

CENTER ON JAPANESE ECONOMY AND BUSINESS

日本経済経営研究所

Working Paper Series

February 2014, No. 336

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This paper is available online at www.gsb.columbia.edu/cjeb/research

C O L U M B I A U N I V E R S I T Y I N T H E C I T Y O F N E W Y O R K

Spinning Tales about Japanese Cotton Spinning: Saxonhouse (1974) Then and Now

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Abstract

We revisit the story of technology adoption and diffusion in Meiji-era cotton spinning industry in Japan, the study of which was pioneered by Gary Saxonhouse in an article published in *JEH* exactly 40 years ago. Using a novel data set and modern methodology, we argue that both the ease with which the best technology diffused and the role of “slavish imitation” in this process may have been overstated. We find an important role played by market competition, including asset reallocation. Our analyses provide researchers with even richer insights into general questions of innovation, technology diffusion, and economic growth.

Introduction

The year 2014 marks the 40th anniversary of the publication of the late Gary R. Saxonhouse’s article, “A Tale of Japanese Technological Diffusion in the Meiji Period,” in the first issue of volume 34 of *The Journal of Economic History* (hereafter “A Tale” and *JEH*). With a history worthy of being called a tale, Japan’s Meiji-era cotton spinning industry led that Asian nation out of its feudal existence to become a highly industrialized economy and a major player in 20th-century war, politics, and global trade, an economic power that would challenge U.S. economic supremacy in the two decades following the appearance of “A Tale.”

At the heart of this story of “the astonishing ascendance of Osaka over Lancashire [and] the first completely successful instance of Asian assimilation of modern Western manufacturing techniques”¹ lies a remarkable (and, as we argue below, still not fully understood) historical episode of technology diffusion. As Nathan Rosenberg pointed out in a highly influential, contemporaneous article, “The rate at which new techniques are adopted and incorporated into the productive process is, without doubt, one of the central questions of economic growth.”² Being the first historical instance of its kind, the Japanese cotton spinning industry experience deserves to be examined to the utmost degree, if only because understanding the mechanism behind the remarkably high rate at which “new techniques were adopted and incorporated into the

¹ Saxonhouse, 1974a, p. 150.

² Rosenberg, 1972, p. 3.

productive process” in this case can generate insights into how it can perhaps be replicated in modern-day developing countries, whose industries, including cotton textiles, still often look much more technologically backward than Japan’s over a century ago, despite sharing largely similar initial starting conditions.³

In what follows, we first summarize Gary Saxonhouse’s early work on Japanese cotton spinning, including “A Tale.” We discuss both the intellectual background of this work and its placement in the broader literature aimed at elucidating the big questions of technology transfer, diffusion and its relationship to economic growth. We also describe remarkably rich and detailed historical data sources available on Japanese cotton spinning, and illuminate the database Saxonhouse assembled from these sources in his doctoral research. Saxonhouse appears to have been the first researcher trained in economics to realize that it was possible to assemble a large database rendering itself to formal econometric (or “cliometric”) analysis from these sources, which provided him with an impressive comparative advantage both early in and throughout his career as a specialist on the Japanese economy.

We then compare and contrast Saxonhouse’s early findings with those we derive from an even finer-grained and more “nanolevel” database on early Japanese cotton spinning that one of us has recently assembled.⁴ In particular, we utilize some of the more detailed information available to us today about technological and managerial decisions (and the personalities behind these) to critically evaluate Saxonhouse’s methodology and his conclusions, especially those that shaped later researchers’ perceptions of what exactly the sources of Japan’s success were.

In particular, we find that Saxonhouse might have overstated both the ease by which best-technology diffused in this industry and the role of Japanese producers’ “slavishly” imitating each other in achieving success. Most importantly, by doing so, Saxonhouse may have inadvertently directed attention away from other important mechanisms that made the remarkably rapid

³ See, e.g., Bloom et al., 2013.

⁴ This database is being developed by Braguinsky jointly with two prominent Japanese scholars, Tetsusji Okazaki from Tokyo University and Atsushi Ohyama from Hokkaido University.

diffusion of the best practices in this industry possible. These mechanisms, which, as the totality of his work shows, Saxonhouse himself was fully aware of, were (1) strong competition in both the input and the output markets (coexisting with intraindustry cooperation in innovation/technology diffusion), which did not allow poor-performing firms to survive; and (2) a highly sophisticated and effective market for assets, both physical and human, which allowed those assets to be reallocated from non-surviving firms to firms (both incumbents as well as new entrants) that could use those assets more efficiently. The new data, which we introduce here, allow us to identify even more clearly these aspects of the technology diffusion in the early Japanese cotton spinning industry and bring them to the forefront where they belong. We hope that accomplishing this task will provide researchers with even richer insights into general questions of innovation, technology diffusion, and economic growth, which should be useful today for developing countries, and, at least in some respects, perhaps even for advanced economies. We offer this piece both in the spirit of and as a memorial to Saxonhouse's pioneering early work in Japanese economic history as conveyed in his 1974 article, "A Tale of Japanese Technological Diffusion in the Meiji Period."

I

"A Tale" was not only Saxonhouse's first *JEH* article but was also his first journal article in what became an illustrious career cut all-too-short in 2006.⁵ Yet, as Saxonhouse quickly noted in "A Tale," he had two other publications in the works, both stemming, as with "A Tale," from his 1971 Yale economics dissertation, "Productivity Change in Japanese Cotton Spinning Industry, 1891-1935." These papers were "Country Girls and the Japanese Cotton Spinning Industry"

⁵ Saxonhouse's second publication, in the *Journal of Political Economy* (Saxonhouse, 1974b), appeared in 1974 but in the second issue, whereas "A Tale" appeared in *JEH*'s first issue of the year, and it was a four-page commentary on Hashimoto, (1974). Gary Saxonhouse died of leukemia at the age of sixty-three November 30, 2006. A short biographical sketch of Saxonhouse can be found at <http://um2017.org/faculty-history/faculty/gary-saxonhouse/memoir>. In addition, we have prepared a short essay that seeks to articulate the intellectual inheritance that Gary Saxonhouse brought to the publication of "A Tale" in particular and his life's work more generally. The essay also provides contextual background to and analysis of the content and structure of "A Tale" and comments briefly on the article's citation record. See Serguey Brraguinsky and David Hounshell, "Behind 'A Tale': Gary R. Saxonhouse's Intellectual Inheritance" This essay can be found at <URL from one of the authors' websites will appear here>.

(Saxonhouse, 1976), a chapter forthcoming in his mentor Hugh Patrick's edited volume, *Japanese Industrialization and Its Social Consequences*, and "Productivity Change and Labor Absorption in Japanese Cotton Spinning, 1891-1935," which would appear in *The Quarterly Journal of Economics* in 1977 (Saxonhouse, 1977).⁶ Saxonhouse would not publish another article in the *JEH* until his and Gavin Wright's "National Leadership and Competing Technological Paradigms: The Globalization of Cotton Spinning, 1878–1933" (Saxonhouse and Wright, 2010) appeared posthumously in 2010, bringing to a close his adult life's fascination with and passion for deeply understanding the development of the Japanese cotton spinning industry.⁷

Born in 1943 in New York City and reared in the Rego Park neighborhood of Queens, Saxonhouse attended Yale University, where he majored in economics, earning his undergraduate degree in the spring of 1964. Yale's Economics Department possessed particularly strong faculty capabilities in Japanese economic growth, including Hugh Patrick, who would eventually direct Saxonhouse's dissertation, and Gustav Ranis, who served as second reader of the dissertation. The university also provided an unrivaled institution to support research on the general phenomenon of economic growth, the Yale Economic Growth Center. Created through the "connivance" of Harvard's Simon Kuznets and Yale's Economics Department head Lloyd Reynolds and with an initial \$2 million dollar gift of the Ford Foundation, the Economic Growth Center was originally established as an inter-university center housed at Yale. By the time Gary Saxonhouse decided to stay at Yale to pursue his PhD in economics, however, the Economic Growth Center had largely become an all-Yale organization. By this time also, Patrick had created with Harvard economic historian Henry Rosovsky and Columbia's James Nakamura the

⁶ Saxonhouse, 1974a, fn. 4, p.150. In fact, Patrick's edited volume did not appear until 1976, and the title of Saxonhouse's contribution had changed to "Country Girls and Communication among Competitors in the Japanese Cotton-Spinning Industry." By this time part of his third dissertation-based paper had already appeared in *The Quarterly Journal of Economics* as "Saxonhouse (1975).

⁷ This is not to imply that Gary Saxonhouse focused only on the Japanese cotton spinning and textile industry throughout his career as a Japan specialist. Rather, he undertook studies of a wide range of industries, almost all of more recent origin, including the Japanese biotechnology industry and the optoelectronics industry.

Japan Economic Seminar, “an inter-university assemblage of faculty, advanced graduate students, and visiting scholars from Japan,” who gathered on eight Saturdays during the academic year to formally discuss and critique two papers and then to top it off with dinner together, which built strong bonds among regulars and visitors as well. Under Patrick’s guidance, Saxonhouse became a regular fixture at the Japan Economic Seminar.

Saxonhouse used the occasion of the 33rd Annual Meeting of the Economic History Association (EHA) in mid-September 1973 and its theme, “The Diffusion of New Technologies,” as the vehicle through which he would interpret the technological dynamics of the Japanese cotton spinning industry. For a session entitled “Agencies for Diffusion of Technology,” chaired by technology specialist and incoming *JEH* editor Nathan Rosenberg, Saxonhouse initially proposed a paper with the daunting title, “Diffusion of Technology in Japanese Industry in the Meiji Period.”⁸ By the time his paper appeared in the March 1974 issue of *JEH*, then called “The Tasks of Economic History” because it printed papers from the EHA’s annual, Saxonhouse had retitled his contribution “A Tale of Japanese Technological Diffusion in the Meiji Period” and narrowed its focus to the Japanese cotton spinning industry.

A large part of “A Tale” is occupied by rigorous quantitative analysis, even though, from the vantage point of 2014, the quantitative proof of his important claim about the “ultra” speed of diffusion of British cotton spinning technology in Japan may not be entirely convincing.⁹ The enduring part of the paper, however, which would serve as scaffolding for all of Saxonhouse’s subsequent publications on Japanese cotton spinning, is entirely qualitative and builds a major causal argument around one particular institution in the nascent Japanese cotton spinning

⁸ The other two papers in the session were Hujiro Hayama, “Conditions for the Diffusion of Agricultural Technology: An Asian Perspective,” and Mira Wilkins, “The Role of Private Business in the International Diffusion of Technology,” with Kozo Yamamura commenting. For the full program of the EHA’s meeting, see the Front Matter of *JEH*, 33, 2 (June 1973) at <http://www.jstor.org/stable/2116683>.

⁹ See Saxonhouse’s effort to test a “homogeneity of practice hypothesis” as a proxy for speed of diffusion of best-practice British cotton-spinning technology, and his inability to reject the null hypothesis in Saxonhouse, 1974, p. 158: “I choose to interpret the result as supporting the hypothesis of substantially uniform technical and managerial practice throughout the industry.” Interpreting not being able to reject a null hypothesis as support for the alternative is, of course, a leap of faith.

industry, an association of firms in the cotton spinning industry named Dai Nihon Bōseki Rengōkai (All Japan Cotton Spinners Association), known simply by its acronym, Bōren. For Saxonhouse, Bōren, largely explained why British technology diffused so rapidly in the industry. Because British spinning machinery was the best that could be had and because Bōren actively spread information about and advocated the adoption of said machinery, this best-available technology diffused rapidly in the nascent Japanese cotton spinning industry along with the requisite know-how as to how best to employ it.

We surmise that the manner in which Saxonhouse structured his paper at the time owed much to the rapidly increasing pressure within the Economic History Association—and economic history more broadly—for scholars to present quantitatively based papers rather than work that two economic historians had pejoratively labeled “good old economic history” in a recent, widely read, stinging review of David S. Landes’s foundational book, *The Unbound Prometheus: Technological change and Industrial Development in Western Europe from 1750 to the Present* (Landes, 1969).¹⁰ One of Saxonhouse’s other Yale mentors, economic historian William N. Parker, had been an enthusiastic champion of “the new-style American quantifiers and theorizers”¹¹—the cliometricians—who had created “the new economic history”—or “cliometrics.”¹² Thus Saxonhouse constructed his paper such that he could demonstrate his credentials in econometrics before he moved on to his principal argument and the main contribution of his paper—an institutionally-based explanation for the rapid and successful diffusion of British cotton-spinning knowhow in Japan. In short, Saxonhouse’s econometrics may have overshadowed his qualitative analysis for listeners and readers of the time.

¹⁰ Hartwell and Higgs (1971). This review subsequently generated numerous, heated exchanges between the author and the reviewers about quantification in economic history, institutional analysis, and history as a social science.

¹¹ *Ibid.*, p. 470.

¹² Sundstrom (1994); Rhode (1991). At the same time, however, the influence of Parker’s own qualitative, institutionally-based work in American economic history was evident in Saxonhouse’s presentation and published paper. See especially “A Tale,” Footnote 29, p. 158, where Saxonhouse cites Parker’s unpublished—and non-quantitative—paper, “The Social Process of Diffusion” as “a[n] excellent example of the fruits of this now almost abandoned approach” to economic history and goes on to note that “[m]uch of this section of my paper draws on the spirit implicit in Parker’s analysis.”

Saxonhouse's qualitative analysis of the diffusion of British cotton-spinning technology in Meiji Japan was strongly influenced by a recently published article by Nathan Rosenberg. There Rosenberg had especially emphasized the importance of understanding not only the processes of technology diffusion but also the rate by which technology diffuses. As Rosenberg emphasized, "The rate at which new techniques are adopted and incorporated into the productive process is, without doubt, one of the central questions of economic growth . . ." ¹³ After including an impressive historical review of the dynamics of technological diffusion and factors affecting it, Rosenberg devoted the last main section of his article to "Diffusion and its institutional context." Here Saxonhouse's qualitative analysis jibed with that of Rosenberg in its emphasis on institutions. Specifically, Saxonhouse identified "the unique institutional arrangements which facilitated such [rapid] diffusion" of state-of-the-art British spinning technology throughout the nascent Japanese cotton spinning industry ¹⁴ In doing so, he relied upon the arguments and evidence that were reasonably well known to Japanese-reading students of Japanese economic history: that the formation and effectiveness of Bōren largely explained why British technology diffused so rapidly in the industry. In terms familiar to economists, the mechanism of Bōren's influence on technological diffusion was in lowering of transaction costs, specifically lowering the "costs associated with acquiring information about new technologies." ¹⁵

Saxonhouse summed up his qualitative findings:

"What is emerging here is a historical example which fits a much less sophisticated view of technological diffusion than economic historians have recently become accustomed to accepting. There do not appear to be any great technological puzzles which demand rationalization. Seemingly inferior techniques do not continue to be embodied in the industry's new investment. Older techniques from which it would appear no quasi-rents could be squeezed do not remain unscrapped." ¹⁶

Saxonhouse concluded "A Tale" by echoing session chair Nathan Rosenberg: "While the study of

¹³ *Ibid.*, p. 3. Rosenberg's analysis of technology diffusion built on the decade-long work of a group of economists who were associated with the landmark NBER conference and resulting publication, *The Rate and Direction of Inventive Activity* (Princeton, 1962).

¹⁴ "A Tale," p. 150.

¹⁵ "A Tale," p. 159.

¹⁶ "A Tale," p. 153.

technological diffusion has surely been pursued with great vigor in the last fifteen years[,] attention could still be profitably focused on the nature of the institutions which gather and transmit technological information.”¹⁷

For the two of us working in 2013-14, we wondered what could be learned by carefully and critically reviewing Saxonhouse’s “A Tale,” particularly in light of the extensive quantitative data on the Japanese cotton spinning industry that one of us has gathered in Japan over the last quarter century. Some of these data duplicate those gathered by Saxonhouse, simply because we use some of the same sources—especially the Bōren monthly bulletins. But Saxonhouse either overlooked or ignored a large trove of other Bōren- and Japanese government-related records that provide even more complete firm- and establishment-level data that allow greater understanding of intra-industry dynamics, including sharp differences in firm performance, including labor productivity and profitability, and firm entry and exit. Indeed, these additional data allow us to understand at a much finer level of detail the evolution of the industry and the dynamics of technical change within that evolution.

II

The emphasis Saxonhouse placed in “A Tale” on the role of institutions in technology transfer was ahead of its time because the term *institutions*, as Gavin Wright recently noted, “had not yet shaken off its negative connotations (‘institutional’ analysis meant descriptive work that did not draw upon economic analysis, the kind of thing Old Economic Historians did).”¹⁸ This could be one reason why the article has remained not very well known or cited.¹⁹ But the goal of this piece

¹⁷ “A Tale,” p. 165.

¹⁸ Gavin Wright, private correspondence.

¹⁹ Remarkably, for all its qualities in addressing issues related to technological diffusion and institutions, its display of virtuosity in linear regression, and its evidence of deep reading (most of it in Japanese) of the history of the cotton spinning industry in Japan, Saxonhouse’s “A Tale” is not a highly cited paper in economic history, economic development, or English language works in Japanese history. As of September 1, 2013 Google Scholar showed only 58 citations to “A Tale.” Our analysis of these citations shows that at least one is in error and that nine are self-citations, with the last one being his *JEH* article with Gavin Wright, which appeared four years after Saxonhouse died. We were also surprised to learn from our citation analysis that 13 of the 58 citations from Google Scholar were by one of us (Braguinsky) and his collaborators.

is not to correct this possible “injustice” and posthumously award Saxonhouse and his “Tale” its deserved status in economic history literature. It is far more important to build upon and develop his pioneering work on Meiji-era Japanese cotton spinning industry, because of the many lessons that remain to be learned from this “tale” of technology and its diffusion in general.

Granted, today we already have answers to some of the questions posed by Saxonhouse in the concluding section of “A Tale.” Specifically, we know now that Japanese cotton spinning firms were by no means unique in their culture of technical cooperation, which flourished despite strong competition in output markets. Indeed, the benefits of “collective search” have since been uncovered in a number of other important historical cases, from the Cleveland Steel District (Allen, 1983) and Cornish steam engine (Nuvolari, 2004) at the dawn of the industrial revolution, to Austrian bentwood furniture industry (Kiriazidou and Pesendorfer, 1999) around the same time as the Japanese cotton spinning industry, to 20th century examples of the U.S. semiconductor industry (Tilton, 1971), Chilean salmon industry (Pietrobelli and Rabellotti, 2004), flat panel display industry (Spencer, 2003), Homebrew Computer Club (Meyer, 2003), and so on. A number of theories have also been developed in the literature to explain these phenomena, from game-theoretic models of industry-wide cooperative research agreements with imperfect competition in product markets (Katz, 1986; Kamien, Schwartz, and Zhang, 1992) to models that even allow such cooperation under perfect competition, as openness to global trade renders local sharing of technical knowledge advantageous without threatening rent dissipation (Braguinsky and Rose, 2009).

But even though today we may have a richer knowledge, both theoretical and empirical, about important instances of rapid technological diffusion through cooperative arrangements encompassing ostensibly competitive firms, the factors that allow the emergence of such arrangements and, most importantly, make them operate efficiently in some but not in other historical contexts are still not very well understood. Rich historical data and archival records available on Meiji-era Japanese cotton spinning industry allow us to conduct an in-depth

investigation of these factors. This helps reveal the actual mechanism behind the remarkable rate of technological diffusion in this industry in a lot of detail, and in the process, to generate lessons that could have very broad applicability in various historical and policy-related contexts.

As already mentioned, the historical data we use in this paper have been compiled by one of the authors (Braguinsky), with cooperation from Okazaki and Ohyama, from a multitude of primary sources and archival materials. The first such source is firm-level monthly data on inputs and outputs in physical units for all firms that participated in Bōren. These are also the data used by Saxonhouse – but it appears that he only had the data starting from July 1889, which is when Bōren, already revamped into an association of independent producers, started publishing its monthly bulletins (“Geppō”). Bōren, however, was originally founded seven years earlier under the government auspices in 1882, and government statistical bulletins (“Kampō”) contain data collected by it starting from June 1883, six years before the first data appeared in Geppō²⁰ As it turns out, the examination of these early years yields important novel insights into the industry’s initially struggles with adopting the British technology, what (and who) was the driving force behind finding the right technological path, and how then the innovations diffused. We supplement these firm-level monthly data with annual plant-level data collected from governmental statistics (Nōshōkōmu Tōkei Nempō, as well as statistical yearbooks from various Japanese prefectures; see Braguinsky, Ohyama, Okazaki and Syverson, 2014, for more details).

The second data source is semi-annual company shareholders’ reports, which contain detailed balance sheets, profit-loss statements, and other firm-level financial information. The reports also contain lists of shareholders and executives. About 80 percent or more of Japanese cotton spinning firms in this industry were joint-stock companies, which were required by Japan’s Commercial Code to produce shareholders’ reports twice a year.²¹ Financial information and

²⁰ To the best of our knowledge, we were the first to systematically extract and code these early data.

²¹ Braguinsky has photocopied over 1,200 such reports—all the reports available for years spanning the 1890s, 1900s, and 1910s—over several trips to Osaka University Library where they are held in the rare

other data about companies whose reports were missing (or which were privately held and did not require submission) were obtained, whenever possible, from Geppō and from the semi-annual publication entitled “Menshi Bōseki Jijō Sankōsho” (Reference Materials on the State of the Cotton Spinning Industry, hereafter, “Sankōsho” for short) started in 1903. Technology data on the machine characteristics ordered by different firms in the 1880s and 1890s used below come from the file compiled by Gary Saxonhouse and Pat McGuire and archived on the ICPSR web site (Wright, 2011).

Finally, we have used the narratives and descriptions published in Geppō for various years, as well as the detailed seven-volume history of the Japanese cotton spinning industry written before World War II by the Japanese historian Taiichi Kinugawa (Kinugawa, 1964). We also consulted various published company histories and several books written more recently by Japanese historians, among which Takamura (1971) was by far the most informative and useful, and we sought and obtained interviews with historians of this industry and its technology in Japan.

II.1 Lessons from early struggles

Saxonhouse begins “A Tale” by recounting the establishment of Osaka Cotton Spinning Company in 1883, which “combine[d] what came to be the ingredients of a successful cotton enterprise in Japan”²²: comparatively large scale (i.e., a large number of spindles), up-to-date British-made spinning equipment laid out by British spinning mill engineers, adequate steam power rather than unpredictable waterpower, double labor shifts made possible by the installation of electric lighting, and a Japanese chief engineer who had worked in a British spinning mill and who had studied the cotton spinning industry. As Saxonhouse emphasized, “The records available on the Japanese cotton spinning industry are so complete that it can be stated unequivocally that every mill subsequently established, and many were established, mimicked the

books depository. To the best of our knowledge, these reports have never been systematically mined and electronically coded before.

²² “A Tale,” p. 150.

leader [i.e., Osaka Spinning Company].”²³ An important nuance Saxonhouse fails to mention explicitly, however, is that Osaka Cotton Spinning Company’s position as a leader that the industry eventually looked up to, was not a bestowed but an acquired one. In fact, the Japanese government had anointed two of its own earlier cotton spinning mills as “model plants” before Osaka Cotton Spinning was even founded, and there had been several more government-sponsored mills that predated Osaka Cotton Spinning Company, as well as a dozen more that were set up by and large at the same time. As Saxonhouse rightly points out in “A Tale,” (p. 151) the subsequent “super-fast” diffusion of the best practices owed nothing to attempts by those government-sponsored mills, and owed everything to the innovations pioneered by Osaka Cotton Spinning Company. But if all it took to create “a tale” was “slavish” imitation of the British and rapid diffusion through Bören’s collaborative institutional arrangement, an obvious question that Saxonhouse does not even pose in “A Tale” is what prevented government-sponsored mills from succeeding in the transfer of the British cotton-spinning technology in the first place. After all, government-sponsored mills also imported machinery from Britain and had the full support of the government, in contrast to Osaka Cotton Spinning, which received no such support. This question becomes even more intriguing once we realize that almost six years had elapsed between the time Osaka Spinning Company started operating (in early 1883), and the time any newly established private mill became fully operational (in early 1889).

In Figures 1a-1c we present the basic statistical data on domestic output, imports and exports of cotton yarn in Japan split into three decades, the 1880s (starting from 1883 which is when the first Kampō data become available), the 1890s, and the 1900s. The import, export and domestic output data are all presented in physical units (thousands of pounds) and taken from “Nihon Chōki Tōkei Sōran” (Sōran), long-term historical statistics compiled by the Japanese Statistical Association under the supervision from the government Statistics Bureau (Sōran,

²³ Saxonhouse left out one other important ingredient in Osaka Spinning Company’s success: it was a joint stock company with limited liability for its stockholders.

1987). The time series for domestic output in Sōran, however, starts only in 1887, so for 1883-1886 we supplement it with our own data, representing the totals for all firms listed in Kampō.²⁴

[Figures 1a-1c about here.]

It is very clear from just observing Figures 1a and 1b (we will come back to Figure 1c later on) that something special happened towards the very end of the 1880s. Domestic output jumped by almost 3 times in just one year, 1889 and increased by more than 10 times in the following decade. Imports, which comprised over 80 percent of domestic consumption as late as in 1888, rapidly became an afterthought, while exports took off and surpassed imports in 1897. Thus, the above-mentioned six-year delay between Osaka Cotton Spinning's entry in 1883 and the real takeoff of the industry in 1889 stand in stark contrast to what happened next.

Examination of what transpired during those initial six years provides us with many additional insights about the factors affecting early technology adoption decisions. It also paints a much more nuanced picture than that of an industry easily adopting a standard ready-to-use technology from Britain and then rapidly diffusing it through a collaborative institutional arrangement. As already mentioned, Bōren was formed and started its efforts to promote the diffusion of best technological practices already in late 1882, that is, at about the same time that Osaka Cotton Spinning was starting up. Until 1888 Bōren, however, was run by the government, and although Osaka Cotton Spinning representatives took part in its meetings, its main mission was to spread the practices from two government-owned "model" cotton spinning mills that were very different from Osaka Cotton Spinning.²⁵

²⁴ The data for 1883 are available only for 6 months, while for 1884-85 these are available for 8 months and for 10 months in 1886. To estimate annual output we have multiplied the total output for all available months by 2 in 1883, by 1.5 in 1884-85 and by 1.2 in 1886. We also checked the consistency of our estimates of industry-wide output using Kampō and Geppō data and the corresponding data from Nihon Chōki Tokei Sōran for overlapping years and found that the difference almost never exceeds 3-4 percent.

²⁵ One of these "model mills" was bought by the government in 1872 from a previous owner (former Satsuma principality on the Southern tip of the Southern most island of Kyushu, which built and started operating the first modern cotton spinning mill in 1867; the mill purchased by the government was its second mill constructed and operating in the city of Sakai, near Osaka). The second one (Aichi National Mill, founded in 1878 but starting operating only in 1881 due to a multitude of problems plaguing it right from the beginning) was constructed by the Meiji government itself. As demonstrated below, these "model

Early government-led Bōren's failure to jump-start the industry does not come as a surprise to us today, as the story turns out to be similar to those behind ubiquitous failures of government-led attempts at technology diffusion in developing countries around the world (see, e.g., Easterly, 2003). First, there was inability to attract the right kind of leadership and provide the necessary incentives. Leadership failures of government-sponsored mills have already been discussed, both theoretically and empirically, in one of our own previous studies (Ohyama, Braguinsky and Murphy, 2004). In a remarkably honest self-assessment, the manager in charge of one those mills, Miyagi Cotton Spinning in North-Eastern Japan, Kokufuku Kan (recruited from the pool of local politicians, with neither knowledge of the industry nor previous business experience), said in 1885,

“Lacking capital and educated knowledge, and guided only by reckless small-town quasi-patriotic feeling because we felt bad about spending 7 million yen per year on imported cotton, we unbecomingly planned a great enterprise, letting government officials dictate things, not gauging our own ability, and almost completely failed to deliver any progress up until this very day.”²⁶

Incentives from competitive pressure were also lacking, as the government constantly gave the mills it sponsored reprieves from paying back the already subsidized loans provided to them at the outset.²⁷

Incompetent leadership led to poor technological choices. The chief architect of government-promoted mills, also wielding huge influence in early Bōren, Masatatsu Ishikawa, was the person whom Satsuma principality originally put in charge of its Sakai mill after he had spent several years working at its first mill in Kagoshima. Ishikawa had no formal engineering

mills” turned to be anything but, and were consistently among the worst performers even compared to other early mills. The Sakai mill subsequently went through several ownership changes and the last company to own it was dissolved in 1889. The Aichi mill kept operating intermittently but was never expanded beyond its original 2,000 spindles size until 1896, when it burnt down and was never rebuilt.

²⁶ Remarks recorded at the 1885 meeting of Bōren (cited in Nawa, 1937, p.98). Kan was echoed at the same meeting by Nobuchika Kurihara, a former ranking samurai placed in charge of Ichikawa Cotton Spinning in central Japan, another government-sponsored mill: “It has been two years since we started ... and it was all filled with hardships and unpleasant things. Not a single day can I remember that would be joyous or easy.” (*ibid.*)

²⁷ In what is a typical case, Mie Cotton Spinning submitted and got approval for six separate petitions for their subsidized loan restructuring in the three years from 1883-1886.

background, and all of his technical knowledge was acquired through his experience in technologically backward Japanese spinning mills (e.g., Takamura, 1971, Vol. 1, p. 42). Curiously, even though the first machines he worked with at the Kagoshima mill came from Platt Brothers of Oldham (the British machinery manufacturer that became the main supplier for the Japanese cotton spinning industry after the establishment of Osaka Cotton Spinning), he chose another British manufacturer, William Higgins & Sons Co., as the supplier for the Sakai mill and then also for Aichi National Mill, the choice that other government-sponsored mills faithfully followed. Saxonhouse in “A Tale” correctly emphasizes the role Platt Brothers later played in supplying the right kind of machinery and thereby diffusing the best practices in the industry; but William Higgins’ machines were equipped with drafting rollers designed for long-stapled U.S.-grown cotton, making it extremely difficult to employ them with the much shorter-stapled Japanese domestically grown cotton (Tamagawa, 1995, p. 13). Moreover, in an arrogant attitude also perhaps typical of government bureaucracy, it was decided that experience operating the Sakai mill gave Ishikawa and his team enough expertise to handle designing and installing machinery in the Aichi National mill on their own, so no foreign technical advisors were invited to help them set up it up (*ibid.*).

But it was the decision to use domestically grown cotton in the first place that turned out to be the main source of the industry’s early struggles. Since overcoming this problem became the key to industry’s expansion starting in the late 1880s, it is a bit odd that Saxonhouse does not even mention it in “A Tale.”

With a staple length of just 5/8 of an inch (Saxonhouse and Wright, 2010, p. 562), Japanese-grown cotton was just too short to be effectively transformed into quality cotton yarn using Western mechanized technology. Archival materials leave no doubt that the problem was well understood by both the British (who had tried importing Japanese-grown cotton for their own industry in Lancashire during the American Civil War-induced “cotton famine” of the early 1860s) and by the Japanese themselves. In 1884, Shinichiro Arakawa, a first-generation graduate

of the Imperial College of Engineering (currently the Department of Engineering of Tokyo University) working for the Ministry of Agriculture, Commerce and Industry at the time, gave a talk at a meeting of Bōren where he declared,

“Our domestically grown cotton ... is way too short-stapled and its fiber is not even. ... Short and strong fiber does not wrap on to the spindle. ... [I]t fits our traditional hand-spinning equipment, but it should not be used with mechanical equipment.” (Quoted in Nawa, 1937, p. 112.)

Nevertheless, no action to remedy this situation would be undertaken for five more years.²⁸ To make things even worse, the government’s initial grand design—coupling industrial policy to agricultural policy—was to establish as many as 250 small 2,000-spindle cotton spinning mills in cotton-producing areas of Japan (estimated to yield the equivalent amount of yarn that Japan was importing in 1878; see Takamura, 1971, Vol. 1, p. 45). The resources to carry out this fantastic plan in full never materialized. But in accordance with its blueprint, all the 20 firms established under the government auspices conformed to the envisaged small scale (i.e., 2,000-spindles) mills and were scattered all over the country, seriously hampering the development of the industry.

Even Osaka Cotton Spinning Company’s thinking was influenced by the prevailing conventional wisdom early on. For example, its leadership sought Ishikawa’s advice on the source of power for their projected mill and wasted almost two years searching for a suitable waterpower site before finally deciding to power the mill with a steam engine (Toyo Boseki, 1986, pp. 22-23). (The latter decision, of course, proved to be the ultimately correct one.) And even though Osaka Cotton Spinning was one of the first mills to realize the inadequacy of relying on domestically grown cotton, the solution it initially tried (importing Chinese-grown cotton) led nowhere because it had the same length as Japanese cotton (Rawski, 1974, p. 45).

²⁸ Incidentally, this historical episode alone, in conjunction with how things started rapidly changing after 1888, is enough to dispel a still popular myth in the literature on economic development that conditions for technological adoption and diffusion can be created by simply providing the right kind of knowledge.

There were things that separated Osaka Cotton Spinning's leadership from all other mills right from the beginning, however. First, there was the audacity of its founder, Eiichi Shibusawa, a legendary personality, dubbed the "father of Japanese capitalism" (see, e.g., Tai, 1993).²⁹ Although government support and sponsorship were available, Shibusawa deliberately eschewed it, instead organizing his firm as a joint stock company, leveraging his clout with the business community to raise capital from a broad and diverse array of private investors. The initial list of Osaka Cotton Spinning shareholders counted 95 individuals, the largest of whom (Shibusawa himself) owned just 12 percent of the total number of shares (the number of shareholders and the diffusion of ownership progressed further over time, of course). This organizational innovation, unheard of in the industry until then, allowed the company to raise enough capital to start on an entirely different scale from all previous firms. When Osaka Cotton Spinning's first mill began operating in 1883, it ran 10,500 steam-powered spindles, more than 5 times the scale of the government's model mills and most other Japanese mills. Its two-story brick building was also the first private facility in Japan to install electricity-powered lighting, and the public interest was so great that the company opened the mill for visitations for three days, during which about 50,000 people came to see it lighted at night (Toyo Boseki, 1986, p. 34).

Equally, if not more importantly, Shibusawa realized the limitations of relying on government technology advisors. To acquire the right kind of technical knowledge, he made a bold decision to invest in suitably educating a 26-year-old family acquaintance, Takeo Yamanobe, in England.³⁰ It cost Shibusawa a small fortune (several hundred thousand dollars in today's money) to cover Yamanobe's educational expenses, the major part of which was the payment required by Rose Hill Mill in Blackburn, Lancashire, for taking him as an apprentice and

²⁹ It appears that Shibusawa arrived at the idea that Japan needed its own cotton spinning industry in order to limit the amount of money it spent on imports in 1879, about the same time as the government embarked on its model mill-building policy (Geppō, 1921, September, pp. 31-32).

³⁰ Saxonhouse in "A Tale" incorrectly transcribes his name as "Yamabe."

providing entrée to other mills in the region.³¹ The investment, of course, paid off big time, and not just for Osaka Cotton Spinning but for the Japanese cotton spinning industry as a whole.³²

Saxonhouse correctly declared that Yamanobe was hardly ready for a fully independent role since he only spent a few months at Cambridge attending cotton spinning engineering classes, and then less than a year at Rose Hill Mill (see also Abe, 2004). But through the contacts he established while in Lancashire, Yamanobe was able to do two important things differently for Osaka Cotton Spinning right from the outset, compared to the prevailing wisdom in Bōren at the time. First, he worked with Platt Brothers of Oldham to customize their machines so that they could be adjusted as much as possible to handle short-staple domestically grown cotton (Farnie and Abe, 2000). This was not a cardinal solution, of course, but, along with the minimally-efficient mill size, it gave Osaka Cotton Spinning an immediate advantage, which made it both more productive and more profitable than any other contemporaneous mill in Japan. This also marked the start of a long-term partnership between Platt Brothers and Japanese cotton spinners, something that Saxonhouse legitimately puts at the center of the subsequent dramatic success of the industry. The close—and trustworthy—relationship that Yamanobe developed with Platt Brothers also led to the arrival of William Nield, a highly regarded veteran Platt Brothers engineer and millwright with vast international experience to guide Yamanobe’s team through all the steps required to correctly assemble and install the machines.³³

The start of a real takeoff for both Osaka Cotton Spinning and the industry, however, had to wait until the government decided to exit the industry. In 1886, as part of austerity measures,

³¹ Shibusawa recalled later that the decision felt like "jumping off the stage at Kiyomizu" (Toyo Boseki, 1986; the expression refers to taking a plunge from the 13-meter-high stage of Kiyomizu Temple in Kyoto).

³² Yamanobe’s illustrious career and the huge impact he had on technology adoption and overall subsequent development of the Japanese cotton spinning industry are described in detail by Saxonhouse in "A Tale," and there is not much that we need to add to his account.

³³ One of the young Japanese assigned to help Nield (and learn from him), Katsumasa Okamura, wrote later that "Nield ... had extremely precise knowledge of the technology and was also a very good teacher. All previous mills had been assembled by uneducated workers, guided by individuals who had worked for Satsuma’s Kagoshima Bōsekijo and possessed only half-baked knowledge themselves. Ours was ... the first time a Japanese cotton spinning mill started operating after being properly assembled and installed, and it made a huge difference." (Toyoboseki, 1986, 26)

the Japanese government withdrew its support from the cotton spinning industry and privatized its mills. At that point, Osaka Cotton Spinning was already a stand-out, with the size almost 10 times the average size of other mills and alone responsible for more than 46 percent of all domestically produced cotton yarn (which, of course, still hardly put a dent in imports at that time). With the government out of the picture, the door was finally open for Osaka Cotton Spinning to become the industry leader. In June 1888, Bōren was reorganized into an association of independent producers, with Yamanobe as the new chairman. Within a year, through the initiative and financing of Osaka Cotton Spinning, Bōren sent a mission to India to explore replacing domestically grown and Chinese cotton with longer-staple cotton imported from India. Once the initial experiment (conducted at Osaka Cotton Spinning mill) turned out to be successful, in line with Bōren's tradition, samples were distributed to all firms. By 1890, Indian cotton already accounted for 18.9% of total consumption by the Japanese cotton spinning firms; two years later it accounted for 48.7%, with 12.6% more comprised of the U.S. cotton. The path for a breakthrough in industry growth was finally open, thanks almost entirely to the vision and effort of a single great firm.³⁴

It is worth mentioning that the other major technological advancement of the late 1880s, switching from mules to ring spinning frames, described in detail in "A Tale," probably would not have succeeded without the switch in the source of supply of raw cotton. While there is some disagreement among the Japanese historians about which of these almost-contemporaneous events was the key, the view that makes most sense to us is the one expressed by Kanji Tamagawa (Tamagawa, 1997). In his analysis of ring adoption by the Japanese cotton spinners, he stresses that

³⁴ To illustrate the nature of the many difficulties faced and overcome in this process, cotton shipped from India was baled, requiring an opening machine, heretofore unknown to the Japanese. (British cotton spinning machinery manufacturers knew that Japanese and Chinese cotton was not baled, so they did not routinely include bale-opening machines when supplying the Japanese mills.) Yamanobe had to figure out that a missing piece of equipment was required and to order it from Britain, only after which experiment with production using Indian cotton became possible (Toyo Boseki, 1986).

“It is hard to determine unequivocally whether at that time it was mules or ring spinning frames that embodied the newest technology. At the very least, it would be wrong to say that the self-acting mule [which the Japanese mills installed before switching to rings – S.B., D.H.] represented old technology. Ring spinning frames had a limitation that they could only produce yarn of thick counts; therefore, while they were indeed newer machines, they were not state-of-the-art. ... The cotton spinning industry in our country started with the goal of replacing imported Indian yarn of the 16th count... But until it started using imported Indian cotton, this goal proved unattainable. ... Complete adoption of ring spinning frames in the 1890s was a natural consequence of our engineers realizing that with Indian cotton they now finally had a chance to conquer the thick-count yarn market.” (Tamagawa, 1997, pp. 8-9, 13-14).

The most important lessons to be learned from the early struggles and the subsequent breakthrough of the Meiji-era cotton spinning industry in Japan can be summarized as follows. First, a collaborative institutional arrangement by itself is not a guarantee of the diffusion of the best practices. Bōren’s first 6 years serve as a stark reminder that rapid diffusion through a cooperative institutional arrangement is a double-edged sword, and can easily lead the industry astray if wrong choices are made at the outset by unqualified or arrogant leadership. Bōren became an *efficient* collaborative institution only after it was taken over by technically competent leadership and completely revamped following the withdrawal of government bureaucracy. Second, successful technology adoption and diffusion require the presence of at least one exceptionally strong leading firm. In the Meiji-era cotton spinning industry in Japan, this role was initially assumed by the joint-stock company Osaka Cotton Spinning, but we can see similar stories repeatedly playing out in numerous other historical cases.³⁵ Finally, the real take-off of a new industry (such as seen in Figure 1b above) cannot happen without a strongly competitive environment, in which new firms are constantly born and old firms that cannot adapt to technological and market change are weeded out. In the next section we turn to an in-depth examination of the importance of this factor.

³⁵ For example, in the Austrian bentwood furniture industry in the second half of the 19th century, the leadership in innovations came from two firms, Thonet Brothers and Kohn Brothers (Kiriazidou and Pesendorfer, 1999, p. 157), in the 1980s Chilean salmon industry it came from Salmones Antartica (Pietrobelli and Rabellotti, 2004). And in the early years of the U.S. semiconductor industry, the Bell Laboratories produced a disproportionately large share of major product and process innovations and also helped their diffusion through its liberal licensing policies and attitudes toward interfirm mobility of scientists and engineers (Tilton, 1971, p. 50).

II.2 Technology adoption and diffusion—older mills

The bird's eye view of the process of technological diffusion presented in "A Tale" is no doubt true in its main contours. Once again, however, there is a lot to be learned by delving more deeply into the available data and archival materials. We split our examination of the actual technology diffusion process in Meiji-era Japanese cotton spinning industry in two parts. In this section, we look at how former government-sponsored mills reacted (or did not react) to innovations introduced by Osaka Cotton Spinning and how these reactions affected their productivity, profitability and ultimate fates. We then turn our attention to newer mills (which were the focus of "A Tale"), and we compare their practices, performance and eventual fates to those of Osaka Cotton Spinning and other leading firms.

In 1887, after almost a decade of government-led promotion efforts, the industry finally faced a clean slate with all mills privatized and having to play by the same competitive market rules. At that point, the field was comprised of 21 mills, with an average equipment capacity of 3,292 spindles and an average of 137 factory floor workers employed per day. As already mentioned, however, looking at the average is not very informative because it was comprised of two very uneven parts. On the one hand, there were 20 former government-owned and -sponsored firms, 2 of which did not operate at all, while those that did, employed on average 2,290 spindles and 99 factory floor workers per day. And then there was Osaka Cotton Spinning, which in that year already operated 28,153 spindles, employed 756 workers, and produced almost half of the combined industry output. It is easy to see from this that Osaka Cotton Spinning's share of output was even far in excess of its share of spindles or labor. Indeed, in the same year, its labor productivity (output in physical units divided by total work-hours of factory floor workers) was 104 percent higher than the average of all other firms in the same year, while the

productivity of its spindles, even conditional on operating (output produced in physical units divided by the total spindle-hours in operation), was 35.1 percent higher.³⁶

As detailed in the previous section, Osaka Cotton Spinning's example clearly demonstrated already in the mid-1880s the importance of having a mill of the size of at least 10,000 spindles and of switching from unsteady and often unavailable hydro-energy as a source of power to steam power. These technological thresholds left the 20 newly privatized (formerly government-sponsored) firms with the task of increasing mill size and employing steam power, or risk losing everything. Subsequent developments (the arrival of Indian and U.S. cotton and of ring spinning frames) also meant that they faced the task of revamping their outdated capital stock (as did Osaka Cotton Spinning, as well). We can learn a lot from the variation in the degree of response to these new challenges by older firms.

Recall that Osaka Cotton Spinning was able to construct a large mill because Shibusawa organized it as a joint stock company, which allowed him to raise the required capital. This was also the first thing that newly privatized incumbent firms had to do in a hurry. Two other firms, Dōjima Cotton Spinning and Tamashima Cotton Spinning, had already reorganized themselves as joint stock companies by 1886. Dōjima Cotton Spinning was clearly influenced by Osaka Cotton Spinning, as it was bought from its previous owner and then incorporated in 1885 by Jutarō Matsumoto, one of the top shareholders and a board member of Osaka Cotton Spinning (Kinugawa, 1964). As for Tamashima Cotton Spinning, it incorporated in 1882, soon after Osaka Cotton Spinning, but it continued to languish until it was rescued in 1884 by Kichijirō Kunitake, a capitalist from the Kyushu area who followed Shibusawa's footsteps in making some of the early investments in this industry. In 1887, several more firms became joint stock companies, including Mie Cotton Spinning, which was directly assisted by Shibusawa. Notably, mills that successfully incorporated gained access not just to more capital but also to better technological

³⁶ Unless explicitly stated otherwise, all the data here and below are authors' calculations or estimates using the data sources described at the beginning of Section II above.

advice. Thus, Dojima Cotton Spinning was supervised by Takeo Yamanobe, and Tamashima Cotton Spinning was able to hire Shinichiro Arakawa (who had so clearly identified the problem with using domestically grown cotton already in 1884); Mie Cotton Spinning, on Shibusawa's and Yamanobe's recommendation, hired Tsunezo Saito, a brilliant young engineer, graduate of the Imperial Engineering College, who turned the struggling small Mie mill into an equal of Osaka Cotton Spinning in less than a decade.

In Table 1 we present some characteristics of the previously government-sponsored mills in comparison to Osaka Cotton Spinning in 1889, the last year of operation for several of them. Eight of the 20 firms had incorporated and become joint stock companies, but 12 remained unincorporated. Ring spinning frames had been fully or partially introduced in 9 of the 20 firms, steam engines (as a sole source of power) had been adopted in 10 out of 20 firms, while only 4 out of 20 firms (the already mentioned Dōjima, Tamashima, and Mie, and also Nagoya Cotton Spinning) managed to reach the capacity size of over 10,000 spindles (the minimum-efficient scale, as demonstrated by Osaka Cotton Spinning back in the early 1880s). In other words, just one out every 5 of the older firms had been able to emulate all the important innovations introduced by Osaka Cotton Spinning by the time the industry was about to start its remarkable growth phase.

[Table 1 around here]

In Table 2 we present the same data for 1897, the year approaching the end of the first expansion phase of the industry. Three out of four mills that already had a head-start in 1889 had continued to expand and modernize (the fourth one, Dōjima, was lost to fire in 1896), with Mie Cotton Spinning having almost completely caught up with Osaka Cotton Spinning. They are joined by Okayama Cotton Spinning, which while still below the minimum efficiency scale in 1889, had already been transformed into a joint stock company by that time and started modernizing its machinery under the technological guidance from Shinichiro Arakawa, who had helped Tamashima Cotton Spinning (it did not hurt that the two firms were located in the same

geographical area, just as Dojima, located in Osaka, could use Yamanobe's services). Still, most other mills continued to be stuck in a low productivity rut more than 10 years after privatization with essentially the same old technology. Indeed, 5 of them were already out of business (through dissolution in three cases and fire accidents in 2 others, where until the fire no marked improvement in technology had ever been observed).

[Table 2 around here]

This experience of older firms, founded initially as government-owned or government-assisted enterprises, highlights the lasting impact of founders and founding conditions on long-term firm performance that has been uncovered time and again in the literature on firm and industry dynamics (see, e.g., Boeker, 1989). Once again, we see evidence here that technology adoption and diffusion is a much more complex task than emulating a leader, even when there are no trade secrets and a collaborative institutional arrangement is firmly in place, as was the case in the Japanese cotton spinning industry at the time.

II.3 Technology adoption and diffusion—new entrants and old leaders

With the notable exception of Mie Cotton Spinning (which was essentially reborn with direct help from Osaka Cotton Spinning in 1886-87) no long-term success emerged from the ranks of older, former government-promoted mills, and this perhaps is not at all surprising given what we saw in the previous section. The rapid growth phase in the 1890s (see Figure 1b above) mostly came through entry by new firms, equipped with steam-powered state-of-the-art machinery, minimum-efficient scale, and without the baggage of old technical and managerial habits.

Two technological breakthroughs of the late 1880s and early 1890s mentioned above (the introduction of Indian and other high-quality raw cotton and ring spinning machines) as well as the willingness by investors (lured by high dividends paid by Osaka Cotton Spinning) to purchase equity stakes in newly forming companies led to a wave of new entry. Thirteen new cotton spinning mills started operating in the industry in 1887-1889. After a brief respite in 1890-91 when, due to adverse business conditions, only 3 firms were founded, 19 more enterprises started

operating in 1892-94, and 27 more entered in 1895-1896. New machines were coming in droves both for new entrants and those among the older mills that had the capacity and willingness to revamp their capital stock.

As documented in Saxonhouse's "A Tale," the best practices of the best firms diffused extremely fast, and all firms had access to the same knowledge diffused through Bören. Hence, with the exception of a dozen or so older firms that could not adapt (see the previous section), there was little difference towards the end of the 1890s among important firms in underlying technologies or organizational forms. In fact, at the peak of new entry and output expansion (around 1895-97), it looked like the early competitive advantage of leading firms was becoming a thing of the past as new entrants outperformed them on several measures of firm performance.

In Table 3 we present the results of estimating a standard production function regression, using monthly data on outputs and capital and labor inputs in physical units (including also year-month fixed effects), for years 1895-97. The variable of interest is "New entrant," which is a dummy equal to 1 if the firm entered the industry in 1890 or later and zero otherwise (choosing other reasonable cutoffs leads to very similar results). The coefficient on this variable is designed to capture how much more or less productive new entrants were compared to the omitted category (firms founded before 1890). We can see that new entrants outperformed older firms by about 9.1 percent [$\exp(0.087) - 1$].

[Table 3 around here]

It is not hard to identify the source of superior productivity of new entrants. While the "best practices" developed by Osaka Cotton Spinning (and other early leading firms) had diffused, new entrants had an additional benefit of being able to order newest, state-of-the-art machines that allowed them to take advantage of availability of Indian, U.S. and other high-grade raw cotton. The data on machine orders from British manufacturers compiled in the late 1990s-early 2000s by Saxonhouse with the help of his research assistant Patrick McGuire (Wright, 2011) contain rich information about various technical characteristics of machines that were

shipped to Japanese cotton spinning producers in each year. These characteristics are (1) average spindle speed, (2) average count of cotton yarn to produce what 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) whether the machine was designed to work with Indian or U.S. cotton.

Unfortunately, matching the names of Japanese entities placing orders with the British in Wright (2011) to the names of firms in Japan that received those machines proved to be not feasible (primarily because many orders were placed in the names of intermediaries, and it is not clear which firm was the actual recipient of the machines in those orders). However, we were able to collect our own data about new machine installations (and decommissionings of older machines) by each firm in Japan in each given year,³⁷ and match these with information about technical characteristics of machines delivered in the same year. This gave us average technical characteristics of machines for each vintage year, which we then assigned to each firm in the industry in that year, based on the vintage-age of its machines.

Table 4 shows the difference in machine characteristics between new entrants and older firms. Note first that the gap in machine age between older and newer firms is 4.4 years, compared to the 8.4 years gap in firm ages. This reflects older firms' efforts to revamp their machine stocks by purchasing new and decommissioning older machines. But we can also see that older firms still had ways to go to catch up to newer entrants in terms of technical characteristics of their machines; for example, the average rotation speed of spindles in machines available to new entrants was about 4 percent higher than in machines installed in older firms, while the number of spindles per frame was also 4.6 percent higher, meaning that the same

³⁷ We used shareholders reports as the source of data on new machine installations and decommissionings of old machines in years 1898 and later. As for earlier years, "Enkakukiji," an unpublished but well-known to Japanese historians hand-written survey article on the industry conducted around the turn of the 20th century contains this information for all firms that had ever operated in the industry from its very inception until about 1900. We thus employed "Enkakukiji" as our source of data for early years, for which shareholders reports were not available. (Takeshi Abe kindly provided us with a copy of "Enkakukiji" from his personal archives.)

number of frames, operating the same number of hours could potentially yield almost 9 percent more cotton yarn (compare this to the productivity advantage measured in our production function regression in Table 3). Machines installed by new entrants were also designed to produce higher counts of cotton and, crucially, were also much more versatile—half of those were designed to work with Indian cotton and 41 percent were designed to work with U.S. cotton, compared to just 13 percent and 18 percent, respectively in older firms (all the above differences in means are statistically highly significant). This gave new entrants greater capacity to engage in blending different types of raw cotton, something that was becoming a hallmark of the Japanese cotton spinning industry's global competitive advantage (Saxonhouse and Wright, 2010).

[Table 4 around here]

These detailed micro-level data thus support the notion that an extremely high rate of diffusion of the best available technologies was the main driving force for the big entry wave into the Japanese cotton spinning industry in the 1890s and propelled the industry to the spectacular growth, which can be seen in Figure 1b. Things, however, played out very differently over the following decade, serving as another illustration that having an opportunity to fully adopt the state-of-the-art technology and being able to take advantage of that opportunity are not the same.

Figures 1b and 1c above show that after peaking in 1899, Japanese output of cotton yarn and its exports fell sharply in the next year and then remained basically stagnant until the start of the Russo-Japanese War in 1905. There was another drop in output and exports in 1908. All in all, industry-wide output grew by just about 50 percent during the first decade of the 20th century, compared to 700 percent in the 10 years prior to that.³⁸ Sixty firms exited the industry between 1898 and 1911, and 50 of those had their production facilities acquired either by other firms or by

³⁸ Under these circumstances, Bōren increasingly assumed the role of a price-keeping industry cartel, in addition to or even in lieu of its previous function promoting technology diffusion. It implemented the first serious industry-wide output restrictions (enforced by its officials' plant inspections) in May 1900 – March 1901, and then again in the second half of 1902. It implemented these again starting January 1908 and lasting for over two years (until March 1910). These measures had little effect on the fates of its individual members, however.

outside investors. Significantly, 38 out of those 50 acquired firms (76 percent) were newer entrants (i.e., they entered the industry in 1890 or later). In contrast, in 40 percent of all acquisition cases (20 out of 50), the acquiring firm was one of the 5 early industry leaders (Osaka Cotton Spinning, Mie Cotton Spinning, Kanegafuchi Cotton Spinning, Hirano Cotton Spinning and Settsu Cotton Spinning), entering before 1890, and playing a pioneering role in technological and managerial innovations of the 1890s.³⁹ In Figure 2 we show the dynamics of the fraction of plants, fraction of industry total capacity and fraction of industry output accounted for by these leaders in 1898-1911. Driven mostly by acquisitions, the leading firms expanded their share of ownership in terms of the number of plants operating in the industry from just over 10 percent in 1898 to almost 40 percent in 1911; their share of industry total spindle capacity and output increased from less than 25 and less than 30 percent respectively, to about 45 percent over the same period of time.

What was it that made older industry leaders so much more fit to the changed market environment than their younger competitors? Since the underlying technology was the same and machine quality was even better in newer firms, we have to look elsewhere for the reasons. A burgeoning recent strand in economic literature emphasizes the role of management in technology diffusion (see, e.g., Bloom et al., 2013, Bloom and Van Reenen, 2010). And the importance of this factor was in full display in the case of Meiji-era cotton spinning industry in Japan.

One insight is provided by “circulars” (“Shihainin Kaishō”) written by the general manager of Kanegafuchi Cotton Spinning (hereafter, “Kanebō” for short), Sanji Mutō, and studied in detail by Japanese historian, Tetsuya Kuwahara.

After Kanebō acquired, one after another, 7 recently founded firms (9 production facilities in total) between 1899-1903, it found itself facing a difficult task of improving efficiency and quality of production in the newly acquired plants. Writes Kuwahara:

³⁹ Hirano Cotton Spinning itself was acquired in 1902 by Settsu Cotton Spinning, in what is a very instructive case discussed in detail below.

“While the quality of cotton yarn produced in the Hyōgo factory [i.e., Kanebō’s own flagship mill—S.B., D.H.] was relatively uniform, the quality of cotton yarn from the other newly bought-out factories was much less so. Kanebō received a flood of complaints regarding the quality of yarn not only from its domestic buyers but also from its overseas buyers. ... [The] complaints were about coarseness, excessively twisted fibres, grayish colour, dullness, unevenness, and high moisture retention. The buyers also complained about the packaging of the yarn. ... [D]ue to poor reeling operations during the final production stage of cotton yarn, much short and broken yarn, waste yarn, was found at the weaver’s end” (Kuwahara, 2004, p. 502).

It is particularly noteworthy that there was no difference among the newly acquired and Kanebō’s own Hyōgo plant in terms of machines and equipment—indeed, with the exception of the Kumamoto plant, all other newly acquired plants had machines produced by Platt Bros. of Oldham and installed after the (first) Sino-Japanese war of 1894-95. (The Hyōgo plant was also a relatively new addition to Kanebō’s production facilities, as it was built and started operating only in 1896.⁴⁰) Types and mixing technology of raw cotton used in all plants were also centrally controlled by the Kanebō’s division of operations. According to Kuwahara:

“[T]here was almost no differences in objective operating conditions across different plants. ... Most quality failures were due to simple errors or lack of discipline among workers. Mutō saw too many of those and realized that quality depended on how rank-and-file workers performed. ... Mutō appointed firm employees whom he personally trained in the firm division of operations and at the Hyōgo plant to positions of plant directors and managers in charge of plant operations to other plants. ... Operation details in each and every plant would be reported personally to Mutō and used by him to improve the organizational structures in all plants. It is through this process that Kanebō’s headquarters finally became capable of precisely and effectively knowing the performance of each and every workers involved in the different production lines in each and every plant.” (Kuwahara, 1994, pp. 39-40).

Kanebō’s struggles with bringing its newly acquired plants up to the required standards clearly illustrates how the same technology and technical practices can still result in very different outcomes in the production process, which continued for some time even after plants became part of the same Kanebō firm. We next use annual establishment-level production data (coded by Braguinsky, Okazaki and Ohyama) matched with the data on the firms that owned those establishments in different years to go beyond case studies and see how ownership (i.e.,

⁴⁰ Kanebō’s original, Tokyo plant had been in operation since 1889, and its productivity was lower than that of the Hyōgo plant in the 1900s (Kuwahara, 1994).

management) changes helped acquired plants realize the full potential of their superior technology for the first time.

As a preliminary step, in Table 5 we compare some important performance measures between early industry leaders (the 5 firms listed above) and the firms whose production facilities they will eventually acquire between 1898-1911 (20 acquisition cases in total). The comparisons are conducted over the average of three years *preceding* the acquisition.

[Table 5 around here]

Looking first at the top two rows, we can see that to-be-acquired firms on average entered 8.5 years later than early industry leaders that were to acquire them. The gap in the age of the machines, however, is less than 2.5 years and is also much smaller compared to what we saw early on after entry (in 1895-97; see Table 4 above). This indicates that leading firms kept revamping and updating their machine stock.

The bottom three rows show the difference in the most important indicators of management performance across these two categories of firms: mean profit rates, unrealized output ratios and spindle capacity utilization rates. Profit rates, which eventually determine firm outcomes are measured as annualized net revenue from firms' profit-loss statements divided by the year-end value of the sum of capital invested by shareholders and companies' interest-bearing debt from the balance sheets. "Unrealized output," which measures the efficiency of the firms' sales operations, is constructed from the companies' balance sheets and includes year-end value of the stock of produced yarn and year-end value of payments accruable (that is, the value of yarn delivered to the customer but not yet paid by the customer). This is then divided by the annual value of output, which is obtained at the establishment level by multiplying the physical volume of cotton yarn produced by the plant-specific output price.⁴¹ Spindle capacity utilization rates are

⁴¹ We also looked at the stock of produced yarn carried over and payments accruable separately and confirmed that balance sheets of leading acquiring firms show lower ratios to output value of both of those measures. The correlation between the stock of yarn carried over and payments accruable is also positive, but not very strong. This suggests that difficulties with selling output to reputable clients (which led to

constructed at the plant level by dividing the number of spindle-days in operation by the total number of spindles installed, times 365. Thus, this is a measure of the degree to which firms utilized the total amount of capital input available to them, with low capacity utilization rates directly linked to lower sales and lower profitability.⁴²

Figures 3-5 show the density distributions of these performance metrics over the 3 years prior to acquisitions. The distribution of profits of leading firms that acquire other firms in Figure 3 looks like a uniform shift of the distribution of acquired firms to the right, while the unrealized output ratios distributions exhibit exactly the opposite pattern (Figure 4). Figure 5 shows that while the modes of spindle capacity utilization rates are similar across the two distributions, the capacity utilization rate distribution of acquired firms has a long and fat left tail, indicating one-time production shutdowns, presumably due to demand problems but also perhaps due to machines breakdowns and/or problems with workers.

We next look at what happened to production facilities acquired by industry leaders from weaker firms after acquisitions. Normally, data problems prevent econometricians from cleanly separating post-acquisition changes in productivity from changes in sales (which can also be driven by changes in market power). The unique nature of the physical input and output data available at the establishment level in our case allows us to estimate what happened to physical productivity of the plants acquired during the “shakeout” decade in this industry, without worrying about our estimates being contaminated by pricing and other factors not directly related to technological efficiency.

increased stock of unsold output) forced weaker firms to seek less reputable clients, which, in turn, increased the amount of payments accruable. Both these measures can therefore be interpreted as problems with realizing produced output, hence, the name used in the text. See Braguinsky et al., 2014, for more on these issues.

⁴² We also looked for differences in prices for output and wages paid to workers but found no significant pre-acquisition differences between acquired firms and industry leaders on these dimensions. This is consistent with what we know about Meiji-era markets for cotton yarn and labor in this industry. Details are available upon request.

To measure the impact of acquisitions, we conduct a within-acquired-plant estimation of changes in its productivity from before to after acquisition by regressing (logged) output on (logged) machine and labor services inputs as well as a dummy equal to one during the post-acquisition period and zero otherwise to gauge the average affect of acquisition on productivity. We include plant fixed effects and calendar year fixed effects in the regression specification, so the coefficients on post-acquisition year dummies capture within-plant differences in productivity, which cannot be attributed to changes in capital or labor inputs, while also removing effects of any systematic changes over the sampling period. Note also that since we measure capital input as spindle-days in operation, our estimates capture the increase in output produced controlling for the amount of capital and labor inputs measured as *flows*, that is, they can be interpreted as measuring a contribution of management technology in the production process itself, net even of capacity utilization considerations.

We carry out these estimations in two specifications. The first equation has the form:

$$y_{it} = \alpha_0 + \beta_{1t}k_{it} + \beta_{2t}l_{it} + \gamma_{it}D_{it} + h_i + \mu_t + \varepsilon_{it} \quad (1)$$

where y_{it} is the (logged) output of plant i in year t (measured in physical units); k_{it} is the (logged) number of spindle-days the plant operated in year t , l_{it} is the (logged) number of workers in year t ⁴³, D_{it} is the dummy equal to 1 for plant i if year t is a post-acquisition year, h_i is a plant fixed effect; μ_t is a year fixed effect; and ε_{it} is the error term. This specification is designed to capture the average difference between pre- and post-acquisition years. The second equation has the full set of pre- and post-acquisition time dummies, so it is designed to also look at both pre- and post-acquisition time trends:

$$y_{it} = \alpha_0 + \beta_{1t}k_{it} + \beta_{2t}l_{it} + \gamma_-D_{i-} + \sum_{t=T-3}^{t=T-1} \gamma_{it}D_{it} + \sum_{t=T+1}^{t=T+5} \gamma_{it}D_{it} + \gamma_+D_{i+} + h_i + \mu_t + \varepsilon_{it}, \quad (2)$$

⁴³ In line with the practice established in the literature, we weighed female worker-days by the ratio of their wages to male workers when aggregating the labor input; these wage data are also available at the plant level. The results remain basically unaffected, however, if male and female workers are included in the regression (1) as separate inputs measured by work-days.

where T is the year of acquisition, and D_{i-} and D_{i+} are the dummies equal to 1 for plant i in years up to 4 years prior to the acquisition year and zero otherwise, and equal to 1 for plant i in years 6 and beyond after the acquisition and zero otherwise, respectively. The estimates are carried out using observations on all productive establishments that changed ownership between 1898 and 1911. We also estimated regressions similar to (1) with outcome variables being (logged) ratios of unrealized output (assigned to each plant from firm-level data in proportion to the plant's fraction in firm output in case of multiple-plant firms) and (logged) plant-level capacity utilization rates.

The results of estimating regression (1) measuring average post-acquisition effects are presented in Table 6, while Figure 6 presents the graph of the year-by-year coefficients estimated from equation (2). Estimation results in Table 6 show that after they are acquired, establishments improve their productivity on average by about 7.5 percent, statistically significant at the 5 percent level (the results are even stronger if we limit the sample to plants acquired by industry leaders only). Acquisitions also result in about 30 percent decrease in the unrealized output ratios and about 9.4 percent increase in the spindle capacity utilization rates.

[Table 6 and Figure 6 around here]

Figure 6 depicts the dynamics of productivity around acquisition time. We can see that there is little dynamics of productivity in acquired plants prior to acquisitions (if anything, there seems to be some mild downward trend). After being acquired, however, these establishments clearly start to improve their productivity, by 5-8 percent in the first 3 years and by even more—up to about 15 percent—in subsequent years.

The comparison of physical productivity of production facilities before and after they were acquired strongly suggests that management was an indispensable factor required to bringing out the full technological potential of newer plants. Having access to the best technology and machines and ability to imitate the leaders did not by itself make weaker firms either more profitable or even more productive in a narrow technological sense. Instead, full

diffusion of the new technologies (and eventual uniformity of technological practices noted in “A Tale”) required the ownership to be transferred to and consolidated in the hands of better managers, which, in turn, required a functioning market for asset acquisitions.⁴⁴

II.3 Industry leadership factors—the role of talent and tacit knowledge

Improvement of physical productivity of newer plants after they were acquired by stronger firms with better management practices serves also as a stark reminder of the importance of tacit knowledge, experience and managerial talent even in a setting, which, as in the Meiji-era Japanese cotton-spinning industry, had almost no barriers to technology diffusion. We already discussed one such case at the dawn of the industry, when William Nield, whose arrival became possible because of Yamanobe’s contacts while in England, helped with machine assembly and installation and start up of the Osaka Cotton Spinning’s first plant. An almost accidental encounter, which happened at the same time, led directly to the birth of another great firm, Mie Cotton Spinning. Tsunezō Saitō, one of the first graduates of the Imperial College of Engineering, came as an observer to learn plant engineering from Nield as the latter was installing machines at the Osaka Cotton Spinning plant. Saitō then discovered an error in the installation manual provided by the manufacturer of the steam engine and was able to correct it, impressing both the British millwright and Yamanobe with his engineering skills (Toyo Boseki, 1986). Several years later, Yamanobe remembered this episode when he was asked to recommend someone for the position of chief engineer at Mie Cotton Spinning, which was trying to rebuild after years of dismal performance (recall that Mie was founded in 1880 as one of the government-sponsored 2,000-spindle mills). Yamanobe recommended Saitō, and this turned out to be an

⁴⁴ All in all, 35 out of 78 plants that operated in 1897 changed ownership at least once between 1898 and 1911. In terms of the fraction of total industry spindle capacity in 1897, the share of future acquired plants was more than 50 percent.

appointment that, along with financial assistance provided by Shibusawa, put Mie Cotton spinning in the same league as Osaka Cotton Spinning itself.⁴⁵

Another cluster of early leading firms, Hirano Cotton Spinning, Settsu Cotton Spinning, and Amagasaki Cotton Spinning was founded around 1887 in the Osaka area and with some overlapping investment interests. It was propelled to success by another capable engineer, Kyōzō Kikuchi, whom Hirano Cotton Spinning sent for training to England, clearly inspired by the Osaka Cotton Spinning example. Kikuchi was even better prepared for the job than Yamanobe as he had already graduated from the Imperial College of Engineering in Japan prior to going to England, where he worked for a year at a spinning factory in Middleton during the day and studied at a technical school in Manchester in the evenings (Abe, 2004, p. 10; see also Hunter, 1991). Upon his return to Japan, Hirano appointed him to the position of the chief engineer, but then agreed to share his services with Settsu and Amagasaki in return for the latter two firms' paying their share of the expenses incurred in Kikuchi's study in England. All the three firms quickly rose to prominence in the industry, but the story then took another twist. As Kikuchi's role was becoming increasingly prominent not just in supervising the engineering aspects but also in other managerial duties, he expected to be promoted to the board of directors. But Hirano Cotton Spinning's directors had a policy according to which they would not appoint people with engineering background to senior management positions. Such a position was, however, offered to him in 1897 by Settsu Cotton Spinning, leading Kikuchi to sever his relationship with Hirano. Hirano Cotton Spinning's fortunes started declining soon after, and in 1902 it was forced to exit the industry, with its plants acquired by Settsu Cotton Spinning. Hirano Cotton Spinning thus paid the price of not realizing the importance of having someone like Kikuchi among its top

⁴⁵ Saitō went on to become Mie Cotton Spinning's CEO and one of the most prominent figures in the industry. After Osaka Cotton Spinning and Mie Cotton Spinning merged in 1914 to form Tōyō Cotton Spinning (Toyo Boseki), Saitō became its second CEO, succeeding Yamanobe himself in this position in 1916.

managers, and the whole episode clearly demonstrates that good managers create good firms, and not vice versa.⁴⁶

Sanji Mutō and Kanebō present yet another instructive case. In contrast to Yamanobe, Saitō, and Kikuchi, Mutō was not an engineer but a professional manager, with experience working for Mitsui Bank in the U.S. In 1894 he was appointed to be the director of Kanebō's second plant, which was being constructed at the time in Hyōgo area (close to Osaka). (Kanebō's first plant and the company headquarters were located in Tokyo.) Mutō's management philosophy stressed the importance of motivating workers by providing them with better living; better living, in his view, started with paying them higher wages. The idea, however, was not welcomed by other firms already operating in the area, which included other industry leaders based in the Osaka-Hyōgo area (including the already-mentioned Osaka Cotton Spinning, Hirano Cotton Spinning, Settsu Cotton Spinning and Amagasaki Cotton Spinning). As Mutō started hiring workers for Kanebō's new plant and offering higher wages than those paid by other firms,⁴⁷ other firms accused Kanebō of worker poaching and put pressure on merchants to boycott Kanebō's products. They reportedly even recruited "yakuza" (Japanese organized crime) to kidnap and bring back workers "poached" by Kanebō as well as promised to pay 300 yen to anyone who would physically hurt Mutō.

Backed by the Mitsui group, Mutō and Kanebō refused to back down, and after a few months the conflict was settled through mediation by the Chairman of the Bank of Japan (Kinugawa, 1964). As already mentioned, Kanebō's Hyōgo plant became the flagship plant of the company and many of the management practices, especially labor management practices

⁴⁶ Kikuchi also became CEO of Amagasaki Cotton Spinning in 1901 where he oversaw the first competitive production of high-quality 42nd count cotton yarn in Japan. By 1916 he was the CEO of both Settsu and Amagasaki Cotton Spinning, which he brought together in a mega-merger in 1918 that created Dainippon Bōseki (currently Unichika).

⁴⁷ For example, in 1897, the first year for which we have wage data for Kanebō's Hyōgo plant, Mutō paid his female workers 18 sen (sen is 1/100 of yen) per day, while the four plants of Osaka, Hirano, Settsu and Amagasaki Cotton Spinning, located in the same area, paid only 15.8 cents (14 percent less). The gap was similar for wages paid to male workers, and it persisted into the first decade of the 20th century.

pioneered by Mutō in this plant were then implemented throughout the Kanebō empire and also industry-wide.

To sum up, having access to the best available technology and knowledge dissemination through a cooperative institutional arrangements were by no means guarantees of long-term success. Not only did the firms that entered on the wave of the new technological paradigm in the mid-1890s fail to survive once the market conditions changed; we can see clear evidence that their (lack of) permanent success was to a large extent due to the fact that they failed to take full advantage of the potential their state-of-the-art production facilities had to offer. As they lost in market competition to established industry leaders, these firms exited, and their production facilities were acquired by stronger, industry-leading firms, which then improved not just the profitability but also physical productivity of those facilities. Thus, both a strong competitive environment and a functioning market for assets were the main factors that enabled the industry to realize fully the opportunities offered by new technologies. In other words, successful technological adoption and uniformity of practices required mediation by the market mechanism that allowed exceptionally talented entrepreneurs and managers (most of whom were vested with a few of the early industry leaders) to greatly expand their span of control.

III

In “A Tale” Saxonhouse presented the picture of technological diffusion in Meiji-era cotton spinning industry in Japan as that of an almost frictionless process, powered by imitation of the British and rapid dissemination of the best practices through the institutional arrangement of Bōren. While there is certainly historical truth in the statement that in this industry, we have what is still a rare example of a developing country’s adopting advanced Western manufacturing technique and creating a globally competitive industry in a historically short period of time, our in-depth investigation in this paper shows that the process was by no means as simple as a casual reader of “A Tale” might imagine. Instead of early firms simply adopting a British blueprint and subsequent entrants “slavishly imitating” them, we saw a lot of confusion at the initial stage,

followed by failure of most firms, both older ones and later entrants, to either adopt or fully exploit the new technological opportunities that were presented to them. Instead, the best practices diffused and fully reached their potential only after production facilities were consolidated under superior managerial talent nurtured by a few industry leaders. Throughout this process, Bōren indeed disseminated knowledge and tried to assist its members in a variety of ways, but it was left to a few exceptional firms to propel the industry to its global competitiveness. And even among those leaders, as we saw, there were often bitter disagreements and conflicts rather than harmony.

All this does not make the lessons that can be learned from the Meiji-era Japanese cotton spinning industry about technology diffusion process in general any less important. On the contrary, only by taking a magnified look at some of the details (as we have tried to do) can we learn what the really important lessons were. We conclude by summarizing those lessons below.

First, technology adoption and diffusion seems to require the presence of a leading firm (or a few leading firms), which pioneer new technologies and then play a crucial role in establishing an effective culture or institutions that promote the diffusion of those technologies. In the Meiji-era Japanese cotton spinning industry this role was played by Osaka Cotton Spinning (and later also by a few other firms listed above) and Bōren, which, however, only became effective after Osaka Cotton Spinning took it over. As already mentioned, there are multiple similar examples in very different historical contexts world-wide, from Thonet Brothers and Kohn Brothers, two leading firms in the Austrian bentwood furniture industry in the second half of the 19th century (Kiriazidou and Pesendorfer, 1999, p. 157), to the Bell Laboratories in the early U.S. semiconductor industry (Tilton, 1971), to Salmenes Antartica in the Chilean salmon farming industry in the late 20th century (Pietrobelli and Rabellotti, 2004) and so on.

Second, technology diffusion, including technology diffusion through technical cooperation, somewhat paradoxically, seems to thrive best under relentless market competition. Japanese adoption of ring spinning frames and other advanced technologies in the 1890s was so

fast and complete that one might think there had to be a large decision-making unit internalizing these externalities. But this was certainly not the case, and as Saxonhouse also did not fail to emphasize, firms were actually ruthlessly competitive in both input and output markets.

Third, neither competition nor technical cooperation work unless the institutional environment allows better managers to increase their span of control and replace inept managers at the helm of production facilities. One underappreciated aspect of the success of the Meiji-era Japanese cotton spinning industry is the relative easiness with which ownership could be transferred due to the joint stock company organization of most firms, pioneered, once again, by Osaka Cotton Spinning. As a result, mergers and acquisitions allowed best production facilities to be constantly matched (and re-matched, if necessary) to the best human capital to manage them; something that is nearly impossible in a lot of other similar contexts because of the lack of institutional trust outside of immediate family members (see, e.g., Bloom and van Reenen, 2010).

Last, but not least, the experience of the technology diffusion in Meiji-era Japanese cottons spinning highlights the importance of embodied (tacit) knowledge in technology adoption and diffusion. This is closely related to the importance of having an environment enabling the matching between the best production facilities and the best managers noted in the previous paragraph, but it goes beyond just mergers and acquisitions. The story of Kyōzō Kikuchi denied promotion by his first employer but being promoted in another firm, which then acquired his initial employer illustrates the importance of competition encompassing not just transactions in outputs and inputs but also the market for managerial and engineering talent itself. The same can be said of the story of Sanji Mutō successfully resisting pressure from the industry cartel trying to prevent him from introducing his pioneering labor management technologies. In the context of the Japanese cotton spinning industry, this market for superior technological and managerial practices happened to have operated mostly through asset acquisitions by stronger firms, but the same process can also operate through the market for top managers or through spinoff processes, financed by venture capital. Indeed, the presence of vigorous markets along all these dimensions

seems to be the key to long-term innovativeness and vitality of Silicon Valley in today's U.S. economy (Saxenian, 1994; Cheyre, Klepper, and Veloso, forthcoming). The parallels across the globe and across historical periods are remarkably striking.

References

- Abe, Takeshi, 2004. "Technological and Organizational Absorption in the Development of the Modern Japanese Cotton Industry," Paper presented at the GENH 5th conference "Textiles," Osaka.
- Allen, Robert C., 1983. "Collective Invention," *Journal of Economic Behavior and Organization*, 4 (1), 1-24.
- Bernhofen, Daniel M., and John C. Brown, 2004. "A Direct Test of the Theory of Comparative Advantage: The Case of Japan," *Journal of Political Economy*, 112 (1), 48-67.
- Bloom, Nicholas, Benn Eifert, Aprajit Mahajan, David McKenzie and John Roberts, 2013. "Does Management Matter? Evidence from India," *Quarterly Journal of Economics*, 128 (1), 1-51.
- Bloom, Nicholas, Raffaella Sadun, and John Van Reenen, 2012. "The Organization of Firms Across Countries," *Quarterly Journal of Economics*, 127 (4), 1663-1705.
- Bloom, Nicholas, and John Van Reenen, 2010. "Why Do Management Practices Differ Across Firms and Countries?" *Journal of Economic Perspectives*, 24 (1), 203-224.
- Boeker, Warren, 1989. "Strategic Change: The Effects of Founding and History," *Academy of Management Journal*, 32 (3), 489-515.
- Boldrin, Michele, and Levine, David K., 2008. "Perfectly Competitive Innovation," *Journal of Monetary Economics*, 55 (3), 435-453.
- Braguinsky, Serguey, Atsushi Ohyama, Tetsuji Okazaki, and Chad Syverson, 2014. "Acquisitions, Productivity, and Profitability: Evidence from the Japanese Cotton Spinning Industry," Working Paper, Carnegie Mellon University.
- Braguinsky, Serguey, and David C. Rose, 2009. "Competition, Cooperation, and the Neighboring Farmer Effect," *Journal of Economic Behavior and Organization*, 72 (1), 361-376.
- Cheyre, Cristobal, Steven Klepper, and Francisco Veloso, forthcoming. "Spinoffs and the Mobility of the U.S. Merchant Semiconductor Inventors," *Management Science*.
- Easterley, William, 2003. *The Elusive Quest for Growth. Economists' Adventures and Misadventures in the Tropics*, MIT Press, Cambridge, MA.

- Farnie, Douglas A. and Takeshi Abe, 2000. "Japan, Lancashire and the Asian Market for Cotton Manufactures, 1890-1990," in *Region and Strategy in Britain and Japan: Business in Lancashire and Kansai, 1890-1990*. Douglas A. Farnie, Tetsuro Nakaoka, David J. Jeremy, John Fl Wilson, and Takeshi Abe, eds., Routledge, London and New York.
- Fletcher, W. Miles, 1996. "The Japan Spinners Association: Creating Industry Policy in Meiji Japan," *Journal of Japanese Studies*, 22 (1): 49-75.
- Geppō (Monthly Bulletin of the Japanese Cotton Spinners' Association), 1889-1920 (in Japanese), Dainihon Bōseki Rengōkai, various issues.
- Hartwell, R.M., and Robert Higgs, 1971. "Good Old Economic History," *American Economic Review*, 76 (2), 467-474.
- Hashimoto, Masanori, 1974. "Economics of Post-War Fertility in Japan: Differentials and Trends," *Journal of Political Economy*, 82 (2, Pt. 2), S170-S194.
- Hunter, Janet, 1991. "British training for Japanese engineers: the case of Kikuchi Kyozo." In: Cortazzi, Hugh and Daniels, Gordon, (eds.) *Britain and Japan 1859-1991: themes and personalities*. Routledge, London, 137-146.
- Kamien, Morton I; Muller, Eitan, and Israel Zang, 1992. "Research Joint Ventures and R&D Cartels," *American Economic Review*, 82 (5), 1293-1306.
- Katz, Michael L., 1986. "An Analysis of Cooperative Research and Development," *Rand Journal of Economics*, 17 (4), 527-543.
- Kinugawa, Taiichi, 1964 (reprinted from the original 1942 edition). *Hompo Menshi Boseki Shi* (History of the Japanese Cotton Spinning Industry) in 7 volumes (in Japanese), Hara Shobo, Tokyo.
- Kiriadidou, Ekaterini, and Martin Pesendorfer, 1999. "Viennese Chairs: A Case Study for Modern Industrialization," *Journal of Economic History*, 59 (1), 143-166.
- Klepper, Steven. (cite one of his works on spinoffs and Silicon Valley)
- Kōkajō (Company reports), 1896-1920 (in Japanese), Osaka University Library.
- Kuwahara, Tetsuya, 2004. "The Development of Factory Management in Japan During the Early Stages of Industrialization. The Kanegafuchi Cotton Spinning Company Before the First World War," Chapter 16 in Farnie, D.H. and Jeremy, eds., *The Fibre That Changed the World*, Oxford University Press, 495-519.
- Kuwahara, Tetsuya, 1994. "Nihon-ni-okeru Kindai-teki Kōjō Kanri-no Keisei: Kanegafuchi Bōseki Gaisha Mutō Sanji-no Soshiki Kaikaku, Part II" (The Emergence of Modern Factory Management in Japan: Structural Reforms by Sanji Mutō at Kanebō) (in Japanese), *Keizai Keiei Ronsen* (Kyoto Sangyō Daigaku), 28 (1), 17-43.

- Landes, David S., 1969. *The Unbound Prometheus. Technological change and Industrial Development in Western Europe from 1750 to the Present*. Cambridge University Press, Cambridge, UK.
- Meyer, Peter B., 2003. "Episodes of Collective Invention," U.S. Bureau of Labor Statistics Working Paper 368.
- Nawa, Tohichi. *Nihon-no Bosekigyo-to Genmen Mondai Kenkyu* (A Study of Japanese Cotton Spinning Industry and the Raw Cotton Problem) (in Japanese), 1937. Daido Shoin, Osaka.
- Nihon Chōki Tōkei Sōran (Historical Statistics of Japan), 1987. In 4 volumes (in Japanese), Japan Statistical Association.
- Nōshōkōmu Tōkei Nempō (Statistics on Agriculture, Commerce and Industry), Nōshōkōmusho (Ministry of Agriculture, Commerce and Industry) (in Japanese), 1896-1911.
- Nuvolari, Alessandro, 2004. "Collective Invention During the British Industrial Revolution: The Case of the Cornish Pumping Engine," *Cambridge Journal of Economics*, 28 (3), 347-363.
- Ohyama, Atsushi, Serguey Braguinsky, and Kevin M. Murphy, 2004. "Entrepreneurial Ability and Market Selection in an Infant Industry: Evidence From the Japanese Cotton Spinning Industry," *Review of Economic Dynamics*, 7 (2), 354-381.
- Otsuka, Keijiro, Rainis, Gustav, and Gary Saxonhouse. *Comparative technology choice in development: The Indian and Japanese cotton textile industries*. New York: St. Martin's Press, 1988.
- Pietrobelli Carlo and Roberta Rabelotti, 2004. "Upgrading in Clusters and Value Chains in Latin America: The Role of Policies," *IDB Publication N. 40778*, Inter-American Development Bank.
- Rhode, Paul, 1991. "An Interview with William N. Parker," *Newsletter of the Cliometric Society*, 6 (2), 3-8, 19-25.
- Rosenberg, Nathan, 1972. "Factors Affecting the Diffusion of Technology," *Explorations in Economic History* 10: 3.
- Saxenian, Annalee, 1994, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge: Harvard University Press.
- Saxonhouse, Gary R., 1977. "Productivity Change and Labor Absorption in Japanese Cotton Spinning, 1891-1935," *Quarterly Journal of Economics*, 91 (2), 195-219.

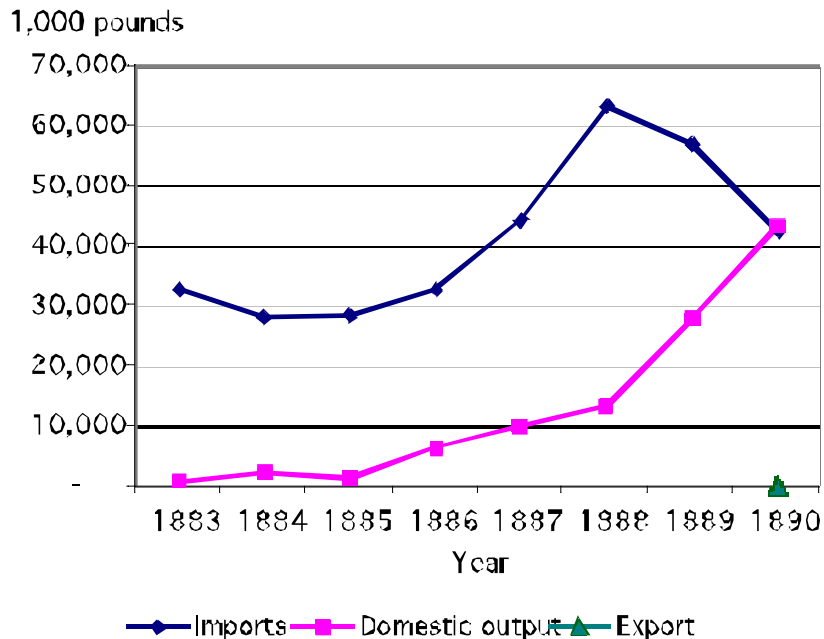
- Saxonhouse, Gary R., 1976. "Country Girls and Communication Among Competitors in the Japanese Cotton Spinning Industry," in Hugh Patrick, ed., *Japanese Industrialization and Its Social Consequences*, University of California Press, Berkeley and Los Angeles, CA.
- Saxonhouse, Gary R., 1975. "Capital Accumulation, Labor Saving, and Labor Absorption Once More, Once More," *Quarterly Journal of Economics*, 89 (2), 322-330.
- Saxonhouse, Gary R., 1974a. "A Tale of Japanese Technological Diffusion in the Meiji Period," *Journal of Economic History*, 34, 149-165.
- Saxonhouse, Gary R., 1974b. "Economics of Post-War Fertility in Japan: Differentials and Trends: Comment" *Journal of Political Economy*, 82 (2, Pt. 2), S195-S199.
- Saxonhouse, Gary R., 1971. "Productivity Change in the Japanese Cotton Spinning Industry, 1891-1935," Unpublished Ph.D. Dissertation, Yale University.
- Saxonhouse, Gary R., and Galvin Wright, 2010. "National Leadership and Competing Technological Paradigms: The Globalization of Cotton Spinning, 1878-1933," *Journal of Economic History*, 70 (3): 535-566.
- Saxonhouse, Gary R., and Galvin Wright, 1984. *Technique, Spirit and Form in the Making of the Modern Economies: Essays in the Honor of Willam N. Parker*. London: JAI Press.
- Spencer, J.W., 2003. "Firms' Knowledge Sharing in the Global Innovation System: Empirical Evidence From the Flat Panel Display Industry," *Strategic Management Journal*, 24, 217-233.
- Sundstrom, William C., 1994. "An Interview with Nathan Rosenberg," *Newsletter of the Cliometric Society*, 9 (3), 3-6, 27-29.
- Takamura, Naosuke, 1971. *Nihon Bosekigyoshi Josetsu* (Introduction to the History of the Japanese Cotton Spinning) in Japanese). In 2 volumes. Hanawa Shobo, Tokyo.
- Tai, Kuo-hui , 1993. "Confucianism and Japanese Modernization: A Study of Shibusawa Eiichi," in Subhash Durlabhji and Norton E. Marks, eds., *Japanese Business: Cultural Perspectives*. State University of New York Press, Albany: 43-56.
- Tamagawa, Kanji, 1997. "Shoki Nihon Menshi Bōseki-ni-okeru Ringu Seibōki Dōnyu-ni Tsuite" (On the Adoption of Ring Spinning Frames in Early-Stage Japanese Cotton Spinning) (in Japanese), *Gijutsu-to Bunmei*, 10 (2), 1-26.
- Tamagawa, Kanji, 1995. "Waga Kuni Menshi Bōseki Kikai-no Hatten-ni Tsuite" (On the Development of Cotton Spinning Technology in Japan) (in Japanese), *Gijutsu-to Bunmei*, 9 (2), 1-20.
- Tilton, John, E., 1971. *International Diffusion of Technology: The Case of Semiconductors*, Brookings Institution Press.

Toyoboseki Hyakunenshi (One hundred years of Toyo Boseki) (in Japanese), 1986. Toyo Boseki, Osaka.

Wright, Gavin, 2011. Cotton Spinning Machinery Orders, British Textile Machinery Firms, 1878-1933. ICPSR27141-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2011-11-18. doi:10.3886/ICPSR27141.v1.

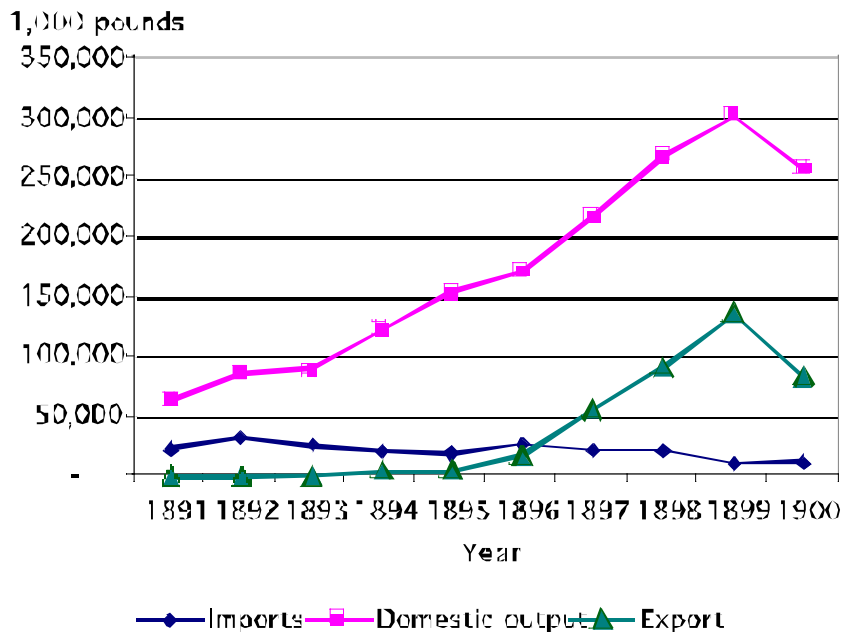
Figures and Tables

Figure 1a. Domestic output, import and export of cotton yarn (1883-1890)

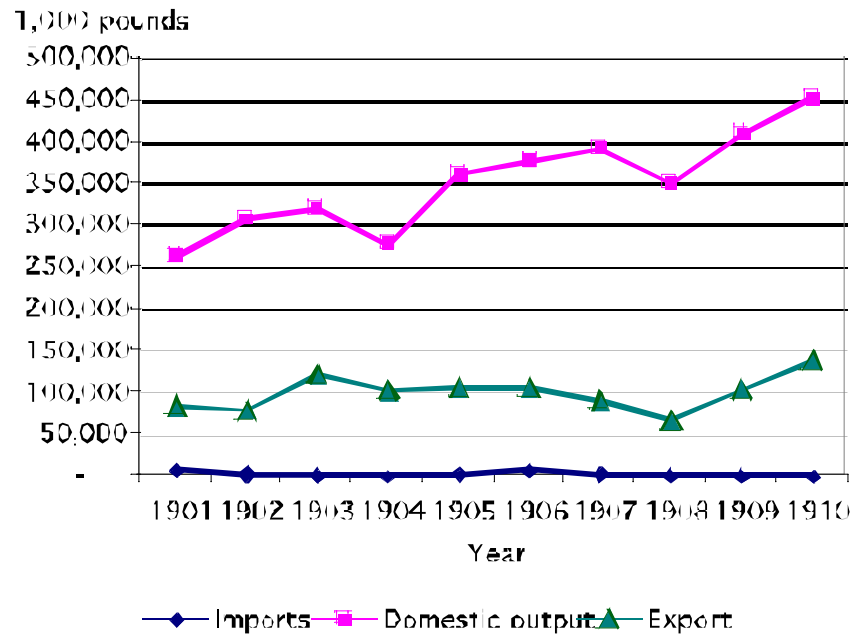


Source: Nihon Chōki Tōkei Sōran, 1987; our estimates.

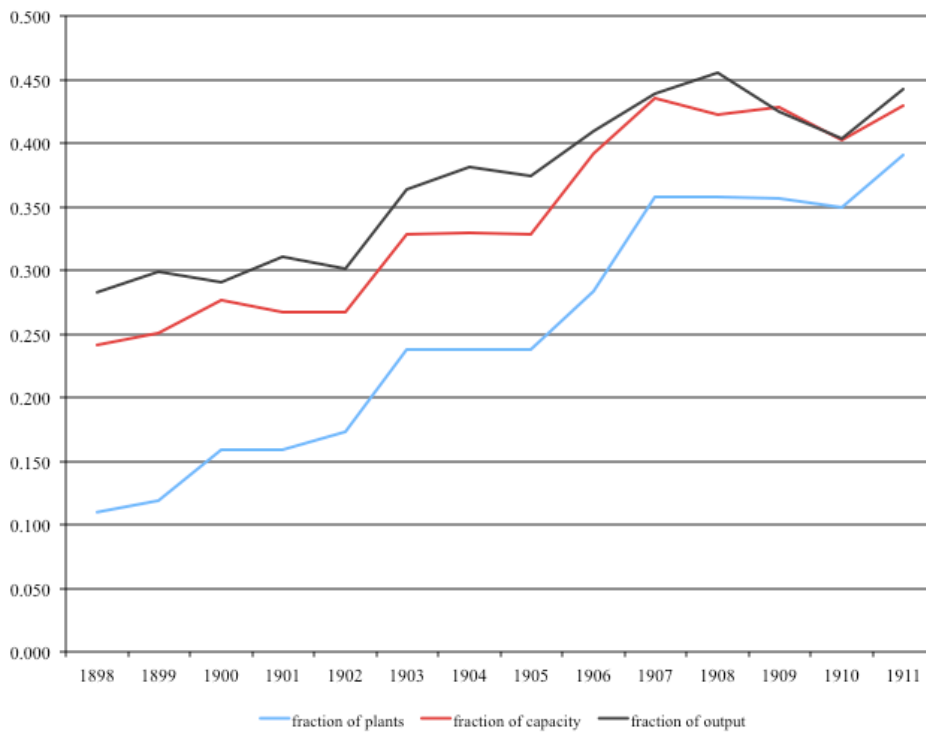
Figure 1b. Domestic output, import and export of cotton yarn (1891-1900)



Source: Nihon Chōki Tōkei Sōran, 1987; our estimates.

Figure 1c. Domestic output, import and export of cotton yarn (1901-1910)

Source: Nihon Chōki Tōkei Sōran, 1987; our estimates.

Figure 2. Ownership concentration in four largest firms (1898-1910)

Note: The figure depicts the evolution of the fraction of plants owned by five early industry leaders (Osaka Cotton Spinning, Mie Cotton Spinning, Kanegafuchi Cotton Spinning, Settsu Cotton Spinning, and Hirano Cotton Spinning—the latter was acquired by Settsu Cotton Spinning in 1902) from 1898-1911.

Figure 3. Distribution of pre-acquisition returns on capital invested, acquired and leading acquiring firms.

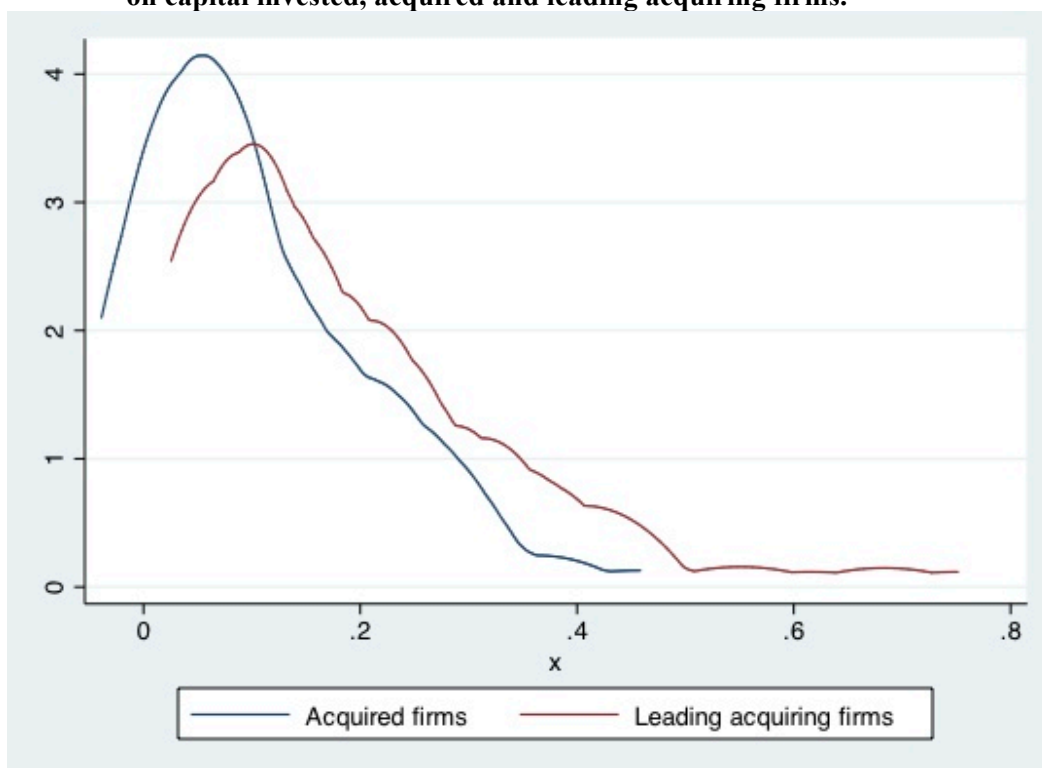


Figure 4. Distribution of pre-acquisition unrealized output ratios, acquired and leading acquiring firms.

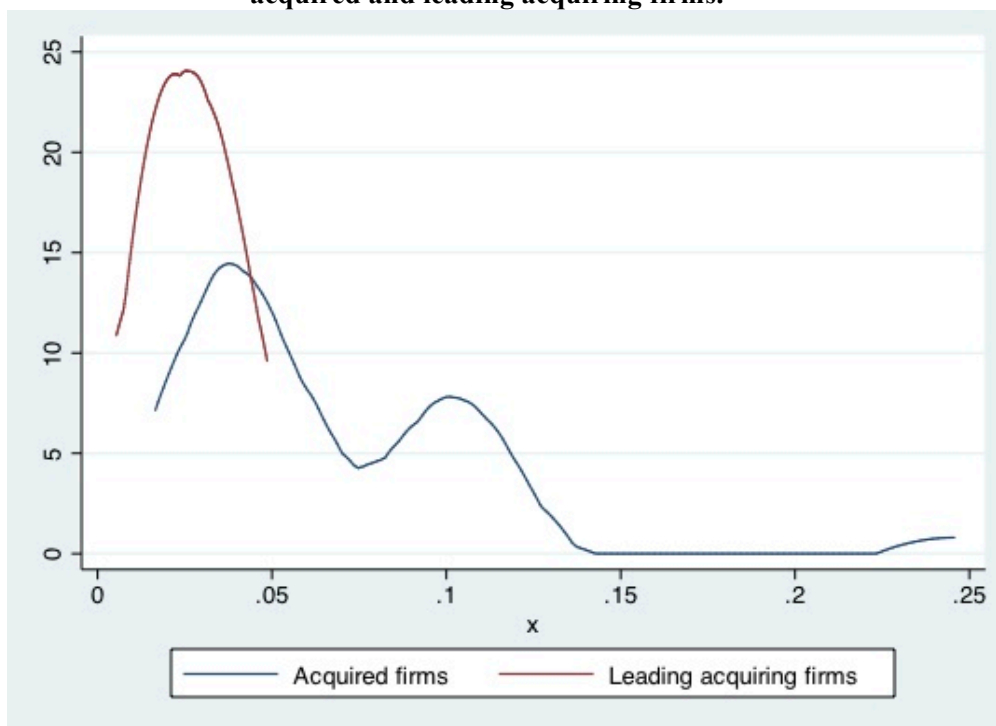


Figure 5. Distribution of pre-acquisition machine capacity utilization rates, acquired and leading acquiring firms.

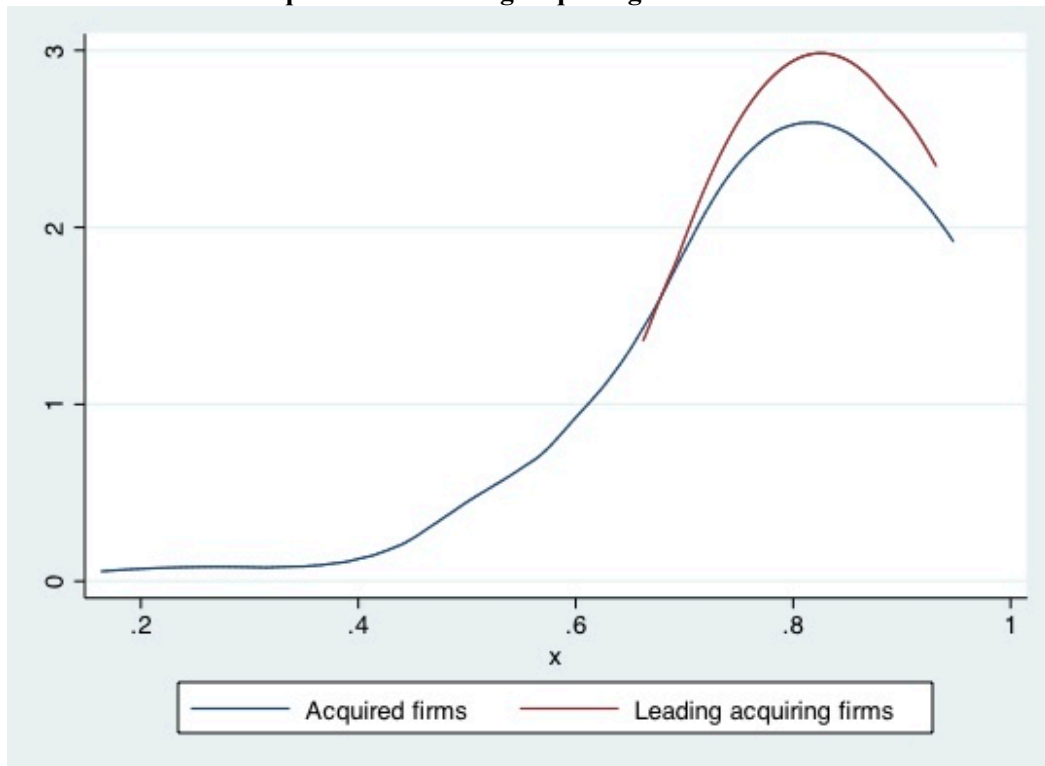
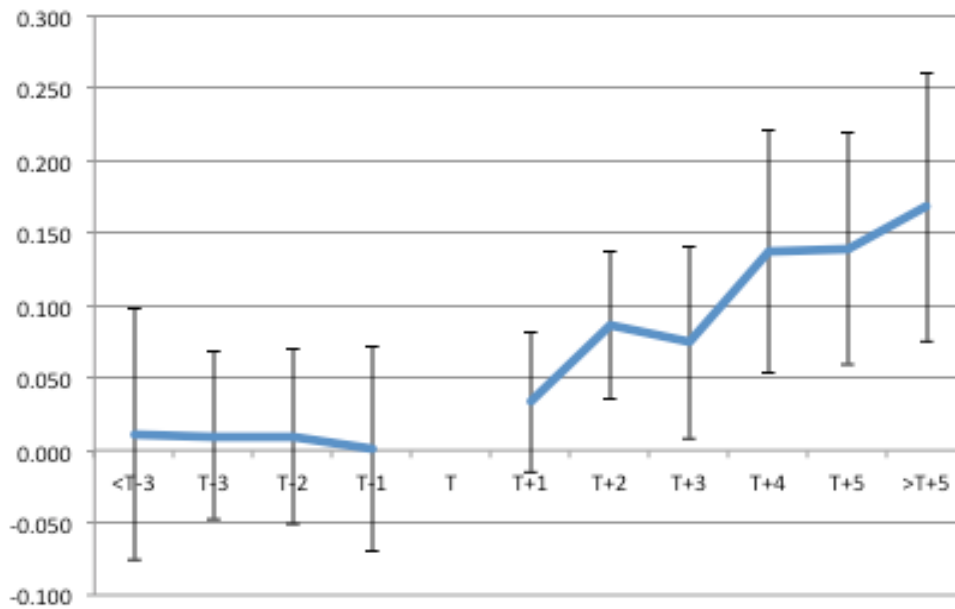


Figure 6. Within-acquired establishments productivity changes



Note: the graph plots the coefficients on dummies set equal to 1 for corresponding pre- and post-acquisition years in the regression ($1'$) in the main text. T is the acquisition year (omitted category). Vertical bars show the 90-percent confidence intervals.

Table 1. Some characteristics of former government-sponsored mills in 1889.

Firm name	Firm capacity (# of spindles)	Machinery age	Power source	Joint stock company	Fraction newer rings
Osaka	60,978	3.1	Steam	Yes	0.55
Aichi	2,000	11.0	Mix	No	0.00
Ichikawa	2,000	9.0	Hydro	No	0.00
Okayama	4,824	2.0	Steam	Yes	1.00
Kagoshima	5,648	20.5	Steam	No	0.00
Kuwanohara	2,000	11.0	Hydro	Yes	0.00
Shimada	2,000	8.0	Hydro	No	0.00
Shimotsuke	4,000	9.0	Mix	Yes	0.00
Shimomura	3,608	5.9	Steam	No	0.45
Tamashima	14,164	3.1	Steam	Yes	0.72
Dojima	10,816	3.0	Steam	Yes	0.77
Enshu	2,000	4.0	Hydro	No	0.00
Nagoya	10,304	3.9	Steam	Yes	0.22
Himeji	4,752	5.9	Steam	No	0.58
Hiroshima	6,456	6.0	Mix	Yes	0.18
Toyoi	2,000	8.0	Mix	No	0.00
Mie	16,272	2.6	Steam	Yes	0.27
Miyagi	2,000	9.0	Hydro	No	0.00
Kashima	720	24.0	Hydro	No	0.00
Nagasaki	4,144	3.9	Steam	No	0.52
Sakai	2,000	21.0	Steam	No	0.00

Note: Capital to labor ratio for Kashima Cotton Spinning not available for 1889 (the firm operated only two months in that year and shut down), so 1888 data are used instead.

Table 2. Some characteristics of former government-sponsored mills in 1897.

Firm name	Firm capacity (# of spindles)	Machinery age	Power source	Joint stock company	Fraction rings
Osaka	55,434	6.8	Steam	Yes	1.00
Aichi			Lost to fire in 1896		
Ichikawa	2,720	9.8	Hydro	No	0.45
Okayama	27,928	4.8	Steam	Yes	1.00
Kagoshima	5,648	28.5	Steam	No	0.00
Kuwanohara			Went bankrupt in 1897; idled plant burned in 1900		
Shimada	1,704	4.7	Hydro	No	1.00
Shimotsuke	9,944	4.0	Hydro	Yes	0.80
Shimomura	4,564	6.2	Steam	Yes	1.00
Tamashima	25,140	6.6	Steam	Yes	1.00
Dojima			Lost to fire in 1896		
Enshu	2,000	12.0	Hydro	No	0.00
Nagoya	20,390	3.4	Steam	Yes	1.00
Himeji	4,128	9.0	Steam	No	1.00
Hiroshima	4,456	14.0	Hydro	Yes	0.26
Toyoi	2,000	16.0	Hydro	No	0.00
Mie	51,408	6.6	Steam	Yes	0.77
Miyagi	2,000	17.0	Hydro	Yes	0.00
Kashima			Dissolved in 1889		
Nagasaki			Dissolved in 1890		
Sakai			Dissolved in 1889		

Note: Osaka Cotton Spinning lost half of its capacity (the older part) to fire in December 1892. Shimada Cotton Spinning lost all its mule machinery capacity to fire in 1895. Shimotsuke Cotton Spinning's expansion continued on its second, centrally located and steam engine-powered plant. Mie Cotton Spinning's expansion came from continued expansion of its second, steam engine-powered plant and from a third plant constructed and powered by steam engine in 1895.

Table 3. Productivity of new entrants and older firms in 1895-97

Variables	Dependent variable: (Logged) output adjusted to 20 th count
Logged number of spindles in operation	0.763*** (0.017)
Log number of workers	0.331*** (0.016)
New entrant dummy	0.087*** (0.012)
Constant	-6.041*** (0.092)
Year-month dummies	Yes
Observations	1878
Adjusted R-squared	0.967

Note: new entrants are firms founded in 1890 or after. Pooled OLS over years 1895-1897 using monthly input-output data. Robust standard errors in parentheses. ***, **, and * indicate that the coefficients are statistically significant at the 1 percent, 5 percent and 10 percent levels, respectively.

Table 4. Average machine characteristics of new entrants and older firms in 1895-97

Means of	Older firms	New entrants
Firm age (years)	11.74	3.33
Machine age (years)	7.40	2.97
Spindle rotation speed (thousand rpm)	7.39	7.68
Cotton yarn count designed for	18.14	19.06
Number of spindles per frame	359.40	376.00
Number of cotton types designed for	1.47	2.35
Designed for Indian cotton	0.13	0.50
Designed for US cotton	0.18	0.41

Source: author's calculations using Wright (2011) data. "Older firms" are those that entered the industry prior to 1890. "New entrants" are firms that entered in 1890 and later. All means differences are statistically significant at least at the 1 percent level, using double sided t-test with unequal variance.

Table 5. Some pre-acquisition performance measures.

Means of	Acquired firms	Leading acquiring firms	St.Signif.
Firm age (years)	9.81	18.35	***
Machine age (years)	7.95	9.39	***
ROCI (%)	0.103	0.180	***
Unrealized output ratio (%)	0.065	0.027	***
Capacity utilization rate (%)	0.788	0.825	**
# of observations	63	65	

Note: the data are averages of 3 years immediately preceding an acquisition. ROCI is return on capital invested, equal to net revenue, divided by the sum of shareholders' paid in equity capital and the firm's interest-bearing debt. "Unrealized output ratio" is the ratio of the end-year value of unsold yarn and payments accruable to the value of output produced during the year. Capacity utilization rate is measured as the total number of spindle-days in operation, divided by spindle capacity, multiplied by 365. *** and ** indicate that the corresponding mean differentials are statistically significant at the 1 percent and 5 percent levels, respectively, using double-sided *t*-test.

Table 6. Within-acquired establishments changes.

Dependent variable	Logged output (adj. to 20th count)	Logged unrealized output ratio	Logged capacity utilization rate
After acquired dummy	0.072** (0.031)	-0.347*** (0.110)	0.090** (0.041)
Logged spindle-days in operation	0.696*** (0.044)		
Logged worker-days	0.255*** (0.042)		
Constant	-0.735 (0.531)	-2.536*** (0.313)	-0.453*** (0.064)
Year dummies	Yes	Yes	Yes
Plant dummies	Yes	Yes	Yes
Observations	1003	448	1015
R-squared	0.940	0.728	0.269

Note: "After acquired dummy" is equal to 1 for years after the acquisition event. The omitted category is years before acquisition and the year of acquisition itself. All usable observations on all acquisitions that happened between 1898 and 1911 are employed. Robust standard errors clustered at the plant level in parentheses. ***, **, and * indicate that the coefficients are statistically significant at the 1 percent, 5 percent and 10 percent levels, respectively.

On-line appendix, not for publication

Behind “A Tale”⁴⁸: Gary R. Saxonhouse’s Intellectual Inheritance⁴⁹

Abstract: This essay provides a perspective on the intellectual context of the late Gary Saxonhouse’s first scholarly publication, which appeared in the *Journal of Economic History* in 1974, a study of the Japanese cotton spinning industry in the Meiji Period. For the remainder of Saxonhouse’s illustrious career, “A Tale” served as scaffolding on which he built subsequent analyses and perspectives on Japan’s early industrialization. Understanding Saxonhouse’s intellectual inheritance enriches our understanding of this pioneering study and the making of an economic historian and, more broadly, a “Japan specialist” in the study of economic growth.

The year 2014 marks the 40th anniversary of the publication of the late Gary R. Saxonhouse’s article, “A Tale of Japanese Technological Diffusion in the Meiji Period,” in that year’s first issue of *The Journal of Economic History* (hereafter “A Tale” and *JEH*). “A Tale” was not only Saxonhouse’s first article in the *JEH* but was also his first journal article in what became an illustrious career cut all-to-short in 2006.⁵⁰ Yet as Saxonhouse noted early in “A Tale,” he had two other publications in the works: a chapter, “Country Girls and the Japanese Cotton Spinning Industry,” forthcoming in his mentor Hugh Patrick’s edited volume, *Japanese Industrialization and Its Social Consequences*, and a third paper, in mimeo, “Productivity Change and Labor Absorption in Japanese Cotton Spinning, 1891-1935,” that would appear in *The Quarterly Journal of Economics* in 1975.⁵¹ Saxonhouse would not publish another article in the *JEH* until his and Gavin Wright’s “National Leadership and Competing Technological

⁴⁸ Gary R. Saxonhouse, “A Tale of Japanese Technological Diffusion in the Meiji Period,” *Journal of Economic History* 34 (1974): 149-165.

⁴⁹ We are most grateful to Arlene Saxonhouse and Hugh Patrick for providing us with biographical and other information on Gary Saxonhouse’s development as a Japan specialist.

⁵⁰ Saxonhouse, “A Tale.” Saxonhouse’s second publication, “Economics of Postwar Fertility in Japan: Differentials and Trends: Comment,” *Journal of Political Economy*, would also appear in 1974 but in the second issue, whereas “Tale of Diffusion” appeared in *JEH*’s first issue of the year. The *JPE* piece was a four-page commentary on Masanori Hashimoto, “Economics of Postwar Fertility in Japan: Differentials and Trends.” 82, 2 (1974): S170-S194. Saxonhouse died of leukemia at the age of sixty-three November 30, 2006. A short biographical sketch of Saxonhouse can be found at <http://um2017.org/faculty-history/faculty/gary-saxonhouse/memoir>.

⁵¹ Saxonhouse, “A Tale,” fn. 4, p.150. In fact, Patrick’s edited volume did not appear until 1976, and the title of Saxonhouse’s contribution had changed to “Country Girls and Communication among Competitors in the Japanese Cotton-Spinning Industry.” By this time his “mimeo” (a.k.a., a “working paper” that he circulated in mimeograph form) had already appeared in *The Quarterly Journal of Economics*—“Capital Accumulation, Labor Saving, and Labor Absorption Once More, Once More,” 89, 2 (1975): 322-330.

Paradigms: The Globalization of Cotton Spinning, 1878–1933,” appeared posthumously in 2010, bringing to a close his adult life’s fascination with and passion to understand deeply the early cotton spinning industry in Japan. With a history worthy of being called a tale, Japan’s Meiji-era cotton spinning industry led that Asian nation out of its feudal existence to become a highly industrialized economy and a major player in 20th-century war, politics, and global trade, an economic power that would threaten U.S. economic supremacy in the two decades following the appearance of “A Tale.” Throughout his academic career, Saxonhouse was an important interpreter of Japan’s economic development, whether his focus was cotton spinning or biotechnology.

In what follows, we focus on Gary Saxonhouse’s early work on Japanese cotton spinning and the training in economics, economic history, and the Japanese language that lay behind it. We introduce Saxonhouse’s mentors and the intellectual tradition he inherited from them and went on to advance throughout his career. We illuminate the database he assembled in his doctoral research that provided him with an impressive comparative advantage both early in and throughout his career as a specialist on the Japanese economy. Finally, we briefly analyze the immediate context in which Saxonhouse first orally delivered “A Tale” in 1973 and subsequently published it in early 1974. We offer this essay as a memorial to Saxonhouse’s early work in Japanese economic history and his perhaps under-appreciated influence on a wider community of scholars seeking to understand the fundamental processes of economic growth.

Born in 1943 in New York City and reared in the Rego Park neighborhood of Queens, Saxonhouse attended Yale University, where he majored in economics, earning his undergraduate degree in the spring of 1964. Yale’s Economics Department possessed particularly strong faculty capabilities in Japanese economic growth, including Gustav Ranis and Hugh Patrick. The university also provided an unrivaled institution to support research on the general phenomenon of economic growth, the Yale Economic Growth Center. Created through the “connivance” of Harvard’s Simon Kuznets and Yale’s Economics Department head Lloyd Reynolds and with an

initial \$2 million dollar gift of the Ford Foundation, the Economic Growth Center was originally established as an inter-university center housed at Yale. By the time Gary Saxonhouse decided to stay at Yale to pursue his PhD in economics, however, the Economic Growth Center had largely become an all-Yale organization that left a enduring influence on his formation as a scholar of economic growth.⁵²

Among others, Reynolds recruited Gustav Ranis to Yale in 1961 after meeting Ranis in Pakistan, where Ranis was serving as Director of the Pakistan Institute of Development Economics. After being on campus for four years, Ranis took a leave from Yale to become Assistant Administrator for Program and Policy, Agency for International Development (AID), at the US Department of State between 1965 and 1967. Upon his return to Yale in 1967, he succeeded Reynolds as Director of the Economic Growth Center, serving until 1975. Ranis had demonstrated an early and passionate interest in Japan's early industrialization and economic development, so he would naturally been supportive of any bright economics graduate student who showed an interest in Japan and its economic growth.⁵³

Ranis's first-hand knowledge of Japanese economic development paled in comparison to that of Saxonhouse's mentor, Hugh Patrick, Yale Economics Department's Japan specialist. Like Saxonhouse, Patrick had attended Yale as an undergraduate, where he majored in mathematics, economics, and philosophy, but the Korean War had removed him from New Haven and

⁵² "Connivance" is the word used by Gustav Ranis in his history of the center given orally at the center's 50th anniversary celebration. According to Ranis, Reynolds, a labor economist, had taken a leave from Yale in the late 1950s to work at the Ford Foundation, and Kuznets saw Reynold's service at Ford as an opportunity to obtain major resources for an inter-college (more properly, an inter-Ivy) "Center for the Quantitative Study of Economic Structure and Growth" that would carry out interdisciplinary research and assemble a common database of economic indicators of twenty-five nations that could be used to understand the phenomenon of growth. Reynolds returned to Yale and became the Economic Growth Center's founding director, which began operations in 1961. As Ranis notes in his brief account, the Ford Foundation continued to fund the Yale Economic Growth Center and eventually made a parting gift to the Center intended as permanent endowment, which Yale's central administration matched on a two-to-one basis. For a transcript of Ranis's 50th anniversary address, see < <http://www.econ.yale.edu/~egcenter/50th-2011/RanisEGC50th.pdf>>.

⁵³ cv_ranis.pdf, downloaded 9/15/2013. For an early expression of his interest in Japanese economic development, see Gustav Ranis, "The Community-Centered Entrepreneur in Japanese Development," *Explorations in Entrepreneurial History* 8 (1955): 80-98.

delivered him to Japan, where he served for two years on a civilian project for the U.S. Army (he had been classified as 4F in the Selective Service system). There, Patrick both became enamored with Japanese culture, society, and economic development and was married to a Japanese woman who would bond him to Japan in a very personal way. Upon completion of his service obligation, Patrick earned a M.A. in Japanese Studies at the University of Michigan, which included a mix of history, literature, and economics. As Patrick noted, “Some really outstanding professors got me very excited about economics,”⁵⁴ so he stayed at Michigan and earned his Ph.D. in economics in 1960 after completing a dissertation on the Japanese banking system, which had taken him to Tokyo and into the inner workings of the Bank of Japan in 1957-58. When Yale University, among several universities, offered him a position in 1960, he chose to return to New Haven because the Economics Department would permit him “to teach and do research on the Japanese economy” rather than teaching the usual introductory course in economics.⁵⁵ With Japanese language skills, a Japanese wife, some three years of work and research in Japan, including a year of work inside the Bank of Japan, Patrick was not only passionate about pursuing research studies on Japanese economic development,⁵⁶ but he was also a brilliant institution builder and a strong, guiding mentor.

As a junior at Yale who was intensely interested in economic development issues, Gary Saxonhouse took Patrick’s course on the Japanese economy.⁵⁷ There he learned from a passionate specialist how extraordinary Japanese economic development was, as the majority of

⁵⁴ “Personal Recollections by Hugh Patrick: An Interview by Edward J. Lincoln,” *Journal of Japanese Studies* 31 (2005): 121-140. Quotation appears on p. 122. Most of our biographical information on Patrick derives from this published interview and from Hugh Patrick, “The Development of Studies of the Japanese Economy in the United States: A Personal Odyssey,” Center on Japanese Economy and Business, Columbia University, Working Paper 141, 1998. The latter also appears in Part III, Finale, Chapter 13, in Masahiko Aoki and Gary Saxonhouse, eds., *Finance, Governance, and Competitiveness in Japan* (Oxford: Oxford University Press, 2000).

⁵⁵ Hugh Patrick, “A Personal Odyssey,” p. 3.

⁵⁶ In a published interview with another of his former Yale/Japan-specialist Ph.D.s, Edward Lincoln, Patrick emphasized that as a Yale faculty member, he was able to win summer grants from such foundations as Ford and Rockefeller and various government agencies that he always spent summers doing research in Japan, which surely worked well for his wife as well. See “Personal Recollections by Hugh Patrick,” p. 126.

⁵⁷ Hugh Patrick, unrecorded telephone interview, October 1, 2013.

American consumers would in the following decades as “the Japanese miracle” stormed the U.S. market in textiles, consumer electronics, and automobiles, among other products. Seemingly, the die had been cast. By the time Gary Saxonhouse became a graduate student, Patrick had created with Harvard economic historian Henry Rosovsky and Columbia’s James Nakamura the Japan Economic Seminar, “an inter-university assemblage of faculty, advanced graduate students, and visiting scholars from Japan,” who gathered on eight Saturdays during the school year to formally discuss and critique two papers and then to top it off with dinner together, which built strong bonds among regulars and visitors as well.⁵⁸ Under Patrick’s guidance, Saxonhouse became a regular fixture at the Japan Economic Seminar.⁵⁹

One additional member of Yale’s faculty would strongly influence Saxonhouse: economic historian William N. Parker.⁶⁰ Though his own research focused on American economic history, Parker’s teaching interests ran more broadly, and he focused students’ minds on questions of processes of economic growth, industrialization, technological change, and innovation. Parker was also a champion of the New Economic History, what some would call “economic history for (and by) economists” or, more commonly, “Cliometrics” in reference to conscious testing of arguments and hypotheses with quantitative, especially econometric, methods.⁶¹ As Cliometricians ransacked one after another of the “old chestnuts” that non-

⁵⁸ The quotation is from Hugh Patrick, “A Personal Odyssey” p. 4. Patrick also discusses the work and importance of the Japan Economic Center in “Personal Recollections by Hugh Patrick,” pp. 133-134.

⁵⁹ Patrick, unrecorded interview, October 1, 2013.

⁶⁰ Parker’s influence on Saxonhouse is emphasized in *Ibid.*, and Arlene Saxonhouse to David A. Hounshell, email of September 16, 2013. That Gary Saxonhouse joined with Gavin Wright to produce a *Festschrift* for Parker is evidence enough, however. See Gary Saxonhouse and Gavin Wright, eds., *Technique, Spirit, and Form in the Making of the Modern Economies: Essays in Honor of William N. Parker*, Research in Economic History, Supplement 3, JAI Press, 1964. We note that in 1977 one scholar described Parker as “the dean of the cliometricians.” See Michael Greenberg, “The New Economic History and the Understanding of Slavery: A Methodological Critique,” *Dialectical Anthropology* 2 (1977): 131-141. On Parker’s role and fervor in championing the New Economic History, see also William C. Sundstrom, “An Interview with Nathan Rosenberg,” *Newsletter of the Cliometric Society* 9, 2 (October 1994): 3-6, 27-29 and Paul Rhode, “An Interview with William N. Parker,” *Newsletter of the Cliometric Society* 6, 2 (1991): 3-8, 19-25.

⁶¹ For discussions of Cliometrics’ early days most relevant in the context of this paper, see Douglass C. North’s EHA Presidential Address given at the same meeting at which Saxonhouse delivered “A Tale”: “Beyond the New Economic History,” *Journal of Economic History* 34 (1974): 1-7. In his address, North

quantitative historians had for years invoked to “explain” economic growth in history, the New Economic History raced through the ranks of the Economic History Association, largely driving out members of the old guard who were not comfortable with quantitative methods and, perhaps, the zealotry of some of its most prominent practitioners.

Exactly when during his undergraduate days at Yale Gary Saxonhouse determined to pursue graduate study in economics; to work with Patrick and become a Japan specialist, which by definition according to Patrick meant becoming fluent in Japanese and doing extensive research in Japan; to emphasize economic history; and to write a dissertation on the early Japanese cotton spinning industry are all unclear. Saxonhouse’s long-time spouse, Professor Arlene Saxonhouse, relates a family story about an incident that solidified in Gary Saxonhouse’s mind his decision to become a Japan specialist:

The story that I like the best and that Gary would generally tell was that he was reading the *NY Times* one day and there was a picture on the front page of an apartment complex [in Japan] with women sitting on benches rocking their baby carriages. The scene reminded him of where he grew up in Rego Park, New York. He was struck at how similar the two seemed and wondered how a culture that was so different from what he experienced as a child could come to look so much like [what] he knew.⁶²

But as Arlene Saxonhouse also stressed, her husband had also developed a strong interest in econometrics, which is also not surprising given Yale’s firepower in econometrics. Perhaps best symbolized by the permanent move of the Cowles Commission, along with many of its most notable economists, from the University of Chicago to Yale’s Economics Department in 1955,

claimed, “The research [of the cliometricians] has been more destructive than constructive. We have destroyed a number of older explanations but we have not replaced them with an explanation of the way economic change has occurred in any systematic fashion. If we have found slavery profitable, railroads less than essential, and the net burden of the Navigation Acts ‘light,’ we have not said what did make the system go—or what did change the distribution of income.” Quotation appears on p. 2. Stanley L. Engerman’s “Recent Developments in American Economic History,” *Social Science History* 2 (1977): 72-89 offers a more restrained assessment. See also the highly perceptive review of Robert Fogel and Stanley Engerman’s edited volume, *The Reinterpretation of American Economic History* (New York: Harper & Roe, 1977) in *Journal of Economic History* 32 (1972): 566-569 for its description of the cliometricians’ missionary zeal, whose essays “are bloody with the corpses of myths and ‘traditional’ accounts—the Marxist belief in rising unemployment, the myth of the land speculator, the Axiom of Indispensability, the Phillips-Ramsdell tradition on slavery, and many more.” Quotation appears on p. 567.

⁶² Arlene Saxonhouse to David A. Hounshell, email of September 17, 2013. We have unsuccessfully searched the *New York Times* database in an attempt to find the photograph that inspired Gary Saxonhouse.

econometrics had become an increasing focus of the department. During its two-decade residence at Chicago, the Cowles Commission had been one of the chief centers for the development of econometrics and economic theory, proudly espousing the motto, “Science is Measurement.” At Yale, James Tobin took immediate charge as director of the renamed “Cowles Foundation for Research in Economics,” but he also switched off twice with Tjalling Koopmans, who had come from Chicago and made fundamental contributions to mathematical economics, econometrics, and statistics, beginning with his own dissertation, “Linear Regression Analysis of Economic Time Series” (1936). During the 1960s, with the founding of the Economic Development Center at Yale in 1961, Koopmans became interested in the theory of economic growth (reportedly clashing repeatedly and hotly with Simon Kuznets around issues of theory versus data). This new interest led Koopmans to work on optimal allocation of economic resources over time rather than devoting most of his time collaborating with colleagues to further formal mathematical economics and econometrics. As Herbert Scarf would write, “By 1960 the battle had been won; the troops no longer had to be massed for assaults on exposed positions. Mathematical reasoning had become an accepted mode of exposition for economic arguments, and the members of the Cowles Foundation felt freer to pursue their own individual substantive interests.”⁶³ Reflecting the new freedom to pursue individual interests, Herbert Scarf, an operations research specialist and game theorist, succeeded Tjallingings as director of the Cowles Foundation in 1967, serving in this position until 1971, the year that Saxonhouse submitted his dissertation.

Saxonhouse’s choice of a dissertation topic—the Japanese cotton spinning industry in the Meiji period—surprised his mentor Hugh Patrick, who thought he would select “a more contemporary topic.”⁶⁴ Gustav Ranis may have introduced Saxonhouse to the topic in a general

⁶³ Herber E. Scarf, “Tjalling Charles Koopmans, 1910-1985. A Biographical Memoir,” in *National Academy of Sciences Biographical Memoir*, Vol. 67, 1995, p. 285-86, National Academies Press, Washington, D.C.

⁶⁴ Patrick, unrecorded interview, October 1, 2013.

way, for Ranis had emphasized the role of the Japanese cotton textile industry in leading Japan's economic development.⁶⁵ But as both Hugh Patrick and Arlene Saxonhouse have emphasized, Gary Saxonhouse's discovery that the Japanese cotton spinning industry and the Meiji government had gathered, tabulated, and published systematic industry- and firm-level data on cotton spinning so deeply impressed him and offered him such possibilities for rigorous econometric analyses that he knew he had found the right topic for a dissertation combining economic history, early industrialization and economic development study, and econometric analysis.⁶⁶ A year of research in Japan, which included archival research at the All Japan Spinners Association, Kanegafuchi Spinning Company, and Tōyō Spinning Company, plus additional archival research in England at textile machine makers Platt Bros., Oldham, and Howard and Bulloughs, Accrington, provided Saxonhouse with a wealth of data that he would subsequently use in his doctoral dissertation, "Productivity Change in Japanese Cotton Spinning Industry, 1891-1935," and throughout much of his career. He submitted his dissertation in 1971, noting in his acknowledgements that "my supervisors, Professors [Charles W.] Bischoff, [Hugh]

⁶⁵ At the same time, the high-profile, hotly debated study of the 1960s by W.W. Rostow, *The Stages of Economic Growth* (Oxford: Oxford University Press, 1960), had identified the cotton textile industry as one of Japan's "leading sectors" that helped drive that nation into sustained economic growth. As did development economists and economic historians of every other country included in Rostow's analysis, Japan specialists immediately contested both Rostow's details of and conclusions about Japanese economic development. Thus, for a budding young scholar interested in the subjects of Japanese economic development and Japanese economic history, there was a wealth of fodder to chew on and sort out. See Yoichi Itagaki, "Criticism of Rostow's Stage Approach: The Concepts of Stage, System and Type," *The Developing Economies* 1, 1 (1963): 1-17, for a review of Japanese criticism contemporaneous to Saxonhouse's studies at Yale. Of course, other critical works that economic development and economic history students at Yale would have read included Bert F. Hoselitz's edited volume, *Theories of Economic Growth* (New York: The Free Press, 1960), and Alexander Gershenkron's *Economic Backwardness in Historical Perspective: A Book of Essays* (Cambridge: Harvard University Press, 1962).

⁶⁶ Arlene Saxonhouse to David A. Hounshell, email of September 17, 2013; Patrick, unrecorded interview by Serguey Braguinsky, October 1, 2013. Gary Saxonhouse's initial decision to become a Japan specialist meant that he first had to acquire language proficiency. In the summer of 1967, he began studying Japanese at Harvard University immediately after passing his Preliminary Examinations. At roughly the same time, he applied for a fellowship from the Social Science Research Council for doctoral research in Japan, which he subsequently received. During the academic year 1967-68, he continued his Japanese language studies at Yale right up to April 1968, when he and Arlene departed for Japan with SSRC support. Arlene Saxonhouse to David Hounshell, email of September 17, 2013

Patrick and [Gustav] Ranis [had] patiently waited for the completion of this study.”⁶⁷ Bischoff’s role in Saxonhouse’s graduate education and as a member of his dissertation committee is not completely clear. At the time Saxonhouse submitted his dissertation, Bischoff was a junior member of the Economics Department faculty and a specialist in econometrics who had published four papers that appeared in the Cowles Foundation for Research’s Economics Reprint series.⁶⁸

Saxonhouse’s dissertation summary provides an interesting perspective on where his graduate education and doctoral research had taken him and, perhaps, how conventional his advisors’—and the economic job market’s—expectations were of him. Because the summary is so short, we reproduce it in its entirety:

“This dissertation attempts to provide an econometrically based explanation of productivity change and labor absorption in the Japanese cotton spinning industry 1891-1935. Using firm data[,] the familiar conventional production model is estimated for each of forty-four years. The resulting time series of conventional production function parameters are regressed on specially constructed time series which reflect changes in spinning firm management’s experience and education, workers’ experience and education, age of the machinery being used, and working conditions. It is found that the role of worker experience and education and working conditions in the explanation of productivity change and labor absorption can be large and pervasive. Management’s education seems to play a more limited role. The other two factors listed above [i.e., management’s experience and age of machinery being used] have no role to play at all. The results here emphasize the importance of labor force characteristics at the expense of managerial expertise and new machinery. By tracing the influence of these characteristics through the conventional production function parameters it becomes possible to gain some understanding of the industry’s alternating episodes of complementarity and conflict between the social objectives of economic growth and labor absorption.”

As Saxonhouse makes clear in his introductory chapter, his study centered on the then-current debates surrounding economic growth accounting models exemplified perhaps most

⁶⁷ Gary R. Saxonhouse, “Productivity Change in Japanese Cotton Spinning Industry, 1891-1935” (Ph.D. diss., Yale University, 1971). The archival sites that Saxonhouse visited are listed in his Acknowledgements.

⁶⁸ We assume that Bischoff advised Saxonhouse on the dissertation’s econometrics. Hugh Patrick’s unrecorded telephone interview by Serguey Braguinsky, October 1, 2013, supports this view. For a list of Bischoff’s Cowles Foundation’s downloadable papers, see <<http://cowles.econ.yale.edu/P/au/b.htm>>. According to a Google search (October 1, 2013), Bischoff earned his Ph.D. in economics from MIT in 1968 and is now Emeritus Professor of Economics at SUNY Binghamton <<http://www2.binghamton.edu/economics/people/bischoff.html>>.

readily by that put forth by Robert Solow in his 1957 paper, “Technical Change and the Aggregate Production Function,” and labor absorption theory exemplified most immediately by the work of one of his own mentors, Gustav Ranis. After taking into account both changes in labor and capital as sources for productivity growth in the American economy between 1909 and 1949, Solow found a surprisingly large “residual,” which he suggested could be attributable to “technical change” and which seemed to account for the lion’s share of growth.⁶⁹ Throughout Saxonhouse’s years at Yale, Ranis, and Ranis’s colleague from his Pakistan Institute of Development Economics days, J.C.H. Fei, a theoretically-oriented development economist, had done joint work on Japan’s labor absorption, inspired in part by Solow’s paper.⁷⁰ Their findings paralleled those of Solow; Japan’s labor absorption (i.e., growth of the work force) through 1915 was not fully accounted for by its capital inputs. Ranis and Fei, too, had found a residual and identified it as technological change.

Ranis and Fei’s work was heavily disputed both in Japan and the United States. Economists in Japan contested their model’s assumption that in the pre-World War I period, Japan’s labor supply was unlimited and also disputed the manner in which they had built their data series both for labor and capital stock. Jeffrey G. Williamson found Ranis and Fei’s model wanting, maintaining that, in Saxonhouse’s words, “the appropriate framework should have the relative growth of inputs as a function of the relative change in factor prices.”⁷¹ These criticisms

⁶⁹ Robert Solow, “Technical Change and the Aggregate Production Function,” *Review of Economics and Statistics*, 39, 3 (1957): 312-320. Some of Solow’s readers were much surer that the residual was technological change than Solow himself believed. In addition to Solow’s work of 1957, a year earlier Moses Abramovitz had identified technical change as an outstanding factor in accounting for the growth of the U.S. economy. See Moses Abramovitz, “Resource and Output Trends in the United States Since 1870,” *American Economic Review Papers and Proceedings* 46 (1956): 5-23.

⁷⁰ J.C.H. Fei and Gustav Ranis, “Innovation, Capital Accumulation and Economic Development,” *American Economic Review* 53 (1963): pages, and Gustav Ranis and J.C.H. Fei, “Theory of Economic Development,” *American Economic Review* 51 (1961): pages. Fei and Ranis, *Development of the Labor Surplus Economy: Theory and Policy* (Homewood, Ill.: Richard D. Irwin, Inc., 1964). John C. H. Fei and Gustav Ranis, “Economic Development in Historical Perspective,” *American Economic Review* 59, 2 (1969): 386-400. On Fei, see Gustav Ranis, “Reflections,” Yale Economic Growth Center Discussion Paper 786, December 1997.

⁷¹ Saxonhouse, “Productivity Change in Japanese Cotton Spinning Industry, 1891-1935” (Ph.D. diss., Yale University, 1971), p. 22.

notwithstanding, Saxonhouse observed, in neither the literature on accounting for productivity growth (a la Solow) nor the work on labor absorption (a la Ranis and Fei) had any systematic attempt been made to determine the factors that accounted for the observed residuals. As Saxonhouse boldly concluded, “Only if we can determine, on the basis of tests of some power and generality, how non-conventional inputs enter into [the] production function can the demands of scientific [proof of] labor absorption analysis and economic growth accounting be met.”⁷²

In the second chapter of his dissertation, Saxonhouse proceeded to develop analytically an alternative to the attempts made to include non-conventional inputs in production functions. Prior work had simply included non-conventional factors as if they were completely symmetrical to capital and labor factors and had assumed that when a conventional input embodied a non-conventional input, it augmented the former. Instead, Saxonhouse developed a model that treated the traditional production function as being conditioned by non-conventional inputs. By doing so, he argued, he would be able to estimate empirically, even with relatively limited data, a new production function. He would do this by estimating conventional production function parameters for each period covered by his data; then, this series of parameters would be regressed using a data set of non-conventional inputs. The history of the Japanese cotton spinning industry would provide the necessary data on capital, labor, productivity change, and a variety of non-conventional factors⁷³ with which he would estimate a new production function that properly accounted for these non-conventional factors the industry’s total output. Saxonhouse’s framing of the residual problem thus drove the research he conducted in Japan and England that was necessary to carry out his estimations.

In executing his model with the data he had gathered in Japan and England and then analyzing his results, Saxonhouse found that several of the non-conventional factors he had enumerated in his design actually provided considerable explanatory power in dealing with the

⁷² Ibid, p. 24.

⁷³ Saxonhouse would focus on six such factors, which he enumerated in his above-quoted dissertation summary.

residuals that were unexplained using conventional production functions. Two unconventional factors—age of capital stock being used and management experience—provided no explanatory power, while management’s technical education had only a small amount of significance.

The results of Saxonhouse’s six-chapter dissertation must have pleased both Gustav Ranis, whose work with Rei had served to set up the big issue being addressed in the dissertation, and Hugh Patrick, the Japan specialist who had inspired Saxonhouse to also become a Japan specialist with a strong preference for economic history. But publication of the results of his dissertation would require Saxonhouse to reconfigure and carve up the work. One thing he would definitely have to do would be to comprehend much more clearly the “technology” dimension of his findings—and the technology dimension of the history of the Japanese cotton spinning industry. This would be one of his first tasks after settling into a tenure-track position in the Economics Department at the University of Michigan from which his mentor Hugh Patrick had come.

Saxonhouse used the occasion of the 33rd Annual Meeting of the Economic History Association in mid-September 1973 and its theme, “The Diffusion of New Technologies,” as the vehicle through which he would interpret the technological dynamics of the Japanese cotton spinning industry. For a session entitled “Agencies for Diffusion of Technology,” chaired by technology specialist Nathan Rosenberg, who was also the incoming Editor of the Association’s *Journal of Economic History*, Saxonhouse proposed a paper with the daunting title, “Diffusion of Technology in Japanese Industry in the Meiji Period.”⁷⁴ By the time his paper appeared in the March 1974 *JEH*, traditionally called “The Tasks of Economic History” issue, Saxonhouse had retitled his contribution “A Tale of Japanese Technological Diffusion in the Meiji Period” and narrowed its focus to the Japanese cotton spinning industry.

⁷⁴ The other two papers in the session were Hujiro Hayama, “Conditions for the Diffusion of Agricultural Technology: An Asian Perspective,” and Mira Wilkins, “The Role of Private Business in the International Diffusion of Technology,” with Kozo Yamamura commenting. For the full program of the EHA’s meeting, see the Front Matter of *JEH*, 33, 2 (June 1973) at <http://www.jstor.org/stable/2116683>.

At least in its published version, Saxonhouse's paper bears the unmistakable imprint of Nathan Rosenberg and his Yale mentor in economic history, William N. Parker. In what is probably the strongest section of the paper (section three), which exploits qualitative data and offers an analytical narrative, Saxonhouse explicitly acknowledges Parker's unpublished paper, "The Social Process of Diffusion," as [a]n excellent example of the fruits of this now almost abandoned approach" to economic history. Moreover, he went further: "Much of this section of my paper draws on the spirit implicit in Parker's analysis."⁷⁵ A recently published article by Nathan Rosenberg, however, appears to have inspired Saxonhouse's overall framing of his paper, just as it served to frame the overall theme of the EHA conference and particularly the session at which the paper was presented.

In "Factors Affecting the Diffusion of Technology," Rosenberg declared, "The rate at which new techniques are adopted and incorporated into the productive process is, without doubt, one of the central questions of economic growth"⁷⁶ After providing an impressive historical review of the dynamics of technological diffusion and factors affecting it, Rosenberg devoted his last main section to "Diffusion and its institutional context." Here he noted:

"Ever since Abramovitz and Solow opened up the problem of 'The Residual,' economists have been attempting to sort out the contributions of various factors to economic growth and, particularly, to measure the contribution of technological change as distinguished from all other possible factors. Whereas the entire residual was for some time uncritically attributed to technological change (although not by Abramovitz or Solow) a later, more discriminating approach has attempted to isolate other factors—changes in organization, improvements in the quality of the labor force, etc.—and to measure their separate contributions. In this difficult but essential process of 'cutting technological change down to size,' however, there is a danger of going too far, by assigning an independent and separate role to factors which really exert their effects upon the growth of productivity by retarding or accelerating the rate of technological diffusion."⁷⁷

⁷⁵ Footnote 29, p. 158, "A Tale." Thanks to the good work of Gavin Wright and his network of other Parker students who studied at Yale in the era Gary Saxonhouse was there, we have had an opportunity to read several published and unpublished papers written by Parker dating to this era that probably bear much of the content and style of Parker's thinking about technical change, technology diffusion, and economic growth. But we have not yet located the exact paper (or "mimeo") cited by Saxonhouse.

⁷⁶ *Explorations in Economic History* 10 (Fall 1972): 3-33. Quotation appears on p. 3.

⁷⁷ *Ibid*, p.29.

In an unusually extensive criticism, Rosenberg provided a “recent example” of economists’ going too far: Douglas C. North’s “otherwise admirable” article, “Sources of Productivity Change in Ocean Shipping, 1600-1850,” which argued that reduction in piracy and organizational improvement explained most of the productivity increase measured during this period and that technological change played little or no role.⁷⁸ Quoting North’s main argument at length in which North said that a superior ocean vessel had been developed in the Baltic region by 1600 but had not been adopted in Atlantic and Pacific shipping because of the prevalence of piracy, Rosenberg argued, “The trouble with this paragraph is that the diffusion [of technology] process has been completely lost from view.” North, Rosenberg stressed, “in his legitimate concern with deflating the overblown spectre of technological change, gives the impression—doubtless unintended—that it was scarcely of any significance whatever in the period with which he is concerned.”⁷⁹

Rosenberg expressed considerable irritation that Robert Fogel and Stanley Engerman had “regularly” trumpeted North’s argument, quoting them in at least two instances, such as, “In the case of ocean shipping, Douglass North . . . found that a rapid and protracted increase in total factor productivity took place despite the absence of a single major *new* invention” and “[t]hus *new* equipment plays virtually no role in Douglass North’s explanation . . .” Rosenberg then nailed down his own argument about the role of institutions in technological diffusion:

“But if a superior ship designed specifically for improved cargo carrying capacity had been developed by 1600, it is no verbal quibble to say that the improvements in ocean shipping productivity due to the eventual adoption of this design should correctly be regarded as belonging to the category of technological change. The portion of North’s paper dealing with piracy is not an explanation of productivity growth which is *independent* of technological change, although it is frequently made to sound that way. Rather it is a cogent and forceful explanation for the very slow *diffusion* of a major technological innovation.”⁸⁰

Thus, as the chairperson of the session devoted to the agencies for technological diffusion, as a

⁷⁸ *Journal of Political Economy* 76 (1968): 953-970.

⁷⁹ *Ibid*, p 31.

⁸⁰ *Ibid*, pp. 32-33. Rosenberg had identified the offending statements of Fogel and Engerman in their volume, *The Reinterpretation of American History* (New York: Harper and Row, 1971), pp. 5, 206.

scholar particularly interested in understanding factors affecting the rate of diffusion, and as incoming editor of *JEH*, Nathan Rosenberg unquestionably affected the way in which Gary Saxonhouse framed his paper dealing with Japanese cotton spinning.⁸¹

Although the structure of “A Tale” is not as clearly delineated as it might have been, Saxonhouse sought to highlight two main factors affecting the diffusion of spinning technologies in the Japanese cotton spinning industry in the Meiji period. First, he wanted to convey that the transfer of British spinning technology to Japan and its diffusion throughout the emergent Japanese cotton spinning industry was “extremely rapid” and thorough.⁸² Second, he sought to explain why this was so. Specifically addressing the theme of the conference session, Saxonhouse identified “the unique institutional arrangements which facilitated such diffusion.”⁸³ In doing so, he relied upon the arguments and evidence that were reasonably well known to Japanese-reading students of Japanese economic history: that the formation and effectiveness of an association of firms in the cotton spinning industry named Dai Nihon Bōseki Rengōkai (All Japan Cotton Spinners Association), known simply by its acronym, Bōren, largely explained why British technology diffused so rapidly in the industry. In terms familiar to economists, the mechanism of Bōren’s influence on technological diffusion was in lowering of transaction costs, specifically lowering the “costs associated with acquiring information about new technologies.”⁸⁴ As to the significance of cotton spinning to Japan’s economic growth, Saxonhouse succinctly stated the case:

This industry was the main Japanese manufacturing activity during much of the first third of the twentieth century. Indeed, the development of this industry culminating in the astonishing ascendance of Osaka over Lancashire stands as the first completely successful instance of Asian assimilation of modern Western manufacturing techniques.⁸⁵

⁸¹ Of course, Saxonhouse cites Rosenberg’s paper (and the paper by Douglass North) in “A Tale” (immediately before he cites William N. Parker’s manuscript), in footnote 28, p. 158.

⁸² Saxonhouse selected the modifiers “extremely rapid” in “A Tale,” p. 150 and (set off in quotation marks) ‘super-fast’ on p. 159 to describe the speed of diffusion of state-of-the-art spinning technology in Japan after the mid-1880s.

⁸³ “A Tale,” p. 150.

⁸⁴ “A Tale,” p. 159.

⁸⁵ “A Tale,” p. 150.

Saxonhouse divided his paper into four main sections, with the fifth serving as short conclusion. In the first section, Saxonhouse recounted the establishment of Osaka Spinning Company in 1883, which “combine[d] what came to be the ingredients of a successful cotton enterprise in Japan”⁸⁶: comparatively large scale (i.e., a large number of spindles), up-to-date British-made spinning equipment laid out by British spinning mill engineers, adequate steam power rather than unpredictable waterpower, double labor shifts made possible by the installation of electric lighting, and a Japanese manager who had worked in a British spinning mill and who had studied the cotton spinning industry. As Saxonhouse emphasized, “The records available on the Japanese cotton spinning industry are so complete that it can be stated unequivocally that every mill subsequently established, and many were established, mimicked the leader [i.e., Osaka Spinning Company].”⁸⁷

He then provided several anecdotes that underscored the speed and thoroughness of technology diffusion in the Japanese cotton spinning industry. Firms that soon followed Osaka Spinning Company ordered the same type of spinning mules from the Platt Brothers textile machinery company of Oldham, Lancashire, England, as had Osaka Spinning. When, in the 1888, the managing director of Osaka Spinning deduced that American-style ring-spinning frames would better suit the Japanese factors of production and switched his Platt Brothers order from more mules to new ring frames, Osaka Spinning Company’s competitors soon followed. Virtually every new Japanese cotton spinning mill bought Platt Brothers-made ring frames in what became exponential growth of the industry in the late Meiji period. If one Japanese mill found ways to expand production or lower costs through minor technological changes, as one British engineer quoted by Saxonhouse noted, “We can expect that the entire [Japanese] industry

⁸⁶ “A Tale,” p. 150.

⁸⁷ Saxonhouse left out one other important ingredient in Osaka Spinning Company’s success: it was a joint stock company with limited liability for its stockholders.

will follow suit.”⁸⁸ By constructing and interpreting two tables showing percentages of Japanese mill orders given to English textile machinery manufacturers for two particular technologies (hank-cop reels and bundling presses), Saxonhouse drove home how the Japanese firms behaved in terms of both followership of lead innovators and also emulation (i.e., domestic production of such ancillary equipment).⁸⁹ Saxonhouse summed up his qualitative findings:

“What is emerging here is a historical example which fits a much less sophisticated view of technological diffusion than economic historians have recently become accustomed to accepting. There do not appear to be any great technological puzzles which demand rationalization. Seemingly inferior techniques do not continue to be embodied in the industry’s new investment. Older techniques from which it would appear no quasi-rents could be squeezed do not remain unscrapped.”⁹⁰

Although Saxonhouse concluded that “[t]he foregoing evidence is most persuasive,” he was not content to rely solely upon anecdotal evidence to make the case for the rapid diffusion of cotton spinning technology among Japanese firms. Despite the “unequivocally” clear qualitative evidence in the records of the Japanese cotton spinning industry, Saxonhouse devoted the second main section of his paper to “additional and more systematic examination [i.e., quantitative proof] of the issue of uniformity of practice among Japanese cotton spinning firms” Saxonhouse’s quantitative exercise seems quite a kludge from the vantage point of twenty-first century statistical methods and standard statistical software packages. From the vantage point of his listeners in 1973 and readers of his article after its appearance in March 1974, however, the work surely passed muster for its Cliometrics, which had become *de rigueur* in economic history. Both the nature of the quantitative data Saxonhouse had gathered in Japan (some firm-level and some industry-level) and the computing power available in his day prevented him from using a linear regression model that directly tested what was the most straight-forward, rigorous statement of the null hypothesis.⁹¹ Therefore, he constructed an alternative “homogeneity of practice hypothesis” for thirty firms in the industry over a 45-year period that yielded a result that,

⁸⁸ Letter from Dohrenfield to Platts, July 25, 1889 quoted in “A Tale,” p. 154.

⁸⁹ Tables 1 and 2, “A Tale,” p. 155.

⁹⁰ “A Tale,” p. 153.

⁹¹ Saxonhouse does state the straight-forward null hypothesis in footnote 25, p. 158, of “A Tale.”

technically speaking, still did not allow him to reject the null hypothesis. In the end, lamented Saxonhouse, “I choose to interpret the result as supporting the hypothesis of substantially uniform technical and managerial practice throughout the industry.”⁹² Thus, ironically, Saxonhouse’s statistical analysis of quantitative data on the Japanese cotton spinning industry’s homogeneity of practice was hardly more convincing, in spite of his commitment to scientific rigor and Cliometric practice, than the abundant qualitative evidence he had gathered in Japan and England, which he had only partially marshaled in the preceding section. Moreover, though not formally proved, his homogeneity of practice hypothesis was but one part of a two-part argument about technological diffusion in Japanese cotton spinning—that the diffusion was extremely rapid and that it was uniformly the same (presumably cutting-edge) technology.

Only in his third section did Saxonhouse get down to the real business of the paper and the focus of the paper session in which he had presented it: “the role of institutional development in the explanation of [Japanese cotton spinning] technology diffusion.”⁹³ His discussion here was based entirely on qualitative historical data and devoted entirely to the role of the All Japan Cotton Spinners Association (Bōren) in facilitating the transfer of best-practice spinning technology to and its diffusion within Japan. Bōren’s creation and operation over a very long period of modern Japanese history had not only facilitated the rapid diffusion of relatively homogeneous best-practice spinning technology within the Japanese cotton spinning industry, but its systematic collection and analysis of data had been critical to this process—and to Saxonhouse’s project. This is the section in which Saxonhouse narrates—or *tells*—the *tale* of the incredibly swift rise of the Japanese cotton spinning industry from near-feudal practice in a non-Western culture to become the world’s leading manufacturer of cotton textiles. The regular reports, meeting minutes, and other records of Bōren, recast in the language of modern economic development, made for an absorbing—and compelling—story. This was true, even though

⁹² “A Tale,” p. 158.

⁹³ “A Tale,” pp. 158-159.

Saxonhouse perhaps worried that he had been unable to demonstrate quantitatively his claims about the diffusion of best-practice cotton spinning technology in Japan. Diffusion of pretty much the same technology was ““super-fast,”” and it stemmed from the manner in which a single, remarkably effective organization (Bōren) had been able to dramatically lower the costs of information to entrepreneurs and investors entering the industry. Indeed, this section demonstrates how only through a deep reading of the history of this industry and the national and international context in which it developed could a student of Japanese economic development such as Saxonhouse truly comprehend just how remarkable and tale-like this history is.⁹⁴

By deeply reading and understanding the qualitative history of Japanese cotton spinning during this era, Saxonhouse positioned himself to extemporize in the paper’s fourth section on the mechanisms that might have been at work in this “tale.” Was the “extremely low” cost (“by international standards”) of technological information available to “any given Japanese spinning firm” socially optimal or suboptimal? What about intellectual property practices, and how did they interact with the flow of technological information and incentives to innovate? If free-flowing information sharing about technological practices at the best-practice frontier was indeed the case in Japan, did any negative consequences accompany this information sharing? On this question Saxonhouse drew from his dissertation work and his chapter in his mentor Hugh Patrick’s forthcoming volume, *Japanese Industrialization and Its Social Consequences*. Specifically he argued that the extreme uniformity of technological practice in Japan cotton spinning was somehow “linked” to the extremely high and persistent turnover rates of the female workforce in Japanese spinning mills.⁹⁵

In a very short and concluding fifth section, Saxonhouse posed several questions about why Japanese cotton spinners had cooperated so thoroughly on matters technological, why they

⁹⁴ Moreover, that Gary Saxonhouse and his fellow Yale economic history grad student and later Michigan colleague Gavin Wright became life-long students of the history of cotton spinning technology and the cotton spinning industry as it diffused throughout the world in the nineteenth and twentieth centuries provides abundant evidence of just how deeply he and Wright read the history of this phenomenon.

⁹⁵ “A Tale,” p. 164 and footnote 46, pp. 164-165.

had adopted uniform technologies procured from a sole supplier (Platt Bros.), and whether and why this proved to be profitable. These questions would remain for future exploration, much of it comparative in nature and most of it carried out over many years in collaboration with Gavin Wright. Saxonhouse concluded his first *JEH* article by echoing session chair Nathan Rosenberg: “While the study of technological diffusion has surely been pursued with great vigor in the last fifteen years[,] attention could still be profitably focused on the nature of the institutions which gather and transmit technological information.”⁹⁶

Remarkably, for all its qualities in addressing issues related to technological diffusion and institutions, its display of virtuosity in quantitative analysis, and its evidence of deep reading (most of it in Japanese) of the history of the cotton spinning industry in Japan, Saxonhouse’s “A Tale” is not a highly cited paper in economic history, economic development, or English language works in Japanese history. As of September 1, 2013 Google Scholar showed only 58 citations to “A Tale.” Our analysis of these citations shows that at least one is in error and that nine are self-citations, with the last one being his *JEH* article with Gavin Wright, which appeared four years after Saxonhouse died.

Moreover, looking at the citation count to “A Tale” in Web of Science, which has become a kind of gold standard in the sciences and many of the social sciences (including at our own institution and many others) when it comes to academic advancement and appointments, we were shocked to see that “A Tale” has received only 18 citations, including two self-citations.⁹⁷ Surely, we suggest, this pioneering article has had greater impact on the economic history profession—and, more broadly, on our understanding of Japanese industrialization in the Meiji and pre-WWII eras—than is indicated by citation counts. Subsequent to its publication in 1974,

⁹⁶ “A Tale,” p. 165. Indeed, owing to the work of another major thinker on the economics of technical change, Kenneth Arrow, the subfield of the economics of information was then gathering steam in the economics profession.

⁹⁷ Data on Web of Science/Web of Knowledge database downloaded October 17, 2013. There is a slight discrepancy in the data since the citation count to “A Tale” in the list of Saxonhouse publication shows 20 citations, but the succeeding two-page list of actual citations to “A Tale” includes only 18 citations.

Saxonhouse used “A Tale” as a kind of scaffolding for different and/or broader studies of Japanese industrialization and the global diffusion of technology. Indeed, over the course of his illustrious career, in each instance in which Saxonhouse self-cited “A Tale,” he displayed either more extensive research on or a deeper understanding of cotton spinning and its role in the industrialization of Japan—and other “non-Western” nations. Saxonhouse and Gavin’s article in the *JEH* in 2010 constitutes a real milestone in two lifetimes of scholarship in economic history that began in Yale University’s Economics Department in the late 1960s.⁹⁸ Regrettably, Saxonhouse did not live to see and to celebrate the appearance of “National Leadership and Competing Technological Paradigms: The Globalization of Cotton Spinning, 1878-1933”; thankfully, Gavin Wright saw this incredibly extensive body of research to publication.

⁹⁸ Gary Saxonhouse and Gavin Wright, “National Leadership and Competing Technological Paradigms: The Globalization of Cotton Spinning, 1878-1933,” *Journal of Economic History* 70 (2010): 535-566.