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

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## Online 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 average number of hours per day 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 mergers or acquisitions 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 were unable to correct the annual plant-level data in about 5 percent of the total number of observations. We elected to drop such observations from our analysis.

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.

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, almost 90 percent 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 1,292 reports on 149 firms, all what was available for the period from the early 1890s until 1920.[1] Each report, in particular, contains a list of all shareholders and board members of the company issuing it. Company reports also contain detailed balance sheets and profit-loss statements.

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 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 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.

While physical input and output data give us a unique chance to examine physical plant productivity as opposed to its revenue productivity, estimating plant 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."[2] Output of yarn in our data is measured in units of weight, but the data record also 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 a standard 20th count using the following procedure. We first ran a regression using all the available data, with (logged) output in weight as the dependent variable, and the independent variables including (logged) spindle and worker inputs (measured as flows), year dummies and various yarn count dummies. Because some counts only have a few observations in the data, we aggregated these into 10 bins: lower than 10, 10-15, 16-18, 19-21, 22-26, 27-30, 31-40, 41-50, 51-60, and higher than 60. The results are presented in Table A1 below.

We then used the coefficients on count bin indicators from Table A1 to convert output to the 19th-21st count bin (90 percent of which is 20th count yarn) according to the formula

$$\widehat{y_i} = y_i * k \equiv y_i * \left(e^{-\beta_i}/e^{-\beta_4}\right),$$

where $y_i$ is output measured in weight and $\beta_i, i = 1, \dots 10$ , are the estimated coefficient on the

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[1] While some of these company reports had been used in previous research by Japanese historians, we were the first to systematically digitize 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.

[2] 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 and sells at a higher price per pound. Producing higher-count (finer) yarn generally requires better quality raw cotton as well as 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.

$i$th yarn count bin indicator above, with $\beta_4$ being the estimated coefficient on the 4th bin (19th-21st yarn count).

Table A1. Estimations used to convert output to a standard count

| | | | | | |
|---|---|---|---|---|---|
| Log spindle-days | 0.725*** | Year dummies: | | | |
| | (0.031) | 1897 | 0.078 | 1910 | 0.241*** |
| Log worker-days | 0.378*** | | (0.059) | | (0.056) |
| | (0.036) | 1898 | 0.065 | 1911 | 0.300*** |
| Yarn count “bin” dummies: | | | (0.053) | (0.060) | (0.052) |
| Counts 10-15 | -0.205 | 1899 | 0.107 | 1912 | 0.389*** |
| | (0.126) | | (0.080) | | (0.055) |
| Counts 16-18 | -0.231* | 1900 | 0.191*** | 1913 | 0.364*** |
| | (0.128) | | (0.058) | | (0.057) |
| Counts 19-21 | -0.362*** | 1901 | 0.094* | 1914 | 0.377*** |
| | (0.127) | | (0.057) | | (0.058) |
| Counts 22-26 | -0.559*** | 1902 | 0.159*** | 1915 | 0.424*** |
| | (0.131) | | (0.057) | | (0.057) |
| Counts 27-30 | -0.759*** | 1903 | 0.212*** | 1916 | 0.328*** |
| | (0.134) | | (0.056) | | (0.056) |
| Counts 31-40 | -0.978*** | 1904 | 0.141** | 1917 | 0.333*** |
| | (0.129) | | (0.059) | | (0.056) |
| Counts 41-50 | -1.035*** | 1905 | 0.288*** | 1918 | 0.315*** |
| | (0.133) | | (0.056) | | (0.057) |
| Counts 51-60 | -1.565*** | 1906 | 0.248*** | 1919 | 0.214*** |
| | (0.149) | | (0.059) | | (0.060) |
| Counts 61+ | -1.950*** | 1907 | 0.214*** | 1920 | 0.206*** |
| | (0.135) | | (0.060) | | (0.060) |
| | | 1908 | 0.262*** | | |
| | | | (0.057) | | |
| | | 1909 | 0.281*** | Constant | -2.233*** |
| | | | (0.057) | | (0.188) |
| | | Observations | | 2,063 | |
| | | R-squared | | 0.932 | |

Note: the dependent variable is logged output measured in weight. The omitted categories are yarn counts less than 10 and year 1896. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Second, the worker count data include factory operatives (“shokko,” divided by gender: male, “danko,” and female, “joko”) but do not include white-collar workers (“shokuin”). 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.[3] Following established practice in the literature (see, e.g., Takamura, 1971) we then divided

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[3] 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,

the aggregate number of work-days by two to account for the fact that most of the time, plants in our sample adopted a two-shift operations regime. 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, even though our data also contain records of the average number of hours plants operated per day in a given year, we elected to measure our inputs by worker- and spindle-days in the main specifications in this paper. As is well known, plants in Japan in this period operated in two shifts around or almost around the clock most of the time (e.g., Takamura, 1971), although occasionally the second shift would be suspended and the plant would operate only for half a day. Unfortunately, the information about average hours in operation reported in the annual plant-level data turned out to be rather inaccurate (in particular, there are large and apparently random discrepancies with the more accurate monthly firm-level data from firm reports in *Geppo*). We did repeat all the estimation below using the information on hours in operation and the results remained very much the same, with the impact of acquisitions on TFPQ even more strongly pronounced than reported in the main text.

### *B. An example of management turnover in our data*

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

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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.

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. (2013). The results of Hibiya's restructuring effort were also equally or perhaps even more impressive. Using our data, we estimate that the plant's TFPQ relative to the industry average more than doubled in the three years after Hibiya took over relative to the three years before, while labor productivity (measured as output in physical units per worker-hours) increased on average by 70 percent. By comparison, labor productivity in two other comparable plants in the same Tokyo area increased by just six percent over the same period. 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.[4]

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[4] 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 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.

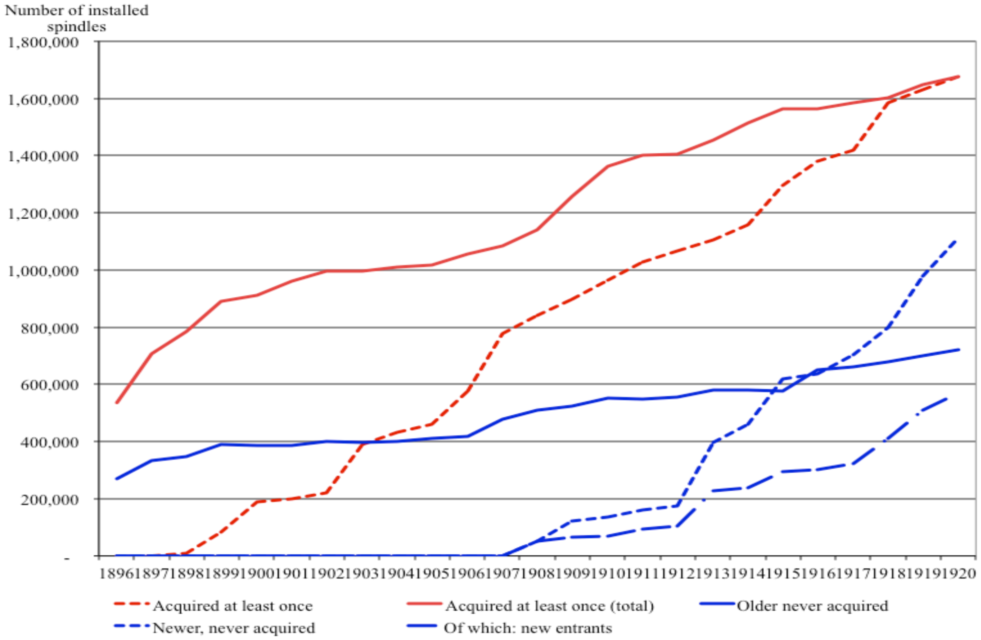
*C. Acquisitions over time and the concentration of ownership in 3 largest firms, 1898-1920.*

Table A2. Number of acquired plants by year

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

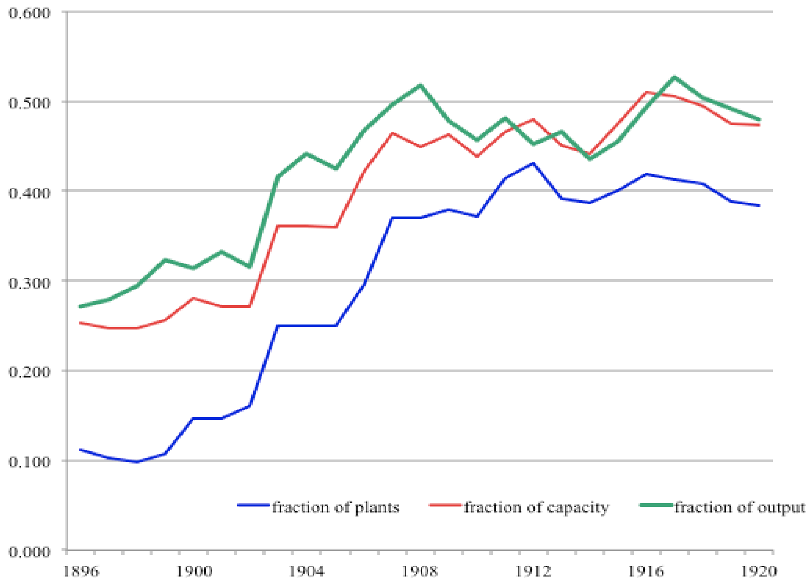
Note: The largest acquirers are Kanegafuchi Boseki, Mie Boseki, Osaka Boseki, Settsu Boseki and Amagasaki Boseki. Table excludes 15 plants that were consolidated in 1914 in the equal-basis merger of Mie Boseki and Osaka Boseki.

Figure A1. Capacity dynamics of older, acquired, and newer plants



Source: Our estimates. "Older never acquired" are plants that came into operation in 1902 or earlier and were never targets in an acquisition. "Newer never acquired" are plants that started operating in 1908 or later and had not been acquired by 1920. The solid line "Acquired at least once (total)" represents the capacity of acquired plants regardless of whether they had been acquired or not yet, while the dashed line "Acquired at least once" is the capacity of those that had already gone through at least one acquisition

Figure A2. Ownership concentration in three largest firms



Source: Our estimates. The figure depicts the evolution of the fraction of plants owned by the three largest firms in 1920 (Kanegafuchi Boseki, Toyo Boseki, Dainippon Boseki) and these plants' capacity and output as a fraction of the industry total. Toyo Boseki data include that of its predecessor firms (Osaka Boseki and Mie Boseki) prior to their 1914 merger, and Dainippon Boseki includes the data of its predecessor firms (Amagasaki Boseki and Settsu Boseki) prior to their 1918 merger.

*D. Evidence of capital vintage effects as reflected in machine characteristics*

We extracted data on a number of specific orders made by Japanese cotton spinning firms during our sample for capital equipment from British suppliers from the general file on worldwide orders from British manufacturers in 1879-1933 compiled by Gary Saxonhouse and archived at the ICSPR (Wright, 2011).[5] We used these data to measure the average values of numerous technical characteristics of the machines that were shipped in each year. These characteristics are (1) average spindle speed (sometimes highest and lowest speeds are also available but mostly the data are on average speed); (2) average (and also highest and lowest) count of cotton yarn to produce which the machine was designed for; (3) number of spindles per frame; (4) how many different types of raw cotton the machine was designed to work with (from 1 to 4); and (5) indicators equal to 1 if the machine was designed to work with Indian cotton and 0 otherwise, and the same for American and Egyptian cotton (the omitted category would be machines designed to work only with shorter-stapled Japanese or Chinese cotton).

This yielded a file of vintage-specific machine characteristics for each year in our data. We then merged this file with our main data file which contains vintage age of machines in all plants (calculated as the weighted average of spindle capacity installed in a given year; in practice we subtract one year from the year machines were equipped to allow for delivery and installation time). This makes it possible to assign average vintage-year characteristics (1)-(5) above to all individual plants in our data.

Table A3 shows the degree of technological progress in machine characteristics from an early vintage to a later vintage during the first waves of large-scale entry into the Japanese cotton spinning industry. Even though we have the data by each year, there are just a few orders until 1887, when they pick up (14 orders in 1887, 16 in 1888, and 11 in 1889). There are only 8 orders in 1890 and only 2 orders in 1891, but orders dramatically rise again staring in 1892. There were 14 orders in that year, 25 in 1893, 35 in 1894, 18 in 1895, 39 in 1896 and 24 in 1897. Despite this large number of observations, machine characteristics are remarkably similar throughout these later years, so we lump them all together into the single 1892-97 vintage (t-tests on mean differences across different subperiods within this period were all insignificant).

Table A3. Average machine characteristics by two vintages

| | Pre-1892 vintage | 1892-97 vintage |
|---|---|---|
| Spindle rotation speed (RPM x 1000) | 7.10 | 7.71 |
| Cotton yarn count designed for | 17.53 | 19.96 |
| Number of spindles per ring frame | 331.17 | 377.71 |
| Number of cotton types designed for | 1.06 | 2.47 |
| Designed for Indian cotton | 0.00 | 0.56 |
| Designed for US cotton | 0.04 | 0.44 |

The differences in average characteristics of the machines of pre- and post-1892 vintage are economically large and statistically significant at the 1 percent level. (Results are similar using 1890 or 1891 as the cutoff year instead.) Along all dimensions, the newer machines embody more technological capabilities. The greater spindle rotation speed means that the same number of spindles operating the same number of hours can produce more cotton yarn when employed at full speed. The differences in average speed over the period would allow output per operating spindle to increase by 6.4 percent. In addition to this there was an 11.4 percent increase in the count of cotton yarn machines are designed for, resulting in a total potential boost to count

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[5] We thank Patrick McGuire for helping us with these data.

adjusted output per spindle of 17.8 percent. The number of spindles per frame also increased by eight percent from the older to the newer vintage. Finally, the newer machines were more versatile. While older machines were almost exclusively designed to work with just one type of cotton (Japanese or Chinese), new machines could work with an average of 2.47 cotton types. Moreover, about half of the new machines were designed to work with Indian or US cotton as compared to virtually none of the older machines.

As already mentioned, second-cohort entrants had access to these new and better machines. However, many earlier entrants—especially those of them who later became our acquiring firms—also ordered new machines and gradually removed old machines from service. Therefore, the gap in machine quality between different firm types is not as dramatic as the difference in vintages may indicate, but it is still considerable, as shown in Table A4. The table follows the same format as Table 1 in the main text, but it shows differences in machine characteristics and therefore differences in potential rather than actual productivity across these categories (recall that these figures are computed for 1896-97, when no acquisition had yet taken place).

Comparing newer (second-cohort) future acquired plants to future acquiring plants, we can see that the average spindle rotation speed was about 3.3 percent higher among newer plants, while the count they were designed to produce was about 9.4 percent higher (both differences are statistically significant). Together, thus, potential increase in count-adjusted output due to machine superiority alone was 12.7 percent. The increase in the number of spindles per ring frame was a statistically significant 3.8 percent, and there are huge differences in machines' versatility (number of cotton types they can work with and the fraction designed to work with better-quality imported cotton). Again, as we saw in the main text, exiting plants are the worst on all aspects in these technical characteristics, which is reflected those plants' very old equipment age in Table 1 in the main text.

Table A4. Technical characteristics of machines by types of plants, 1896-97

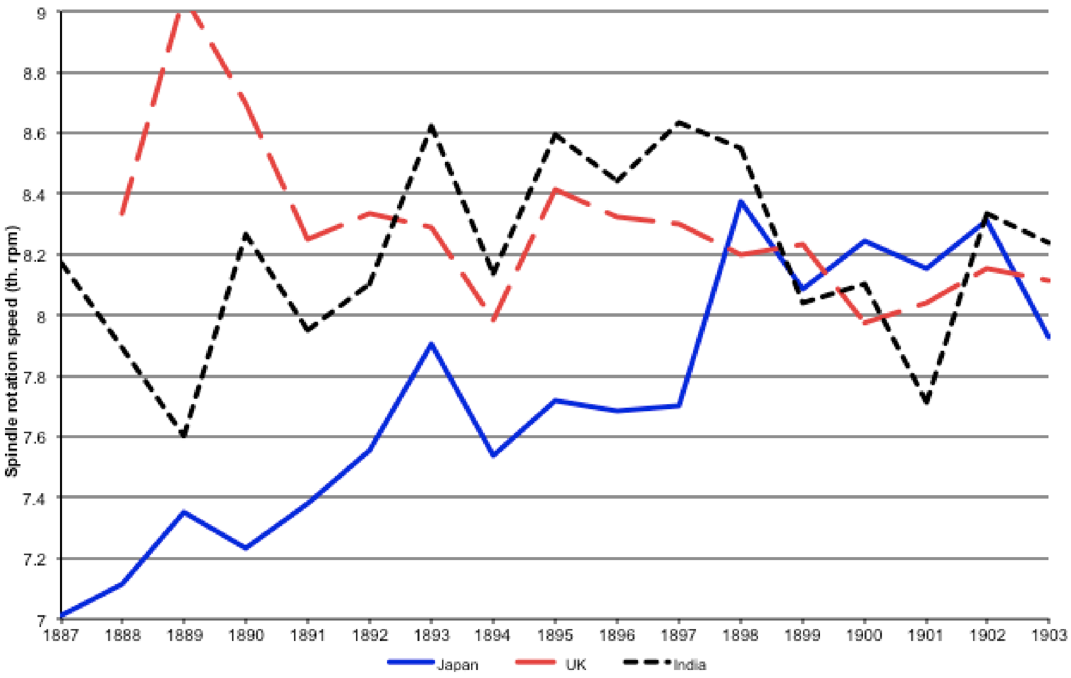
| | | Acquiring plants | Acquired plants | | Exiting plants |
|---|---|---|---|---|---|
| | | | First cohort | Second cohort | |
| Spindle rotation speed (RPM x 1000) | Mean | 7.46 | 7.44 | 7.70 | 7.01 |
| | (SD) | 0.33 | 0.29 | 0.14 | 0.33 |
| Cotton yarn count designed for | Mean | 18.57 | 18.35 | 20.32 | 17.80 |
| | (SD) | 1.46 | 1.87 | 2.24 | 0.84 |
| Number of spindles per ring frame | Mean | 362.85 | 357.01 | 379.92 | 314.69 |
| | (SD) | 28.16 | 33.43 | 8.60 | 47.46 |
| Number of cotton types designed for | Mean | 1.89 | 1.57 | 2.48 | 1.29 |
| | (SD) | 0.69 | 0.70 | 0.22 | 0.61 |
| Designed for Indian cotton | Mean | 0.32 | 0.17 | 0.59 | 0.11 |
| | (SD) | 0.30 | 0.25 | 0.15 | 0.25 |
| Designed for US cotton | Mean | 0.28 | 0.21 | 0.43 | 0.11 |
| | (SD) | 0.24 | 0.25 | 0.13 | 0.14 |
| Observations | | 32 | 31 | 38 | 23 |

Notes: See Table 1 in our main text.

Thus we have direct evidence of technological superiority of younger future acquired plants compared to future acquiring plants in those years. In the language of our model, the younger plants' $\omega$ was indeed higher (by perhaps 13-16 percent overall) than that of the acquiring plants. The fact that acquired plants didn't exhibit big TFPQ differences compared to acquiring plants before their acquisition (even though they did exhibit this difference in 1896-97, which were very good years for the industry without few worries about demand management) suggests that after the onset of industry-wide demand problems starting around 1898, these plants started squandering their potential productivity advantage. It was only regained after acquisition and the influence of new management.

It also appears that Japanese mills could import better quality machines starting in the 1890s due to endogenous innovative process in the Japanese industry itself, not because such machines had previously been unavailable. In Figure A3 we plot the dynamics of rotation speeds of machines (ring spindle frames) ordered by Japanese, UK and Indian mills from 1887 until early in the 20th century. As can be clearly seen from the Figure, in the 1890s machine speeds exhibit a pronounced upward trend only on Japanese orders, while speeds are basically unchanged in the UK (which represents the technological frontier) and increase only marginally in India (Japan's main Asian competitor at the time). As a result, Japan, which lagged behind both UK and India in the late 1880s-early 1890s, completely caught up with those two countries by 1898. We can thus see that the progress in technical characteristics of machines that we saw in Tables A3 and A4 above was not driven by exogenous technological progress at the frontier (which remains more or less constant, at least during the 1890s) but by Japan's catch-up to the frontier. This in turn was made possible by the penetration of longer-stapled Indian and U.S. raw cotton, a process that began in the early 1890s and was by and large completed by the end of that decade. Short-stapled domestically grown Japanese and imported Chinese cotton used by the industry prior to that required machines ordered by Japanese mills to be specially adapted and did not allow high rotation speeds because of frequent thread breaks (see Braguinsky and Hounshell, 2014, for more details).

Figure A3. Dynamics of rotation speeds on machine orders by Japanese, UK, and Indian mills (1887-1903), thousands RPM, ring spindle frames.



Source: our calculations based on Gary Saxonhouses' data (Wright, 2011).

### *E. Construction of plant-level profitability measure*

We construct a plant-level analogue to ROCE (return on capital employed) according to the following procedure. Output of cotton yarn, output price, and the number of male and female work-days as well as the corresponding daily wages are observed directly at the plant level. Capital cost is the sum of depreciation and the interest cost of debt. For deprecation, we use firm-level accounting data and apply a standard depreciation rate of five percent of fixed capital. We assign this to each plant in a multiple-plant firm proportionately to the plant's share of the firm's installed capacity. Interest costs are imputed for each plant as the plant's share of the firm's interest-bearing debt, multiplied by the economy-wide interest rate (proxied by the Bank of Japan discount rate), times 1.31. This multiplier is the coefficient on the economy-wide interest rate estimated from a firm-level regression of the ratio of firms' actual interest payments to their interest-bearing debt on the economy-wide interest rate and year dummies.

To complete the construction of plant-level ROCE, we also need a proxy for the margin on the gross value of output (parameter $\psi=1-\nu$ in the first decomposition equation (7) in the main text). To do so, we must estimate the cost of intermediate inputs (raw cotton) and other non-labor operation expenses (packing, shipping, engine fueling, etc.). Since there were also markets for yarn and raw cotton wasted in the production process and subsequently recovered, we also need to add the amount of sales of waste yarn and recovered waste cotton as those are the by-products of the spinning process.

The production of cotton yarn uses raw cotton in almost fixed proportion to output (the correlation coefficient between yarn output and raw cotton inputs, both measured in weight units, is 0.997). Data from profit-loss statements suggest that non-labor expenses were also a more or less constant fraction of sales. We thus assume a fraction of intermediate inputs and other operational expenses in the value of output to be a common parameter for all plants, and we calculate it from available firm-level profit-loss statements. Physical volume of waste yarn and recovered raw cotton are observed at the plant level, and we estimate the sales of these by-products by multiplying their quantities by their yearly market prices. The main parameters obtained in this way are presented in Table A5, and they lead to calculated value of $\psi = 0.15$. We employ this value in constructing plant-level ROCE measure and our first decomposition analysis.[6]

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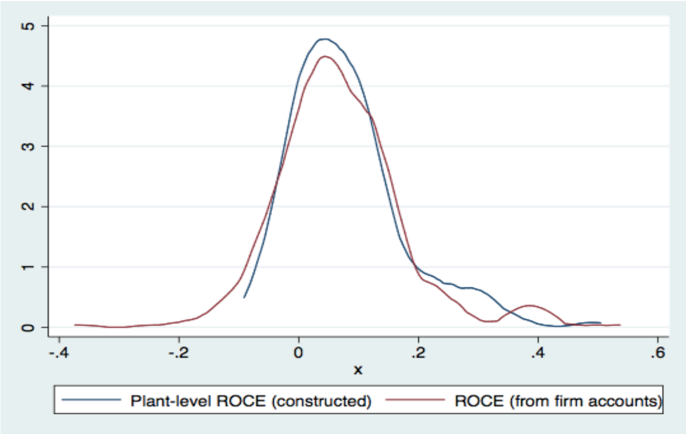
[6] While we assume these to be the same for all firms, it is possible that less successful future acquired firms may have had higher (non-wage) operating costs than future acquiring firms. Available data from company profit-loss statements do not, however, indicate that this was the case. Future acquired firms may have also faced higher interest rates on their borrowings than more successful future acquiring firms. Based on available data from company reports, we cannot reject this possibility; the ratio of interest payments to the amount of borrowing is indeed considerably (and statistically significantly) higher for target firms in pre-acquisition years than for the firms that eventually acquired them in the same years. The impact of this on our overall profitability differential measure is fairly small, but inasmuch as it is present, our plant-level ROCE measure would actually understate the profitability disadvantage of acquired plants relative to plants of acquiring firms. The decomposed differentials reported in the main text should therefore be considered lower bounds.

Table A5. Parameters in cost calculations

| | |
|---|---|
| Cotton input to output ratio | 1.162 |
| Relative cotton price | 0.677 |
| Waste yarn to output ratio | 0.012 |
| Relative waste yarn price | 0.294 |
| Recovered cotton to input ratio | 0.113 |
| Relative recovered cotton price | 0.438 |
| Net input cost to total output value ratio | 0.746 |
| Non-labor operating expenses rate | 0.105 |
| Margin before labor and capital cost | 0.150 |

The plant-level ROCE measure obtained in this way (and Winsorized at the top 2 percent) is highly correlated with firm-level ROCE measure available for pre-acquisition years; the coefficient of correlation is 0.7. Figure A4 plots the density of our constructed plant-level ROCE distribution and the corresponding firm-level ROCE from firm accounts in pre-acquisition years, and visually confirms that our measure of plant-level profitability is a reasonable proxy for profitability as reported in firm accounts.

Figure A4. Distributions of plant-level ROCE measure and ROCE from firm accounts (pre-acquisition years)



*F. Robustness Checks*

In this section we describe the details of the design and the results of robustness checks summarized in Section III.F of the main text.

We are interested in estimating the following parameters:

$$\beta_1 = \frac{1}{N_M}\sum_{i\in M}\left\{\frac{1}{\#m_i}\sum_{j\in m_i}\omega_j\left(y_{ja}^C - y_{jb}^C\right)\right\}, \tag{A1}$$

$$\beta_2 = \frac{1}{N_M}\sum_{i\in M}\left\{y_{ib}^A - \frac{1}{\#m_i}\omega_j\sum_{j\in m_i}y_{jb}^C\right\}, \tag{A2}$$

$$\beta_3 = \frac{1}{N_M}\sum_{i\in M}\left\{\left(y_{ia}^A - y_{ib}^A\right) - \frac{1}{\#m_i}\sum_{j\in m_i}\omega_j\left(y_{ja}^C - y_{jb}^C\right)\right\}, \tag{A3}$$

where $M$ is a set of matches, and acquired plant $i$ is matched with "comparison" plants to form match $m_i$. Outcome variables $y_{ib}^A$ are TFPQ and ROCE of acquired plant $i$ before an acquisition event, and outcome variables $y_{jb}^A$ are these variables after the acquisition event. Superscript C indicates the corresponding variables for comparison plants. $N_M$ is the total number of matches,

$\#m_i$ is the number of comparison plants within match $m_i$, and $\omega_j$ is a weight attached to the outcome variables, $y^C_{ja}$ and $y^C_{jb}$.

The parameters $\beta_1$, $\beta_2$ and $\beta_3$ can be estimated by

$$\bar{y}_{it} = \alpha_0 + \beta_1 AA_{it} + \beta_2 Acquired_{it} + \beta_3 Acquired_i \times AA_{it} + \mu_t + \varepsilon_{it}, \quad \text{(A4)}$$

where $\bar{y}_{it}$ is the outcome variable of plant *i* at time t if it belongs to a group of acquired plants. The outcome variables of comparison plants within the match $m_i$ are collapsed to $\bar{y}_{it} = \sum_{j\in m_i} \omega_j y_j$, the weighted average of outcomes of comparison plants within the match $m_i$. The variable $AA_{it}$ is a dummy equal to 1 if acquisition $m_i$ happened prior to year *t* and zero otherwise, while the variable $Acquired_i$ is equal to 1 if plant *i* is purchased in acquisition case $m_i$ and zero otherwise. $\mu_t$ is an acquisition-year fixed effect. The estimate $\hat{\beta}_3$ reflects the post-acquisition difference-in-difference between acquired and incumbent plants of acquiring firms by accounting for acquisition-case effects.

### *F.1 Production function coefficient estimates*

We use the De Loecker (2013) method to estimate the production function. The estimated coefficients on labor (work-days of factory operatives) and capital (spindle-days in operation) are 0.323 and 0.738, respectively, in our benchmark cubic specification. The estimated coefficients on labor are 0.265 in the linear specification and 0.287 in the non-parametric specification. The estimated coefficients on capital are 0.795 in the linear specification and 0.779 in the non-parametric specification.

### *F.2 Alternative TFPQ measures*

In the main text, we used TFPQ estimates obtained from a variant of the De Loecker (2013) method where the production function is approximated by a cubic polynomial. Here we report the results of a robustness check that uses TFPQ values obtained from four alternative production function estimation methods.

The first alternative measure uses De Loecker's approach but assumes the productivity control function $g(\omega_{it}, \mathbf{acq_{it}})$ is linear with respect to $\omega_{it}$. That is,

$$g(\omega_{it}, \mathbf{acq_{it}}) = \gamma_j \omega_{it} + \theta_1 lb\_acq_{it} + \theta_2 ea\_acq_{it} + \theta_3 la\_acq_{it}.$$

In the second measure, $g(\omega_{it}, \mathbf{acq_{it}})$ is specified semi-parametrically by including interaction terms between productivity and acquisition-related timing dummies. The third measure of TFPQ is the residuals from the simple OLS regression of the production function. The fourth approach follows the system GMM approach of Blundell and Bond (1998). Here, we do the two-step implementation of the Blundell and Bond estimator with two-period lags, treating the number of worker- and spindle-days as endogenous variables alongside with output, and generating GMM-style instruments for them. All these alternative approaches follow the main specifications in that they include year dummies, the change in log plant capacity from the previous year, and (logged) age of the plant's machines as additional variables.

### *F.3 Within-acquired plants estimations*

Table A6 presents the results of estimating within-acquired plants effects of Table 2 using the four alternative TFPQ measures. The two De Loecker method specifications produce results that are almost exactly the same as in the main text. Estimations using residuals from the OLS regression and using Blundell and Bond method (with two lags) lead to somewhat lower estimated effects of acquisitions on productivity, especially in the short run. This is entirely consistent with the fact that the De Loecker method is designed to correct for the fact that inputs may change systematically with events that shift productivity levels (acquisitions in our case). If input use rises during acquisition, as we observe in our data, then other approaches may attribute too much of any output growth to input use rather than productivity. That is likely why the OLS and Blundell-Bond approaches find smaller productivity effects immediately after the acquisition. The larger changes observed in the De Loecker estimates avoid this bias. The differences in the estimated TFPQ effects across the methods are smaller in the longer run, however, as much of plants' post-acquisition input utilization growth has occurred by that point.

Table A6. Within-acquired plants effects of acquisitions—alternative TFPQ methods

| | All acquisitions | | | |
|---|---|---|---|---|
| | Dependent variable: TFPQ | | | |
| | De Loecker | | OLS | Blundell-Bond |
| | Linear | Non-parametric | | |
| Late before acquisition | -0.005 | -0.004 | -0.041 | -0.027 |
| | (0.018) | (0.020) | (0.033) | (0.033) |
| Early after acquisition | 0.047* | 0.049* | 0.012 | 0.025 |
| | (0.026) | (0.028) | (0.042) | (0.036) |
| Late after acquisition | 0.126*** | 0.130*** | 0.092 | 0.076 |
| | (0.033) | (0.036) | (0.060) | (0.048) |
| Constant | 0.510*** | 0.682*** | 0.077 | 0.049 |
| | (0.033) | (0.035) | (0.045) | (0.040) |
| Observations | 1,078 | 1,078 | 1,151 | 1,026 |
| Adj. R-squared | 0.769 | 0.772 | 0.297 | 0.193 |

### *F.4 Same owner matching*

We construct two different matched samples to estimate equation (A4). In the first matched sample, which is the one we use in the main text, a match is made based on whether an incumbent plant of an acquiring firm belongs to the same owner who acquired plant *i*. Thus, comparison plants of acquired plant *i* are incumbent plants that had been managed by the same owner who acquired the plant *i*. We call this the "same owner matching" sample.

For this matched sample, we use two different weights to estimate (A4). In the main text, we use a simple weight by setting $\omega_j = 1$ for all $j$ so that all incumbent plants of an acquiring firm carry an equal weight. The other weight first calculates the Mahalanobis distance between an acquired plant and each incumbent plant using plant size, plant age, and plant location. We then generate a weight for an incumbent plant by using this distance and normal kernel. A larger weight is assigned to an incumbent plant similar to the acquired plant in terms of these variables.

Tables A7 and A8 report estimation results using this matched sample with different weighting schemes as above. For comparison, we also include results from the standard difference-in-difference estimation where we ignore matching altogether. Table A9 presents the estimation results using different measures of TFPQ as described in Section F.1 and simple weights (results using other types of weights are similar). All specifications include acquisition and calendar year fixed effects, as in the main text.

Tables A7-A9 indicate our results are robust to alternative weights and TFPQ measures.

Table A7: Estimation results from same owner matching, all acquisitions

| | Simple weights | | Kernel weights | | Standard DID estimation | |
|---|---|---|---|---|---|---|
| | TFPQ | Plant ROCE | TFPQ | Plant ROCE | TFPQ | Plant ROCE |
| After acquisition | -0.055*** | -0.004 | -0.050*** | -0.005 | -0.046*** | -0.004 |
| | (0.013) | (0.012) | (0.012) | (0.013) | (0.010) | (0.011) |
| Acquired plant | -0.025 | -0.030*** | -0.029 | -0.038*** | -0.032 | -0.028*** |
| | (0.021) | (0.011) | (0.022) | (0.011) | (0.020) | (0.009) |
| After acquisition x Acquired plant | 0.091*** | 0.040*** | 0.074*** | 0.038** | 0.092*** | 0.041*** |
| | (0.023) | (0.014) | (0.022) | (0.015) | (0.022) | (0.013) |
| Constant | 0.480*** | 0.145*** | 0.462*** | 0.144*** | 0.471*** | 0.143*** |
| | (0.034) | (0.018) | (0.024) | (0.018) | (0.027) | (0.018) |
| Observations | 1,487 | 1,392 | 1,208 | 1,124 | 1,487 | 1,392 |

Note: Robust standard errors clustered at the acquisition-case level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. These symbols apply to all the tables below.

Table A8: Estimation results from same owner matching, serial acquirers

| | Simple weights | | Kernel weights | | Standard DID estimation | |
|---|---|---|---|---|---|---|
| | TFPQ | Plant ROCE | TFPQ | Plant ROCE | TFPQ | Plant ROCE |
| After acquisition | -0.048*** | -0.012 | -0.049*** | -0.019 | -0.029*** | -0.006 |
| | (0.008) | (0.016) | (0.010) | (0.019) | (0.006) | (0.014) |
| Acquired plant | -0.032* | -0.032** | -0.035* | -0.046*** | -0.026 | -0.022* |
| | (0.017) | (0.013) | (0.018) | (0.014) | (0.017) | (0.011) |
| After acquisition x Acquired plant | 0.113*** | 0.058*** | 0.098*** | 0.057** | 0.108*** | 0.053*** |
| | (0.028) | (0.017) | (0.028) | (0.021) | (0.029) | (0.016) |
| Constant | 0.410*** | 0.069*** | 0.388*** | 0.083*** | 0.408*** | 0.060*** |
| | (0.008) | (0.013) | (0.018) | (0.014) | (0.009) | (0.011) |
| Observations | 1,067 | 994 | 822 | 764 | 1,067 | 994 |

Table A9: Estimation results from same owner matching, several TFPQ measures

| | All acquisitions and Simple weights | | | |
|---|---|---|---|---|
| | De Loecker | | OLS | Blundell-Bond |
| | Linear | Non-parametric | | |
| After acquisition | -0.059*** | -0.060*** | -0.064** | -0.053** |
| | (0.013) | (0.014) | (0.026) | (0.021) |
| Acquired plant | -0.030 | -0.028 | 0.004 | 0.036 |
| | (0.021) | (0.023) | (0.028) | (0.022) |
| After acquisition x Acquired plant | 0.098*** | 0.097*** | 0.094*** | 0.080*** |
| | (0.023) | (0.024) | (0.031) | (0.023) |
| Constant | 0.330*** | 0.463*** | -0.009 | 0.110** |
| | (0.034) | (0.035) | (0.123) | (0.054) |
| Observations | 1,487 | 1,487 | 1,537 | 1,467 |

### *F.5 Pre-acquisition characteristics and trend matching*

While matching on the same ultimate owner seems to be the most natural procedure in our case, we also created an alternative matched sample to estimate equation (A4) by forming matches based on whether a non-acquired plant is similar to acquired plant *i* in terms of pre-acquisition characteristics or pre-acquisition trends of outcome variables. To construct this matched sample, we first specify a group of non-acquired plants that could be potentially matched with each acquired plant. Potential non-acquired plants include all those plants that were owned by acquiring firms and were never acquired themselves, but also include plants of firms that did not participate in the acquisition process at all as well as plants that were acquired during the sample but at a time that is sufficiently removed from the event for which they serve as a control.[7]

We calculate the Mahalanobis distance between a particular acquired plant and each non-acquired plant using two sets of variables. One includes the pre-acquisition plant size, plant age, and plant location. The other set includes average pre-acquisition TFPQ growth and ROCE growth. A small distance value indicates that an acquired plant and a non-acquired plant are similar with respect to pre-acquisition TFPQ and ROCE growth rates. A non-acquired plant is included in a particular match only if its distance is below the median of the overall sample.[8] We use the simple weight (i.e., $\omega_j = 1$) for this estimation.

Tables A10, A11, and A12 present estimation results using this matched sample. Again, the main results are robust to alternative matching criteria and alternative measures of TFPQ.

Table A10: Estimation results from pre characteristics and trend matching, all acquisitions

| | Matching Criteria | | | |
|---|---|---|---|---|
| | Plant age, size, location | | TFPQ growth rate | Plant ROCE growth rate |
| | TFPQ | Plant ROCE | TFPQ | Plant ROCE |
| After acquisition | -0.053*** | -0.007 | -0.042*** | 0.020*** |
| | (0.010) | (0.007) | (0.011) | (0.007) |
| Acquired plant | -0.007 | -0.029*** | 0.009 | -0.034*** |
| | (0.021) | (0.011) | (0.026) | (0.010) |
| After acquisition x | 0.078*** | 0.038*** | 0.065** | 0.032** |
| Acquired plant | (0.024) | (0.012) | (0.024) | (0.013) |
| Constant | 0.332*** | 0.039*** | 0.402*** | 0.087*** |
| | (0.021) | (0.005) | (0.081) | (0.022) |
| Observations | 9,680 | 7,966 | 8,640 | 4,687 |

---

[7] More specifically, acquired plants in 3 years prior to and 5 years after their own acquisition events are excluded. A plant was also excluded when it does not have any usable observations before or after the acquisition event.

[8] We used other cutoff values such as the mean and lower quartile for this estimation, and the results remained unchanged qualitatively.

Table A11: Estimation results from pre characteristics and trend matching, serial acquirers

| | Matching criteria | | | |
|---|---|---|---|---|
| | Plant age, size, location | | TFPQ growth rate | Plant ROCE growth rate |
| | TFPQ | Plant ROCE | TFPQ | Plant ROCE |
| After acquisition | -0.048*** | -0.006 | -0.045*** | -0.009 |
| | (0.009) | (0.009) | (0.009) | (0.010) |
| Acquired plant | 0.019 | -0.015 | 0.030 | -0.028* |
| | (0.018) | (0.014) | (0.032) | (0.014) |
| After acquisition x Acquired plant | 0.092*** | 0.041*** | 0.089** | 0.045** |
| | (0.031) | (0.015) | (0.032) | (0.017) |
| Constant | 0.329*** | 0.039*** | 0.292*** | 0.065*** |
| | (0.006) | (0.005) | (0.016) | (0.014) |
| Observations | 6,197 | 5,086 | 5,155 | 3,050 |

Table A12: Estimation results from pre characteristics and trend matching, several TFPQ measures

| | Matching criteria: Plant age, size, location | | | |
|---|---|---|---|---|
| | Dependent variable: TFPQ | | | |
| | De Loecker | | OLS | Blundell-Bond |
| | Linear | Non-parametric | | |
| After acquisition | -0.054*** | -0.057*** | -0.052*** | -0.036*** |
| | (0.010) | (0.010) | (0.016) | (0.012) |
| Acquired plant | -0.005 | -0.014 | -0.009 | 0.001 |
| | (0.021) | (0.023) | (0.022) | (0.018) |
| After acquisition x Acquired plant | 0.079*** | 0.082*** | 0.084*** | 0.059*** |
| | (0.024) | (0.025) | (0.028) | (0.020) |
| Constant | 0.180*** | 0.307*** | 0.027 | -0.004 |
| | (0.022) | (0.025) | (0.111) | (0.032) |
| Observations | 9,680 | 9,680 | 9,989 | 9,469 |

### *F.6 Placebo test*

We also perform a placebo test as a further robustness check. We randomly assign acquisition status to plants in the sample and estimate how the outcome variables are related to this randomly generated acquisition status. Specifically, we use the same-owner matched sample and generate a random variable from the uniform distribution for each plant in the whole matched sample.[9] We assign an acquired plant status to a plant that obtained the maximum value within a particular match. We then estimate the parameters of specification (A4) by using all acquisition cases and simple weights. We repeat this procedure 1000 times, and calculate a sample mean of estimated coefficients from these 1000 simulations, and their standard errors.

Table A13 reports the results from this placebo test. The magnitudes of both the acquisition main effect and its interaction with the after-acquisition dummy approach zero and are economically insignificant.

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[9] The results are robust to using a pre-characteristics and trend matched samples.

Table A13: Placebo test

| | TFPQ | | | |
|---|---|---|---|---|
| | Mean | Std. Err | 95% Conf. Interval | |
| After acquisition | -0.0149 | 0.0003 | -0.0155 | -0.0143 |
| Acquired plant | -0.0010 | 0.0006 | -0.0023 | 0.0002 |
| After acquisition x Acquired plant | 0.0010 | 0.0006 | -0.0002 | 0.0022 |
| Constant | 0.4666 | 0.0003 | 0.4659 | 0.4672 |
| | Plant ROCE | | | |
| | Mean | Std. Err | 95% Conf. Interval | |
| After acquisition | 0.0139 | 0.0002 | 0.0135 | 0.0143 |
| Acquired plant | 0.0002 | 0.0003 | -0.0005 | 0.0009 |
| After acquisition x Acquired plant | 0.0000 | 0.0004 | -0.0008 | 0.0008 |
| Constant | 0.1364 | 0.0002 | 0.1360 | 0.1368 |

### *F.7 Direct estimation of within-acquired plants productivity changes using non-parametric function of the productivity process*

Table A14 presents the expected value of acquisition effects and of persistent effects of lagged productivities. In this estimation, we use our TFPQ measure and the cubic specification specified in equation (3). The estimation results in Table A14 are similar to the ones in Table 2, though late pre-acquisition dummy is now positive and statistically significant at the 5 percent significance level. Table A15 shows the distribution of marginal effects of acquisition dummies. In this estimation, we estimate acquisition effects non-parametrically, and compute its marginal effects, $\frac{\partial g}{\partial acquisition}$ for each acquisition dummy. Our estimation results show that the distribution of marginal effects shifts to the right after acquisition.

Table A14: Average of Marginal Effects from Parametric Estimation

| | Estimated Coefficient |
|---|---|
| Late pre-acquisition dummy | 0.023** |
| | (0.011) |
| Early post-acquisition dummy | 0.060*** |
| | (0.012) |
| Late post-acquisition dummy | 0.106*** |
| | (0.016) |
| Lagged productivity | 0.021 |
| | (0.230) |
| Lagged productivity squared | 0.690* |
| | (0.368) |
| Lagged productivity cubed | -0.361* |
| | (0.189) |
| Observations | 1,029 |

Note: Robust standard errors clustered at the acquisition-case level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. These symbols apply to all the tables below.

Table A15: Distribution of Marginal Effects from Non-parametric Estimation

| Moment | Late pre-acquisition | Early post-acquisition | Late post-acquisition |
|---|---|---|---|
| Mean | 0.032 | 0.067 | 0.113 |
| 10th pct | 0.015 | 0.061 | 0.095 |
| 25th pct | 0.016 | 0.062 | 0.098 |
| 50th pct | 0.022 | 0.063 | 0.109 |
| 75th pct | 0.039 | 0.067 | 0.127 |
| 90 pct | 0.066 | 0.075 | 0.137 |
| Observations | 219 | 216 | 477 |

### *G. Decline in total input to total asset ratios in later post-acquisition years*

As mentioned in the main text, the decline in the input-to-asset ratio in the late post-acquisition period (see Table 5) is not a result of less utilization of available physical plant capacity. It instead reflects a sharp increase in total assets due to retained earnings. Table 5 indicates the ratio of physical plant capacity to those total assets that declines in late post-acquisition years, not physical capacity utilization rates. To see this more clearly, in Table A16 we further decompose the logged ratio of physical plant capacity to total assets from Table 5 into the sum of (logged) ratio of total input to plant (spindle) capacity, and the (logged) ratio of plant spindle capacity to total capital employed.

We can see from Table A16 that the six-percent drop in the total input to capital employed ratio from early to late post-acquisition period is entirely accounted for by the drop in the ratio of plant capacity to capital employed ratio. To explore this issue more deeply, we looked at changes in the composition of balance sheets of acquiring firms in our sample.

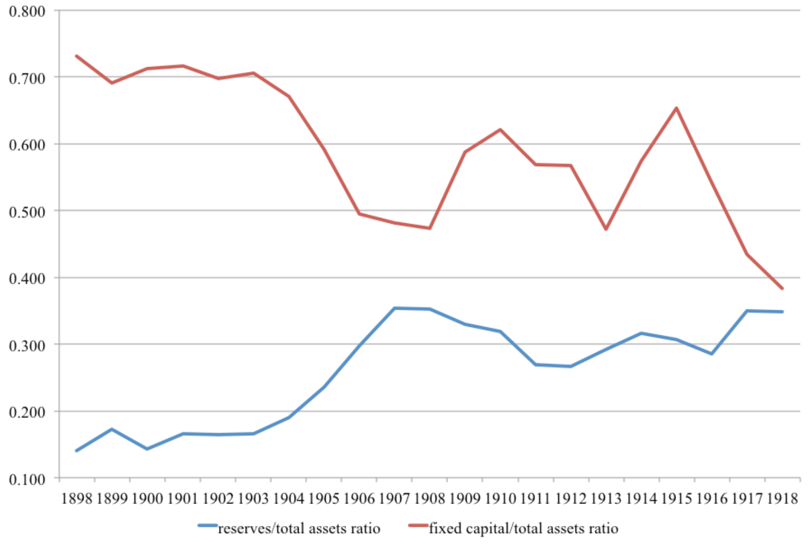
Figure A5 shows that starting in the middle of the 20$^{th}$ century's first decade, there is a sharp increase in the share of reserves (retained earnings) on the debit side of the balance sheets of major acquiring firms. Correspondingly, there is also a pronounced decline in the share of fixed assets (land, buildings, machines and other equipment) in total assets on the credit side, compensated by higher liquidity in banking accounts as well as oftentimes large amounts of funds tied up in "production facilities expansion accounts" (that is, new fixed assets yet to be installed). As shown in Figure A1 above, capacity expansion which had been on hold for the first 8-10 years of our sample resumed towards the end of the first decade of the 20$^{th}$ century. Thus the decline in existing plants' capacity in the total assets amassed by acquiring firms simply reflects their rapid expansion (building of new plants and expanding old ones) financed mostly through accumulated retained earnings. Since late post-acquisition years in our sample coincide with this expansion period, decomposition results create an appearance of reduced capacity utilization towards later post-acquisition period. However, this does not mean that existing physical capacity of acquired plants was once again underutilized. In fact, directly measured capacity utilization rates (ratios of spindle-days in operation to total number of installed spindles, times 365) increase by 7.5 percent from pre- to early post-acquisition period and by 9.3 percent from pre- to late post-acquisition period, with both differences statistically significant at 1 percent level. These differentials are considerably higher than the total input/plant capacity ratio differentials in Table A16, and closely correspond to the differentials between our TFPQU and TFPQ measures reported in Table 6.

Table A16: Decomposition of plants’ total input to total capital employed ratios: incumbent and acquired plants and acquired plants pre- and post-acquisition

| Pre-acquisition means of logs | Acquired plants (A) | Incumbent plants (B) | Difference (B)-(A) | Percentage difference |
|---|---|---|---|---|
| Total input/capital employed | -0.883 | -0.627 | 0.256 | 29.2*** |
| Total input/plant capacity | -3.087 | -2.976 | 0.111 | 11.8*** |
| Plant capacity/capital employed | 2.204 | 2.349 | 0.145 | 15.6*** |
| Observations | 129 | 262 | | |
| **Pre- and early post- acquisition means of logs** | **Pre-acquisition (A)** | **Early post-acquisition (B)** | **Difference (B)-(A)** | **Percentage difference** |
| Total input/capital employed | -0.795 | -0.593 | 0.202 | 22.4*** |
| Total input/plant capacity | -3.059 | -3.018 | 0.041 | 4.2$^{\#}$ |
| Plant capacity/capital employed | 2.264 | 2.425 | 0.161 | 17.5*** |
| Observations | 157 | 157 | | |
| **Pre- and late post- acquisition means of logs** | **Pre-acquisition (A)** | **Late post-acquisition (B)** | **Difference (B)-(A)** | **Percentage difference** |
| Total input/capital employed | -0.795 | -0.644 | 0.151 | 16.3*** |
| Total input/plant capacity | -3.059 | -3.007 | 0.052 | 5.4* |
| Plant capacity/capital employed | 2.264 | 2.363 | 0.099 | 10.4*** |
| Observations | 157 | 278 | | |

Note: The pre-acquisition time period includes observations on up to 4 years prior to acquisition. “Early post- acquisition” period includes 3 years immediately following acquisitions. “Late post-acquisition” period includes years starting from year 4 after acquisitions. ***, **, and * indicate that the corresponding difference is statistically significant at the 1 percent level, 5 percent level and 10 percent level, respectively, using a double-sided *t*-test; # indicates that the corresponding difference is statistically significant at the 10 percent level using a one-sided *t*-test.

Figure A5. Mean reserves to total liabilities and fixed capital to total assets ratios, eight major acquiring firms (1898-1918)



Source: calculated from firms’ financial reports

*H. In- and out-of-network firms distribution densities of ROCE, unrealized output rates, capacity utilization and prices*

Figures A6-A11 show the full density distributions of in- and out-of network firm characteristics, the means for which are presented in Table 8 in the main text.

Figure A6. TFPQ, 1898-1902

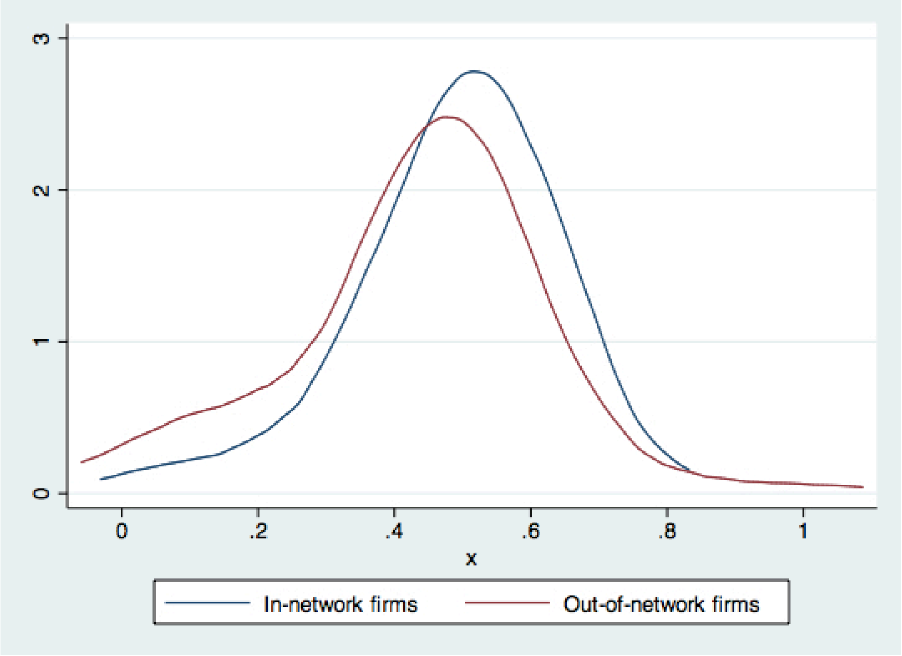


Figure A7. TFPQU, 1898-1902

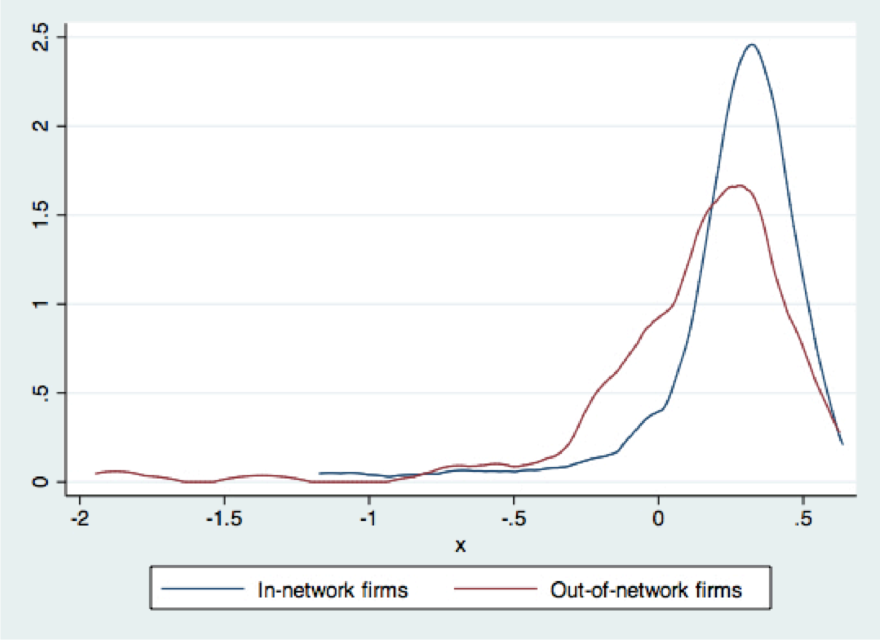


Figure A8. Return on capital employed, 1898-1902

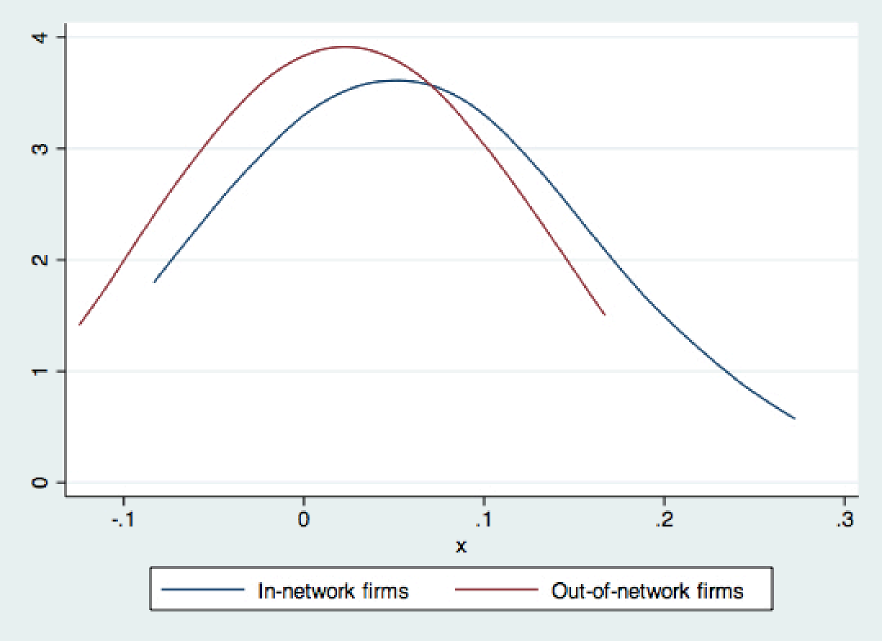


Figure A9. Unrealized output to produced output ratios, 1898-1902

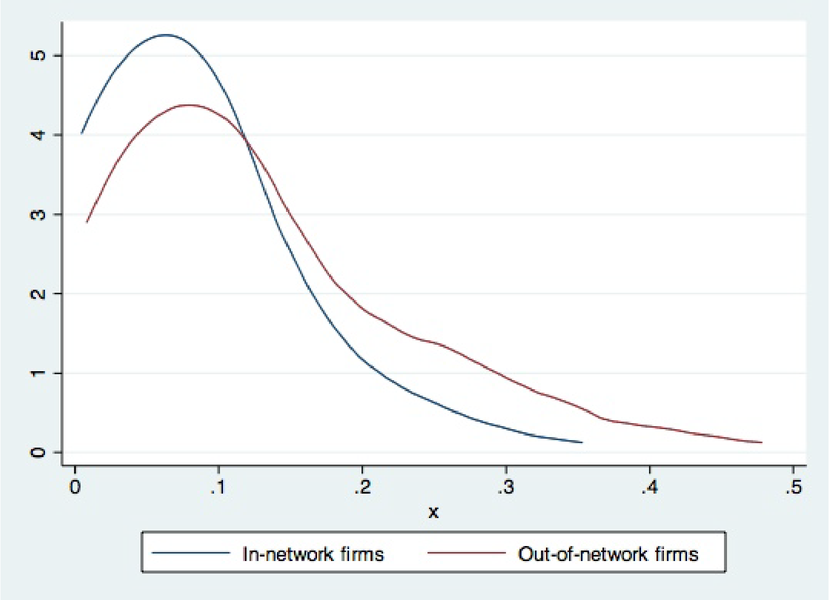


Figure A10. Spindle utilization rates, 1898-1902

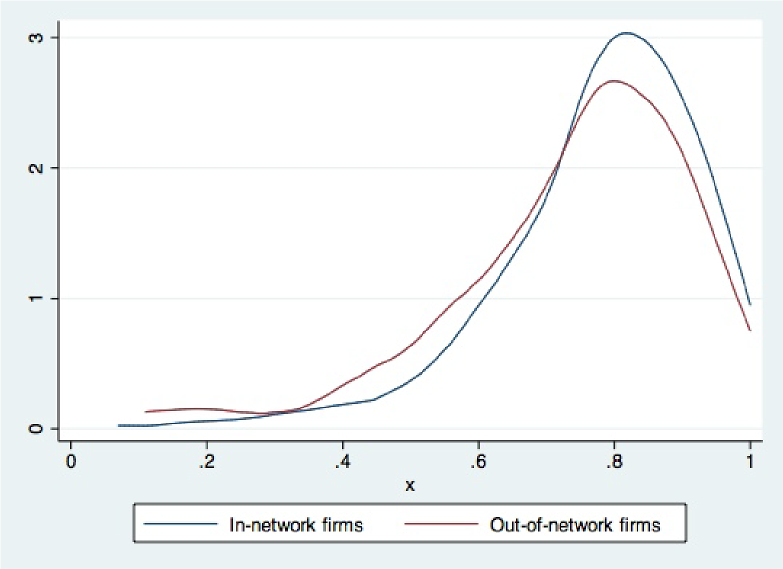
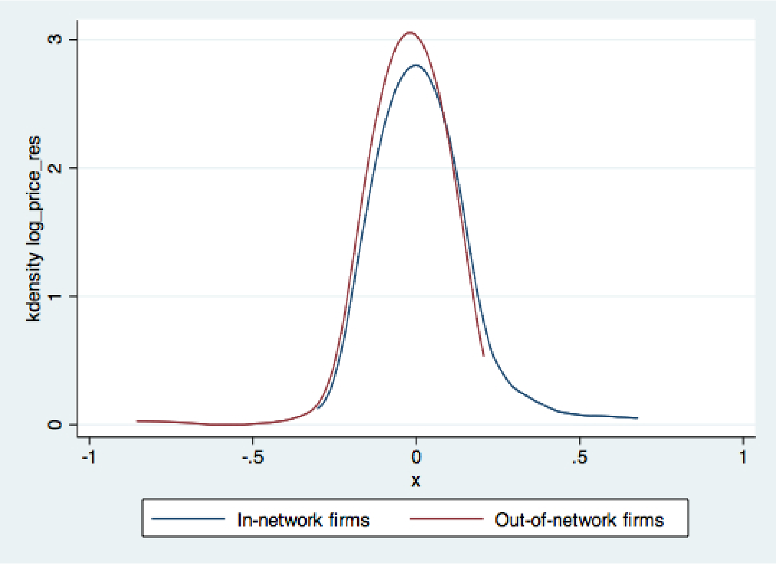


Figure A11. Logged price residuals, 1898-1902



*I. Proofs of the results in Section IV and the model of industry evolution and acquisitions*

<u>Proof that *u* = *v* at the optimum (equation (14) in the main text)</u>:

The two first order conditions for the maximization of (12) are given by

$$\frac{\partial \pi}{\partial u} = 0 \Rightarrow \left(p - \frac{1}{\sqrt{uv\omega}}\right) = (\gamma - u - v)\frac{1}{2u\sqrt{uv\omega}}, \text{ and}$$

$$\frac{\partial \pi}{\partial v} = 0 \Rightarrow \left(p - \frac{1}{\sqrt{uv\omega}}\right) = (\gamma - u - v)\frac{1}{2v\sqrt{uv\omega}}.$$

The claim follows immediately.

Proof of Lemma 1(i): Straightforward from (10) and (12) in the main text.

Proof of Lemma 1(ii):

We have

$$\pi(\gamma,\omega) = p\gamma + \frac{2}{\omega} - 2\sqrt{\frac{2p\gamma}{\omega}}.$$

$$\frac{\partial\pi(\gamma,\omega)}{\partial\gamma} = \frac{p}{\gamma}\left(\gamma - \sqrt{\frac{2\gamma}{p\omega}}\right) = \frac{p}{\gamma}(\gamma - m) > 0.$$

$$\frac{\partial\pi(\gamma,\omega)}{\partial\omega} = \frac{m}{\omega}\left(\sqrt{\frac{2p\gamma}{\omega}}\frac{1}{m} - \frac{2}{\omega m}\right) = \frac{m}{\omega}\left(p - \frac{2}{\omega m}\right) > 0.$$

The first two claims follow immediately. Also, $x^* = \frac{2(\gamma-m)}{m\omega} = \sqrt{\frac{2\gamma p}{\omega}} - \frac{1}{\omega}$, which is also clearly increasing in $\gamma$.

Proof of Lemma 1(iii):

We have

$$\frac{\partial^2\pi(\gamma,\omega)}{\partial\gamma\partial\omega} = \sqrt{\frac{p}{2\gamma\omega^3}} > 0.$$

Details of the acquisition model in Section IV.C:

*Stage I*

Each first-cohort entrant is endowed with some initial level of demand management ability, $\gamma_0$ (and a plant of quality $\omega_1$). Given a fixed (flow) operation cost, $f$, and a demand structure $D(p)$, free entry implies that the number (mass) of first-cohort entrants, $N_1$, and the initial equilibrium price $p_0$, will be determined by the following two equations comprised of the market-clearing and the free-entry zero-profit conditions:

$$D(p_0) = [\gamma_0 - m(\gamma_0\omega_1; p_0)]N_1 = \left[\gamma_0 - \sqrt{2\gamma_0/p_0\omega_1}\right]N_1,$$

$$\pi(\gamma_0, \omega_1; p_0) = f.$$

We assume that during Stage I some first-cohort entrants obtain a management ability level above $\gamma_0$ (for instance, they make connections with traders or are able to hire an educated engineer). Thus, at the end of Stage I, the first cohort's ability is distributed with support $[\gamma_0, \gamma_{max}]$. An equilibrium at the end of Stage I would thus be characterized by a price $p^*$ and a threshold ability level $\gamma^* > \gamma_0$, that satisfy the following market-clearing and zero-profit conditions:

$$D(p^*) = \int_{\gamma^*}^{\gamma_{max}}\left[\gamma - \sqrt{2\gamma/p\omega_1}\right]dF(\gamma), \tag{A5}$$

$$\pi(\gamma^*, \omega_1; p^*) = f, \text{ or } \gamma^* = \left(\sqrt{f\omega_1} + \sqrt{2}\right)^2/p^*\omega_1 \tag{A6}$$

*Stage II*

At this stage, the refinement arrives but each firm can still only manage one plant (its original one for first-cohort entrants). Assume that the size of the "refinement" (the jump from $\omega_1$ to $\omega_2$) is high enough to justify new entry under the previous equilibrium (A5)-(A6) (that is, that $\pi(\gamma_0, \omega_2; p^*) > \pi(\gamma^*, \omega_1; p^*) = f$). As the second-cohort firms enter, the equilibrium price starts falling until a new industry equilibrium is reached, characterized by (i) the new market clearing condition (where $N_2$ is the total mass of the second cohort entrants):

$$D(p^{**}) = \int_{\gamma^{**}}^{\gamma_{max}}\left[\gamma - \sqrt{2\gamma/p^{**}\omega_1}\right]dF(\gamma) + N_2\left[\gamma_0 - \sqrt{2\gamma_0/p^{**}\omega_2}\right], \tag{A7}$$

(ii) zero-profit condition for the first cohort:

$$\pi(\gamma^{**}, \omega_1; p^{**}) = f, \text{ or } \gamma^{**} = \left(\sqrt{f\omega_1} + \sqrt{2}\right)^2 / p^{**}\omega_1, \tag{A8}$$

and (iii) zero-profit condition for the second cohort:

$$\pi(\gamma_0, \omega_2; p^{**}) = f \text{ or } \gamma_0 = \left(\sqrt{f\omega_2} + \sqrt{2}\right)^2 / p^{**}\omega_2. \tag{A9}$$

These three conditions jointly determine the new equilibrium price $p^{**}$, the cutoff ability of remaining first-cohort entrants $\gamma^{**}$, and the mass of second-cohort entrants, $N_2$. Comparing conditions (A7) and (A5), we see that $p^{**} < p^{*}$ implies $\gamma^{**} > \gamma^{*}$, so that only first-cohort plant owners whose ability exceeds a threshold level $\gamma^{**} \in (\gamma^{*}, \gamma_{max})$ can remain in the industry; those below it exit. To make things interesting (and correspond to the specifics of the industry), we also assume that $\gamma^{**} < \gamma_{max}$. That is, the mass of remaining first-cohort entrants is non-degenerate (and actually is large enough in a sense made more precise below).

*Stage III*

The third stage is a merger and acquisition stage where physical assets are exchanged. To ease notation, we assume that each firm can buy at most one plant in the market for physical assets. (An extension where it can buy more than one plant is straightforward.) We assume as in Jovanovic and Braguinsky (2004) that assets (plants) are simply bought and sold in the market for a given price. In reality, of course, most acquisition deals are negotiated bilaterally. Available evidence from our sample (the qualitative descriptions of acquisition deals in, e.g., Kinugawa, 1964, as well as in company histories) suggests, however, that all such deals involved both acquirers' and targets' shareholders meetings debating the terms, sometimes comparing multiple offers and occasionally rejecting proposed deals and deciding to continue soldiering on alone or seek another acquirer (target). In many cases, the parties involved in a deal were also brought together by prominent mediators (including those from major trading houses), with good knowledge of the market environment. The detailed operations and financial data which we use in this paper, and which were in open access already at that time, also made it easier to estimate a plant's fair market price. Hence, assuming that acquisition deals were consummated at a market price does not seem to be that far removed from how those deals actually happened in our sample.

Let the price of a plant of quality $\omega_i$ be given by $s_{\omega_i}, i = 1,2$. A firm will sell its plant if

$$s_{\omega_i} - \pi(\gamma, \omega_i; p) + f \geq 0 \text{ or } \frac{\left(\sqrt{\omega_i\left(s_{\omega_i} + f\right)} + \sqrt{2}\right)^2}{p\omega_i} \geq \gamma. \tag{A10}$$

Since there is no variation in $\gamma$ for the second-cohort firms, given price $s_{\omega_2}$, all their plants are offered for sale in Stage III as long as

$$\frac{\left(\sqrt{\omega_2\left(s_{\omega_2} + f\right)} + \sqrt{2}\right)^2}{p\omega_2} \geq \gamma_0. \tag{A11}$$

The aggregate supply of plants with quality $\omega_2$ is given by

$$Q_{\omega_2}\left(s_{\omega_2}, p\right) = N_2 \tag{A12}$$

if condition (A11) is met. It is easy to see that this condition will be met in any equilibrium, as there is value created by reallocating a plant of quality $\omega_2$ from its second-stage owner to a first-cohort firm. Thus condition (A11) simply implies that price $s_{\omega_2}$ should be high enough to induce those plant owners to sell. In what follows we also assume there is enough demand from higher-ability owners for $\omega_2$-type plants to induce a high enough price such that inequality (A11) is strict. (In particular, this will always be the case if we relax the assumption that a firm can buy at most one plant.)[10] The total supply of such plants is thus fixed and given by $N_2$, while price $s_{\omega_2}$ is

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[10] If the parameters of the model are such that the total mass of first-cohort firms remaining in the industry is less than $N_2$ (the mass of second-cohort entrants), there will be not enough demand for second-cohort

determined solely by the demand side (discussed below).

The aggregate supply of plants with quality $\omega_1$, on the other hand, is given by

$$Q_{\omega_1}\left(s_{\omega_1}, p\right) = \int_{\gamma^{**}}^{\tilde{\gamma}} dF(\gamma), \tag{A13}$$

where $\tilde{\gamma}$ is the ability level where condition (A10) is met with equality (for $i = 1$). As we can see, $Q_{\omega_1}\left(s_{\omega_1}, p\right)$ is an increasing function of $s_{\omega_1}$. The ability of the marginal seller, $\tilde{\gamma}$, is also increasing in $s_{\omega_1}$.

We turn now to the demand for plants. A firm buys a plant of quality $\omega_i$ if its profit, net of purchasing price and operating cost, is positive:

$$\pi(\gamma, \omega_i; p) - f > s_{\omega_i}. \tag{A14}$$

Note that since ability $\gamma$ and plant quality $\omega$ are complements in the profit function (Lemma 1 in the main text), the demand for higher-quality ($\omega_2$-type) plants comes entirely from the top of the ability distribution $\gamma$. This complementarity makes sure that in equilibrium, the price $s_{\omega_2}$ will "ration" the demand for second-cohort plants to just the first $N_2$ highest-ability firms. Hence, this demand is given by

$$X_{\omega_2}\left(s_{\omega_2}, p\right) = \int_{\gamma_{N_2}}^{\gamma_{max}} dF(\gamma), \tag{A15}$$

where $\gamma_{N_2}$ satisfies the condition under which the buyer with ability $\gamma_{N_2}$ is just indifferent between buying plants of either quality:

$$\pi\left(\gamma_{N_2}, \omega_2; p\right) - \pi\left(\gamma_{N_2}, \omega_1; p\right) = s_{\omega_2} - s_{\omega_1}. \tag{A16}$$

The remaining first-cohort entrants then reallocate their $\omega_1$-type plants among themselves. More specifically, the demand for plants with quality $\omega_1$ is given by

$$X_{\omega_1}\left(s_{\omega_1}, p\right) = \int_{\tilde{\gamma}}^{\gamma_{N_2}} dF(\gamma), \tag{A17}$$

where $\tilde{\gamma}$ is as in (A13). As we can see, $X_{\omega_1}\left(s_{\omega_1}, p\right)$ is a decreasing function of $s_{\omega_1}$.

To close the system, we need the output market clearing condition:

$$D(\hat{p}) = \int_{\tilde{\gamma}}^{\gamma_{max}} \left[\gamma - \sqrt{2\gamma/\hat{p}\omega_1}\right] dF(\gamma)$$
$$+ \int_{\tilde{\gamma}}^{\gamma_{N_2}} \left[\gamma - \sqrt{2\gamma/\hat{p}\omega_1}\right] dF(\gamma) + \int_{\gamma_{N_2}}^{\gamma_{max}} \left[\gamma - \sqrt{2\gamma/\hat{p}\omega_2}\right] dF(\gamma), \tag{A18}$$

where the first term on the right-hand side is the supply of incumbent plants of all the remaining firms, the second term is the supply of newly acquired $\omega_1$-type plants, and the third term is the supply of newly acquired $\omega_2$-type plants. Together, the output market clearing condition (A18), the two conditions that clear the markets for $\omega_1$-type plants and $\omega_2$-type plants (namely, that (A13) and (A17) equal one another and that (A15) is equal to $N_2$), along with two indifference conditions for marginal buyers of $\omega_1$-type plants ((A10) with equality for $i = 1$) and of $\omega_2$-type plants (A16), pin down the equilibrium quintuple of prices and cutoff ability levels $\left(\hat{p}, \hat{s}_{\omega_1}, \hat{s}_{\omega_2}, \tilde{\gamma}, \gamma_{N_2}\right)$.[11] One important feature is that high-ability early entrants with aged plants acquire more recent entrants with lower ability management but newer plants.

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plants, pushing the price $s_{\omega_2}$ all the way down until condition (A11) is met with equality. (In this situation, owners of second-cohort plants will be indifferent between selling and operating, so some will sell their plants and exit the industry, while others will keep operating their plants. There will be no market for plants of $\omega_1$ quality in this case.) While we cannot rule out such a situation on *a priori* grounds, it does not fit the industry specifics.

[11] The proof of existence, uniqueness (under suitable parametric restrictions) and (constrained) optimality parallels closely the proof of Proposition 2 in Jovanovic and Braguinsky (2004), so we do not reproduce it here. In the model here, the equilibrium in Stage III involves all firms participating in the acquisitions market. Jovanovic and Braguinsky (2004) introduce a fixed cost of acquisition ("due diligence"), which makes sure that there are firms that do not participate in the acquisition markets as either buyers or sellers. Such firms exist in our data too, and a fixed cost of acquisition would account for this feature here as well (details are available upon request).

Proof of Proposition 2:

We show that $\frac{\partial ln[\pi(\omega,\gamma)]}{\partial\gamma} > \frac{\partial ln[TFPQ]}{\partial\gamma}$ for any given $\omega$. We have:

$$ln[\pi(\omega,\gamma)] = ln\left[p\gamma + \frac{2}{\omega} - 2\sqrt{\frac{2p\gamma}{\omega}}\right].$$

Differentiating with respect to $\gamma$ yields

$$\frac{\partial ln[\pi(\omega,\gamma)]}{\partial\gamma} = \frac{p - \frac{1}{\gamma}\sqrt{\frac{2p\gamma}{\omega}}}{\pi}.$$

Also,

$$ln[TFPQ] = \frac{1}{2} ln\left[\frac{\gamma\omega}{2p}\right].$$

Differentiating with respect to $\gamma$ yields

$$\frac{\partial ln[TFPQ]}{\partial\gamma} = \frac{1}{2\gamma}.$$

Comparing the two,

$$\frac{\partial ln[\pi(\omega,\gamma)]}{\partial\gamma} - \frac{\partial ln[TFPQ]}{\partial\gamma} = \frac{p\gamma + \sqrt{\frac{2p\gamma}{\omega}} - \frac{2}{\omega}}{2\pi\gamma} = \frac{p\gamma\omega - 2 + \sqrt{2p\gamma\omega}}{2\omega\pi\gamma} > 0,$$

because $p\gamma\omega - 2 = \left(\sqrt{p\gamma\omega} + \sqrt{2}\right)\left(\sqrt{p\gamma\omega} - \sqrt{2}\right) > 0$ by (13) in the main text.

Proof of Proposition 3:

Let subscripts $A$ and $T$ denote acquiring and target plants, respectively. The TFPQ difference between the acquiring and the target plants is given by

$$\sqrt{\frac{\gamma_A\omega_A}{2p}} - \sqrt{\frac{\gamma_T\omega_T}{2p}}. \tag{A19}$$

The difference in profits between the acquiring and target plants, on the other hand, is given by

$$\begin{aligned}
&\left(p\gamma_A + \frac{2}{\omega_A} - 2\sqrt{\frac{2p\gamma_A}{\omega_A}}\right) - \left(p\gamma_T + \frac{2}{\omega_T} - 2\sqrt{\frac{2p\gamma_T}{\omega_T}}\right)\\
&= p(\gamma_A - \gamma_T) + \left(\frac{2}{\omega_A} - \frac{2}{\omega_T}\right) - 2\left(\sqrt{\frac{2p\gamma_A}{\omega_A}} - \sqrt{\frac{2p\gamma_T}{\omega_T}}\right)\\
&= p(\gamma_A - \gamma_T) + 2\left(\frac{1}{\omega_A}\left(1 - \sqrt{2p\gamma_A\omega_A}\right) - \frac{1}{\omega_T}\left(1 - \sqrt{2p\gamma_T\omega_T}\right)\right).
\end{aligned} \tag{A20}$$

Assume now that the difference in (A19) above is zero. This means that the difference (A20) boils down to

$$p(\gamma_A - \gamma_T) + 2\left(\frac{1}{\omega_A} - \frac{1}{\omega_T}\right) > 0,$$

which is positive because $\gamma_A > \gamma_T$, while $\omega_T > \omega_A$ by the assumption that the target plant has higher quality. We have thus shown that if the TFPQ of the acquiring and target plants are the same, the profit of the acquiring firm will be higher than the profit of the target firm (this also follows directly from Proposition 2, of course). By continuity, the profit of the acquiring firm will still be higher than that of the target firm even for some range of parameters where TFPQ(acquirer) < TFPQ(target). It is also clear from the expression above that this range will be larger when the difference $\gamma_A - \gamma_T$ is larger.

### *J. Numerical Example of the Model*

Set the value of model's parameters as follows: $p = 3, \omega_{entrant} = 1.5, \omega_{incumbent} = 1, \gamma_0 = 2$. Assume that surviving incumbents' ability, $\gamma_{incumbent}$, is uniformly distributed over the interval

$[2.45, 3.5]$. The choice of the lower bound for $\gamma_{incumbent}$ ensures that the lowest-ability incumbent attains the same profits as all entrants, while the upper bound gives the highest-ability incumbent profits that are twice as large as entrants' profits.

Under these parameters, the optimal choice of $m$, the maximized profit, input utilization and TFPQ are given by the values in Table A17 below.

Table A17. Numerical example: New entrant, low- and high-ability incumbents

| | New entrant | Low-ability incumbent | High-ability incumbent |
|---|---|---|---|
| Time managing production | 0.94 | 1.28 | 1.53 |
| Total input | 1.50 | 1.83 | 2.58 |
| Input utilization | 0.69 | 0.80 | 0.87 |
| TFPQ | 1.03 | 0.80 | 0.87 |
| Profit | 1.68 | 1.68 | 3.33 |
| Profit/total input | 1.12 | 0.92 | 1.29 |

As can be seen from Table A17, high-ability incumbent's profit is double the profit of both new entrant and low-ability incumbent, but its TFPQ is lower than that of a new entrant. Input utilization is the lowest for a new entrant, higher for a low-ability incumbent, and highest for the high-ability incumbent. These are exactly the patterns we saw in the data.

What happens after a high-ability incumbent acquires a new entrant or a low-ability incumbent in the setup above? Recalculating optimal $m$ using the acquirer's ability level $\gamma = 3.5$ yields the changes presented in Table A18 below.

Table A18. Numerical example: New entrant and low-ability incumbent from before to after acquisition by a high-ability incumbent

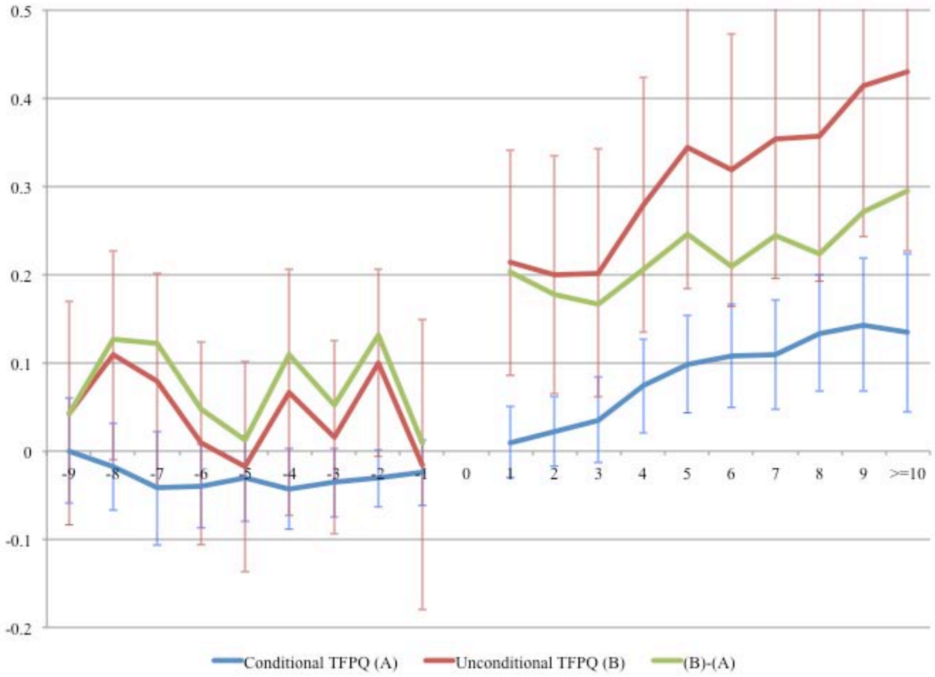
| | New entrant | | Low-ability incumbent | |
|---|---|---|---|---|
| | Pre-acquisition | Post-acquisition | Pre-acquisition | Post-acquisition |
| Time managing production | 0.94 | 1.25 | 1.28 | 1.53 |
| Total input | 1.50 | 2.41 | 1.83 | 2.58 |
| Input utilization | 0.69 | 0.79 | 0.80 | 0.87 |
| TFPQ | 1.03 | 1.18 | 0.80 | 0.87 |
| Profit | 1.68 | 4.35 | 1.68 | 3.33 |
| Profit/total input | 1.12 | 1.81 | 0.92 | 1.29 |

Under the new, more capable ownership, plants of both new entrants and low-ability incumbents improve input utilization and TFPQ. Profits jump by even more; they double for the low-ability incumbent plant from before to after acquisition, and increase 2.6 times over for the plant formerly owned by a new entrant. Even when normalized by total input, the profit rate improves by more than TFPQ, again consistent with the patterns we discovered in our sample.

### *K. Year-by-year estimates of within-acquisition comparisons between incumbent and acquired plants*

We first estimate TFPQ and TFPQU regressions similar to (5) with a full set of *annual* pre- and post-acquisition year dummies. The year-by-year coefficients for TFPQ and TFPQU and the difference between them are plotted in Figure A12 along with the corresponding 95-percent confidence intervals (using robust standard errors clustered at the acquisition level). There is no discernible pre-acquisition trend in either TFPQ or TFPQU, while there is a clear upward trend in both after acquisitions. Moreover, TFPQU jumps up immediately after the acquisition event, while TFPQ grows more slowly. The difference between the two thus stays more or less constant for much of the post-acquisition period, indicating that capacity utilization improves almost instantaneously following acquisition and then grows relatively slowly, with lion's share of the improvement in plant productivity in later years coming from TFPQ (more efficient use of capital and labor flows conditioning on operating).

Figure A12. TFPQ and TFPQU dynamics of acquired plants



Note: The horizontal axis represents time to and after acquisition events, with year 0 being the acquisition year. The graph plots coefficients on each pre- and post-acquisition year dummies estimated using equation (5) with the full set of pre-acquisition and post-acquisition dummies, excluding the acquisition year itself. Years 10 and earlier before acquisition event and years 10 and later after acquisition events are collapsed into a single dummy. The omitted category is 10 years or more before acquisition. Error bars display 95 percent confidence intervals.

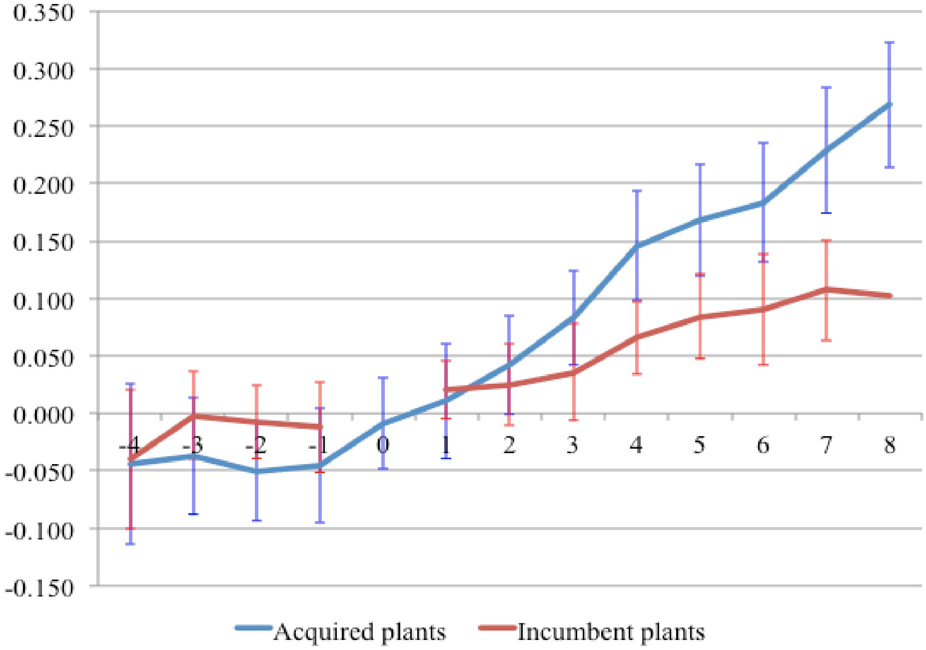
Figure A13 presents the results of TFPQ estimated by the "difference-in-difference" estimation equation (6) in the main text, also with a full set of yearly time dummies (the results for TFPQU are similar):

$$\bar{y}_{it} = \alpha_0 + \sum_{t=T-4,t\neq o}^{8} \beta_s \overline{Inc_{\iota s}} + \sum_{t=T-4}^{8} \beta_s Acq_{is} + m_{it} + \varepsilon_{it} \ , \qquad \text{(A21)}$$

where, as in the main text, $\bar{y}_{it}$ is TFPQ (relative to industry-year average) of plant $i$ at time $t$ if it is an acquired plant, while TFPQs (also relative to industry-year average) of incumbent plants are collapsed to $\bar{y}_{it} = \frac{1}{\#m_A}\sum_{j\in m_A} y_{jt}$, where $m_A$ denotes the particular acquisition case in which plant $i$ was acquired and $\#m_A$ is the number of incumbent plants in acquisition $m_A$. The timeline is, once again, from 4 years before to 8 years after acquisitions. (The omitted category is TFPQ of incumbent plants in the year of acquisition, so all other variables are measured relative to the incumbent plants' average TFPQ in the acquisition year.)

Consistent with the results in Table 3 in the main text, TFPQ of acquired plants is somewhat higher than TFPQ of incumbent plants before acquisition, but the difference is not statistically significant. There is no particularly pronounced trend in incumbent or acquired plants' TFPQ before acquisition. After acquisition, however, acquired plants clearly diverge upward from incumbent plants (and the rest of the industry—recall that TFPQ are the residuals from production function estimates using all available data for all years, including also year dummies).

Figure A13. Within-acquisition TFPQ of acquired and incumbent plants



Note: The horizontal axis represents time to and after acquisition events, with year 0 being the acquisition year. The graph plots coefficients on each pre- and post-acquisition year dummies estimated using within-acquisition "difference-in-difference" equation (6) with the full set of year dummies. The omitted category is year 0 (acquisition year) of incumbent plants, hence all productivity effects are measured relative to year 0 of incumbent plants. Error bars represent 95 percent confidence intervals.

## *Appendix References*

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