wide discontinuous rules on fishmeal. Recall focused firms should not care about fishmeal bans for their investment, as they have no stake in the fishmeal business. This kind of placebo analysis would serve to rule out the explanation that something about the industry environment is driving the investment jumps graphically displayed in Figure 3 regardless of the multibusiness or focused nature of firms. The placebo analysis is also important because identification in equation (4) arises from time-series variation, as the assignment variable is the same for all firms.

Figure 4 shows the daily mean investments of focused non-fishmeal firms, finding no systematic boost in investment comparable to Figure 3. In other words, *the fishmeal bans only matter for non-fishmeal investment in multibusiness firms.* This evidence strongly confirms the validity of bans as exogenous shifters that only matter when they should.[15]

3.2 Baseline models

Table 2 reports estimates of equation (1). The dependent variable is daily investment in non-fishmeal production, measured in tons of fish (left-hand side panel) or their dollar value (right-

[15]The regression versions of these placebo tests, fitting equations (1) and (4) for the case of focused non-fishmeal firms, also confirm that fishmeal bans do not matter for focused firms: the estimates on β are always far from the usual levels of statistical significance.

hand side panel). The first column shows a high statistical and economic influence of fishmeal bans on non-fishmeal investments in the absence of controls variables. This result is essentially the regression version of Figure 3. The second column shows that this influence is strong (t-stat=2.70) after controlling for firm fixed effects and port-season interaction fixed effects. The third column introduces exogenous shifters of revenue and cost as controls — the weekly global price of fishmeal and the daily cost of fuel after local taxes — as well as productivity quartile dummies from residuals of equation (5) and size quartile dummies, leaving the influence of fishmeal bans unchanged (t-stat=2.71). The standard errors are conservatively clustered at the firm level to allow for serial correlation within the same firm. The fourth column of Table 2 repeats the linear specification in a smaller sample, that of a short symmetric window before and after the fishmeal end-of-active-season ban comes into effect. In this linear test using a restricted discontinuity band, the influence of the fishmeal ban is also positive and significant (t-stat=2.00), thus giving strong support to the idea that identification is coming from a discontinuous change in points close to the threshold.

The right-hand side panel of Table 2 reports estimates of equation (1) using the dollar value of fish acquisitions or transfers as the dependent variable. The goal of using this alternative measure of investment is to give a more uniform account of investment, especially because non-fishmeal species are quite diverse and may have very different market values. The results on β are positive and significant in the fifth, sixth, and seventh column of Table 2, suggesting that the discontinuity is also observed in the value of investments. The effect in the narrow discontinuity window, displayed in the eighth column, is also economically significant but imprecisely estimated, with a p-value of 0.15 (t-stat.=1.48). In untabulated regressions, I test for the *symmetric discontinuity effects* in the narrow window at the *end* of the post-season and the *beginning* of the active season; in those tests, I find that fishmeal bans are positive and significant when explaining non-fishmeal investment in tons of fish (p-value=0.06) and thousands of dollars (p-value=0.08). Overall, the results in these narrow windows around the threshold events are reassuring that the regression discontinuity approach is valid (Bakke and Whited 2010).

To strengthen the interpretation of the findings, I also analyze the investment behavior of *focused* non-fishmeal firms, that is, those firms that do not have fishmeal operations. In untabulated regressions, I find that fishmeal bans do not affect investment behavior among these firms, a control group in which in fact fishmeal bans should not matter. This is compelling evidence that mechanisms only present in multibusiness firms trigger the differential responses to investment opportunities discovered so far.

3.3 Regression discontinuity exploiting distance to quota

Table 3 shows the results of the regression discontinuity specification (4), using daily fish quantity and fish value as the dependent variables. The first two columns show that the assignment variable determining the bans — the distance between the cumulative tons of anchovy fished and the total anchovy quota for a season, measured in hundreds of thousands of anchovy tons — significantly explains non-fishmeal investment in the expected direction. This influence is intuitive: when firms get closer to the end of the active season (i.e., when the distance to the quota approaches zero), they tend to invest more in non-fishmeal. The third column of Table 3 shows the discontinuous positive influence of entering the fishmeal ban period on the investment in non-fishmeal, after controlling for third-order polynomials of the distance to quota variable. The point estimate on fishmeal ban is sizable (almost 50% of the mean value of the dependent variable) and highly significant (t-stat.=2.55). Moreover, a low-order polynomial of the distance variable ensures that a run-up in the short window closer to the end-of-season ban is not a concern. The fourth column uses fifth-order polynomials instead, leaving the results and point estimates largely unchanged. The influence of the cost and revenue shifters is also of interest. The price of fishmeal has a positive influence on non-fishmeal investment, thus reflecting some kind of cross-subsidization mechanism; by contrast, the cost of fuel does not shift investment in non-fishmeal. Note also that the use of size and productivity quartile dummies isolates the influence of fishmeal bans from any good-vs-bad firm alternative explanation.

When analyzing the dollar investments in non-fishmeal as the dependent variable (right-hand side panel of Table 3), I find exactly the same pattern as the one described for fish quantities. The assignment variable has a strong negative influence on non-fishmeal investments, and the fishmeal bans generate a strong boost in non-fishmeal investment (t-stat.=2.39 in the eighth column), equivalent to more than 35% of the unconditional mean of investments in dollars. Hereafter, to test for the causal mechanisms using split samples, the specification employed will be that of the eighth column of Table 3.

The fact that multibusiness firms shift to non-fishmeal investments when they get closer to the end of the active fishmeal season suggests that the reallocation of resources may in part be driven by a temporary depletion of anchovies, a natural consequence of intensive fishing for this resource. To investigate whether this depletion increases the marginal cost of anchovies (and the price of anchovy paid by fish processing firms) in a mechanical way that explains the discontinuity effect through the price system, I exploit granular data on end-of-active-season prices of anchovy for fishmeal. In untabulated tests using transaction-level prices provided by a large firm,[16] when regressing the price of anchovy for fishmeal on distance to quota during active seasons, I find a nearly flat point estimate: one standard deviation reduction in the distance to quota increases anchovy prices by only 3%. In addition, when measuring the evolution of non-anchovy (i.e., non-fishmeal) prices around the threshold, I find no statistically significant change. Therefore, the equalization of marginal productivity of capital through the price mechanism cannot account for the discontinuous behavior reflected in a jump of 35% of non-fishmeal investments following the discontinuous switch in investment opportunities.

To reinforce the interpretation that the *relative value of investment opportunities of different divisions of the same firm is driving capital allocation*, it is important to consider whether cash flows rather than investment opportunities may be driving the results. Recall that most fishmeal is exported, thus being financed with international trade loans from banks. In theory, the shutdown of fishmeal operations may increase or decrease daily cash flows coming from fishmeal: it would *increase* cash flows if the export cycle is completed and processing firms receive the total amount of their sales to repay working capital loans and keep their residual cash flows; it would *decrease* cash flows if banks stop giving working capital loans and the fishmeal export cycle is prolonged. Clearly, only an increase in cash flows story would pose a challenge

[16] Recall that fish prices provided by the government are monthly averages for each species, thus making difficult a more detailed analysis of what happens in the precise days when the end-of-active-season ban is approaching. Hence, I obtained a more granular price series of over 45,000 fish purchases of a large processing firm covering exactly the period studied.

to the interpretation of the results: if there is a decrease in fishmeal cash flows, the increase of non-fishmeal investment found here is even more surprising (Lamont 1997) and cannot be explained by a cash flow story. Two arguments contradict the story that an increase in cash flows is driving the results. First, for the story to matter, the export cycle of all firms in the industry should precisely end at the discontinuity point: but this fact is falsified by a simple inspection (omitted here for brevity) of the very prolonged balance of short-term bank loans that extend beyond the precise date of the end-of-active-season ban. Second, I accessed the *daily cash position* of a large fish-processing firm and observed how the cash position evolved around the end-of-active-season bans; I found that the cash position of the firm *decreased* in the days after the bans were enacted. Therefore, detailed supplementary evidence confirms that negative shocks to investment opportunities are driving the results.

3.4 Investment shifts and physical resource constraints

So far, the regression discontinuity models have shown that a negative shock to the investment opportunities of the fishmeal business segment positively affects the investment layouts into the non-fishmeal segment. A trivial explanation for this intermittent investment behavior would be resource-scheduling constraints that impede the non-fishmeal unit to operate when the fishmeal season is in full swing. In Table 4, I test whether the results are robust to eliminating physical resource explanations for why non-fishmeal investments may jump up following fishmeal bans. I implement these tests through the same regression discontinuity model (4), focusing on restricted samples, that is, firm-port-day observations in which the effect of a mechanical resource constraint is unlikely to be binding.

A first story involves situations with technological and cost structures that delay investment in non-fishmeal. Specifically, if companies have fixed start-up costs for non-fishmeal, it may be optimal to mothball the non-fishmeal segment during the fishmeal season and then increase production when the ban is enacted. To address this explanation, I create a proxy based on "switching events" reflecting how often each company's plants start non-fishmeal production during the calendar year previous to each observation. Because firms with a large number of start days can be conceived as the ones with more flexibility in their production processes (i.e., low start-up costs), the mothballing story is unlikely to be valid for their investment behavior around fishmeal bans. The results in the first column of Table 4, however, indicate that these very flexible plants actually jump in their investment behavior once the fishmeal ban is enacted, thus confirming that mechanical start-up frictions are not explaining discontinuous investment.

The second column of Table 4 shows that multibusiness firms with fleets dedicated exclusively to non-fishmeal operations are significantly affected by the enactment of fishmeal bans. This case is important because these firms should not be constrained mechanically by fishmeal operations, as their dedicated non-fishmeal fleet is indeed available during the fishmeal season. Although this is a small sample (only three firms have dedicated non-fishmeal fleets), the regression discontinuity model yields a positive and significant (t-stat=36.55) influence of fishmeal bans on non-fishmeal behavior, suggesting that an asset lock explanation is not likely to generate the discontinuous investment pattern discovered here.

A different physical friction possibly hindering investments in non-fishmeal when the fishmeal business is active might be the operational linkages at the plant-location level. Consider, for example, location-specific labor or other manufacturing resources. While the technological configuration of the fish-processing industry indicates that fishmeal and non-fishmeal operations are entirely separate in labor and transformation processes,[17] it is important to probe this kind of mechanical connection. I select from the main sample those non-fishmeal plants in which there has been no adjacent fishmeal production during the season. (An attempt to select non-fishmeal plants that have no adjacent fishmeal plant at the same location leaves an empty set, revealing that firms choose to co-locate the plants of their business units). A total of 23 firms show some period in which this criterion is met, thus constituting the sample for my new test. The third column of Table 4 shows a regression discontinuity model in which fishmeal bans exert a significant (t-stat=1.77) influence on the non-fishmeal investment of plants that are clearly disconnected from any concurrent fishmeal production, suggesting that plant-level constraints are not explaining the cross-segment investment jump.

[17] Recall that fishmeal is consumed by animals, whereas non-fishmeal goods such as canned or frozen seafood are consumed by humans, thus following strict sanitary rules of separation in their processing.

In a fourth test, I consider whether days on which government had restrictions on some widely-used non-fishmeal species are driving the discontinuity results. In particular, mackerel and hake are two of the main species processed for seafood; if some fishing restriction on these species was in place, then some non-fishmeal firms may have been discouraged to invest. (Note that non-fishmeal firms processed a maximum of 29 different fish and other marine species in the period studied, as per Table 1.) The fourth column of Table 4 estimates the regression discontinuity model in a sample including only days without restrictions on mackerel or hake fishing. The results show a positive and significant (t-stat=1.82) influence of fishmeal bans on non-fishmeal investments.

Overall, the results in Table 4 confirm that startup costs, shared capital equipment, shared production inputs, and non-fishmeal government restrictions do not explain the discontinuous investment in non-fishmeal triggered by the end of the active fishmeal season. Even if other physical constraint stories might be conceived through additional proxies, and some may actually bind, the main interpretation of the results thus far is that a nontrivial mechanism is generating a substantial boost in non-fishmeal investment once fishmeal operations are shut down. I turn to two plausible causal mechanisms next.

3.5 The role of financial constraints

A first-order explanation for why firms wait to invest in one business segment until after the other segment's investment opportunities are exogenously switched off is the existence of financial constraints. In the absence of financial constraints, each business unit would pursue its investment opportunities regardless of shocks to the opportunities faced by other units. I test for this financial mechanism by replicating the regression discontinuity model of Table 3 but splitting the sample of firm-port-day observations according to proxies of firm-level financial constraints measured at the monthly level. First, I use the quality of bank loan repayment, proxied by the ratio of the sum of loans received by the fish-processing company that are refinanced, restructured, or in recuperation, divided by the total sum of all loans. Second, I use the mortgage collateral required by banks to give loans to these firms, modeled as the ratio of the amount of mortgage guarantees provided by the fish-processing firm to its banks divided by the loans received by the firm. Higher values of each of these variables represent a clear symptom of tighter financial constraints.

The first and second column of Table 5 show that firms with a higher share of troubled loans are significantly affected by fishmeal bans for their investment in non-fishmeal, while those firms with less-than-median troubled loans do not show a significant jump in investment. An equivalent (untabulated) model using interaction terms rather than split samples shows the same results, with a p-value of 0.09 for high troubled loans firms interacted with fishmeal ban. Note that the models control for size quartiles and productivity quartiles so that the results cannot be attributed to the fact that less efficient firms may be more financially constrained. The regressions instead measure how firms with different levels of loan repayment capabilities react to a shock in their relative investment opportunities after controlling for production efficiency.

In addition, the third and fourth column of Table 5 show that firms with a high requirement of mortgage collaterals for their bank loans have a significant jump in their non-fishmeal investments when fishmeal bans are enacted; by contrast, firms with low collateral requirements do not show this discontinuous pattern. An equivalent (untabulated) model using interaction terms rather than split samples reveals that the difference is significant at the 13% level. Mortgage collateral is not directly related to the operations of the firm and is therefore a suitable proxy for how difficult it is to obtain external financing. Overall, the results are consistent with the existence of financial constraints that may bind multibusiness firms in their pursuit of non-fishmeal opportunities. Moreover, the results suggest that the influence of the shock to investment opportunities is not universal for all multibusiness firms, thus providing a specific channel for the results found thus far.

If financial constraints are so stringent for multibusiness firms, it is also reasonable to expect that internal cash plays a prominent role in their operations. To bolster the interpretation of the financial constraints mechanism, I employ auxiliary evidence on how one financially constrained firm (unnamed here for confidentiality) conducts its fishmeal operations in relation to its daily cash balances. Figure 5 depicts the daily series of fishmeal investments and cash balances for each day during all active fishmeal seasons in the data. The relation between investment and cash for this financially constrained firm is generally positive, suggesting that fishmeal production leaves little room for non-fishmeal production during the fishmeal season, a result broadly consistent with the existence of financial constraints in multibusiness firms.

3.6 The role of managerial attention

In addition to financial constraints, scarce managerial attention is a plausible mechanism for why firms do not follow otherwise important investment opportunities. In an analogous way to how investment across segments may be hamstrung by the lack of financial capital leading to discontinuous investment, managers' time and skill may also be too scarce to take on different activities at the same time. On the one hand, the most obvious explanation for neglecting the non-fishmeal business may be that it is not really too important for the firm; in this logic, firms with relatively unimportant non-fishmeal operations should be the ones with more jumpy behavior. On the other hand, if the non-fishmeal business is indeed important, firms may be too constrained during the fishmeal season to pay any serious attention to it, thus postponing (rather than neglecting) investment into it. I test for these contrasting explanations in Table 6, exploiting the granular nature of the data and the availability of different proxies for the importance of the non-fishmeal division.[18]

First, firms with *larger* non-fishmeal operations appear to be the ones most affected during the fishmeal season. The first panel of Table 6 details that those firms with a low level of operation in the non-fishmeal segment (measured over the previous calendar year) do not increase their non-fishmeal investment when the fishmeal ban is enacted; by contrast, firms with a high level of non-fishmeal involvement show a significant (t-stat.=3.21) increase in investment. A full-sample test using high volume of non-fishmeal operations as an interaction term yields a 5% significance level. The lack of investment in non-fishmeal is thus directly related to this segment's importance.

A second test of the divisional importance conjecture in Table 6 breaks the sample

[18] The proxies capturing the role of managerial attention do not map directly onto more or less financially constrained firms.

according to how many fish species are used in the non-fishmeal business. Because firms with a more complex product mix require more attention than firms with simpler operations, the highly significant jump (t-stat.=3.38) displayed in the fourth column suggests that non-fishmeal operations requiring more attention will be avoided during the fishmeal season. The analogous test using a full sample yields a 5%-significant interaction term for this proxy of divisional importance.

Finally, multibusiness firms with more countries of destination for their non-fishmeal products appear to increase their non-fishmeal investment substantially when the active fishmeal season is over. As displayed in the third panel of Table 6, firms with relatively few countries of destination for their exports do not significantly change their investment behavior around the fishmeal ban, whereas those exporting to many countries show a significant jump (t-stat.=2.74) once the fishmeal ban is enacted. A full-sample test using the high number of countries variable as an interaction yields similar results at the 5% level.

Taken together, these results suggest that divisional importance is positively associated with how much that division is affected by lower investments while a corner solution is pursued, and alternatively, how its investments increase substantially afterwards. Moreover, the findings differ from arguments about power struggles typical of internal capital markets in which large divisions are the ones receiving most investment. In this case, it is precisely because of their size and importance that attention-constrained managers wait for the off-season to focus on investing.

3.7 Assessing the consequences of discontinuous investment

To investigate the consequences of discontinuous investment in multibusiness firms, I analyze productivity patterns in the non-fishmeal segment that may be directly related to the jumpy behavior originated by the fishmeal bans. Because the non-fishmeal (i.e., seafood) segment is quite diverse in terms of fish species and final products, the most sensible productivity metric that can be found in this setting is a simple output per input ratio, defined as the exact weight of fish that a seafood product contains divided by the weight of raw fish that enters production. Moreover, because the output information is available at the monthly level while the regression discontinuity design is cast on daily frequency, only months with a relatively sharp change in the number of fishmeal-banned days are appropriate to investigate the consequences of discontinuous investment on productivity.

Table 7 reports linear panel fixed effects models of non-fishmeal output per input using the sample of all multibusiness firms at a monthly frequency. Calendar month dummies control for the seasonality of production, and firm fixed effects and year fixed effects control for unobserved heterogeneity for a given firm and a given year. The first column shows the pooled effect of a sharp increase in the number of fishmeal-banned days with respect to the prior month; the output-per-input ratio in the non-fishmeal segment decreases significantly (t-stat.=-2.64). When introducing firm, year, and calendar month fixed effects, the result is also significantly negative (t-stat.=-2.37), as shown in the second column of Table 7. An exogenous reduction of investment opportunities, leading to an increase in focus, makes firms less productive with respect to the prior month in which they had both investment opportunities available.

To make sure that firms that are unproductive in the fishmeal segment are not driving the lower yield result in non-fishmeal, the third column of Table 7 introduces the usual size and productivity quartiles, both based on the fishmeal segment; after including these additional controls, the sharp increase in fishmeal bans (equivalent to an increased focus on non-fishmeal) continues to effect significantly lower yields in the non-fishmeal business (t-stat.=-2.21). Overall, this evidence is consistent with a suboptimal allocation of resources in the banned periods that surpasses the adequate scale of non-fishmeal segments, confirming that firms suffering from discontinuous investments (and their underlying frictions) destroy value.

4 Conclusion

In multibusiness capital budgeting, a negative shock to the investment opportunities of a firm's business unit increases the relative attractiveness of investment opportunities of other business units of the same firm. In this paper, I implement a regression discontinuity model exploiting government production bans on a regulated business segment (fishmeal) to study the daily investment behavior of non-fishmeal units in multibusiness firms. I find that the increased investment in the non-fishmeal segments due to the bans is quite large. Moreover, this discontinuous investment pattern reduces productivity and it is only found among firms that are more financially constrained and those with more attention-demanding operations.

More broadly, this paper introduces a framework to view multibusiness scope, investment and productivity jointly inside the firm. While multibusiness scope introduces fundamental challenges in the way managers deploy their investment strategies, the alleviation of financial and managerial constraints in diversified firms may have a substantial impact through the more sustained pursuit of value-creating investment opportunities.

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Figure 1: Fishmeal Investments and Fishmeal Bans

This figure plots the sum of daily tons of fish received by all fishmeal plants at the Callao port regardless of whether they are focused or diversified (scatter dots, left-hand side axis). The figure also plots the government bans on fishing for fishmeal, or fishmeal processing, applicable to all firms at the Callao port (solid lines switching between 0 and 1, where 1=ban, 0=no ban). The only fish species permitted for fishmeal is anchovy. Bans on anchovy fishing for fishmeal are equivalent to bans on fishmeal production because anchovy is caught in the sea and brought to plants on land within hours — there is no refrigeration aboard ships. Fishmeal companies may fish anchovy themselves (if they are vertically integrated into extraction) or acquire fish on the market. The government bans depicted include end-of-active-season bans (longer periods without fishing anchovy until the next reproductive cycle of the species is over) as well as short-term moratoriums on anchovy fishing to ensure the adequate sustainability of the resource in a given location.

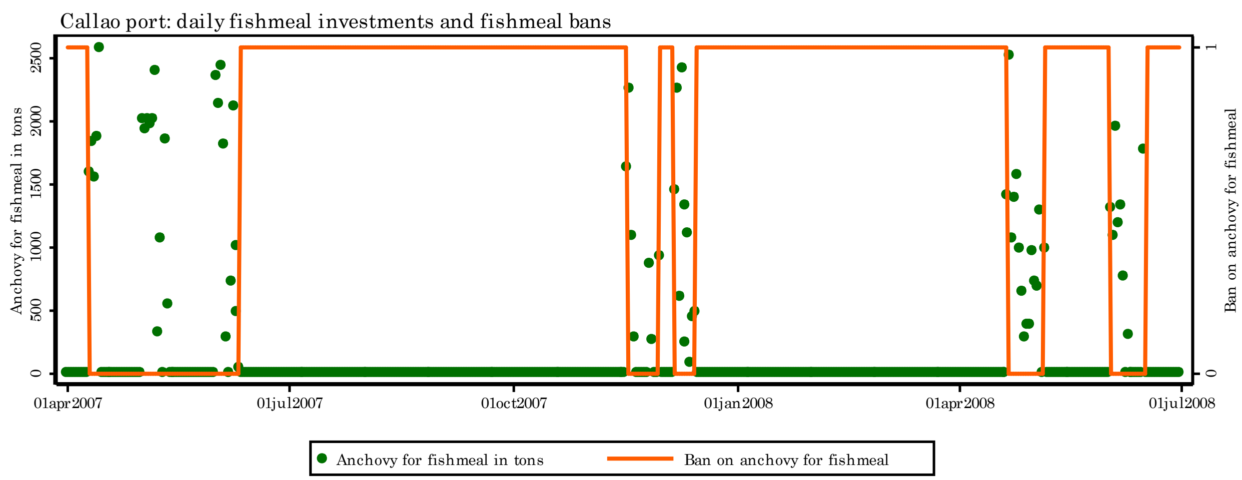


Figure 2: Fishing Quotas and Cumulative Extraction for Fishmeal

This figure depicts the daily series of industry-wide cumulative catch of anchovy for fishmeal per season (scatter dots) and the end-of-active-season dates (vertical dashed lines) when all extraction in the industry reaches the pre-established global extraction quota set by the government. The anchovy season is defined in this paper to include both the *active season* and the *post-season*; during the active season, typically announced two weeks in advance by government, fishing anchovy for fishmeal is allowed; during the post-season, which starts automatically when the industry-wide quota is reached (regardless of the date), no anchovy for fishmeal can be caught and fishmeal plants are paralyzed.

The figure helps illustrate that the government end-of-active-season bans effectively paralyze fishmeal plants: the flat areas after the kink when the industry reaches a quota are indeed flat rather than upward sloping.

The figure also helps understand the regression discontinuity design. Consider points “A” and “B” in the plot. Because the industry-wide quota is known by all participants ex ante, and because the “distance to quota” is also published daily and known by all firms, the end-of-active-season is somehow expected by fishmeal processing firms. However, within a small window between points “A” and “B,” the business conditions and investment opportunities in the *non-fishmeal* segment are essentially the same; therefore, the shock modeled in the empirical analysis consists in the exogenous shift in investment opportunities between the fishmeal and non-fishmeal segments of multibusiness processing firms in the vicinity of the end-of-active-season bans. Point “C” does not represent an end-of-active-season ban; instead, it is a temporary moratorium on anchovy fishing for fishmeal.

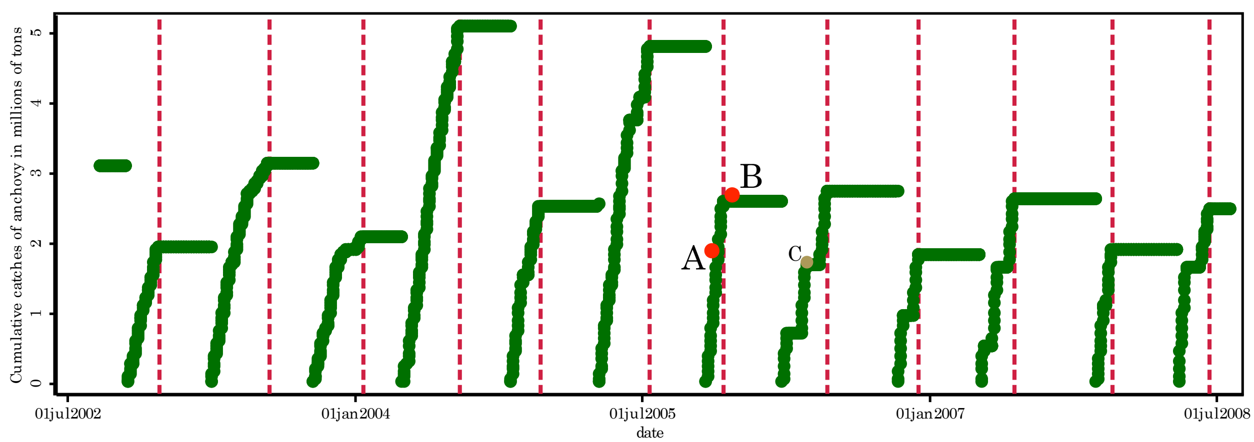


Figure 3: Non-Fishmeal Investments in Multibusiness Firms

The figure shows the mean daily non-fishmeal activity (scattered dots) performed by multibusiness firms, that is, by those that also have a fishmeal segment. The plot also includes the end-of-active-season government bans on fishing for fishmeal (solid lines switching between 0 and 1, where 1=ban, 0=no ban). The series depicted are on fish inputs, measured in tons (Panel I) or market value in the raw fish market (Panel II).

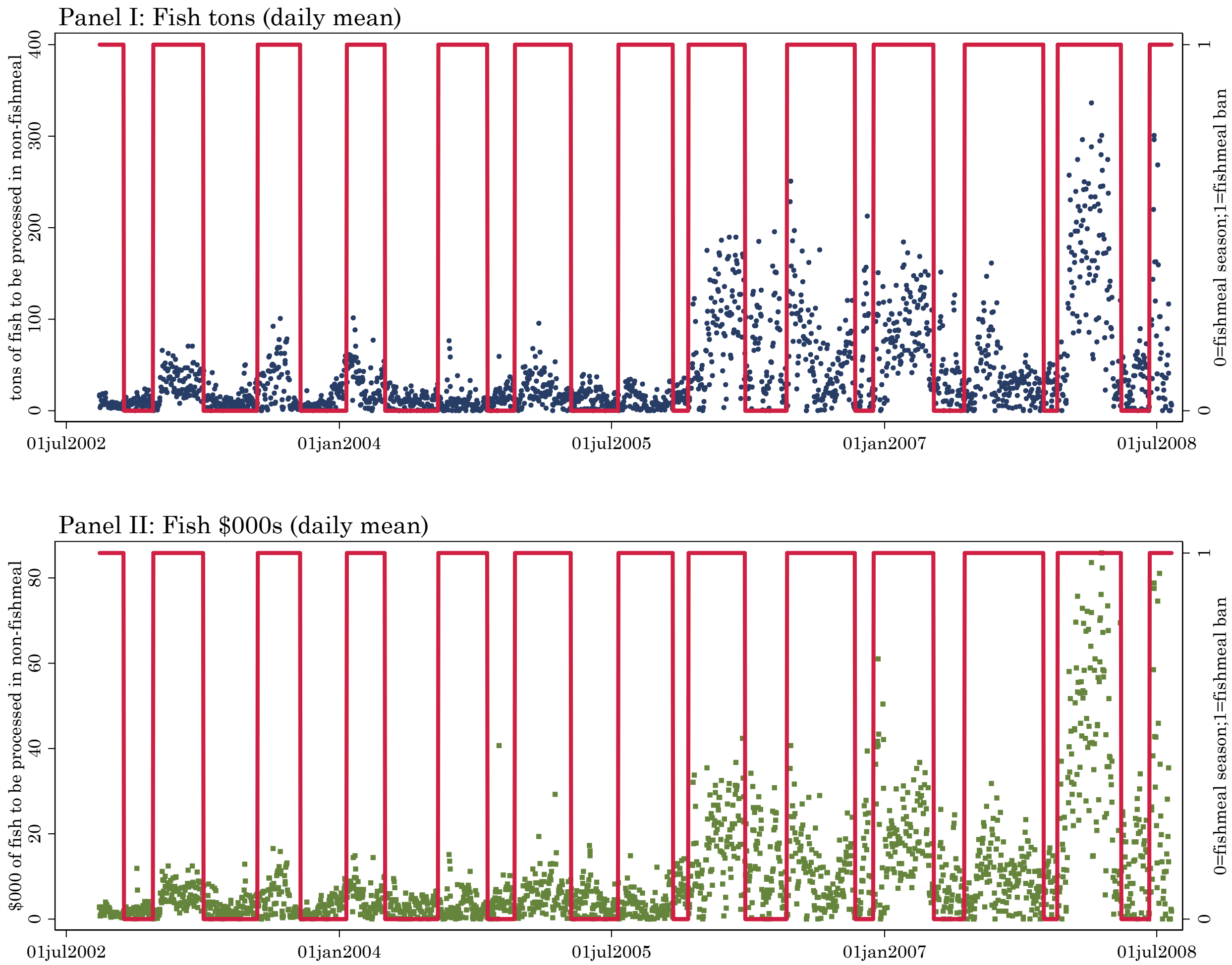
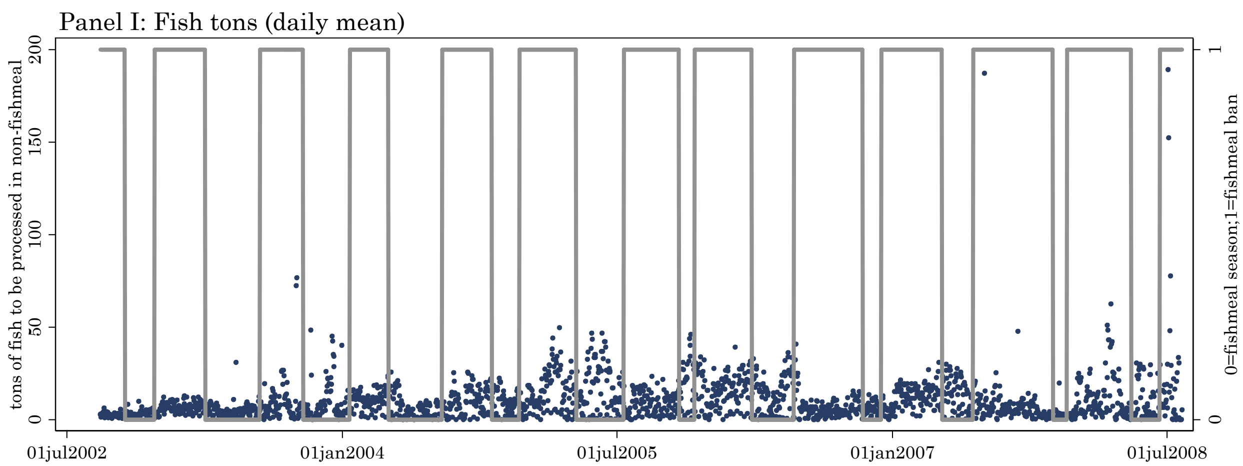


Figure 4: Non-Fishmeal Investments in Focused Firms

The figure shows the mean daily non-fishmeal activity (scattered dots) performed by focused firms, that is, by those that do not have a fishmeal segment. The plot also includes the end-of-active-season government bans on fishing for fishmeal (solid lines switching between 0 and 1, where 1=ban, 0=no ban). The series depicted are on fish inputs, measured in tons (Panel I) or market value in the raw fish market (Panel II).



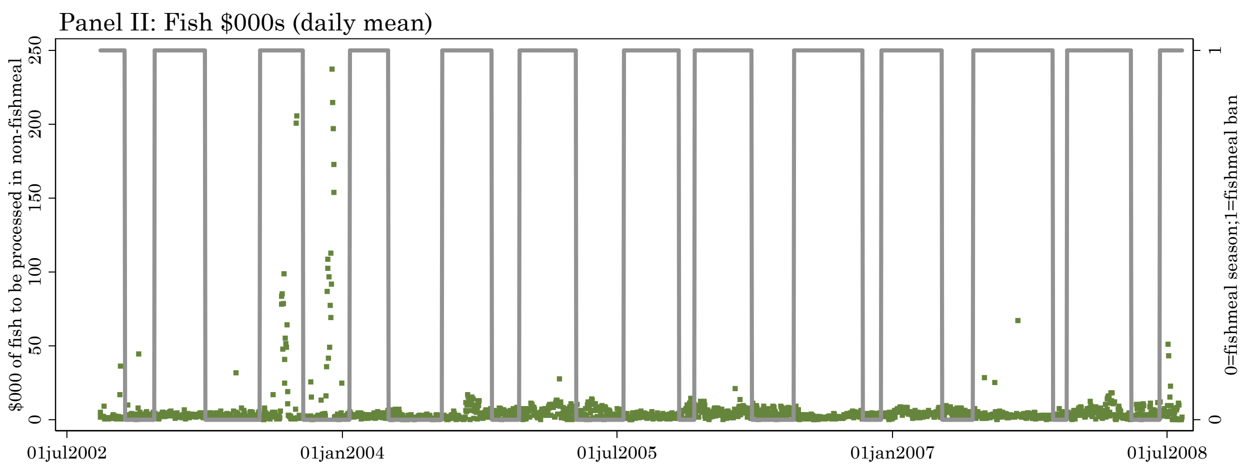
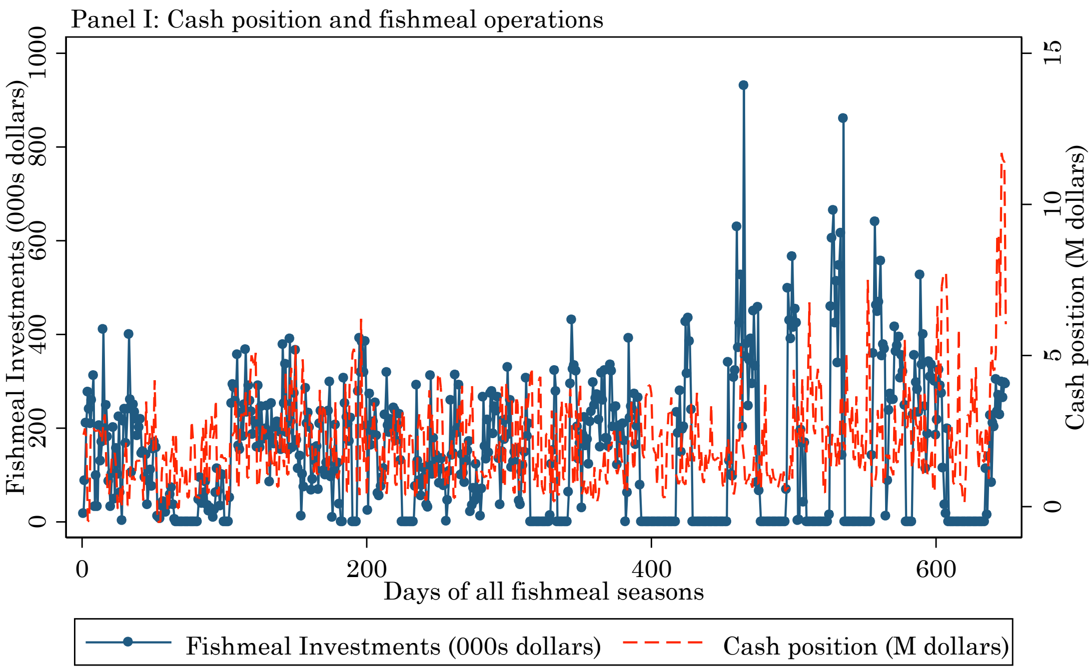


Figure 5: Internal Cash and Fishmeal Operations

The figure displays the daily cash position (in millions of dollars) and the fishmeal investments (in thousands of dollars) of a large, financially constrained multibusiness firm during all days of the fishmeal seasons between 16 October 2003 and 16 June 2008. Panel I displays the two series in chronological sequence. Panel II shows a linear fit of investments on internal cash.



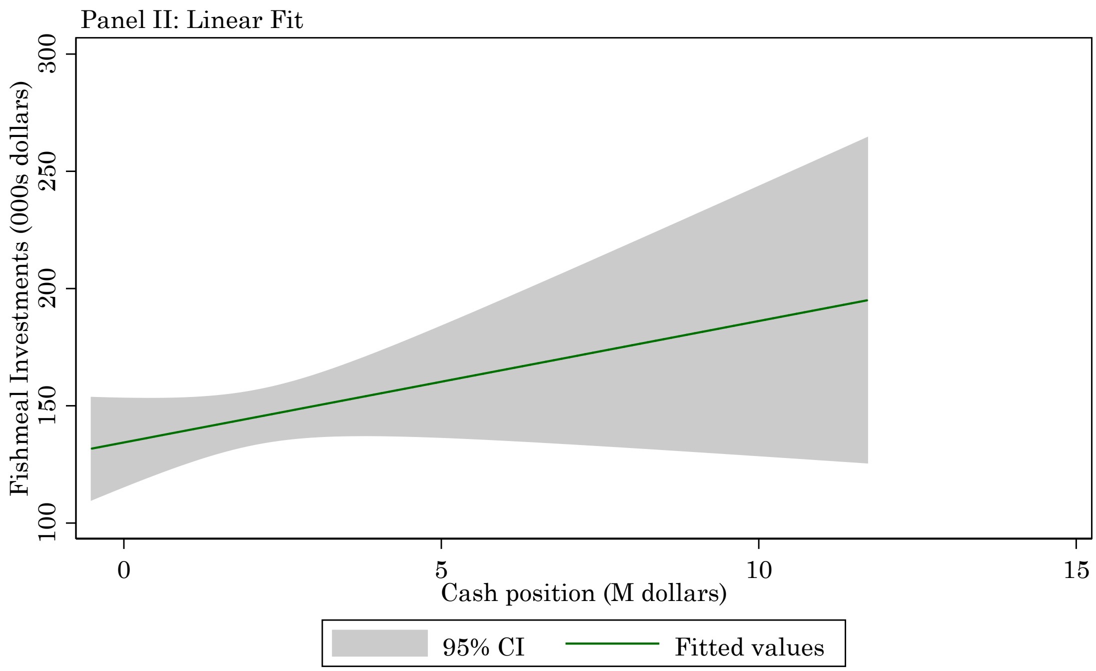


Table 1: Summary Statistics

The table reports firm-plant-day observations of the main sample of the study: all 26 multibusiness firms with joint presence both in the fishmeal and non-fishmeal segments of the industry at any point between 6 September 2002 and 31 July 2008. Non-fishmeal fish quantity is the sum of all fish tons (1 ton = 1,000 kilos) received by a firm's plant on a day, consisting in fish species reported to be used for canned, cured or frozen seafood. Non-fishmeal fish $000 is the market value of fish quantity in thousands of U.S. dollars, using the average monthly price of each species collected by government from all processing plants. Fishmeal Ban is a dummy for whether there is a ban on fishing for fishmeal that day at that location; the value of 1 includes end-of-active-season bans (longer periods without fishing anchovy for fishmeal until the next reproductive cycle of the species is over) as well as short-term moratoriums on anchovy fishing for fishmeal to ensure the adequate sustainability of the resource in a given location. Price of fishmeal (i.e., the output of processing fish for fishmeal) is a monthly series of from the global commodity market. Cost of fuel after taxes is a daily series. Troubled loans over total is the ratio of the sum of loans received by the fish-processing company that are refinanced, restructured, or in recuperation, divided by the total sum of all loans; this is a monthly series from the public credit registry, and the beginning-of-month data are used for the daily panel; the information is available for most but not all firms (see smaller number of observations). Mortgage collateral per loan is the ratio of the amount of loans received by the fish processing firm divided by the total amount of mortgage guarantees provided to its banking creditors; this variable is also monthly for each firm, and the beginning-of-month data are used for the daily panel. Tons of fish for non-fishmeal is summed across all species and calculated over the calendar year prior to the observations for the main tests. The number of fish species used in non-fishmeal is a count based on the previous calendar year's operation of the firm. The number of export countries for the firm's non-fishmeal products is calculated over the prior calendar year.

Variable	Median	Mean	Std. Dev.	Min	Max	n
Non-fishmeal fish quantity (in tons)	0.00	34.54	101.84	0.00	1347.40	32523
Non-fishmeal fish $000	0.00	7.84	22.89	0.00	506.51	32523
Fishmeal Ban (1/0)	1.00	0.65	0.48	0.00	1.00	32523
Price of fishmeal ($ per ton)	585.00	699.99	212.84	490.00	1350.00	32523
Cost of fuel ($ per gallon after local taxes)	2.19	2.21	0.38	1.15	3.12	32523
Troubled loans over total	0.08	0.25	0.33	0.00	1.00	26251
Mortgage collateral per loan	0.08	0.17	0.85	0.00	23.80	26251
Tons of fish for non-fishmeal (000)	2.93	21.92	32.89	0.00	125.03	31486
# of fish species used in non-fishmeal	5.00	7.06	6.81	0.00	29.00	31486
# of export countries	3.00	12.07	14.70	0.00	48.00	32523

Table 2: Fishmeal Bans and Non-Fishmeal Investment

The table reports estimates of equation (1), that is, linear panel fixed effects models of how fishmeal bans affect non-fishmeal investments. The unit of analysis is the firm-plant-day for all multibusiness fish-processing firms participating in the non-fishmeal segment, as described in Table 1. The fourth and eight model restrict the sample observations to a Discontinuity Sample using the following bandwidth: only days for which the the cumulative catches of anchovy are above the 75% of the permitted quota. The post-season days for the bandwidth are kept symmetric to the number of days in the active-season that are above the 75% cutoff. Control variables include price of fishmeal, cost of fuel, size quartile dummies and productivity quartile dummies, as defined in Section 2.3. Robust t-statistics (clustered by firm when indicated) are shown in parentheses.

	Non-fishmeal investment:							
Dependent Variable:	**Fish tons**				**Fish $000**			
Sample:	All	All	All	Disc.	All	All	All	Disc.
DV Unconditional mean:	34.54	34.54	34.54	21.30	7.84	7.84	7.84	4.39
Fishmeal ban	31.867***	17.732**	19.654**	11.278*	6.518***	3.029**	3.239**	1.353
	(27.30)	(2.70)	(2.71)	(2.00)	(24.79)	(2.59)	(2.53)	(1.48)
Price of fishmeal			0.129***	−0.180			0.014**	−0.022
			(2.82)	(−1.65)			(2.14)	(−1.04)
Cost of fuel			−11.386	8.820*			−0.823	0.896
			(−1.20)	(1.83)			(−0.50)	(1.26)
Size quartile dummies$_{it}$	No	No	Yes	Yes	No	No	Yes	Yes
Productivity quartile dummies$_{it}$	No	No	Yes	Yes	No	No	Yes	Yes
Firm Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Port × Season Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
R^2	0.02	0.32	0.32	0.25	0.02	0.32	0.32	0.26
Sample size	32523	32523	32523	8171	32523	32523	32523	8171
N clusters (firms)		26	26	24		26	26	24

***, **,* significant at the 1%, 5% and 10% level. Standard errors are heteroskedasticity-robust and clustered by firm.

Table 3: Distance to Quota, Fishmeal Bans and Non-Fishmeal Investment

The table reports estimates of equation (4), that is, regression-discontinuity models of how fishmeal bans affect non-fishmeal investments. The unit of analysis is the firm-plant-day for all multibusiness fish-processing firms participating in the non-fishmeal segment, as described in Table 1. The assignment variable for the regression discontinuity models is Distance to Quota, defined in equation (3) as the difference between the cumulative amount of anchovy caught by all firms up to the previous day and the government quota for the season. Polynomials of Distance to Quota (of the third degree and fifth degree) are introduced in the third and fourth models for the regressions using fish tons as the dependent variable, and in the seventh and eight models for the regressions using fish $000 instead. Control variables include price of fishmeal, cost of fuel, size quartile dummies, and productivity quartile dummies as defined in Section 2.3. Robust t-statistics clustered by firm are shown in parentheses.

	Non-fishmeal investment:							
Dependent Variable:	Fish tons				Fish $000			
DV Unconditional mean:	34.54	34.54	34.54	34.54	7.84	7.84	7.84	7.84
Fishmeal ban			17.246**	17.229**			2.826**	2.788**
			(2.55)	(2.55)			(2.37)	(2.39)
Distance to Quota	−0.343***	−0.340**	−1.897**	−1.713***	−0.051**	−0.048**	−0.374***	−0.381*
	(−2.82)	(−2.74)	(−2.76)	(−2.98)	(−2.69)	(−2.39)	(−2.85)	(−1.89)
Price of fishmeal		0.117***	0.134***	0.136***		0.012*	0.015**	0.016**
		(2.79)	(2.81)	(2.82)		(2.03)	(2.19)	(2.22)
Cost of fuel		2.938	−10.971	−11.344		1.824	−0.643	−0.715
		(0.38)	(−1.17)	(−1.21)		(1.31)	(−0.39)	(−0.43)
5-degree Polyn. of Distance to Quota	No	No	No	Yes	No	No	No	Yes
3-degree Polyn. of Distance to Quota	No	No	Yes		No	No	Yes	
Size quartile dummies$_{it}$	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Productivity quartile dummies$_{it}$	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Port × Season Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.31	0.32	0.33	0.33	0.32	0.32	0.32	0.32
Sample size	32523	32523	32523	32523	32523	32523	32523	32523
N clusters (firms)	26	26	26	26	26	26	26	26

***, **,* significant at the 1%, 5% and 10% level. Standard errors are heteroskedasticity-robust and clustered by firm.

Table 4: Discontinuous Investment without Physical Resource Linkages

The table reports estimates of regression discontinuity equation (4) in restricted samples that eliminate physical resource linkage explanations for a jump in investment behavior in non-fishmeal. The unit of analysis is the firm-plant-day for all multibusiness fish-processing firms participating in the non-fishmeal segment, as described in Table 1. The assignment variable for the regression discontinuity models is Distance to Quota, defined in equation (3) as the difference between the cumulative amount of anchovy caught by all firms up to the previous day and the government quota for the season. The first model focuses on firms with a large number of start days for their non-fishmeal production (after days of shutdown) in the prior calendar year. The second model focuses on firms with ships dedicated exclusively to human consumption (i.e., not able to fish for fishmeal) —only three multibusiness firms are such. The tird model focuses on non-fishmeal plants adjacent to which there has been no fishmeal production of the firm during the active-season. The fourth model focuses on non-fishmeal plants but only on the sample of days on which there are no regulatory restrictions on the quantity of mackerel and hake that can be extracted, and are among the most common species for non-fishmeal processing. Control variables include price of fishmeal, cost of fuel, the fifth-degree polynomial of Distance to Quota, size quartile dummies, and productivity quartile dummies as defined in Section 2.3. Robust t-statistics clustered by firm are shown in parentheses.

Dependent Variable:	**Non-fishmeal investment (Fish $000)**			
Restricted Sample:	Low startup costs	Dedicated fleet	No adjacent fishmeal prod.	Unrestricted mackerel or hake
DV mean in Restricted Sample:	9.10	19.00	0.80	5.00
Fishmeal ban	2.802*	7.914***	0.542*	1.015*
	(1.83)	(36.55)	(1.77)	(1.82)
Price of fishmeal	0.014	0.032***	0.003	0.018*
	(1.39)	(118.53)	(1.39)	(1.73)
Cost of fuel	1.995	3.664***	−0.963	7.356***
	(0.73)	(120.81)	(−1.24)	(2.93)
5-degree Polyn. of Distance to Quota	Yes	Yes	Yes	Yes
Size quartile dummies$_{it}$	Yes	Yes	Yes	Yes
Productivity quartile dummies$_{it}$	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Port × Season Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.30	0.23	0.35	0.26
Sample size	15783	4394	3744	14997
N clusters (firms)	16	3	23	23

***, **,* significant at the 1%, 5% and 10% level. Standard errors are heteroskedasticity-robust and clustered by firm.

Table 5: Discontinuous Investment and Financial Constraints

The table reports estimates of regression discontinuity equation (4) across split samples above and below the median value of a proxy for financial constraints. Troubled loans over total is the ratio of the sum of loans received by the fish-processing company that are refinanced, restructured, or in recuperation, divided by the total sum of all loans. Mortgage collateral per loan is the ratio of the amount of mortgage guarantees provided by the fish-processing firm to its banking creditors divided by the loans received by the firm. Control variables include price of fishmeal, cost of fuel, the fifth-degree polynomial of Distance to Quota, size quartile dummies, and productivity quartile dummies as defined in Section 2.3. Robust t-statistics clustered by firm are shown in parentheses.

Dependent Variable:	**Non-fishmeal investment (Fish $000)**			
Split sample:	Troubled loans over total		Mortgage collateral per loan	
	Low	High	Low	High
DV Unconditional mean:	8.09	9.85	8.19	9.75
Fishmeal ban	2.611	3.543**	1.582	5.042**
	(1.32)	(2.43)	(1.11)	(2.65)
Price of fishmeal	0.017**	0.012***	0.011	0.020***
	(2.22)	(3.28)	(1.11)	(5.90)
Cost of fuel	−1.309	1.048	−2.987	2.241
	(−0.72)	(0.33)	(−0.90)	(1.53)
5-degree Polyn. of Distance to Quota	Yes	Yes	Yes	Yes
Size quartile dummies$_{it}$	Yes	Yes	Yes	Yes
Productivity quartile dummies$_{it}$	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Port × Season Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.36	0.33	0.33	0.30
Sample size	13184	13067	13171	13080
N clusters (firms)	15	15	17	15

***, **,* significant at the 1%, 5% and 10% level. Standard errors are heteroskedasticity-robust and clustered by firm.

Table 6: Discontinuous Investment and Attention-Demanding Operations

The table reports estimates of regression discontinuity equation (4) across split samples above and below the median value of a proxy for the importance of the non-fishmeal segment. The underlying variables for the split samples are all based on the non-fishmeal business, exclusively, taking the historical median value across all multibusiness firms as the cutoff, and classifying firms depending on their value below or above this benchmark during the previous year. Control variables include price of fishmeal, cost of fuel, the fifth-degree polynomial of Distance to Quota, size quartile dummies, and productivity quartile dummies as defined in Section 2.3. Robust t-statistics clustered by firm are shown in parentheses.

Dependent Variable:	**Non-fishmeal investment (Fish $000)**					
Split sample:	Tons of Fish		# of Fish Species		# of Export Countries	
	Low	High	Low	High	Low	High
DV Unconditional mean:	2.34	12.96	3.51	13.47	2.09	13.64
Fishmeal ban	1.276	4.820***	1.388	4.979***	1.474	4.617**
	(1.33)	(3.21)	(1.38)	(3.38)	(1.64)	(2.74)
Price of fishmeal	0.008	0.021***	0.018	0.016**	0.010	0.021**
	(1.11)	(3.01)	(1.26)	(3.15)	(1.37)	(2.71)
Cost of fuel	0.083	−1.798	−1.281	0.181	0.592	−1.622
	(0.14)	(−0.66)	(−0.43)	(0.10)	(0.85)	(−0.58)
5-degree Polyn. of Distance to Quota	Yes	Yes	Yes	Yes	Yes	Yes
Size quartile dummies$_{it}$	Yes	Yes	Yes	Yes	Yes	Yes
Productivity quartile dummies$_{it}$	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Port × Season Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.33	0.28	0.37	0.26	0.33	0.27
Sample size	15685	16838	17004	14482	16344	16179
N clusters (firms)	21	15	22	9	21	10

***, **,* significant at the 1%, 5% and 10% level. Standard errors are heteroskedasticity-robust and clustered by firm.

Table 7: The Value Consequences of Discontinuous Investment

The table reports linear fixed effects models of *non-fishmeal* (i.e., seafood) output per fish input for all multibusiness companies in the period of interest at a monthly frequency, for months in which there is a substantial jump in the number of fishmeal banned days and for the month preceding that jump. The unit of observation is the firm-month. The independent variable is a dummy for whether the month has a large number of fishmeal banned days (i.e., 20 or more) in comparison with the prior month, which must be a month with few (less than 10) days of banned fishmeal production; both types of months (few bans and many bans) must be consecutive, with the sharp fishmeal ban month being always posterior to the few-bans month. Size quartile dummies and productivity quartile dummies are based on fishmeal production as in the previous tables. Robust t-statistics clustered by firm are shown in parentheses.

Dependent Variable:	**Non-fishmeal Output per Fish Input**		
DV Unconditional mean:	0.46	0.46	0.46
Sharp fishmeal ban month	-0.180^{**}	-0.189^{**}	-0.166^{**}
	(-2.64)	(-2.37)	(-2.21)
Size quartile dummies$_{it}$	No	No	Yes
Productivity quartile dummies$_{it}$	No	No	Yes
Firm Fixed Effects	No	Yes	Yes
Calendar Month Fixed Effects	No	Yes	Yes
Year Fixed Effects	No	Yes	Yes
R^2	0.10	0.73	0.81
Sample size	68	68	68
N clusters (firms)		20	20

***, **,* significant at the 1%, 5% and 10% level.

Standard errors are heteroskedasticity-robust and clustered by firm.