Acquisitions, Productivity, and Profitability: Evidence from the Japanese Cotton Spinning Industry

Serguey Braguinsky, Carnegie Mellon University
Atsushi Ohyama, Hokkaido University
Tetsuji Okazaki, University of Tokyo
Chad Syverson, University of Chicago Booth School of Business

July 2013

Abstract
We explore how changes in ownership and managerial control affect the productivity and profitability of producers. Using detailed operational, financial, management, and ownership data from the Japanese cotton spinning industry at the turn of the last century, we find a more nuanced picture than the straightforward “higher productivity buys lower productivity” story commonly appealed to in the literature. Acquired firms’ production facilities were not on average any less physically productive than the plants of the acquiring firms before acquisition, conditional on operating. They were much less profitable, however, due to consistently higher inventory levels and lower capacity utilization—differences which reflected problems in managing the inherent uncertainties of demand in the industry. When these less profitable plants were purchased by more profitable establishments, the acquired plants saw drops in inventories and gains in capacity utilization that raised both their productivity and profitability levels, consistent with acquiring owner/managers spreading their better demand management abilities across the acquired capital.
1. Introduction

The influence of changes in corporate control of assets on productivity has been a focus of theoretical and empirical research for some time.\(^1\) In principle, mergers and acquisitions can reallocate control of productive assets to entities that are able to apply them more efficiently. Besides increasing the productivity of the individual production units that are merged or acquired, a broader process of such reallocations can also lead to aggregate productivity growth. Such a mechanism therefore has the potential to explain patterns of productivity at both the micro and macro levels. Implicit in the story of this mechanism—though not often treated explicitly in the empirical work on the subject—is the notion that productivity growth occurs when changes in ownership and control put assets in more able managers’ hands.\(^2\)

Despite the comfortable intuition of this logic, previous research has not been fully conclusive about the effects of ownership and management turnover, particularly regarding the nature of any measured productivity growth but especially regarding the particular manners in which this growth is obtained. This reflects in part the inherent limitations of the data available in the earlier studies. For instance, this research could not cleanly distinguish between physical (quantity) productivity and revenue productivity. This distinction can be important (Foster et al., 2008). It is not particularly surprising, excepting bounded rationality or agency problems, that acquisition deals could yield expectedly profitable synergies. However, such between-firm synergies need not be tied to improvements in the efficiency with which producers convert inputs to outputs. For example, mergers or acquisitions may increase market power that leads to higher output prices for the merged firm. In the typical revenue-based productivity measures of the literature (separate price and quantity information is rarely available at the producer level), this would be reflected in increased productivity measures even absent changes in technical efficiency. These and related measurement issues mean we are still limited in our knowledge of how turnover in asset ownership and management affects the level and growth of producers’


\(^2\) The idea that managers or management practices—even independent of any considerations of ownership—shape differences in productivity across plants, firms, and even countries, is itself a focus of a separate, budding literature. Examples include Bloom and Van Reenen (2007 and 2010) and Bloom et. al (2013).
efficiency levels.

In this paper, we seek to make progress on this front. A primary advantage of our effort is a data set that allows us to investigate the production and input allocation processes at an unusual level of detail. We observe the operations, financial reports, management, and ownership of the universe of plants in a growing industry over the course of several decades (the Japanese cotton spinning industry at the turn of the 20th Century). These data, which we describe in the next section and in the Appendix, contain records in physical units of inputs employed and output produced at each plant in the years it operated as well as plant-specific output prices and wages. We have matched these production and financial data with business histories of the industry’s firms to let us identify all major ownership and/or management turnover events and the personalities involved. These combined data let us measure directly how ownership and management turnover events were reflected in plants’ physical productivity levels, profitabilities, prices, and other operational and financial metrics.

Our findings draw a more nuanced picture of the effects of ownership and management turnover than the straightforward “higher productivity buys lower productivity” story that has motivated much of the previous theoretical and empirical work. In our sample, acquired firms’ production facilities were not on average any less physically productive than the plants of the acquiring firms before acquisition; both parties were equally adept at transforming physical inputs into physical outputs, at least conditional on operating. Acquired firms were much less profitable than acquiring firms, however. This profitability gap did not result from any output price differences between the firms. Instead, as we show, it reflected systematically lower unit capital costs among acquirers, coming from two sources: lower average inventory levels and systematically higher capacity utilization. When these better acquirers bought less profitable establishments, the acquired plants saw drops in inventories and gains in capacity utilization that raised both their productivity and profitability levels. The pre-acquisition equality in physical productivity between the acquired and the acquiring arose because, as we document below, acquired plants were newer and had more productive capital of younger vintages. This canceled out their capital utilization disadvantages in productivity terms.

Therefore ownership/management turnover in the industry is best characterized as “higher profitability buys lower profitability.” More profitable companies took over firms with capital that was actually better, but that was being used suboptimally. The new management took control of this superior capital and, by improving the manner in which it was employed, raised
the acquired plants’ productivity and profitability.

As to the specific source of the better owners’ and managers’ advantage, the explanation most consistent with the data is that better firms have a superior ability to manage the vagaries of demand in the industry. (We describe just what this means in our context in the next section.) This explanation is consistent not just with the productivity and profitability levels and changes we observe, but also with the differences in inventory levels and capacity utilization. This link between demand management, productivity, and profitability is, to our knowledge, a new mechanism in the literature examining how management can affect business performance. We present below a simple theoretical framework of managerial time allocation that offers one possible mechanism through which this demand management difference might operate. While illustrative, we note this time allocation mechanism is not the only possible source of differences in demand management, nor is it directly testable in our data, as we have no information on the allocation of owners’ or managers’ time. Any mechanism that creates disparity in companies’ abilities to manage the demand uncertainty inherent in this industry can create the patterns we document.

This ownership and management reallocation process helped drive considerable productivity growth in the industry. Between 1897 and 1915, industry TFP growth averaged an impressive 2.3 percent per year, while over 75 percent of industry capacity changed hands during our sample. And while acquirers were fairly concentrated—the asset reallocation process resulted in the emergence of several very large firms (we look more closely at these “serial acquirers” below)—what set the leading firms apart was not their market power (we show there was little during the sample) but rather the ability to acquire and fully utilize the most productive capital.

While our setting is historical in nature, it offers additional advantages besides detailed data and a novel mechanism. Specifically, the data span a time of critical economic development and industrialization for Japan, which at the time was less than two decades removed from the completion of a difficult and often violent process of transition to modernity after 250 years of an isolated, traditionalist society. Information as detailed as our data is unusual even for producers in today’s advanced countries, to say nothing of developing countries whose situation might be more similar to that of Japan at the time of our analysis. Hence, we believe that broader lessons that can be drawn from this study. By digging deep into the micro-evidence, we aim to complement past empirical work and provide fresh insights for further development of economic theory about resource reallocation.
2. Entry and Acquisitions in the Japanese Cotton Spinning Industry: Background Facts

The development of the Japanese cotton spinning industry in the late 19th and early 20th centuries has long fascinated economists because of its unique nature “as the only significant Asian instance of successful assimilation of modern manufacturing techniques” before World War II (Saxonhouse, 1971). The historical circumstances surrounding this development made the story even more intriguing. Japan unexpectedly opened up to foreign trade in the 1860s after 250 years of complete autarky. Cotton yarn, in particular, experienced the combination of the largest fall in relative price from autarky to the free trade regime and the highest negative net exports (Bernhofen and Brown, 2004). But starting from the late 1880s, the domestic cotton spinning industry began a remarkable ascendance. As late as in 1887, domestically produced output was still a fraction of imports, but it exploded over the following decade. Net exports turned positive for the first time in late 1896, and two decades after that Japan was exporting a sizeable fraction of its output while imports became negligible (see Figure 1).4

Figure 1 reveals that the development went through several stages. During the first stage, Japanese knowledge of the technology was rudimentary, and as a result spinning mills were small and had low productivity. In 1887, the industry included 21 firms, but the average equipment capacity was just 3,292 spindles and the average number of factory floor workers employed per day was 137. The industry was also hampered by low quality of domestically grown cotton (Chinese-grown cotton was also used, but it was not much better) and by the choice of what turned out to be inferior equipment (mules instead of ring spinning frames).

The second stage, that of explosive growth in the 1890s, was ushered in by two major technological breakthroughs: the switch to higher-quality raw cotton imported from India, and the adoption of ring spinning frames (a new type of cotton spinning machinery first invented in the U.S.).5 The success of early experiments using the new technological paradigm led to wide-

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3 See also Saxonhouse (1974), (1977); Miwa and Ramseyer (2000).

4 Import tariffs on cotton yarn remained negligible throughout this period as Japan only regained full control over its import tariffs in 1911. Export tariffs on cotton yarn were abolished in the early 1890s, and this did help exports somewhat. However, the tariff rates had been just a few percent to begin with, so they were hardly a decisive factor.

5 See, e.g., Ohyama, Braguinsky and Murphy (2004) and Braguinsky and Rose (2009) for detailed accounts of these
spread emulation, with entrants purchasing only ring frames for their newly constructed mills and using almost exclusively Indian cotton (and later, even higher quality raw cotton from the U.S. and Egypt). By 1896, the total number of active firms in the industry had reached 63 (with 17 more in the process of being set up), with the average plant having a capacity of 12,789 spindles and employing 719 workers. Thus the number of firms tripled over the first decade of growth, while the average size of the plant almost quadrupled and the average number of workers per plant rose fivefold. Industry output in physical units increased 17 times over during the same period (Nihon Choki Tokei Soran, Vol. 2, pp. 346).

Industry entrants in earlier cohorts that set up their production facilities before the major innovations of the 1890s found themselves stuck with older vintage capital equipment. An important advantage some of them had developed by the time the breakthrough happened, however, was a superior ability to “manage sales.” Since this will play an important role in mergers and acquisitions analysis below, we dwell upon this in some detail here.

Japanese cotton yarn producers at the time generally faced a very competitive market (see Saxonhouse, 1971 and 1977; also Ohyama, Braguinsky and Murphy, 2004). Most of the yarn was purchased and distributed by trading houses based in the largest commercial centers of Osaka, Tokyo and Nagoya (Takamura, 1971, Vol. 1, pp. 322-328). The market power of even the largest cotton spinning firms was on par or below that of trading houses, so no producer could exercise much influence over the price at which its yarn was being sold (ibid., p. 325). This does not mean, however, that the playing ground was equal for all firms. In order to sell their output,

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6 The Japanese cotton spinning industry eventually led the world in the speed of ring frames adoption, with even the U.S. behind it; see Otsuka, Rainis, and Saxonhouse, 1988.
7 Jovanovic (1998) and Jovanovic and Yatsenko (2011), among others, offer models where firms rationally stick to older-vintage capital even after newer vintage has become available.
8 Cotton yarn was also traded on the Osaka exchange. The gross transaction volume on the exchange was very large—sometimes several times larger than the amount of output—and the prices set there strongly influenced the prices trading houses were willing to pay even in seemingly isolated local markets (ibid., p. 327). Cotton spinning firms did take collective action to support prices by enacting output restriction measures during slow years. By their nature, however, these restrictions affected all firms uniformly and they were enforced by on-site inspections conducted by the All-Japan Cotton Spinners Association.
firms had to connect to trading houses. This wasn’t an easy task, especially during anticipated business downturns when large established trading houses would often limit their purchases to reputable producers with whom they had a long-term relationship (Takamura, 1971, Vol. 2). Of course, firms could (and did) sometimes offer to sell at discounted prices in situations like this, but this practice appears to have been limited by reputational considerations (all price information was public and even hidden discounts, such as increasing the amount of yarn delivered over and above the contracted amount, were often reported—and decried—by the journal published monthly by the All-Japan Cotton Spinners’ Association; hereafter “Geppo”). Going outside of the network of reputable trading houses entailed risks of its own, as unscrupulous traders could renege on contracts or their promissory notes could bounce, failing to deliver real cash. We will see below (Section 4) that these problems were indeed quite severe, and that the most successful early entrants (who later became major acquirers of production facilities in the mergers and acquisition market) managed these sales-related issues than other firms early on.

This acquired (or possibly innate) superior ability to manage sales may not have been crucial during the rapid expansion phase, but we show in Section 4 that it started playing a major role in firms’ fortunes once the third stage of the industry development set in at the start of the 20th century. After driving out imports, the Japanese cotton spinning industry felt the limits of the market size for the first time. A temporary reprieve came in the form of burgeoning exports (mostly to China), but once the Boxer Rebellion effectively shut down the Chinese market in 1900, the first major “overproduction crisis” in the industry was in full swing. Most of the following decade saw industry consolidation with little if any growth on the extensive margin but with a lot of firm-by-firm (and firm-by-outside investor) acquisitions of existing production facilities, the first one of which happened in 1898.

Figure 2 depicts the total capacity of several categories of plants from 1896-1920, which is our merger and acquisition analysis timeframe. During the first decade of the 20th century especially, almost all capacity growth among existing firms came through acquisitions. There was virtually no new entry or plant construction. While entry and new construction eventually resumed by the end of the decade, acquisitions continued to play an important role.

A lack of trust outside immediate family members who operate the business can make it difficult for superior firms in today’s developing countries to increase their spans of control
through acquisitions (Bloom, Sadun and Van Reenen, 2012). The Japanese cotton spinning industry avoided this problem because the large majority of the firms at the time were set up and run as joint stock companies, with easily transferable ownership. In Appendix B we present an example where a new CEO turned around a struggling firm by implementing a set of measures whose description reads amazingly similar to the script laid out by outside consultants for Indian firms in Bloom et al. (2013). The fact that acquisitions assumed such a prominent role in firm growth process so early on also seems at first glance to be at odds with the established theoretical view that investment by purchasing new capital should come before acquisitions (e.g., Jovanovic and Rousseau, 2002). However, the intuition behind the underlying theory (which Jovanovic and Rousseau find support for in U.S. data) is simply that new capital purchases do not involve fixed costs, while acquisitions do. This was less true in the early Japanese spinning industry. Because the industry had to import almost all its capital equipment from England, taking over existing plants at the right price was actually a potentially cheaper alternative for Japanese firms looking to expand.

These factors led to the consummation of 73 distinct acquisition deals in the industry between 1898 and 1920, during which 95 plants changed hands (sometimes more than once). Fifteen more plants were consolidated under a single ownership in the deal that in 1914 created Toyo Cotton Spinning Company (Toyobo) from an equal merger of Osaka Cotton Spinning Company (Osaka Boseki) and Mie Cotton Spinning Company (Mie Boseki). All in all, 50 out of the 78 plants (64 percent of plants and 76 percent of capacity) that were in operation in the industry in 1897, the year before the first acquisition took place, were subsequently acquired by another company at least once.

Several large firms emerged from this process, mostly through serial acquisitions. These were Kanegafuchi Cotton Spinning Company (Kanebo), Mie Boseki, Osaka Boseki (as already mentioned, the latter two competed an equal merger in 1914 to form Toyobo), Settsu Cotton Spinning Company (Settsu Boseki) and Amagasaki Cotton Spinning Company (Amabo; the

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9 How a functioning market for assets emerged so early in the process of economic modernization is a subject for a separate study; see Miwa and Ramseyer (2000) for some insights on this issue.

10 In support of this, Saxonhouse estimates that the time lag between receipt of spinning mill orders from Japan and shipments of equipment ranged from one to two years for most of the 1890s and the 1900s. It increased to 3-5 years after the start of World War I (Saxonhouse, 1971, p. 51).
latter two merged in 1918 to form Dainippon Boseki). Figure 3 traces the dynamics of the fraction of the industry’s plants, spindle capacity, and output that were owned by the above five firms (which shrank to four after a merger in 1914 and to three after another merger in 1918) over the 25-year period of our analyses. These five firms went from owning 10 percent of the plants and 25 percent of industry capacity and output at the beginning of the period to 40 percent of plants and half of capacity and output by the end. As no other firm owned more than 10 plants or had more than 10 percent of industry-wide capacity under its ownership at the end of our period, these serial acquirers stood out by their sheer size and importance. The concentration of ownership could in principle be due to multiple factors, but as our empirical analysis below will show, it appears to be mostly due to their superior ability to manage sales and as a consequence improve the productivity and profitability of the plants they acquired. It is also worth noting that the three super large firms all survived long into the post-World War II era.

[Figure 3 about here]

3. Data

Our main data source is the plant-level data gathered on the annual basis by governments of various Japanese prefectures and available in historical prefectural statistical yearbooks. For this paper, we have collected and processed all the available data between 1899 and 1920 (prior to 1912 these data are also available in the Statistical Yearbook of the Ministry of Agriculture and Commerce (“Noshokomu Tokei Nempo”). Since the first acquisition of an operating plant happened in 1898, we added similar data for 1896-1898 using the information published in the bulletin (hereafter “Geppo”) of the All-Japan Cotton Spinners’ Association (hereafter “Boren”). Our data thus cover 1896 to 1920. Saxonhouse (1971, p. 41) writes that “the accuracy of these published numbers is unquestioned.”

11 All these firms were founded before the technological breakthroughs of the early 1890s: Mie Boseki was founded in 1880, Osaka Boseki in 1882, Kanebo in 1887, while Settsu Bosseki and Amabo were both founded in 1889. The former three firms also struggled with older-vintage capital equipment for some time.

12 Here we describe only the most important features of our data; a more detailed description is in Appendix A.

13 We scrutinized these numbers ourselves and found occasional, unsystematic coding errors as well as obvious typos. In the vast majority of cases we found that the annual data in statistical yearbooks and the annualized monthly data corresponded very closely (the discrepancy, if any, did not exceed a few percentage points).
Our data contain inputs used and output produced by each plant in a given year in physical units. In particular, the data contain the number of spindles in operation, number of days and hours the plant operated, the number of factory floor workers (male and female workers separately), average daily wages separately for male and female workers, data on intermediate inputs such as the consumption of raw cotton, type of engine(s) that powered the cotton spinning mill (steam, water, electrical or gas/kerosene) and their total horsepower, output of the finished product (cotton yarn) in physical units, the average count (measure of fineness) of produced yarn, and the average monthly price per unit of yarn produced.\textsuperscript{14} We observe each plant’s owning firm in a given year, so we can see plant-level variables before and after ownership changes.

We also collected detailed information surrounding each acquisition and ownership turnover event, including but not limited to identities and backgrounds of the most important individuals involved (shareholders, top managers and engineers). Several data sources made this possible. First, 90 percent or more of the Japanese cotton spinning firms were public (joint stock) companies, obligated by law to issue shareholders’ reports every half a year. Those reports contain detailed balance sheets and profit-loss statements as well as qualitative information about shareholders’ meetings, deaths, illnesses, resignations, and replacements of board members. We also use the information in the seven-volume history of the industry written in the late 1930s by the Japanese historian Taiichi Kinugawa (Kinugawa, 1964) as well as company histories.

Several unique properties of our research variables need to be explained in some detail. First, cotton yarn is a relatively homogeneous product, but it still comes in varying degree of fineness, called “count.”\textsuperscript{15} While output of cotton yarn in our data is measured in weight, we also observe the average count produced by a given plant in a given year. To make different counts

\textsuperscript{14} See Foster et al. (2008) and Syverson (2011) for the discussion of the importance of separating quantity and revenue productivity and the difficulties encountered by researchers trying to do it using conventional data that contain sales and expenditures on inputs but not direct evidence on the quantity of inputs and outputs.

\textsuperscript{15} The yarn count expresses the thickness of the yarn, and its number indicates the length of yarn relative to the weight. The higher the count, the more yards are contained in a pound of yarn. Thus higher-count yarn is thinner (finer) than lower-count yarn. Producing higher-count (finer) yarn generally requires more skill and superior technology than lower-count (thicker) yarn. High-count yarn is often improved further by more complex technological processes known as doubling, gassing, and so on, which were quite challenging for the fledgling Japanese cotton spinning mills to master at that time.
comparable for the purpose of productivity analysis, we converted various counts to the standard 20\textsuperscript{th} count using a procedure detailed in Appendix A. Second, we used the plant-year-specific ratios of female to male wages to convert one unit of female labor to units of male labor.\textsuperscript{16} Third, in addition to the number of spindles installed, we also have data on the actual number of spindle-days in operation for each plant-year. In other words, the data offer us the unusual ability to directly measure the flow of capital services at the plant level rather than to infer it from capital stocks or through the use of other proxies like energy use.\textsuperscript{17} Finally, we follow Saxonhouse (1971 and 1977) and exclude intermediate inputs when estimating the production function. As discussed by Saxonhouse, yarn production is essentially Leontief in raw cotton when both input and output are measured in units of weight (the raw correlation between the two variables in our data is 0.95). As a practical matter, including raw cotton in a log-linear production function therefore renders all other inputs economically and statistically insignificant. One can therefore interpret our production function estimates as relating yarn output to other inputs, conditioning on the use of the physically necessary quantity of raw cotton.

4. Empirical Analysis

Table 1 presents year-by-year counts of acquired plants during our sample. The total is broken out separately by plants taken over by the five largest (serial) acquirers. On average, 4.3 percent of the industry’s mills were acquired per year, with the largest acquirers responsible for about 40 percent of all acquisitions.\textsuperscript{18} These acquisition episodes form the base of our estimation

\textsuperscript{16} In the division of labor between sexes in Japanese cotton spinning mills, opening, mixing, carding, repairing and boiler room work were generally (although not exclusively) men’s jobs. Tending, drawing, roving and operating ring frames were generally women’s work (Clark, Cotton Goods in Japan, pp. 191-194, cited in Saxonhouse, 1971, p. 56). Using female-to-male wage ratios to aggregate the labor input assumes that wages reflect the marginal productivity of each gender. All our estimates are robust to including the number of male and female workers separately in the production function estimations.

\textsuperscript{17} While spinning frames (and their spindles) account for only 25-30 percent of the total equipment cost of a mill, the correlations in our data between spindles and other equipment (cards, draw frames, slubbing frames, intermediate frames, roving frames, etc.) are over 95 percent. Thus spindles are a good proxy for equipment as a whole (Saxonhouse, 1971, p. 55-56).

\textsuperscript{18} This average acquisition rate is higher than the 3.9 percent acquisition rate for large U.S. manufacturing plants
sample.

4.1. Differences between Acquirers and Targets

We first use our detailed data to see, before there were any acquisitions in the industry, if there were systematic differences among firms that would eventually a) acquire other firms, b) be acquired, and c) exit without either acquiring or being acquired. We compare these firms’ plants along several dimensions: physical (quantity-based) productivity, accounting profitability, average output price, the number of days of the year the plant is operational, the average age of the plant’s spindles, and the firm’s age.

To measure plants’ physical total factor productivity levels (henceforth TFPQ, for quantity-based TFP), we estimate a Cobb-Douglas production function using the available data on output in physical units, labor and capital service flows, year dummies, and the plant’s change in capacity from the previous year (as a control for possible adverse effects on output of adjustment costs of installing new equipment). The residuals from this production function reflect plants’ TFPQ levels relative to the industry-year average. To measure profitability, we calculate shareholders’ return on equity; that is, we divide firms’ profits by the amount of equity capital paid in by shareholders.\(^\text{19}\) Equipment age is calculated as the current year minus the equipment vintage year, where vintage year reflects the composition of the years the plant’s spindles were purchased.\(^\text{20}\) Firm age, on the other hand, is always equal to the calendar year minus the year the firm was founded.\(^\text{21}\)

\(^{19}\) We do not have firm balance sheets data for 1896-97, but we do have these for subsequent years, so we will also measure profitability as return on total capital invested. See below.

\(^{20}\) For example, if the plant’s initially installed spindles were purchased in year \(t\) and then the plant underwent an expansion during which the same quantity of new spindles were purchased in year \(t+k\), plant age is calculated as the calendar year minus \(t\) until the year new equipment is installed, after which it becomes the calendar year minus \([t+(t+k)]/2\), the average vintage age of equipment (or the weighted average if the number of spindles installed later were different from the number initially installed).

\(^{21}\) Since the plant’s capital stock includes various pieces of machinery as well as buildings, engines, and various elements of infrastructure, equipment (spindles) age adjusted for vintage as above makes the plants look younger.
Table 2 shows the means and standard deviations of the aforementioned plant characteristics for each group of firms: future acquiring firms, future target firms, and future exiting (not by acquisition) firms. We further separate plants of target firms into those in firms founded before 1890 (labeled “first cohort”) and those founded in 1890 or later (“second cohort”), as the former are more likely to have older-vintage capital. The table includes only data from 1896-97—that is, before any acquisitions took place in the industry.

We first look across the table’s top row to compare the average physical productivity levels across the different groups of plants. In contrast to the “higher productivity buys lower productivity” scenario, plants in future acquiring firms—at least conditional on the plant operating—are not more physically efficient than those in future acquired firms. Indeed, the most efficient group of plants is the second cohort of the acquired. (On the other hand, the ubiquitous result in the literature that exiting plants are less productive than continuing establishments is borne out in our data.)

This pattern is reversed when we look at profitability. The most profitable establishments (significantly so) are those in firms that will be acquirers. Plants in the first cohort of target firms are the second most profitable, and exiting and second-cohort acquired plants follow up the rear.

As seen in the third row of the table, these profitability gaps are not tied to differences in the prices the plants fetch for their output. All firms earn more or less similar price per unit weight of output. (Acquiring plants’ average price is slightly higher, though none of the differences in the table are statistically significant at conventional levels. Furthermore, when we adjust for the average count of the plants’ yarn, these differences become even smaller.) This result, which we will see repeatedly below, supports what we know about the institutions of the industry’s output market: the pricing process did not reflect large differences in market power across industry producers and is unlikely to contribute to firm- or plant-level outcomes examined in this paper.

The days-in-operation and age comparisons at the bottom of the table offer insight into the possible sources of the productivity and profitability patterns. Second-cohort acquired plants

than they actually are. Firm age, on the other hand, certainly makes those plants that had added new spindles (or scrapped old ones, which is also captured in our measurement) look older than they are. Equipment age thus provides the lower bound, and the firm age the upper bound, for the true overall plant age.
are more productive than other plants, yet less profitable. Their productivity advantage is tied to the fact that they have significantly newer capital (whether measured by equipment or firm age), as reflected in the table’s final rows. As we described in Section 2, capital vintage effects (particularly for equipment spanning 1890, the year we use to split cohorts) were important in the industry. A hint at why their productivity advantage did not yield a profitability advantage can be seen in the comparison of plants’ average days in operation. Second-cohort acquired plants only operated about 80 percent of the time as plants in future acquiring firms. And plants that were to exit the industry had the worst of both worlds: their capital was old (not only were they the oldest firms, their equipment and firm ages were almost the same, indicating they did almost no upgrading of their equipment), and their factories were often idle. They were unproductive and unprofitable as a result.

4.2 Changes in Productivity and Profitability within Acquired Plants

The analysis in the previous subsection revealed some systematic pre-acquisition differences between acquiring and target firms. In this subsection, we investigate whether and how acquired plants’ attributes change when they are taken over by acquiring firms.

To measure these changes, we estimate specifications that regress acquired plants’ attributes on three sets of time dummies defined around each acquisition event: a “late pre-acquisition” dummy that equals 1 for the two years immediately preceding the acquisition and zero otherwise, an “early post-acquisition” dummy that equals 1 for the first three years after the acquisition and zero otherwise, and a “late post-acquisition” dummy that equals 1 for all subsequent post-acquisition years after the first three and zero otherwise. The omitted category therefore includes the period at least three years prior to the acquisition. (We do not include the acquisition year itself in the regression because acquisitions often happen mid-year, making it hard to attribute outcomes solely to the acquirer or the acquired.) We include plant fixed effects in the specifications, so the coefficients on the time dummies reflect within-plant differences in attributes. We also include calendar year fixed effects to remove any systematic changes in attributes over the sample.

Thus our estimating equations have the general form:

\[ y_{it} = \alpha_i + \beta_{lbA_{it}} + \beta_{eaA_{it}} + \beta_{laA_{it}} + \eta_i + \mu_t + \varepsilon_{it}, \]  

(1)

where \( y_{it} \) is the attribute of plant \( i \) in year \( t \); \( lbA_{it} \) is the “late before acquisition” dummy; \( eaA_{it} \) is the “early after acquisition” dummy; \( laA_{it} \) is the “late after acquisition” dummy; \( \eta_i \) is a plant
fixed effect; $\mu_t$ is a year fixed effect; and $\epsilon_{it}$ is the error term.

The first numerical column of Table 3 shows the results for TFPQ. Rather than first estimate physical TFP with a production function regression and then use the residual as the left-hand-side variable in (1), we perform the equivalent one-step estimation by using the plant’s logged output as the dependent variable and adding the explanatory variables from the production function to the right hand side of (1): the plant’s logged number of composite worker-days (the sum of male and female workdays, weighted by the relative plant-level ratio of female to male wages)\(^{22}\), its number of spindle-days in operation (flow of capital services), and the change in log plant capacity from the previous year (control for equipment installation adjustment costs).

The results in the table indicate that in the first 3 years after acquisition, acquired plants’ TFPQ levels are 3.2 percent higher and not statistically different from their levels in the pre-acquisition years. In subsequent years, however, the TFP of acquired plants rises to a level 11 percent above their pre-acquisition baseline, and the hypothesis that the coefficients on the early and late post-acquisition dummies are equal is rejected at the 1 percent confidence level. Thus acquired plants’ TFPQ levels do improve considerably following an acquisition, although it takes time for this to manifest itself fully.

[Table 3 around here]

Table 3’s second column looks at acquired plants’ profitability around acquisition episodes. Unfortunately, we cannot directly evaluate plant-level changes in profitability from before to after acquisition that are analogous to the cross sectional comparisons in Table 2. This is for the obvious reason that there are no separate post-acquisition firm profit accounts. We work around this issue by using plant-level gross operating surplus, computed as the difference between the value of output produced (output times the plant-specific price) and input costs, where the latter equals the sum of capital costs (capital invested, including equity, various borrowings, and corporate bonds, times the market interest rate) and labor costs (number of male and female work-days, multiplied by the corresponding daily wages). We convert this gross surplus to a rate by dividing it by input costs. Since the data on capital invested are available at the firm level only, for multiple-plant firms we assign firm-level capital cost to each plant in proportion to the fraction of its revenue (plant-specific output, times plant-specific price) in total

\(^{22}\) We also conducted all estimates using male and female work-days separately and the results were almost identical.
firm revenue. We estimate (1) with (logged) gross operating surplus as the dependent variable.\footnote{The raw correlation between the plant-level gross operating surplus rates constructed in this way and the ROC measure (defined in Section 4.2.1 above) for pre-acquisition years is 0.7, so our measure is a reasonably good proxy for plant-level profitability. Using logs does not result in losing observations because while firm-level profits can be negative, plant-level operating surplus gross of expenses on intermediate inputs, as constructed here, is always positive in the data.}

In contrast to the TFPQ patterns in the first column, acquired plants’ gross operating surplus jumps immediately after acquisition, and by a lot: over 18 percent within the first 3 post-acquisition years. It increases yet another 13 percent in subsequent years (the difference between the early and late post-acquisition coefficients is also statistically significant). Hence, profitability improves even more than productivity following acquisition and, in contrast to TFP improvement, more than half of the change is observed soon after the acquisition.

Finally, to see if changes in plant-specific price contributed to profitability changes, we estimated a regression similar to (1) with the dependent variable being the (logged) plant-specific price, divided by the main count of yarn produced by the plant to adjust for quality differences. The table’s last column shows that post-acquisition prices are statistically and economically indistinguishable from pre-acquisition prices. Thus again the source of improved profitability over and above TFPQ improvement is not related to plants charging higher prices.

We next see whether these changes within acquired plants are systematically related to the attributes of the acquiring firm. While acquiring firms could be quantitatively demarcated along a number of dimensions, a natural one is whether they were one of the “serial acquirers” we discussed in Section 2. Thus we repeat the specifications in Table 3, but with the sample limited to only acquisitions conducted by one of the five serial acquirer firms. The results are presented in Table 4.

[Table 4 about here]

The picture offered by the table is qualitatively similar to Table 3, but all the changes are indeed more pronounced. In particular, acquisitions by serial acquirers correspond to long run improvements in acquired plants’ physical TFP of more than 20 percent, while profitability increases by more than 60 log points. The point estimates on the price changes are larger than in Table 3, but $t$-tests fail to reject at conventional confidence levels the hypothesis that the coefficient on either of the post-acquisition dummies are equal to the pre-acquisition dummy
Overall, the within-plant results in Tables 3 and 4 indicate that acquired plants see growth in both their TFPQ and profitability levels after they are acquired, though the latter occurs sooner and is larger in magnitude. Moreover, both of these changes are larger for plants that are acquired by the most prolific of acquiring firms.

4.3 Changes within Acquisition Episodes

We also look at productivity and profitability changes from before to after acquisition events in a slightly different way, by comparing acquired plants to the incumbent plants of acquiring firms. Including incumbent plants results in the loss of data because in 37 acquisitions the acquirer came from outside the industry and hence had no incumbent plants. Additionally, the timelines of available data on some incumbent plants were missing or too short to be usable. Therefore, the exercise here is limited to only 58 out of 95 total acquisitions in the sample. The benefit is that this within-acquisition approach allows us to explicitly compare plants’ productivity and profitability levels and changes while controlling for any specific circumstances surrounding each acquisition by including acquisition fixed-effects.24

The specification is as follows:

\[ y_{int} = \alpha_0 + \beta_1 A_{AA_{mt}} + \beta_2 A_{Acquired_{im}} + \beta_3 A_{Acquired_{im}} \times AA_{mt} + a_{im} + \varepsilon_{int}, \]  

where \( i \) indexes plants, \( t \) indexes years, and \( m \) indexes acquisition cases. The outcome variables \( y_{int} \) are the physical TFP measure and the (log of) the plant gross operating surplus rate as defined in the previous subsection relative to industry-year average. The variable \( A_{AA_{mt}} \) is a dummy equal to 1 if acquisition \( m \) happened prior to year \( t \) and zero otherwise, while the variable \( A_{Acquired_{im}} \) is equal to 1 if plant \( i \) is purchased in acquisition case \( m \) and zero otherwise. The acquisition-case fixed effect is \( a_{im} \), so \( \hat{\beta}_3 \) reflects the post-acquisition difference-in-difference between acquired and incumbent plants of acquiring firms. We limit the sample time period to 4 years before and 8 years after acquisition event, but reasonable alternative timeline cutoffs

24 To avoid problems stemming from the fact that previously acquired plants by serial acquirers are already “incumbent” plants when another acquisition happens (which can be as early as in the same year), we impose a rule that a previously acquired plant only becomes labeled as an incumbent after being under the new ownership for five years. The results presented below are not sensitive to other reasonable cutoffs or to leaving only serial acquirers’ originally owned plants in the “incumbent” category, however.
produce similar results.

The estimation results are presented in Table 5. The first two columns of numbers reflect TFP and gross surplus results (respectively) for all acquisitions, while the latter two columns look only at acquisitions by the five serial acquirers.

In both physical TFP specifications, the estimates of the interaction coefficient $\hat{\beta}_1$ are positive and statistically significant at the 5 percent level. The results indicate that the post-acquisition improvement of TFP of acquired plants (this time relative to incumbent plants) is on average about 13 percent on average for all acquisitions and 17.5 percent for acquisitions by serial acquirers. (Excluding serial acquirers, the estimated value of $\hat{\beta}_1$ is just about 5 percent and statistically not significant at conventional levels; partly this is due to the fact that we have relatively few observations on acquisitions carried out by non-serial acquirers where the acquiring firm also had usable incumbent plant data.) In addition, the coefficients on the acquired plant dummy are small and statistically insignificant in both samples, confirming the Table 2 result that there is no systematic difference between the physical TFP of acquired and incumbent plants prior to acquisitions.

[Table 5 about here]

In the profitability regressions, $\hat{\beta}_3$ is also positive and statistically significant. In both the overall and serial acquirer samples, profit rates of acquired plants rise by about 23-25 percent relative to the plants in the acquiring firms. Here, acquired plant dummy coefficients are large and negative, reflecting the profitability deficit of acquired firms prior to acquisition.25

These results further reinforce what we document above: acquisition is accompanied by growth in the acquired plants’ productivity and profitability levels. We see here that this is true relative not only to the plants’ own levels before the acquisition, but also relative to changes within incumbent plants owned by their acquiring firms.

4.4 The Link from Profitability to Productivity: Management Ability

In principle, the pre-acquisition gap in profitability without a comparable gap in TFPQ might suggest price differences due to market power between acquiring and acquired firms. The

25 We also estimated a regression similar to (2) with the outcome variable being count-adjusted plant output price (relative to the industry-year average). As in the previous subsection, we did not find any significant differences between pre- and post-acquisition trends in either acquired or incumbent plants.
results above, however, decisively reject this hypothesis. This is consistent with what we know about how the market for output operated in this industry at the time, as discussed in Section 2.

But as also mentioned in Section 2, a lack of price differentiation does not mean no other forms of output-market differentiation existed between firms. Stronger companies were more reputable among buyers and had a more solid network of clients than weaker companies.

To quantitatively explore these possible differences in firms’ demand-facing operations, we investigate plants’ finished goods inventory and capital utilization metrics before and after acquisitions. We choose these metrics because holding finished product in inventory may indicate that the plant is having difficulty finding buyers in a timely manner, and because (as hinted at in Table 2 above) capital utilization differences—which may also reflect poor management of matching production to demand, or difficulty in finding buyers—may explain a considerable portion of the profitability differences across plants. In fact, anecdotal evidence from company histories suggests that inventories and utilization were intrinsically linked in the industry, as firms would often halt production as unsold yarn and uncollected revenues piled up, and would resume only after the gridlock had been cleared. We again use the within-acquisition difference-in-difference specification (2) so as to characterize whether acquired plants converged toward incumbent plants after they were bought.  

Table 6 presents the estimation results. The first column looks at producers’ ratios of period-end finished goods inventories to the value of their output over the period. (Plant-level inventories are imputed from firm-level reports in post-acquisition observations by assigning a firm’s inventories across its plants in proportion to the plant’s share of firm output.) The second through fourth columns of the table look at three measures of plants’ capital utilization: the ratio of their fixed capital costs to their output (capital costs are imputed from firm-level reports in post-acquisition observations in proportion to the plant’s share of the firm’s revenue), the number of days the plant is in operation during the year, and the plant’s capacity utilization rate (defined as the number of total spindle-days the plant operated during a given year divided by the product

26 We also looked at unit labor costs (measured as the plant-level wage bill over output) and found them to be remarkably similar between acquired and acquiring plants (details are available upon request). This leaves unit capital costs (capital outlays per unit of output produced) with both fixed and inventory costs as primary components as our main “suspects.” We note for the sake of completeness that intermediate goods and unfinished products on the firms’ balances do not appear to be systematically influencing outcomes and thus are not considered here.
of the plant’s number of spindles installed and 365 days). The latter two measures are observed directly at the plant level and do not involve any imputations (nor does the pre-acquisition difference between acquired and incumbent plants on the former two measures).

[Table 6 about here]

The estimates in the table show that acquired plants were notably inferior to incumbent plants on each of these dimensions before they were purchased. The “acquired plant” indicator coefficients imply that, prior to acquisition, these plants held higher inventories, had higher unit fixed capital costs, operated fewer days out of the year, and had lower capacity utilization. All these deficits are statistically significant and economically large. These are strong indicators of these plants’ lower pre-acquisition profitability levels, and are consistent with the demand management mechanism discussed above.

Once the plants were purchased, the gaps closed along every dimension. In fact, the acquired plants completely caught up to incumbent plants at least in inventories to output ratio and the days they were in operation, as witnessed by the fact that the interaction term’s coefficients are of similar magnitude to the acquired plant indicator.

Thus it appears that while acquired plants suffered a relative inability to manage sales, their purchase by firms with higher-ability owners and managers led to the transference of this capability to the acquired operations, leading to the gains in profitability observed in the previous sections. This mechanism can explain why an initial profitability gap existed, and why it was closed by acquisition. But of course we observed TFP gains upon acquisition too (though there was no prior gap). This is also consistent with the profitability story above if demand management is correlated with broader managerial ability. In this case, acquisition by higher-ability firms also acted to raise the productive efficiency of acquired plants, as reflected in the TFPQ results.

4.5. Do Better Acquiring Firms Improve Acquired Plants More?

In the above results that focus on acquisitions by the five serial acquirers, we have already seen that, at least at a rough cut level, being bought by a higher ability acquirer results in larger productivity and profitability improvements. In this subsection we take one step further and try to measure acquirer ability in a more continuous way and see if it is correlated with productivity improvements.

If, as consistent with the results in the previous subsection, the inventory and fixed capital
cost ratios are functions of owner/manager ability, then this suggests these values may be used to proxy for such ability. Specifically, if the ratios are monotonically decreasing in ability, we can invert this function to control for ability. That is, \( ability = g_1^{-1}\left(\frac{\text{inventory}}{\text{output}}\right) \) and \( ability = g_2^{-1}\left(\frac{\text{fixed capital cost}}{\text{output}}\right) \). By estimating regressions similar to (1) while including functions of the two ratios for the acquirer, we can see the extent to which the estimated post-acquisition improvement in acquired plants’ TFPQ is explained by acquirer ability.

Table 7 presents the results of this estimation. It shows regression specifications of the form (1), comparing results both with and without including log of the acquirer’s inventory or fixed capital cost to output ratios as controls for acquirer ability.

When controls for acquirer ability are included (the table’s second and third columns), the magnitudes of coefficients on all post-acquisition dummies drop noticeably and even become negative in magnitude (albeit not statistically significant) in the third column. Additionally, the coefficients on the ability control functions are negative and economically and statistically significant, indicating that increases in both ratios reduce productivity, which is consistent with the notion that TFPQ is positively associated with ability.

5. A Mechanism

Our empirical results point to some sort of demand management ability (reflected empirically in inventory and capital utilization levels) as driving variation in productivity and profitability across plants, both in the cross section and over time (the latter with regard to acquisition events). In this section, we offer a simple theory that elucidates one channel through which fundamental heterogeneity across owner/managers leads to variations in the ability to manage demand, and through this, TFPQ and profitability. Further, if this heterogeneity is “carried” with the owner/manager in an acquisition into the target plants’ operations, it also explains the productivity and profitability changes that surround acquisition events that we estimated above.

The specific mechanism in the model involves a managerial time allocation decision, where owners/managers must trade off spending more time managing demand (and increasing sales in the process) but at the cost of spending less time managing production (decreasing
productivity in the process). Further, managers and plants are both of heterogeneous quality. We show below how this framework delivers the empirical patterns we document above. That said, it is possible that other possible mechanisms could explain the data, and in any case we cannot test the time allocation model directly because we have no data on owners’/managers’ time allocations. Nevertheless, we find it useful to explicitly lay out a set of conditions and economic decisions that can yield the empirical patterns above.

5.1 Plant Production and Demand

For simplicity, we focus on a single plant, though implications from the model remain qualitatively the same if a firm operates several plants. The plant’s owner has access to the following production technology:

$$y = u\omega x$$

(3)

where $u \in [0,1]$ is the fraction of the manager’s time allocated to managing the plant, $\omega$ is the given quality of a plant, and $x$ is the composite input of labor and capital, weighted appropriately. (For example, if the technology is Cobb-Douglas and there are constant returns to scale, the composite would be the plant’s inputs raised to their respective input elasticities). We assume that the firm first chooses $x$ to minimize the cost of producing a given $y$ and then optimally chooses $u$ and $y$. Since the input $x$ is the only choice variable in the cost minimization problem, the optimal choice of $x$ is given by

$$x^* = \frac{y}{u\omega}.$$ 

Hence the plant’s cost function is $c(y) = p_x x^* = \frac{y}{u\omega}$, where to simplify notation we have normalized the price of $x$ to 1 by an appropriate choice of units.

We assume the plant faces the following isoelastic demand:

$$q = \lambda(u; \gamma)p^{-\sigma},$$

(4)

where $q$ is quantity demanded, $p$ is the output price, and $\sigma > 1$. Note that demand also depends on $u$, the manager’s time allocation. This is the channel through which we introduce the notion of demand management. From (3) and (4), standard profit maximization solution leads to the optimal price:

$$p = \left(\frac{\sigma}{\sigma-1}\right)\frac{1}{u\omega},$$

and the optimal profit:

$$\pi(u; \gamma) = \mu(\omega; \sigma)\lambda(u; \gamma)u^{\sigma-1},$$

(5)
where $\mu(\omega; \sigma) = \sigma^{-\sigma}(\sigma - 1)^{\sigma-1}\omega^{\sigma-1}$.

5.2 Optimal Allocation of Manager’s Time

The plant’s owner, who is also its manager, allocates his time between managing the plant and managing demand (sales) so as to maximize profit in (5). This optimal time allocation problem can thus be written as

$$\text{Max}_u \lambda(u; \gamma) u^{\sigma-1}. \quad (6)$$

The function $\lambda(u; \gamma)$ is assumed to satisfy the following properties:

(a) $0 \leq \lambda(u; \gamma) \leq 1$,

(b) $\frac{\partial \lambda(u; \gamma)}{\partial u} < 0$,

(c) $\frac{\partial \lambda(u; \gamma)}{\partial \gamma} > 0$, and

(d) $\frac{\partial}{\partial \gamma} \left( \frac{\partial \lambda(u; \gamma)}{\partial u} \right) > 0$.

Properties (a) and (b) clarify the interpretation of $\lambda$ as a fraction of demand that the firm loses if the manager’s time is allocated away from managing sales, $1 - u$, to managing the production facility, $u$. Property (c) says that higher “sales management ability,” such as networking relationship with trading houses, quality certification, as well as perhaps the ability to effectively collect debt (see the previous section) leads to smaller loss of demand for any $u$. Finally, (d) says that the demand loss due to a marginal increment in $u$ decreases with the manager’s ability. The optimal resource allocation problem (6) thus captures the fundamental tradeoff faced by the manager: if he devotes more time to managing sales, production is lost, and vice versa. This tradeoff, however, is mitigated by higher ability.

The first order condition for an interior solution is

$$\frac{\partial \lambda(u; \gamma)}{\partial u} u = -(\sigma - 1)\lambda(u; \gamma). \quad (7)$$

Let $u(\gamma)$ denote an optimal solution from (7). A simple comparative exercise yields the following results.

**Lemma 1**: Assume that the function $\lambda(u; \gamma)$ satisfies properties (a)–(d). Then,
(i) \( \frac{du(\gamma)}{d\gamma} > 0 \); Time allocated to managing production at the plant, \( u(\gamma) \), increases with ability \( \gamma \).

(ii) \( \frac{\partial \pi(u(\gamma);\gamma)}{\partial \gamma} > 0 \) and \( \frac{\partial \pi(u(\gamma);\gamma)}{\partial \omega} > 0 \); Profits increase in ability \( \gamma \) and plant quality \( \omega \).

(iii) \( \frac{\partial^2 \pi(u(\gamma);\gamma)}{\partial \gamma \partial \omega} > 0 \); Ability \( \gamma \) and plant quality \( \omega \) are complements in the profit function.

Proof: See Appendix.

5.3 Mergers and Acquisitions

This subsection describes one way the merger and acquisition process can work in this framework. In doing so, we employ a setting inspired by the structure in Jovanovic and MacDonald (1994), which was developed with the evolution of the U.S. tire industry in mind but also fits some stark patterns in our data.

We assume that an initial “basic” state of technological knowledge arrives which offers the possibility of entry by the industry’s first cohort of entrants. The “basic” nature of this initial technological knowledge is manifested in the low quality of plants, \( \omega_1 \), available for the first entry cohort. Later, at some time \( T \), there is an unanticipated jump in the state of technological knowledge (aka “refinement” in the Jovanovic-MacDonald model; this would be knowledge about ring spinning frames and imported raw cotton in our context). This is reflected in higher quality, \( \omega_2 > \omega_1 \), of plants available for new entrants after time \( T \).

Each entrant comes into the industry with some initial level of sales management ability, normalized to be equal to 1 for all cohorts. Producers from the early cohort, however, have an opportunity to develop this ability above and beyond the initial level. How much any given producer develops his ability before time \( T \) is a random process, but its outcome is that at time \( T \), when the second cohort enters the market, the first cohort’s ability is distributed with support \([1, \gamma_{\text{max}}]\).

Even though all entrants in the second cohort possess only the initial level of sales management ability, the quality of their plants is higher. We assume that this leads to a new market equilibrium where only plant owners in the first cohort whose ability exceeds a threshold level \( \gamma_e \in (1, \gamma_{\text{max}}) \) can remain in the industry, while those with ability below this threshold
have to exit. Thus, after time \( T \), the industry is comprised of a mixture of incumbents with (differentiated) high ability levels operating low-quality plants and new entrants with only basic ability but operating high-quality plants.

After time \( T \), an opportunity to negotiate a merger or acquisition arrives at a random rate, and plant owners are matched into negotiating pairs also randomly. It is clear that under the circumstances described above, whenever an acquisition actually occurs, it involves a higher-ability manager acquiring a plant managed by a lower-ability manager. Let a negotiating pair be formed between a manager with ability \( \gamma_H \) and a manager with ability \( \gamma_L \), where \( \gamma_H > \gamma_L \geq 1 \). By Lemma 1, we have \( \pi(\omega, \gamma_H) > \pi(\omega, \gamma_L) \). Therefore a manager with ability \( \gamma_H \) has potential incentive to acquire the plant of the manager with ability \( \gamma_L \) regardless of the plant’s quality. Also, the acquisition is more likely to be consummated if, in addition, the plant quality is high than if it is low. To see this more explicitly, note that the highest bid price is given by \( \delta \pi(\omega, \gamma_H) \), which is the profit that the manager with ability \( \gamma_H \) can obtain if he takes over this plant. The lowest asking price, on the other hand, is given by \( \pi(\omega, \gamma_L) \). Assuming that the actual price will be somewhere between, an acquisition will be consummated whenever

\[ \delta \pi(\omega, \gamma_H) > \pi(\omega, \gamma_L). \]  

Other things equal, Lemma 1(iii) implies that the potential gains from an acquisition will be higher when \( \omega \) is higher, so that plants owned by recent entrants (with quality \( \omega_2 \)) will indeed be more likely to be acquired than plants owned by first-cohort entrants (with quality \( \omega_1 \)).

Condition (8) also implies that for any plant quality, an acquisition is more likely to happen when a difference between \( \gamma_H \) and \( \gamma_L \) is large. Once again, this is more likely to happen when an incumbent (first-cohort) firm meets a new entrant (second-cohort) firm than when two incumbents meet. Also, since the ability level of new entrants never exceeds that of incumbents, new entrants never act as acquirers.  

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27 See Appendix for an explicit derivation of one such industry-wide equilibrium. In our data, 10 out of 21 firms that operated in the industry in 1887 had remained small and exited by shutting their plants.

28 The parameter \( \delta \in [0,1) \) captures any possible transfer costs (rent dissipation) associated with an acquisition.

29 In reality there were a few cases where new entrants acted as acquirers. A detailed examination of the data revealed, however, that in all such cases new entrants were actually “spinoffs” from the early entry cohort, that is, they were founded by entrepreneurs with previous experience in incumbent firms. It is well known that such spinoff entrants tend to inherit the ability of their parent firms (see e.g., Klepper and Simons, 2000), so such cases actually
We summarize the empirical predictions implied by this discussion in Proposition 1.

Proposition 1: In any acquisition, a higher-ability plant owner acquires a plant managed by a lower-ability plant owner. Higher-quality plants are more likely to change ownership than lower-quality plants. Together, these imply that the most common acquisition pattern will be an high-ability early entrant with a relatively aged plant acquiring a more recent entrant with lower ability but a newer plant.

5.4 Implications for Productivity and Profitability

We now derive implications of the merger and acquisition process outlined above for productivity and profitability of acquired plants. These implications are consistent with the patterns documented in our empirical analyses in Section 4.

To discuss the implications for productivity, note that a plant’s TFPQ can be defined as

\[ TFPQ \equiv \frac{\nu}{x} = \omega u(\gamma). \]  

This measure of productivity is predicated on the notion that manager’s optimal time allocation is not directly observed by an econometrician.

Lemma 1(i) implies that, for a given \( \omega \), TFP will increase with the acquiring firm manager’s ability \( \gamma \). Proposition 1 says that a higher-ability manager acquires a plant managed by a lower-ability manager. Thus, we have the following.

Proposition 2: The productivity of an acquired plant rises after an acquisition.

Similarly, Lemma 1(ii) says that profits increase with manager’s ability. Combining it with Proposition 1, we have the following.

Proposition 3: The profits of an acquired plant increase after an acquisition.

The key intuition behind both Propositions 2 and 3 is that the new manager’s superior ability to manage sales allows him to increase the time allocated to managing the production facility without sacrificing (or even increasing) actual sales at any given price.

render additional support to our theory.
Corollary: Under suitable functional form restrictions on $\lambda(u;\gamma)$, the ratio of effective sales to output in a given plant increases following an acquisition, and its profitability increases by more than its TFPQ.\(^{30}\)

Proof: See Appendix.

We next derive implications that allow us to compare the pre-acquisition levels of productivity and profitability of acquired plants with those of acquiring plants. We first discuss profitability. Write the logarithm of the profit as

$$\ln[\pi(\omega, \gamma)] = (\sigma - 1) \ln \omega + \ln[\lambda(u(\gamma); \gamma)] + (\sigma - 1) \ln[u(\gamma)],$$

where we drop the constant term containing $\sigma$. Combined with the first-order condition (7), the total derivative of this expression reduces to

$$d \ln[\pi(\omega, \gamma)] = (\sigma - 1) \frac{1}{\omega} d\omega + \varepsilon_{\lambda\gamma} \frac{1}{\gamma} d\gamma$$

(10)

where $\varepsilon_{\lambda\gamma} = \frac{\partial \lambda}{\partial \gamma}$. The first term in (10) captures the effect of plant quality differential between acquired and acquiring plants on profitability, whereas the second term is the effect of managers’ ability differential on profitability.

If two incumbents are involved in a merger negotiation, the plant quality is the same, i.e., $d\omega = 0$. In this case, (10) immediately implies that the profit of the acquiring plant is higher in the pre-acquisition period than that of the acquired plant because the acquiring plant has a higher-ability owner; i.e., $d\gamma > 0$ and $\varepsilon_{\lambda\gamma} > 0$. When the acquired plant is owned by a new entrant, on the other hand, the acquiring plant’s quality is lower than the acquired plant’s quality; i.e., $d\omega < 0$. Therefore, the relative pre-acquisition profits depend on whether the plant quality effect dominates the manager’s ability effect. From equation (10), a sufficient condition for the pre-acquisition profitability of the acquiring plant to be higher than that of the acquired plant is

$$\frac{\omega_1}{\omega_2} > \delta^{\frac{1}{\sigma-1}},$$

since equation (8) implies that $\varepsilon_{\lambda\gamma} \frac{1}{\gamma} d\gamma \geq -\ln\delta$. Furthermore, (10) shows that managerial ability effects are increasing with the ability differential between acquired and acquired plants.

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\(^{30}\) The example above shows that this property holds for some simple and reasonable functional forms and, as shown in the next section, this appears to be the empirically relevant case. We have not yet been able to establish Corollary 1 for a general function form satisfying properties (a)–(c) above, and we suspect that it may not be true in general.
acquiring plants, so incumbents who have developed large enough ability to deal with sales will be more profitable than their target plants even though their plant’s quality may be considerably lower.

To summarize, the profit of the acquired plant is lower than that of the acquiring plant before acquisition in all acquisitions involving two incumbents. When an incumbent is matched with a new entrant, the profit of the acquired plant is lower than that of the acquiring plant either if \( \omega_1/\omega_2 > \delta \frac{1}{\sigma - 1} \), or if the acquirer’s sales ability is high enough.

Similarly, we can write the total derivative of the logarithm of TFPQ to compare pre-acquisition levels of productivity:

\[
dln[TFPQ(\omega, \gamma)] = \frac{1}{\omega} d\omega + \varepsilon_{u\gamma} \frac{1}{\gamma} d\gamma
\]

where \( \varepsilon_{u\gamma} = \frac{du}{d\gamma} \). Again, the sign of equation (11) is determined by two opposing effects, and the basic relation in (11) is similar to the relation in (10).

To connect pre-acquisition level of profitability with pre-acquisition level of TFPQ, we can use the fact that \( \pi = \sigma^{-\sigma}(\sigma - 1)(\sigma - 1)\lambda \) and obtain the following relationship:

\[
dln[\pi(\omega, \gamma)] = (\sigma - 1) dln[TFPQ(\omega, \gamma)] + dln[\lambda(u(\gamma); \gamma)],
\]

which can be written as

\[
dln[\pi(\omega, \gamma)] = (\sigma - 1) dln[TFPQ(\omega, \gamma)] + \frac{1}{\gamma} [\varepsilon_{\lambda u} \varepsilon_{u\gamma} + \varepsilon_{\lambda \gamma}] d\gamma,
\]

where \( \varepsilon_{\lambda u} = \frac{\partial \lambda}{\partial u} \). Note that \( \varepsilon_{\lambda u} < 0 \), \( \varepsilon_{u\gamma} > 0 \), and \( \varepsilon_{\lambda \gamma} > 0 \). Thus equation (12) indicates that it is possible that \( dln[\pi(\omega, \gamma)] \) is strictly positive but \( dln[TFPQ(\omega, \gamma)] \) can be zero or negative when ability effects are sufficiently large, i.e., the term \( \varepsilon_{\lambda \gamma} \) is sufficiently large. We then have

**Proposition 4**: Under suitable parametric restrictions, pre-acquisition TFPQ of an acquiring plant can be lower than that of an acquired plant even if pre-acquisition profitability of an acquiring plant is higher than that of an acquired plant.

This property is consistent with the empirical patterns we saw in our data and it is in sharp contrast to the assortative matching theory of mergers and/or Q-theory of merger.

To illustrate that the empirical patterns in our empirical analysis can be consistent with
the mechanism outlined above, we work through a simple numerical example of the model in the appendix.

We have shown how a managerial time allocation decision, in the presence of heterogeneous quality managers and plants, can yield the empirical patterns document above. We note again, however, that other possible mechanisms may be able to tie demand management to productivity and profitability levels and changes through acquisition. Further, we do not have data on owner/managers’ time allocations, so we cannot test the model directly. Nonetheless, the theoretical framework outlined in this section offers a concrete example against which both the data and other theories can be compared.

6. Discussion and Conclusions

To be written.
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Figures, Tables and Appendix

Figure 1. Domestic output, import and export of cotton yarn (1887-1914)

Source: Nihon Choki Tokei Soran, our estimates.
Figure 2. Capacity dynamics of older, acquired, and newer plants

Source: Our estimates using the data described in Section 4 below. 31

31 “Older never acquired” represents plants that came into operation in 1902 or earlier and were never targets in an acquisition. “Newer never acquired” represents plants that started operating in 1908 or later and had not been acquired by 1920. “Acquired plants” is the total capacity of those plants (regardless of whether they had been acquired or not yet), while the dashed line is the capacity of those that had already gone through at least one acquisition.
Figure 3. Ownership concentration in three largest firms

Note: The figure depicts the evolution of the fraction of plants owned by the three largest firms in 1920 (Kanebo, Toyobo, Dainippon Boseki) and these plants’ capacity and output as a fraction of the industry total. Toyobo data include that of its predecessor firms (Osaka Boseki and Mie Boseki) prior to their 1914 merger. Dainippon Boseki includes the data of its predecessor firms (Amabo and Settsu Boseki) prior to their 1918 merger.
Table 1. Number of acquired plants by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of acquired plants</th>
<th>Fraction of total</th>
<th>Of which: acquired by largest acquirers</th>
<th>Fraction of total number of acquisitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1896</td>
<td>0</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1897</td>
<td>0</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1898</td>
<td>1</td>
<td>0.012</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1899</td>
<td>5</td>
<td>0.060</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1900</td>
<td>7</td>
<td>0.085</td>
<td>3</td>
<td>0.429</td>
</tr>
<tr>
<td>1901</td>
<td>1</td>
<td>0.012</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1902</td>
<td>2</td>
<td>0.025</td>
<td>1</td>
<td>0.500</td>
</tr>
<tr>
<td>1903</td>
<td>15</td>
<td>0.188</td>
<td>7</td>
<td>0.467</td>
</tr>
<tr>
<td>1904</td>
<td>2</td>
<td>0.025</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1905</td>
<td>3</td>
<td>0.038</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1906</td>
<td>5</td>
<td>0.062</td>
<td>3</td>
<td>0.600</td>
</tr>
<tr>
<td>1907</td>
<td>11</td>
<td>0.136</td>
<td>6</td>
<td>0.545</td>
</tr>
<tr>
<td>1908</td>
<td>2</td>
<td>0.025</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1909</td>
<td>1</td>
<td>0.011</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1910</td>
<td>1</td>
<td>0.012</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1911</td>
<td>6</td>
<td>0.069</td>
<td>4</td>
<td>0.667</td>
</tr>
<tr>
<td>1912</td>
<td>5</td>
<td>0.057</td>
<td>2</td>
<td>0.400</td>
</tr>
<tr>
<td>1913</td>
<td>0</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1914</td>
<td>0</td>
<td>0.000</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1915</td>
<td>4</td>
<td>0.038</td>
<td>2</td>
<td>0.500</td>
</tr>
<tr>
<td>1916</td>
<td>5</td>
<td>0.048</td>
<td>2</td>
<td>0.400</td>
</tr>
<tr>
<td>1917</td>
<td>3</td>
<td>0.028</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1918</td>
<td>11</td>
<td>0.100</td>
<td>7</td>
<td>0.636</td>
</tr>
<tr>
<td>1919</td>
<td>3</td>
<td>0.026</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>1920</td>
<td>2</td>
<td>0.017</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>0.043</td>
<td>37</td>
<td>0.389</td>
</tr>
</tbody>
</table>

Note: Largest acquirers are Kanebo, Mie Boseki, Osaka Boseki, Settsu Boseki and Amabo. Excluding 15 plants that were consolidated in 1914 in the equal merger between Mie Boseki and Osaka Boseki.
Table 2. Future acquiring, acquired and exiting plants in 1896-97.

<table>
<thead>
<tr>
<th></th>
<th>Acquiring plants</th>
<th>Acquired plants</th>
<th>Exiting plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First cohort</td>
<td>Second cohort</td>
<td></td>
</tr>
<tr>
<td>TFPQ</td>
<td>Mean</td>
<td>0.016</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(0.184)</td>
<td>(0.226)</td>
</tr>
<tr>
<td>ROE</td>
<td>Mean</td>
<td>0.274</td>
<td>0.183</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(0.205)</td>
<td>(0.076)</td>
</tr>
<tr>
<td>Price (yen/400lb)</td>
<td>Mean</td>
<td>94.7</td>
<td>92.8</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(6.5)</td>
<td>(4.2)</td>
</tr>
<tr>
<td>Days in operation</td>
<td>Mean</td>
<td>311</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(65)</td>
<td>(29)</td>
</tr>
<tr>
<td>Equipment age</td>
<td>Mean</td>
<td>5.28</td>
<td>5.87</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(3.49)</td>
<td>(2.77)</td>
</tr>
<tr>
<td>Firm age</td>
<td>Mean</td>
<td>9.13</td>
<td>11.30</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td>(5.08)</td>
<td>(3.56)</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>32</td>
<td>33</td>
</tr>
</tbody>
</table>

Note: TFPQ (quantity-based total factor productivity) is estimated as residuals from the Cobb-Douglas production function using all available observations as described in the main text. ROE is return on equity, accounting profits divided by shareholders’ paid-in capital. Days in operation per year, equipment and firm age are measured in years. First cohort is plants of firms founded before 1890, second cohort is plants of firms founded in 1890 and after. Acquiring plants refer to plants belonging to future acquiring firms, exiting plants refer to plants belonging to future exiting firms (exiting not through acquisition) that will be scrapped.
Table 3. Within-acquired-plants comparisons of productivity, profitability and prices

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Log output</th>
<th>Log gross operating surplus rate</th>
<th>Log count-adjusted price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late pre-acquisition dummy</td>
<td>-0.017 (0.028)</td>
<td>0.000 (0.064)</td>
<td>-0.006 (0.030)</td>
</tr>
<tr>
<td>Early post-acquisition dummy</td>
<td>0.032 (0.033)</td>
<td>0.184** (0.078)</td>
<td>0.012 (0.035)</td>
</tr>
<tr>
<td>Late post-acquisition dummy</td>
<td>0.111** (0.048)</td>
<td>0.318*** (0.094)</td>
<td>0.007 (0.038)</td>
</tr>
<tr>
<td>Log spindles-days in operation</td>
<td>0.715*** (0.039)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log worker-days</td>
<td>0.248*** (0.037)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log capacity change</td>
<td>-0.090* (0.050)</td>
<td>-0.205* (0.108)</td>
<td>0.026 (0.031)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.076* (0.544)</td>
<td>2.311*** (0.043)</td>
<td>1.722*** (0.027)</td>
</tr>
</tbody>
</table>

| Plant fixed effects | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes |

Observations | 1,248 | 957 | 1,213 |
R-squared | 0.944 | 0.649 | 0.844 |

Note: The omitted category includes period three years or more prior to acquisition. Robust standard errors clustered at the plant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Table 4. Within-acquired-plants comparisons of productivity, profitability and prices: acquired by serial acquirers

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Log output</th>
<th>Log gross operating surplus rate</th>
<th>Log count-adjusted price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late pre-acquisition dummy</td>
<td>-0.009</td>
<td>0.034</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.075)</td>
<td>(0.032)</td>
</tr>
<tr>
<td>Early post-acquisition dummy</td>
<td>0.110*</td>
<td>0.442***</td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td>(0.084)</td>
<td>(0.070)</td>
</tr>
<tr>
<td>Late post-acquisition dummy</td>
<td>0.204**</td>
<td>0.601***</td>
<td>0.094</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
<td>(0.101)</td>
<td>(0.077)</td>
</tr>
<tr>
<td>Log spindles-days in operation</td>
<td>0.695***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.073)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log worker-days</td>
<td>0.245***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log capacity change</td>
<td>-0.140</td>
<td>-0.561***</td>
<td>-0.045</td>
</tr>
<tr>
<td></td>
<td>(0.114)</td>
<td>(0.194)</td>
<td>(0.051)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.775</td>
<td>1.031***</td>
<td>1.754***</td>
</tr>
<tr>
<td></td>
<td>(1.009)</td>
<td>(0.889)</td>
<td>(0.042)</td>
</tr>
</tbody>
</table>

| Plant fixed effects                      | Yes        | Yes                              | Yes                       |
| Year fixed effects                       | Yes        | Yes                              | Yes                       |
| Observations                             | 555        | 472                              | 530                       |
| R-squared                                | 0.930      | 0.644                            | 0.866                     |

Note: Serial acquirers are Kanegafuchi Boseki, Mie Boseki, Osaka Boseki, Settsu Boseki, and Amagasaki Boseki. The omitted category includes period three years or more prior to acquisition. Robust standard errors clustered at the plant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Table 5. Within-acquisition comparisons of productivity and profitability: acquired and incumbent plants.

<table>
<thead>
<tr>
<th></th>
<th>TFPQ</th>
<th>Log normalized GOS rate</th>
<th>TFPQ</th>
<th>Log normalized GOS rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All acquisitions</td>
<td>By serial acquirers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TFPQ</td>
<td>Log normalized GOS rate</td>
<td>TFPQ</td>
<td>Log normalized GOS rate</td>
</tr>
<tr>
<td>After acquisition</td>
<td>-0.064</td>
<td>0.005</td>
<td>-0.062</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>(0.052)</td>
<td>(0.034)</td>
<td>(0.067)</td>
<td>(0.040)</td>
</tr>
<tr>
<td>Acquired plant</td>
<td>-0.003</td>
<td>-0.202***</td>
<td>-0.019</td>
<td>-0.173***</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.051)</td>
<td>(0.061)</td>
<td>(0.063)</td>
</tr>
<tr>
<td>After acquisition x</td>
<td>0.126**</td>
<td>0.233***</td>
<td>0.175**</td>
<td>0.247***</td>
</tr>
<tr>
<td>Acquired plant</td>
<td>(0.060)</td>
<td>(0.056)</td>
<td>(0.074)</td>
<td>(0.066)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.027</td>
<td>0.095***</td>
<td>0.033</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>(0.048)</td>
<td>(0.030)</td>
<td>(0.061)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Acquisition dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1,512</td>
<td>1,319</td>
<td>1,093</td>
<td>936</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.163</td>
<td>0.493</td>
<td>0.189</td>
<td>0.202</td>
</tr>
</tbody>
</table>

Note: Serial acquirers are Kanegafuchi Boseki, Mie Boseki, Osaka Boseki, Settsu Boseki, and Amagasaki Boseki. TFPQ is estimated residual from the production function using all available data. GOS rate is gross operating surplus rate of the plant as defined in the main text, divided by industry-year average for each year. Robust standard errors clustered at the plant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Table 6: Within-acquisition inventory/output value ratio, fixed capital cost/output ratio, days in operation per year and capacity utilization rate comparisons.

<table>
<thead>
<tr>
<th></th>
<th>Logged inventory/output</th>
<th>Logged fixed capital cost/output</th>
<th>Days in operation per year</th>
<th>Capacity utilization rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>After acquisition</td>
<td>-0.414*** (0.103)</td>
<td>-0.064 (0.054)</td>
<td>5.925*** (2.229)</td>
<td>-0.004 (0.022)</td>
</tr>
<tr>
<td>Acquired plant</td>
<td>0.597*** (0.188)</td>
<td>0.258*** (0.067)</td>
<td>-11.093*** (2.950)</td>
<td>-0.060*** (0.013)</td>
</tr>
<tr>
<td>After acquisition x</td>
<td>-0.631*** (0.231)</td>
<td>-0.218*** (0.080)</td>
<td>11.468*** (3.709)</td>
<td>0.044** (0.018)</td>
</tr>
<tr>
<td>Acquired plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-4.714*** (0.179)</td>
<td>-1.824*** (0.165)</td>
<td>272.836*** (41.243)</td>
<td>0.701*** (0.098)</td>
</tr>
</tbody>
</table>

| Acquisition dummies | Yes                     | Yes                             | Yes                        | Yes                       |
| Year dummies        | Yes                     | Yes                             | Yes                        | Yes                       |
| Observations        | 732                     | 1,464                           | 1,564                      | 1,561                     |
| R-squared           | 0.624                   | 0.749                           | 0.285                      | 0.238                     |

Inventory/Output value ratio is the ratio of finished yarn, plus accounts accruable on the company balance, divided by the value of output produced (output, times plant-specific price). Unit fixed cost is the book value of fixed assets, multiplied by the interest rate, divided by count-adjusted output produced. The time period is up to 4 years prior to acquisition and up to 8 years after acquisition. Robust standard errors clustered at the plant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Table 7. Within-acquired plants comparisons of productivity, not including and including ability control functions

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variable: log output (adjusted for count).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late pre-acquisition dummy</td>
<td>-0.017, 0.002, -0.053</td>
</tr>
<tr>
<td></td>
<td>(0.028), (0.029), (0.033)</td>
</tr>
<tr>
<td>Early post-acquisition dummy</td>
<td>0.032, 0.011, -0.025</td>
</tr>
<tr>
<td></td>
<td>(0.033), (0.037), (0.045)</td>
</tr>
<tr>
<td>Late post-acquisition dummy</td>
<td>0.111**, 0.074, -0.002</td>
</tr>
<tr>
<td></td>
<td>(0.048), (0.050), (0.054)</td>
</tr>
<tr>
<td>Log spindles-days in operation</td>
<td>0.715***, 0.678***, 0.702***</td>
</tr>
<tr>
<td></td>
<td>(0.039), (0.066), (0.086)</td>
</tr>
<tr>
<td>Log worker-days</td>
<td>0.248***, 0.187***, 0.228***</td>
</tr>
<tr>
<td></td>
<td>(0.037), (0.041), (0.053)</td>
</tr>
<tr>
<td>Log capacity change</td>
<td>-0.090*, -0.085, -0.173*</td>
</tr>
<tr>
<td></td>
<td>(0.050), (0.060), (0.092)</td>
</tr>
<tr>
<td>Log fixed cost to output ratio</td>
<td>-0.165***</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
</tr>
<tr>
<td>Log inventory to output ratio</td>
<td>-0.075***</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.075*, 0.173, -0.742</td>
</tr>
<tr>
<td></td>
<td>(0.544), (1.006), (1.194)</td>
</tr>
<tr>
<td>Plant fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>Year fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1,248, 997, 572</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.944, 0.932, 0.942</td>
</tr>
</tbody>
</table>

The omitted category includes period three years or more prior to acquisition. Robust standard errors clustered at the plant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Appendix

A. Data Description

Our main data source is plant-level data collected annually by Japan’s prefectural governments. The collection of these data started in 1899, and until 1911 they were brought together and published nationally in a single source, the *Statistical Yearbook of the Ministry of Agriculture and Commerce* (Noshokomu Tokei Nempo). Even though the national government discontinued publishing these data after 1911, the subsequent data can still be found in prefectural statistical yearbooks. For this paper we have collected and processed all the available data between 1899 and 1920.

The plant-level annual data record inputs used and output produced by each plant in a given year in physical units. In particular, the data contain the number of spindles in operation, number of days and hours the plant operated, output of the finished product (cotton yarn) in physical units, the average count (measure of fineness) of produced yarn, the average monthly price per unit of yarn produced, the number of factory floor workers (subdivided into male and female workers), average daily wages separately for male and female workers, as well as the data on intermediate inputs, such as the consumption of raw cotton, type of engine(s) that powered the cotton spinning mill (steam, water, electrical or gas/kerosene), their total horsepower, etc.

We supplement the plant-level data from prefectural governments’ statistics by several other data sources. In particular, we employed the data containing the same variables as above collected at the firm level by the All-Japan Cotton Spinners’ Association (hereafter “Boren,” using its name’s abbreviation in Japanese) and published in its monthly bulletin (Geppo). Even though the data were collected at the firm- and not plant level, there were no acquisitions and mergers to speak of until 1898 and all but 2 firms were single-plant firms, so the data are usable for pre-acquisition plant-level comparisons. We thus converted monthly Geppo data for 1896-1898 to annual data and use these in our estimations alongside government-collected annual plant-level data for 1899 and beyond.

With regard to data reliability, past literature has concluded that “the accuracy of these published numbers is unquestioned.” (Saxonhouse, 1971, p. 41). Nevertheless, we scrutinized these numbers ourselves and found occasional, unsystematic coding errors as well as obvious typos. We then used the overlap between the government-collected annual plant-level data and the firm-level monthly data published in Geppo to cross-check the data for single-plant firms. In the vast majority of cases we found that the annual data in statistical yearbooks and the annualized monthly data corresponded very closely (the discrepancy, if any, did not exceed a few percentage points). We were also able to use annualized monthly data to correct above-mentioned coding errors and typos in annual plant-level data in a significant number of cases. In the end, we have not been able clean the annual plant-level data.
in just about 5 percent of the total number of observations. We elected to drop such observations from our analysis.\footnote{To the best of our knowledge, we were the first to conduct this comprehensive cleaning of published plant-level records for the Japanese cotton spinning industry for 1896-1920. Our cleaned plant-level data tables and the details of the procedure outlined above are available upon request.}

Each plant in the records is associated with the firm that owned it in a given year, making it possible to directly compare the plant’s physical (quantity) productivity before and after the change in ownership. This feature makes our data particularly attractive for analyzing plant productivity changes following ownership and/or management turnover.\footnote{See Foster et al. (2008) and Syverson (2011) for the discussion of the importance of separating quantity and revenue productivity and the difficulties encountered by researchers trying to do it using conventional data that contain sales, values of inputs and prices but not direct evidence on the quantity of inputs and outputs.} We also collected actual stories surrounding each acquisition and ownership turnover case, including but not limited to identities and backgrounds of the most important individuals involved (shareholders, top managers and engineers). Several data sources made this possible. First, 80 percent or more of the Japanese cotton spinning firms (and all significant firms) were public (joint stock) companies, obligated to issue shareholders’ reports every half a year. Copies of these reports were also sent to Boren’s headquarters in Osaka and those of them that have survived until the present day are currently hosted in the rare books section of Osaka University library. With the permission from the library we have photocopied the total of 1,292 reports on 149 firms, all what was available for the period from the early 1890s until 1920.\footnote{While some of these company reports had been used in previous research by Japanese historians, we were the first to systematically digitalize them. The Osaka University library plans to launch a web site that will make our digital copies available in the public domain in the near future.} Each report, in particular, contains a list of all shareholders and board members of the company issuing it, making it possible to see whether shareholders or top management teams had already been substantially overlapping even prior to the formal acquisition event and what were the new positions (if any) of major shareholders and top managers of acquired firms in the new integrated firms. Company reports also contain detailed balance sheets and profit-loss statements as well as qualitative information about shareholders’ meetings, deaths, illnesses, resignations and replacements of board members and so on, which we use as appropriate.

We supplement these primary data sources by the information contained in the seven-volume history of the industry written in the 1930s by the Japanese historian Taiichi Kinugawa (Kinugawa, 1964). The book is basically a collection of chapters each of which is dedicated to a particular firm, describing its background, evolution and major personnel involved since the firm entered the industry; in its totality, the chapters cover all but a
few firms that entered the industry from its inception in the 1860s and until the beginning of the 20th century. While it appears that Kinugawa had access to the same company reports that we have (in particular, he cites as missing the same reports that we found missing in the Osaka University library), his book nevertheless provides us with a lot of additional insights because he was able to conduct interviews with many important individuals involved in those firms who were still alive at the time he wrote his book. Kinugawa also presents invaluable information about the background of most important shareholders and managers of each firm covered in his book as well as the storyline about how each firm was conceived.

Finally, we also used published company histories of firms that had survived until after World War II (some of them still surviving), although these are of less significance both because the information could be biased and because the level of detail is not nearly as great as in company reports or in Kinugawa’s history of the industry. Nevertheless, some qualitative information contained in those company histories proved to be usable and is used in this paper as appropriate.

While physical input and output data give us a unique chance to examine physical plant productivity as opposed to its revenue productivity, estimating the plant’s TFPQ still presented several challenges. First, even though cotton yarn is a relatively homogeneous product it still comes in varying degree of fineness, called “count.”

Output of cotton yarn in our data is measured in units of weight, but there is also information about the average count produced by a given plant in a given year. To make different counts comparable for the purpose of productivity analysis, we converted them to the standard 20th count using a procedure in which we first estimated coefficients on different count dummies in the production function regression, with (log) output measured in weight as the dependent variable, including also (logged) spindle and worker input and year dummies. We then used the estimated coefficients on count dummies to convert output of other counts to the 20th count (details are available upon request). We also conducted all our estimations in an alternative way, using output in weight units and including the average count as a separate regressor when estimating the production function and confirmed that the results were similar.

Second, the worker count data include blue-collar workers (by gender—male, “danko” and female,

35 The yarn count expresses the thickness of the yarn and its number indicates the length of yarn relative to the weight. The higher the count, the more yards are contained in the pound of yarn, so higher-count yarn is thinner (finer) than lower-count yarn. Producing higher-count (finer) yarn generally requires more skill and superior technology than producing lower-count (coarser) yarn. High-count yarn is often also improved further by more complex technological processes known as doubling, gassing, and so on, which were quite challenging for the fledgling Japanese cotton spinning mills to master at that time.
“joko”) but do not include white-collar workers (“shyain”). Hence, in our total factor productivity estimates, the residual should be interpreted as reflecting the managerial input in a broad sense, including the input of all white-collar personnel. As the data give us the number of male and female blue-collar workers separately, we used the plant-year-specific ratios of female to male wages to convert one unit of female labor to one unit of male labor.\(^{36}\)

Third, while we have direct measures of capital input in the data in the form of the number of spindles in operation, spinning frames are just one part of capital equipment which accounts for 25-30 percent of the total equipment cost of a mill (Saxonhouse, 1971, p. 55). Correlation between spindles and other equipment (cards, draw frames, slubbing frames, intermediate frames, roving frames, etc.) is, however, extremely high (over 95 percent), so “there is no question that spindles are a good proxy for equipment as a whole” (Saxonhouse, 1971, p. 56). We also have the data on the number of spindles installed in each plant in each year, which allows us to measure capacity utilization rates and follow any plant upgrades as the new equipment is installed.

Finally, when estimating the production function we followed Saxonhouse (1971 and 1977) and excluded intermediate inputs. The reason, already discussed by Saxonhouse, is that the coefficient of transformation of raw cotton into cotton yarn is almost fixed, at least when both input and output are measured in weight units (the raw correlation in our data is 0.95), so it renders all other inputs economically and statistically insignificant in the production function. Raw cotton can be added to inputs without running into this problem when output is adjusted for count but such a procedure would still be problematic because finer counts of cotton yarn are typically produced from higher-quality raw cotton (e.g., American or Egyptian cotton instead of Indian cotton) and we do not have plant-level data about the type of raw cotton used. Nevertheless, we did check the robustness of our estimates to including the raw cotton input (and also engine horse power) with output adjusted for count and confirmed that the results pertaining to total factor-productivity presented in this paper still hold, although the estimated magnitude of the coefficients is reduced by about one half (most of them still retain statistical significance, however).

B. An example of ownership turnover in our data

In August 1898, the shareholders of the decade-old struggling Onagigawa Menpu (Onagigawa Cotton

---

\(^{36}\) In the division of labor between sexes in Japanese cotton spinning mills, opening, mixing, carding, repairing and boiler room work were generally (although not exclusively) men’s jobs, while tending, drawing, roving and operating ring frames were generally women’s work (Clark, Cotton Goods in Japan, pp. 191-194, cited in Saxonhouse, 1971, p. 56). Using female to male wage ratios to aggregate the labor input assumes that wages reflect the marginal productivity of each sex. All our estimates are completely robust to using the number of male and female workers separately in the production function estimations.
Fabrics) company in Tokyo, Japan appointed a new board member. His name was Heizaemon Hibiya, a cotton trader and also founder and CEO of Tokyo Gasu Boseki (Tokyo Gassed Cotton Spinning) company, one of the more recent and successful high-tech entrants in the Japanese cotton spinning industry at the time. When Hibiya first toured the Onagigawa factory, he was reportedly in shock at what he saw. Workers brought portable charcoal stoves and smoked inside the plant. Women cooked and ate on the factory floor, strewing garbage. Cotton and other materials were everywhere, blocking hallways, while workers in inventory room gambled. Managerial personnel were out at a nearby river fishing (Kinugawa, 1964, Vol. 5).

Hibiya, who was promoted to company president in early 1899, wasted no time in introducing much needed change. All work-unrelated and hazardous activities on factory premises were immediately banned. Plant deputy manager tried to stir workers’ unrest and was quickly fired, together with the head of the personnel department and the chief accountant (an off-duty police officer was temporarily stationed inside the plant as a show of new management’s determination). But Hibiya did not stop at just introducing disciplinary measures. Even though he had another plant of his own to take care of, he and his right-hand man from Tokyo Gasu Boseki came to the Onagigawa factory and personally inspected equipment and checked output for defects on a daily basis, while also teaching workers how to do it on their own. During these visits, Hibiya reportedly engaged workers in conversations related to technology and production practices, taking questions, writing down those that he couldn’t answer immediately and coming back the next day with answers obtained from outside sources. Having determined that one reason for poor quality was that factory resources were spread too thinly, he concentrated production in just a few key areas, shutting down some workshops and switching from in-house production of finer counts of cotton yarn to procuring those from his other newer and more high-tech plant. Other measures included selling older equipment and purchasing more modern machines.

The above account reads remarkably similar to the description of the experiment in modern Indian textile industry conducted by Bloom et al. (2012). The results of Hibiya’s restructuring effort were also equally or perhaps even more impressive. Using our data described in detail below, we estimate that the plant’s TFP relative to the industry average more than doubled in the 3 years after Hibiya took over compared to 3 years before that while labor productivity (measured as output in physical units per worker-hours) increased on average by 70 percent. Over the same period, labor productivity in two other comparable plants in the same Tokyo area increased by just 6 percent. It is also worth noting that Hibiya was not part of an international aid effort; he was hired through an internal decision-making process of the shareholders, dishing out their own money.37

37 Hibiya’s story is typical of industrialization pioneers in Japan and shows how much it was a land of opportunity at the time. Born Kichijiro Ohshima, third child of the owner of a hotel in a small provincial town, the future
C. Examples of acquisition of underperforming and disrupted targets

Hakata Kinuwata, founded in 1896 by a local capitalist on Japan’s southernmost island of Kyushu was among relatively new entrants, in pursuit of its share of what appeared to be the ever-growing pie offered by the booming cotton spinning industry at the time. But its business did not go well from the outset and it soon found itself losing money and having to borrow heavily from banks. In February 1900 a revolt by shareholders led to the resignation of the founder and company president Seizo Ohta but things did not turn around. In December 1902 the company sold itself to Kanebo, which was actively expanding its presence in the Kyushu area, with Hakata Kinuwata shareholders taking a loss of about 50 percent on their invested capital (Kanegafuchi Boseki Kokajo, No. 32, 1902; Okamoto, 1993, pp. 307-308). Our plant-level data estimates show that following this acquisition, the labor productivity of the plant increased by 35 percent, while the TFP which had been about the same as industry average prior to acquisition exceeded it by 25-30 percent starting from the second post-acquisition year.

The acquisition of Nihon Boseki by Amagasaki Boseki in late 1915 presents a very different picture. The long-time CEO of Nihon Boseki was taken ill and had to resign in May 1915. His successor was also frail and started searching for an acquirer. In November 1915 the deal was struck with Amagasaki Boseki whose CEO Kyozo Kikuchi had been a board member of Nihon Boseki and long-term advisor to the company. Despite this, and despite the fact that Amagasaki Boseki was one of the most prominent firms in the industry (see above), the transition apparently did not go very smoothly.

Table A1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Output/worker</th>
<th>Relative TFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>5.834</td>
<td>0.069</td>
</tr>
<tr>
<td>1915</td>
<td>5.435</td>
<td>0.008</td>
</tr>
<tr>
<td>1916</td>
<td>3.240</td>
<td>-0.212</td>
</tr>
<tr>
<td>1917</td>
<td>2.853</td>
<td>-0.261</td>
</tr>
<tr>
<td>1918</td>
<td>3.499</td>
<td>-0.018</td>
</tr>
<tr>
<td>1919</td>
<td>4.004</td>
<td>0.039</td>
</tr>
</tbody>
</table>

Source: our estimates.

Heizaemon Hibiya was noticed by a cotton trader who stayed at the hotel when the boy was 13 and went to Tokyo to become the trader’s apprentice. At the age of 20 he was doing trades on his own. He went on to grow one the most successful cotton trading houses in the Tokyo area, while also playing a major role in several prominent cotton spinning and other firms and eventually becoming vice-chairman of the Tokyo Chamber of Commerce.
The above two examples are typical. They illustrate the fact that acquisitions happening for different reasons can have very different effects on plants' productivity even where the acquiring firms are technologically and managerially sophisticated top-notch firms such as Kanebo or Amagasaki.

**D. Proofs of Lemma 1 and Corollary**

**Proof of Lemma 1(i):** It follows from the first order condition that \( \frac{\partial \lambda(u; \gamma)}{\partial u} u(\gamma) = -(\sigma - 1) \lambda(u; \gamma; \gamma) \).

Differentiating this equation with respect to \( \gamma \) and rearranging yields

\[
\frac{du(\gamma)}{d\gamma} = -\frac{(\sigma - 1) \frac{\partial \lambda}{\partial \gamma} \frac{\partial^2 \lambda}{\partial \gamma \partial u} u}{\frac{\partial^2 \lambda}{\partial u^2} u + (\sigma - 1) \frac{\partial \lambda}{\partial u}} > 0.
\]

The denominator of the right hand side of the equation above is negative because of the second order condition. The numerator is negative because of the assumptions that \( \frac{\partial \lambda}{\partial \gamma} > 0 \) and \( \frac{\partial^2 \lambda}{\partial \gamma \partial u} \geq 0 \).

**Proof of Lemma 1(ii):** By the envelope theorem, we have

\[
\frac{\partial \pi(u; \gamma)}{\partial \gamma} = \mu(\omega; \sigma) \frac{\partial \lambda(u; \gamma)}{\partial \gamma} u \sigma^{-1} > 0.
\]

We also have

\[
\frac{\partial \pi(u; \gamma)}{\partial \omega} = \sigma^{-\sigma}(\sigma - 1) \omega \sigma^{-2} \lambda(u; \gamma) u \sigma^{-1} > 0.
\]

**Proof of Lemma 1(iii):** The results in Lemma 1(ii) immediately imply

\[
\frac{\partial^2 \pi(u; \gamma)}{\partial \gamma^2} = \sigma^{-\sigma}(\sigma - 1) \omega \sigma^{-2} \frac{\partial \lambda(u; \gamma)}{\partial \gamma} u \sigma^{-1} > 0.
\]

**Proof of the Corollary:** The total derivative of the logarithm of the profit function is given by

\[
d\ln[\pi(\omega, \gamma)] = (\sigma - 1) \frac{1}{\omega} d\omega + \varepsilon_{\lambda y} \frac{1}{\gamma} dy
\]

where \( \varepsilon_{\lambda y} = \frac{\partial \lambda}{\partial \gamma} \). Similarly, the total derivative of the logarithm of TFPQ is written as

\[
d\ln[TFPQ(\omega, \gamma)] = \frac{1}{\omega} d\omega + \varepsilon_{uy} \frac{1}{\gamma} dy
\]

where \( \varepsilon_{uy} = \frac{du}{dy} \). When an acquisition takes place, plant quality is held constant, i.e., \( d\omega = 0 \). If we impose the condition that \( \varepsilon_{\lambda y} > \varepsilon_{uy} \) on the functional form of \( \lambda \), then we have \( d\ln[\pi(\omega, \gamma)] > d\ln[TFPQ(\omega, \gamma)] \).

**E. A Numerical Example of the Model**

Assume that the function \( \lambda \) takes a particularly simple form \( \lambda(u; \gamma) = \gamma - u \) and set the value of model's parameters as follows: \( \omega_{\text{entrant}} = 1.5 \omega_{\text{incumbent}}, \delta = 0.5, \) and \( \sigma = 2 \). Thus, we assume that the quality of an entrant’s plant (potential target) is 50 percent higher than the quality of an incumbent’s plant (potential acquirer), and that the potential profit loss due to the acquisition is 50 percent. The entrants’ ability level is set to 1, \( \gamma_{\text{entrant}} = 1 \), and the surviving incumbent ability, \( \gamma_{\text{incumbent}} \), is uniformly distributed over the interval \([1.2, 2]\).
Under the assumptions above, profits are written as \( \pi = \frac{1}{4} \omega (\gamma - u) u \). The optimal choice of \( u \), the maximized profit, and TFPQ are given, respectively, by

\[
\begin{align*}
u^* &= \frac{1}{2} \gamma, \\
\pi(\omega, \gamma) &= \frac{1}{16} \omega \gamma^2, \\
\text{TFPQ}(\omega, \gamma) &= \frac{1}{2} \omega \gamma.
\end{align*}
\]

These equations show that Lemma 1 and Propositions 1 to 3 hold.

To see whether or not the Corollary holds, note that \( \ln \pi(\omega, \gamma) = \ln \frac{1}{16} + \ln \omega + 2 \ln \gamma \) and \( \ln \text{TFPQ}(\omega, \gamma) = \ln \frac{1}{2} + \ln \omega + \ln \gamma \). Differentiating both equations with respect to \( \gamma \), we get

\[
\begin{align*}
\frac{\partial \ln \pi}{\partial \gamma} &= \frac{1}{2 \gamma}, \\
\frac{\partial \ln \text{TFPQ}}{\partial \gamma} &= \frac{1}{\gamma}.
\end{align*}
\]

In other words, a percentage change of profits is higher than a percentage change of TFPQ when a plant owner with higher ability acquires a plant managed by a lower ability owner.

To compare pre-acquisition levels of profitability and productivity, write \( d \ln \pi = \frac{1}{\omega} d \omega + 2 \frac{1}{\gamma} d \gamma \), and \( d \ln \text{TFPQ} = \frac{1}{\omega} d \omega + \frac{1}{\gamma} d \gamma \). In a discrete variable case, these equations can be written as

\[
\begin{align*}
\ln \pi_{\text{acquiring}} - \ln \pi_{\text{target}} &= \left(1 - \frac{\omega_{\text{target}}}{\omega_{\text{acquiring}}}\right) + 2 \left(1 - \frac{\gamma_{\text{target}}}{\gamma_{\text{acquiring}}}\right), \\
\ln \text{TFPQ}_{\text{acquiring}} - \ln \text{TFPQ}_{\text{target}} &= \left(1 - \frac{\omega_{\text{target}}}{\omega_{\text{acquiring}}}\right) + \left(1 - \frac{\gamma_{\text{target}}}{\gamma_{\text{acquiring}}}\right)
\end{align*}
\]

Recall that the acquisition takes place if

\[
\frac{\pi(\omega_{\text{target}} \gamma_{\text{acquiring}})}{\pi(\omega_{\text{target}} \gamma_{\text{target}})} = \left(\frac{\gamma_{\text{acquiring}}}{\gamma_{\text{target}}}\right)^2 \geq \frac{1}{\delta}
\]

Under the assumed parameter values, this inequality can be written as

\[
0.5 \leq \frac{\gamma_{\text{target}}}{\gamma_{\text{acquiring}}} \leq \sqrt{\frac{1}{\delta}} \approx 0.71
\]

Since the incumbents are a potential acquirer and the entrants are a potential target, a range of ability distribution of actual acquirers is determined by

\[
\frac{1}{\sqrt{\delta}} \approx 1.41 \leq \gamma_{\text{acquiring}} \leq 2
\]

Under the assumed parameter values, we have

\[
\begin{align*}
\ln \pi_{\text{acquiring}} - \ln \pi_{\text{target}} &= -0.5 + 2 \left(1 - \frac{\gamma_{\text{target}}}{\gamma_{\text{acquiring}}}\right) \geq 0, \\
\ln \text{TFPQ}_{\text{acquiring}} - \ln \text{TFPQ}_{\text{target}} &= -0.5 + \left(1 - \frac{\gamma_{\text{target}}}{\gamma_{\text{acquiring}}}\right) \leq 0
\end{align*}
\]

Hence, pre-acquisition TFPQ of an acquiring plant can be lower than that of an acquired plant even if pre-
acquisition profit of an acquiring plant is higher than that of an acquired plant.