

The Japanese Software Industry:

WHAT WENT WRONG AND WHAT CAN WE LEARN FROM IT?

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Recent findings indicate that the Japanese IT sector increasingly lags the U.S. IT sector in software innovation and that this underlies Japan's weakening competitive performance vis-à-vis U.S. IT. This article explores alternative explanations for this outcome and analyzes what explains the Japanese software industry's trajectory. The sources are found in the late understanding of the transformational role of software and its value-creating potential as well as in the evolution of the industry's structure. Finally, this article considers what policy makers in other nations might learn from the Japanese experience in building a more vibrant software industry. (Keywords: High Technology, Software Industry, Information Technology, Path Dependency, Strategic Management, Japan, Learning)

It is hard to even imagine that just some twenty-odd years ago, Americans were being warned that Japan was positioned to become the next software superpower, following upon its success in manufacturing. Small fragmented Silicon Valley firms were seen as no match for the financial resources of large integrated Japanese high-tech manufacturers. Moreover, the factory approach to software development, favored by large Japanese firms, was seen as superior to the craft approach dominant in the U.S.¹

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Notwithstanding these predictions, the last two decades have not been kind to Japanese IT firms as well as many high-tech manufacturing firms. In this article, we explore recent research on the impact of software innovation on national competitiveness using Japanese experiences, focusing primarily on factors that underlie these reported developments.² In particular, we explore how is it that in the world's third-largest economy, and in one considered to be among the most competitive in manufacturing, software intensive products are, to a large extent, increasingly not globally competitive. Japanese executives, government officials, and educational leaders grossly underestimated

the importance of software for competitiveness across a wide range of industries and products in both the consumer and enterprise arenas.

There is a lesson here for all national economies about the importance of institutional leaders not only sensing and monitoring, but then acting on emergent technological shifts, lest they lose out. To be sure, it is not always easy to distinguish between what might appear as a technological fad or minor development and the early signs of a seismic shift. Moreover, it is easy for institutional leaders to be caught up in their existing technology visions, which continue to yield positive if declining revenue streams. Japanese leaders, with their strong success in manufacturing hardware, found it much more difficult to envision software as a full partner, much less alternative model. It is also a plausible hypothesis that the weakness of American manufacturing globally, relative to Japanese firms, gave American firms stronger incentives to search, sense, monitor, and respond to the new opportunities created by software. In our conclusion, we will engage in a simple counterfactual analysis by considering what Japanese firms might have done differently to increase the probability of better capturing the returns associated with the growing importance of software. Our aim is to provide guidance to those policy makers everywhere who seek to build their economy's IT capabilities.

Japanese IT firms have been steadily losing global share in major consumer products. Not only have they failed to compete globally in the most transformational consumer products like smartphones and tablets, but they have suffered strong inroads in their domestic market in just these products. Moreover, collateral capabilities and features of these products, including the rise of mobile games and camera smartphones, are savaging their previously successful global firms in console-based game software and point-and-shoot cameras and more recently appear to be eroding sales of sophisticated SLR cameras.

Japan's electronic products' output produced in Japan, much of which contains embedded software, declined 50% from 2000 to 2011. Electronic exports are down 37% in that same period. Japanese electronics firms are increasingly engaged in intermediate goods transactions producing parts and components for other manufacturers. Consumer electronic components and devices accounted

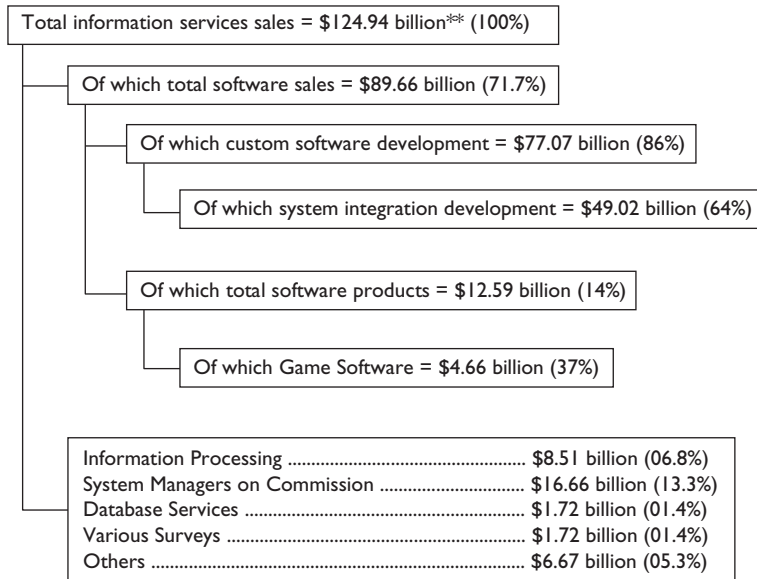
for 45% of production in 2000, rising to 56% by 2011; in the same period, industrial components rose from 8 to 12%.³ The problem is that the bulk of profits for these kinds of products typically go to sellers of final products, the Apple's and Samsung's of the world; while parts and components suppliers (excepting those with strong proprietary technology, including system integration capabilities, and/or strong IP protection) are most likely to be left with the crumbs.⁴ The combined market capitalization of Japanese electronics manufacturers was more than halved by the end of December 2011 from its year 2000 level. Nor is this decline simply a reflection of the overall decline in market capitalization during this period; the first section (large firms) of the Tokyo Stock Exchange declined just 16% over the same period.⁵ Even where Japanese technology firms retain strong sales globally, their profit margins, already low compared to competitors, have fallen even lower in recent years, many in the 1-2% range by 2009.⁶ That means that less funds became available for future capital investment relative to many of their foreign competitors. To what extent the recently weakened yen can reverse this trend long term is an open question.

More recently to escape the carnage in consumer electronics, Hitachi, Toshiba, and Mitsubishi Electric have shifted their primary business focus to large social infrastructure projects (energy, transportation, and utilities). For these projects, these firms see software more as a glue holding different project components together rather than as primary value creators. Yet, it is only a matter of time before some competitors with strong software capabilities, like Siemens, build competitive advantage in these infrastructure markets by also using software to drive front-end functionalities and services.

The IT sector is more than electronics. IT products are included in the Information and Communication Technology (ICT) sector. According to World Bank data, services accounted for 5% of global ICT value in 1996 but rose to 22% by 2009. Most of the value of ICT services is contributed by software. Yet, a disturbing portent for Japan's future competitive performance is that services accounted for a little less than 2% of Japan's ICT exports in 2009.⁷ Clearly, Japan is lagging in the hardware to services transition and a large part of the weakness can be attributed to a weakness in software. An additional factor in their weak export of ICT services is that product customization and system integration are often done in the local language based on knowledge of local business practices. It is plausible that Japanese firms have been at a disadvantage in their service export efforts because of the typically weak English language capabilities of Japanese management.

Consistent with these just mentioned observations are large Japanese software and information services imports, and a paucity of path-breaking software startups, indeed an absence of a large and vibrant independent software sector. The miniscule size of software exports and reliance on high levels of software imports is associated with the weakness of their domestic packaged software market, with the great majority of applications being one-of-a-kind customized solutions (see Figure 1).⁸ Eighty-six percent of total Japanese software sales in the information services market in 2012 were accounted for by custom software whereas only 14% came from software products. Notably, game software accounted for 37% of total software product sales or 5% of total software sales.

FIGURE 1. Information Services Market in Japan (2012)*



* The computer programming and other software services covered in this survey are from business establishments, which are involved in services such as production, surveys, analysis, and advice concerning computer programs [made-to-order software, software products (e.g., packaged software for business use or software packaged in a box), embedded software, and software for games.]

** U.S. \$1 = ¥ 81 (average rate of exchange in 2012).

Source: Ministry of Economy, Trade and Industry, "Tokutei Sābisu Sangyou Doutai Tokei Geppou [Monthly Report on the Current Survey of Selected Service Industries, Information Service Industry]," Tokyo, 2013.

Notwithstanding, Japan, the world's third-largest economy, is second only to the U.S. in software sales. Its embedded software capabilities are impressive. Machine tools, robotics, and autos are just three of the major outlets for their high-quality globally recognized embedded software products. Independent research ranks Japanese software quality (as measured in defects over a wide range of different kinds of software projects) and the productivity of the software development process (code productivity) at levels far above the sampled American projects.⁹ These are impressive accomplishments.

It is the gap between their strong process capabilities in software development and their weakness in product innovation as reflected in the lack of a global presence in software products and services, which lies at the heart of this analysis. Michael Cusumano talks about this juxtaposition in terms of "the puzzle of Japanese software."¹⁰

Recent Patent Study Findings

In a recent article, Arora, Branstetter, and Drev reported findings from their study of U.S and Japanese IT patents granted by the U.S. Patent Office

(USPTO) from 1983-2004.¹¹ The authors examined U.S. and Japanese non-hardware patents (in effect, embedded-application, system, and enterprise-application software patents) in the high-tech sector. They found that despite the growth in citation of software patents in both Japan and the U.S., Japanese firms file fewer software patents than their U.S. counterparts and that the difference has grown steadily since the late-1980s and especially after the mid-1990s. Their findings indicate first that IT inventions have become much more software intensive over time. Second, U.S. firms have more actively incorporated software inventions into their products and services than have their Japanese counterparts. Third, they find that U.S. firms have improved their innovation performance vis-à-vis Japanese firms in just those IT segments that are most software intensive (computers and peripherals). Finally, the researchers found that within IT, Japanese firms are now disproportionately located in less-software-intensive sectors.

They conclude that their findings provide a new explanation for the “precipitous global decline” of Japan’s IT industry in the 1990s. The authors discuss two possible sources for Japan’s shortfall in software innovation. First, they point to a constrained supply of software knowledge and skills (human resource constraints) and second to the slowness of Japanese IT firms to recognize the transformational nature of software. They conclude that the former rather than the latter is primarily responsible for Japan’s growing shortfall in software innovation relative to the U.S.

University Computer Science Education

We build on their analysis and add a piece to the puzzle solution first by surveying over time U.S. and Japanese university efforts to provide a new generation of students with the knowledge, analytic skills, and tools to address the rapidly evolving field of computer science (CS). While we focus on CS, our analysis also covers the broad field of information technology.

Given the criticality of skilled human capital to software development, an examination of IT software education allows us to partially evaluate IT human capital in the respective economies through the timing and quality of their software investments.¹² Steinmueller argues that the U.S. software industry’s advantage over Japan lay in its first-mover advantage, one that was enabled by government R&D policy, and the early development of CS education at the university level.¹³ The latter advantage over Japan, and indeed over all other advanced industrial nations, persists to this day.

Some 20% of software developers in the U.S. have some amount of graduate school education compared to 10% in Japan.¹⁴ The gap in PhDs is even larger than suggested by this 10% difference. Until recently, the majority of Japanese PhDs in engineering were earned by industrial researchers in Japanese companies. These degrees (*ronbun hakase*) are awarded by the employees’ former university, typically after many years of R&D research. No coursework is necessary, only submission of a dissertation with some articles published in well-regarded journals. These PhD degree holders are very unlikely to be on the forefront of software innovation. Putting aside the *ronbun hakase* degrees, most CS PhDs (and most Japanese engineering PhDs for that matter) are earned by those aiming for an

academic career. Behind the limited numbers of Japanese PhDs in software related private sector jobs is the long-term lack of demand by Japanese industry for engineering PhDs overall and the paucity of software startups.

By contrast, most CS PhDs from U.S. universities are hired by industry or government.¹⁵ A great deal of new value in the private sector has been and is being created in the U.S. by PhD and Masters of Science engineers. Some 22,000 PhDs have been granted in CS and IT in the United States between 1978 and 2008.¹⁶ PhD students at the best U.S. universities experience rigorous coursework and practicums and not a few go on to envision and then create and sustain a whole new world, e.g., UNIX, relational databases. Startups founded by those with PhDs include Adobe, Qualcomm, Google, Sun, Cadence, Synopsys, VMware, and Symantec. Still other PhDs like Edgar Codd, with a PhD in CS, worked at IBM but inspired startup firms such as Oracle to develop commercial products building on his path breaking research on relational databases. PhD contributions are where the Americans have excelled. One is hard put to compile a comparable list of path breaking equivalents in Japan.

Notable also has been the long, slow process of incorporating state of the art software knowledge into the curriculum of Japanese Faculties of Science and Engineering. It was well recognized by CS professors in Japan in the 1990s that CS faculties in Japanese universities were weak.¹⁷ They relied heavily on U.S. created standards of IEEE-CS (Institute of Electrical and Electronics Engineers-Computer Science) and ACM (Association of Computing Machinery) for successive curriculum upgrades, but with long delays each time right up to 2007. Six years was the typical gap. Moreover, the standards were often outdated even when they were adopted in the U.S.¹⁸ This lag suggests a lack of appreciation by the Japanese educational establishment of the speed at which IT technology was changing and the importance of quickly accommodating to these changes.

Critical to the incorporation and communication to students of up-to-date curriculum is faculty with up-to-date knowledge. Here, Japanese universities were at a disadvantage. Much new IT knowledge was being developed in the U.S, especially with the advent of the PC era in the early 1980s. At this time, Japanese IT firms, which had achieved significant competitive success through modeling IBM's mainframe architecture, remained committed to building new generations of still larger mainframe computers.¹⁹ This misplaced focus put them still further behind the U.S. in developing, integrating, and deploying new software knowledge. The modest number of Japanese startups, more open to new knowledge, led to lost opportunities to close the gap.

The expansion of IT departments in Japanese universities in the 1980s was associated with a shortage of well-trained CS and information engineering faculty. To fill positions, many universities hired "retired" IT executives from major companies like NEC, Fujitsu, Hitachi, and Toshiba. These new academics helped fill out the faculty in IT departments in the 1980s and 1990s. While they had practical experience in IT business issues and some technical matters, most of their corporate training and experience was in mainframe hardware and software. In the U.S., mainframes were quickly being displaced by PCs, workstations, newer programming languages, networked systems, the internet, and the like.

Most of the Japanese faculty with these corporate careers, were not competent to teach university students state-of-the-art software. Nor were most of those with corporate backgrounds capable of making contributions on the research front at a time when research scientists, mostly from the U.S., were transforming the field of CS.²⁰ All this contributed further to the Japanese, and other nations, falling further behind the U.S. in software innovation during these formative years.

Professor Nobumasa Takahashi, a key player in the Information Processing Society of Japan, analyzed the National Universities' activities, as they typically set the direction on new technical curriculum for all other universities. He observed that the Japanese postwar university departmental structures were shaped by continual expansion in the fields of civil engineering, machinery, electrical engineering (EE), and chemistry. In many cases, new departments were formed from the Ministry of Education's budgetary appropriations pushed by these existing departments. "As a result, the new departments were created with the strong coloration of colonies of the old departments."²¹

The new departments of informatics (*jouhougaku*), roughly equivalent to what Americans call information science and including both the core of CS as well as content from related scientific disciplines, were subject to still other constraints. These arose from an unanticipated interaction of two developments. In 1991, a de facto Ministry of Education deregulation of universities took place that no longer required science and engineering schools to offer liberal arts for the first two years of undergraduate education. Thus, many of the science and engineering schools substituted engineering and science courses in their stead. As a consequence, a large number of redundant faculty were created. Since they could not be fired, they needed to be relocated from their original departments, a dilemma that found a "fortuitous" solution.

At roughly, the same time, the Ministry, concerned about declining national birth rates, imposed limits on the expansion of university departments and faculties. They made a few exceptions, however, for growing fields of national importance, one of which, to their credit, was for information technology. The universities took advantage of this exception, however, to "offload" many of the aforementioned redundant faculty to these growing fields. Many of the transferred faculty continued to teach their existing specialties despite now being in CS and related departments.

Prof. Masato Takeichi found that the total faculty (2,615) of the Japanese information science departments in Schools of Science and Engineering in 1998 were constituted roughly as follow: only 30% were core CS faculty whose academic specialties were in CS and mathematical informatics. Viewing information science more broadly to include system informatics, electrical informatics, and intelligent informatics added another 45%. A remarkable 25%, however, had educational specializations with little or nothing to do with CS.²² So although the Ministry recognized the importance of the new disciplines for Japan's future by designating them a growth area, they then ignored the blatant subversion of the new field in the filling of the new faculty slots. As a result, the new departments were weighed down by non-contributing CS faculty. In turn, this meant that students had far less access to up-to-date knowledge in CS. More subtly, it made it more difficult for CS to be recognized as a distinctive scientific discipline.²³

Writing in the mid-1990s with primary focus on mainframe software, Baba, Takai, and Mizuta observe that computer science education is not well accepted in Japan with most software personnel acquiring their professional skills through on-the-job training. They further note that, consistent with heavy customization, knowledge in the Japanese software industry, unlike in the U.S., tends to be locally accumulated and exploited primarily within the boundaries of a firm.²⁴ As one reads the recent admonitions of the Information Technology Promotion Agency (IPA), a subsidiary of the Ministry of Economy Trade and Industry (METI), it is not hard to see that these characteristics persist to this day as major barriers to software innovation. Prof. Fumihiko Kimura, a member of the Science Council of Japan, at a public forum held at the University of Tokyo in March 2013, stated that CS (called *jouhoukagaku* in Engineering Schools) is still not recognized by most interested parties in Japan as a clearly defined discipline.²⁵

One measure of a new field's coalescence into a recognized discipline is the willingness of those in established disciplines to contribute to the emerging discipline. Such contributions both reflect positive assessments of the emerging discipline and bestow further legitimacy on the new field. In the case of the U.S., both theoretical and applied mathematicians played a key role in building the new CS discipline. Mathematical logic, the theorems of Turing and Godel, Boolean algebra for circuit design, and algorithms for solving equations and other classes of problems in mathematics played strong roles in the early development of the CS as a discipline.²⁶ By contrast, Prof. Masato Takeichi, Dean of the Graduate School of Information Science and Technology at the University of Tokyo from 2004-2007, reports that mathematicians have not been as drawn to the new IT fields in Japan as was the case in the U.S. He attributes this to CS not being seen as a distinct discipline in Japan.²⁷ Similarly, information engineering in the Faculty of Engineering typically has relatively low status in the hierarchy of engineering related fields in Japan.

Overall, some 63,300 U.S. CS and mathematics majors received bachelor degrees in 2009 compared to some 16,300 in Japan.²⁸ This is a much larger gap than would be expected given that that Japan's total labor force is some 43% that of the U.S. and its nominal GDP is roughly 37.5% that of the U.S.

At leading U.S. engineering schools, those departments like CS, which experience sharp growth, drawing on a highly qualified applicant pool, have the discretion and strong incentives to grow their department. Faculty can be motivated to "put their brand on" a new generation of smart young people and they also use growth to claim greater departmental resources. The historically decentralized education system in the United States means that the Department of Education, unlike its counterpart in Japan, has been a non-actor on such matters. As expressed by David Hodges, former Dean of Engineering at UC Berkeley, "deference tends to be given to those faculty and departments which show leadership."²⁹ This captures the entrepreneurial spirit that underlay the leading U.S. engineering schools' rapid adaptation to new circumstances.

This adaptation process contrasts sharply with practices at Japanese universities. We may use the University of Tokyo, Japan's leading Information and Communications Technology department, as a case in point. In the engineering faculty, as in all Japanese universities, each undergraduate major (such as information

and communication engineering) has a prescribed student quota. Until the University deregulation of 2006, these quotas were rigidly prescribed by the Ministry of Education. Since a 2006 university deregulation policy was enacted, enrollment limits became the responsibility of faculty. The faculty in question, however, is not the faculty of specific engineering departments but rather the entire engineering faculty. Thus when discussion of student quotas occur, each department tries to protect its turf and not suffer losses at the expense of other departments. This disadvantages emergent departments, which struggle to expand.³⁰ One consequence of this zero-sum game is that enrolment limits are changed rather infrequently.

In the case of the University of Tokyo's Information and Communications Engineering Department the admission quota as of May 2012 for electrical and electronics engineers was 150 (the combined total for juniors and seniors) while it was only 80 for the Information and Communications Technology department.³¹ This distribution looks quite different at Stanford University. Those undergraduates graduating in EE total 50 a year; the number has been stable for some time but the number of those graduating with CS degrees has been on a sharp upward trajectory in recent years. In 2012, some 250 students graduated with CS majors, five times more than EE majors.³²

The allocation of student quotas between EE and information and communications technology at Japan's most elite university appears more suitable for two decades ago when IT and software, in particular, were not such global competitive forces. The current distribution supports traditional hardware-centric manufacturing education.

In summary, there is ample evidence that the Japanese educational establishment was slow to incorporate strong software education into the curriculum and that it still lags. This situation contributed to human resource constraints as regards to developing software developers with up-to-date knowledge. Yet, the data are also consistent with the failure of Japanese corporate, governmental, and educational establishments to recognize and to act upon the emerging importance of software innovation. In the second half of this article, we suggest that these factors, at best, served as proximate causes of lagging software innovation. We will explore the position that they arose primarily from deeply embedded structural factors.

An Institutional and Structural Perspective

One Japan software veteran reported his understanding of Japan's software innovation problems as follows:

"We did have some labor shortage around the 2000. The problem, currently, is not an overall labor shortage but rather that there are not enough Japanese products focused on software, and not enough Japanese software professionals are focused on product. Both of these lead to a lack of demand for excellent software architects/designers. Taken together, it results in not enough software innovation."³³

In the rest of this article, we explicate the factors relevant to this perspective. It is a perspective that accommodates human resource constraints for specific skills

(managers in both the U.S and Japan will always complain that they lack sufficient access to really top-flight software talent). Yet, at the same time, it sees the Japanese IT sector's lag in software innovation arising primarily from weak corporate incentives for creating innovative software products. If firms aren't pushing to create such products, then they don't believe they have a pressing need to hire, train, and use increasingly large numbers of high-talent software personnel.

Lest we be accused of suppressing evidence for an alternative view, we note the following: in reviewing the Japanese scholarly and popular/practitioner literature on the Japanese IT industry over the last decade, we find no widespread discussion that Japanese industry was or is suffering from severe human resource constraints in software. In our interviews with Japanese software leaders across industry, government, and academia, not once were we told that software industry growth or IT innovation was currently being constrained by significant labor shortage. The Information Technology Promotion Agency (IPA) annually surveys IT firms for their executive's perception of the sufficiency of total IT labor force supply. Those selecting "large-scale shortage" fell from 28% in 2007 to 5% in 2009, and then gradually rose to 19% by 2013 (no distinction is made between the supply of high- vs. low-skilled employees).³⁴ The initial decline is most likely explained by poor economic conditions and the large-scale increase in outsourcing of both enterprise and embedded software development to India and especially China over the last decade, primarily of low- and mid-level programming work. The periods covered by the IPA data are well after the time periods evaluated by Arora, Branstetter, and Drev's patent research. Since the IPA data do not reveal a widespread sense of severe labor shortage among IT executives, we might presume that such a shortage per se would not largely account for any continuing lag in Japan's IT sector performance.

Our claim is that the Japanese IT sector's lag in software innovation arises primarily from weak corporate incentives for creating innovative software/IT products. Initial evidence for this claim can be gleaned from comparative data on IT investment provided by Gartner Inc., the information technology research and advisory firm. They report IT investment as a percentage of annual revenue in private sector firms for 2007/2008. For Japanese private sector firms overall in 2007, it was 1.03. The comparable percentage in 2008 for the U.S. was 4.3. If U.S. firms are spending 4 times as much of their annual revenue on IT as the Japanese, and if they were allocating it productively, it should be highly probable they would be generating notably more software innovation than their Japanese counterparts.

The Gartner data are broken down further into 8 industry sectors. The biggest gap is found in process and assembly manufacturing where the U.S. firms invested 3.5% and 4.6% respectively of their annual revenue on IT, while their Japanese counterparts invested .69% and .75%. In only one sector were Japanese private sector firms spending more than U.S. firms; it was in the banking/insurance/securities sector (5.89 in Japan vs. 5.1 in the U.S). Their higher investment in this sector may possibly be explained by the continued greater reliance by Japanese banks in particular on mainframes (with their especially high upgrade costs for software) while their U.S. counterparts have migrated in somewhat greater numbers to client-server systems.³⁵

Perhaps more important than any difference in size of IT investments are differences in deployment of IT investment in industries (as suggested by Gartner survey results); types of IT investment (Japanese firms have higher investment in customizing vs. producing products and exhibit much stronger strategic focus on hardware than software); and uses of IT investment (Japanese firms are more inclined to customize software to support their current business practices rather than change those practices to take advantage of new opportunities offered by innovative IT technology).³⁶ These differences will be further elaborated below.

We pursue this matter first by examining the contributions software makes at a national level to total factor productivity (TFP). Kazuyuki Motohashi has conducted just such analysis of software's contribution to TFP in three selected time periods. In the U.S., software contributed a rising amount to TFP growing from 3% in the period 1960-1995, to 6% in 1995-2000, to 8% in 2000-2006. In those same time periods, the contribution of software to TFP in Japan were almost non-existent: -3%, -1%, and 1%.³⁷ This difference between the two economies is consistent with our interpretation that there has been a misallocation in the deployment of IT investment in Japan relative to the U.S.

Second, we dig deeper into these matters by examining the composition of IT investment. Table 1 compares the distribution of software investment in the U.S. and Japan by type of investment. The Japanese figures from the year 2000 show a heavy reliance on outsourcing (70%), seemingly contrary to the literature stressing the low level of foreign outsourcing done by Japanese firms. Japanese outsourcing, focused on customization, however, has been primarily to the domestic firms' sequentially involved in the software development process.

As also shown in Table 1, Japan's in-house software development for a firm's own use is a modest 20%. Together these two customized development types account for some 90% of all Japanese software investment, with packaged software left with just 10%. This is roughly consistent with the distribution of sales accounted for by customization cited in Figure 1. Nobuyuki Yajima, a long-term software analyst, writing in 2012, believes that the Japanese data have not changed all that much since the year 2000, though he estimates that the use of packaged software is closer to 15% in recent years; this compares to 29% in the U.S.

TABLE 1. U.S. and Japanese Software Investment by Type (in percent)

	Packaged	Outsourced (customized)	In-House for Own Use (customized)
Japan*	10	70	20
United States**	29	34	37

* N. Yajima, "Keiei joushiki: sofuto o taini ni tsukuraseru Nihon, jibun de tsukuru beikoku [Management's Common Sense: Japan has Others Make Software, U.S. Makes it Themselves]," *Nikkei Business Online*, October 12, 2009, pp. 1-7. Japanese data from the year 2000.

** Bureau of Economic Analysis, Department of Commerce, Table 11 Business (Private) Software Investment and Prices, Washington, 2012. U.S. Data from the year 2010, <<http://search.bea.gov/search?query=software+investment+2011&commit=Go&utf8=%E2%9C%93&affiliate=u.s.bureauofeconomicanalysis>>, accessed November 10, 2012.

The comparable U.S. figures for 2010 reveal a strong contrast with the Japanese distribution. They show a relatively even balance between investments in packaged software, outsourcing, and investment in in-house software intended for the firm's own use. In-house investment for own-use software development accounts for almost twice as much of U.S. private sector investment compared to Japan (37% versus 20%). These differences are consistent with the thinning out of IT capabilities of large Japanese manufacturing and service sector firms in the 1990s as firms spun off their IT departments as subsidiaries and/or came to rely more on system integrators. In some cases, the motivation was to take advantage of new technological or market opportunities, but firms also used these spinoffs to reduce labor costs.³⁸ At this time, Japanese high-tech firms were still relatively competitive globally and they didn't see their success dependent on IT. Thus they thought an easy way to reduce costs was to reduce IT staff.

One would expect that the differences noted above would be reflected in the distribution of IT employees by type of firm. Indeed, they are. The IPA reports that some 75% of Japan's IT technical employees are located in IT service sector firms (large system integrators and their tiered subcontract firms, often characterized as software factories).³⁹ At most of these firms, the opportunities for creating innovative software products for sale to large numbers of customers, is very limited. The priority of software vendors is meeting cost as well as delivery and quality specifications for specific customers. In this environment, vendors have few incentives to provide solutions with the latest system architecture, and product innovation overall is a low priority. It is not uncommon that projects led by top vendors are actually carried out by many layers of subcontractors with little involvement by the prime vendor.

IPA also reports that U.S. IT employee distributions are almost the reverse of the Japanese distributions with only 29% of the U.S.'s IT technical employees located in IT service sector firms.⁴⁰ The reported respective distributions, even allowing for considerable underestimation of IT service sector employees on the U.S. side, do suggest vast differences in the sectoral location of software talent. Implicitly, they also suggest that software personnel in the U.S. are much better positioned to create software innovation. When it comes to software innovation, location in one rather than another sector matters.

Yasuhide Hosokawa offers an alternative and more benign interpretation of Japan's lagging IT investment and its related outcomes.⁴¹ Hosokawa is the former Executive Director of the Japan Users Association of Information Systems (JUAS), an organization of over 1,000 of Japan's leading corporations and users of IT. Mr. Hosokawa has been an influential voice in government policy making as regards IT. He professes no great concern for the low Japanese IT investment for four reasons. First, he cites data showing that the unit costs of Japanese software developers is about half that of the United States. Second, he states that the life of Japanese business application systems is long, an average of 17 years according to METI data. He acknowledges that the average life of U.S. business applications is much shorter but suggests it may be due to new U.S. CIOs seeking to make their mark by adopting new application systems (unnecessary churn). Third, he notes that Japanese firms have executed severe cost reductions over the last decade and

a half by moving information system functions to their subsidiaries (with lower salary costs). Fourth, he displays data showing the Japanese IT vendors are offering high quality and high-productivity services at a lower cost than the U.S. and other competitors and that Japanese companies are the major beneficiaries.

What can we say about this set of alternate explanations? What his four explanations reveal is that Japanese firms have chosen to compete in IT on operational effectiveness (cost, productivity, and quality) and not to seek new revenue growth through innovation. It's a classic Japanese hardware competitive mode, effectively used by many Japanese manufacturing firms in the past. It is a competitive mode that can work with slow-moving technologies until competitors catch up.⁴² In rapidly evolving technology domains, such as IT, the limitations are obvious. In such domains, customers often eagerly pay for high valued added innovations and companies compete on strategy. Furthermore, consistent with our earlier discussion, one of the consequences of competing on operational effectiveness in creating business application systems is a heavy reliance on modestly trained IT personnel without a large demand for highly trained software professionals.

The limitations of competing on operational effectiveness in business application systems can perhaps best be seen in Hosokawa's acknowledgement that the life of Japanese business application systems is an average of 17 years. What this means, in practice, is that Japanese firms effectively forego many IT innovations over the course of 17 years in order to hold down IT investment costs. Extreme customization associated with adoption of new business application systems is expensive and thus updates and replacement are not undertaken lightly. In making such decisions, Japanese IT decision makers deny their firm opportunities to use new IT technology for innovation in a timely fashion to improve their decision making, to deliver further benefits to their existing customers, and to grow their businesses. To dismiss the more rapid uptake of new technology in American firms by attributing it primarily to new CIO's making unnecessary IT investments to advance their careers is surely a gross overstatement. In short, we see that there is a rationale to be made for the current Japanese approach, but it is one that seems destined to leave Japan falling still further behind on software innovation.

In this context, it is critical to capture the differential impact of software startups in the two economies. For truly innovative software, large U.S. technology firms rely heavily on software startups, which attract the most creative talent. Large publicly listed firms are typically unwilling to tolerate the large costs arising from learning failures associated with developing breakthrough software technologies. Instead, it is left to U.S. venture capital to fund these risky new technologies. Software firms get a very large portion of total venture capital investments in the U.S.

In 1989, .04 percent of total venture capital investment in Japan went to software startups; this compared to 11% in the U.S. at that time.⁴³ By 2011, total venture capital investment in the U.S. totaled some 29 billion dollars while the sums invested in Japan were roughly 12% of that total. At this time, computer software startups investment accounted for some 24% of venture capital funded startups in the U.S., and IT investment, more broadly, accounted for 57% of all U.S. venture capital investment. For Japan, software startups accounted for just 9% of venture capital startups.⁴⁴ So not only has there been a much lower percentage

of venture capital funded investments in Japan devoted to developing software, but total venture capital investment was far less as well.

Given the relatively low costs of software startups, one might hypothesize that the percentage of software startups among all startups would be higher than among only venture capital funded startups. To examine this possibility, we use Teikoku Data Bank data on all annual startups (not just venture capital funded startups). Of the 5,292 firms from 2005-2011 meeting inclusion criteria, only 7% were software firms.⁴⁵ It is thus highly probable that the much smaller number of software startup firms in Japan both contributes to the weakness of Japan's software innovation capabilities and deprives large Japanese technology firms of their potential products.

The former CEO of Infosys Technologies, the Indian outsourcing giant, estimated in 2010 that up to 80% of annual IT spending in Japan goes toward maintaining and operating existing systems compared with no more than 60% in the U.S.⁴⁶ Even allowing for some exaggeration, the upshot is that there is far less left in the average Japanese IT budget than in the average U.S. corporate IT budget for funding innovative software projects. These observations apply to enterprise and application software budgets of Management Information Systems (MIS) departments; embedded software budgets and specialists are more typically located in product development departments.

As was shown in Figure 1, system integrators capture 64% of total custom software development sales in Japan. Thus, the system integrator relationships with corporate customers are important to understand.⁴⁷ Because of the customer's weak capabilities in IT resulting from their thin staffing, corporate customers often don't capture and articulate their own IT needs very well. Moreover, many don't understand their own weak capabilities. It then becomes difficult for the system integrators to understand and respond to their needs.⁴⁸ This leads to mismatches. For example, a customer may say that they want the system integrator to help reduce inventory. That may not, however, be their real concern. They may really be concerned with trying to understand the risks associated with different size inventories and how to hedge these risks. The customer's IT department may be of little help in clarifying customer needs because they are mainly in charge of financial IT systems with little knowledge of other department's activities. The system integrator, however, must often act on what the customer says, rather than confront them, because of "the customer is king" mentality that pervades Japanese organizational culture. Since corporate customers often don't understand their weak capabilities, they may demand specific solutions, but be unaware of the full consequences of those solutions. If the system integrator does what they request, however, without challenging them with alternative approaches, the system integrator can make a profit. At the same time, to the extent that top executives understand at some level they are thinly staffed in IT talent, it tends often to make them risk averse when exposed to new strategic IT opportunities.

The high dependency of large firms on their system integrators, as well as the lack of strategic importance many firms give to IT, can be seen in the low proportion of large Japanese firms with full-time Chief Information Officers (CIOs). The Mitsubishi Research Institute's software specialists estimate that only 30-40% of large Japanese firms had full-time CIOs in 2008.⁴⁹ It would be rare to find U.S.

firms with annual revenues over \$500 million that did not have a full-time CIO in 2008.⁵⁰ A later survey by the Japan Users Association of Information Systems reports that over 50% of large Japanese firms have someone with the title of CIO, but the amount of time they spend on IT work is little more than 10%.⁵¹

Just having a CIO work full-time on IT, of course, is no guarantee that they are performing strategic roles for the firm.⁵² The absence of the CIO role, however, suggests that large Japanese firms are making far fewer efforts in this regard and that CIO work itself is regarded as non-strategic. This situation reflects top management's long-term view of IT as a cost center rather than enabling strategic activities to grow the firm. It is this, above all, that underlies weak software innovation in Japan relative to the U.S. Underlying any differences in the supply of IT human resources is the institutionalized maldistribution of software professionals. To wit, as already reported, the overwhelming majority of Japanese software professionals focus on customization and its imperatives rather than on creating products/services sold to a multitude of customers in horizontal markets.

Still another measure of the lack of strategic (product-oriented) emphasis on IT is the relatively slow rollout among Japanese firms of agile (iterative) software development relative to its more widespread use among U.S. firms. Agile development is particularly valuable for its ability to meet dynamic customer requirements through continuous customer/client collaboration and feedback.⁵³ This lack of IT capabilities on the part of firms referred to above inhibits their adoption of agile development methods. While firms increasingly push system integrators to adopt agile, system integrators are typically reluctant because of the lack of IT capabilities among their large-firm customers.

Japanese firms also have been slow to create and employ state-of-the-art enterprise software to create flexible enterprises ready to take quick advantage of strategic opportunities. We see this in their slow and limited adoption of enterprise software (ERP). Even when adopted, Japanese firms select few modules, typically for personnel management and/or finance and accounting.⁵⁴ They also tend to focus on achieving local rather than enterprise-wide optimization. As such, they end up often optimizing sub-systems while sub-optimizing the total enterprise system.

Since enterprise software systems integrate internal and external management of information across an entire organization, they, in principle, enable firms not only to be managed more efficiently, but more strategically as well. Past surveys reveal that American firms are much more likely to use IT investment for strategic benefits (e.g., winning new customers, sales increase, faster access to market information). Japanese firms by contrast, are more focused on extracting its operational benefits.⁵⁵ A 2013 survey conducted by the Japan Electronics and Information Technology Industries Association (JEITA) in conjunction with the Japanese subsidiary of the U.S. consulting firm IDC provides further confirmation. They carried out a web survey of company heads and high-level executives, excluding IT managers, in 216 U.S. and 196 Japanese global companies in a broad range of public and private sector industries.⁵⁶ Asked about their expectations for IT investment, the Japanese companies checked as their top choice, using IT to improve operational efficiency/cost reduction (48%), followed by less than half as many choosing using IT to strengthen development of products and services (22%). The American firms

choose first, using IT to strengthen development of products and services (41%), followed by using IT to reform business models (29%). Business model reform ranked seventh among Japanese firm choices, chosen by only 13%. Consistent with these results, 75% of the U.S. firms saw IT investment as extremely important, an additional 20% as important, and 2% responded “can't say.” The comparable Japanese responses were 16%, 53%, and 24%. As seen in these choices, Japanese firms are far less likely to assess IT investment as strategic. This cannot help but diminish their need for high-level software talent.

Path Dependency and Hardware Centricity

What can explain the delayed understanding of Japanese corporate, government, and educational leaders of the emergent importance of software? Here we add the following puzzle piece: the manufacturing sector's successful hardware-centric history and its implications for how firms have approached embedded software in particular.

We take a page from Arthur Stinchcombe in his seminal contribution. He observed that organizations that are founded at a particular time and place must of necessity construct their social systems with the social resources available.⁵⁷ This includes, of course, the human capital seen as necessary to enable organizational growth and survival. His particular insight was that once established, an organization of a given type tends to retain many of the basic characteristics it assumed at the time of its founding. Key organizational characteristics are imprinted so that the nature of incentives used to drive performance and the characteristics of those initially recruited are often sustained.

Stinchcombe stressed the importance of understanding what enables those founding characteristics to persist over long periods of time. The answer lies in what researchers have come to label the path dependency of organizational and technological learning. A firm's prior organizational routines, norms, and corporate culture (its history), often reproduced over long periods, can constrain its future behavior. This is partly because opportunities and incentives for learning often will be close to previous capabilities. The more a firm uses a technology, the better it gets at that technology with cumulative sunk costs in human and physical capital. If a firm succeeds over time using a given technology, dynamic increasing returns may cement its commitment to that technology.⁵⁸

One can apply this understanding to the hardware-centric origins and sustained commitment to their technology on the part of established Japanese electronics and other high-tech firms. Their very success reinforced these capabilities over long periods of time. In the case of electronics firms, electronic engineers were dominant in the founding of these firms. This occupational specialty dominated management as they evolved into IT firms. It is plausible that this history continues to constrain their transition to software.

As noted above, skilled human capital remains the most crucial factor for software innovation. The quantity and quality and deployment of such skilled human capital is decisive. Sony has been one of Japan's quintessential hardware-centric companies. The Walkman epitomized Sony's technical capabilities; it was a triumph

of electronic engineering. Since then, a major portion of Sony's innovations have involved making products smaller, thinner, and lighter—outcomes achieved largely through creative hardware design. They, however, have been weak in developing innovative application software.⁵⁹ Howard Stringer, former President of Sony, in a 2006 interview, provides a revealing insight into a major source of this weakness. The following quote speaks specifically to the issue of human capital deployment.

“We did not bring software engineers into product development at the beginning. The hardware engineers would begin the product and then software would come in after the fact. And that's because in a company that has jobs for life, the older people are at the top and the younger software engineers are on the bottom, pushing up. So there is a kind of a generation gap.”⁶⁰

Stringer explains the late entry of software engineers into the product development process in terms of the Japanese age and seniority promotion system. Yet, it is not just that older hardware engineers have greater seniority. We can gain an understanding of these other factors through further exploration of Stinchcombe's analysis. Those managers, now at the upper leadership levels, rose to their positions at a time when hardware capabilities were critical factors leading to their own personal as well as their company's success. Under these conditions, top people tend to associate success with hardware innovation, unconsciously downplaying the growing contributions that can be made by software and service orientations.

There is long-standing research that shows managers feel most comfortable promoting into their ranks people who are most like them.⁶¹ Managers see those similar to them as easier to communicate with, to understand, and to trust. Lauren Rivera, in a recent study of hiring in professional service firms, observes that assessors used their own experiences as models of merit. Because the assessors had reasonably successful careers, they believe that candidates who have similar work experiences would also have a higher probability of career success.⁶² So if hardware engineers dominate the top management positions, they are most likely to feel most comfortable promoting hardware engineers. They know what hardware engineers do and can relate to that but software engineers produce a hard to understand intangible product. These factors slow the inevitable transition to the software era.

This lag in leadership recognition of current realities is hardly unique to Japan but may be more prevalent because of the strength of the age and length of a service system that delayed the promotion of young employees with new capabilities, the company's extraordinary hardware-based manufacturing successes in the past, and the strong association of hardware manufacturing with Japanese management ideology. Change is taking place with the passing of the older leadership generation. Yet, it is questionable whether the rate of change is keeping pace with global competitive realities.

In the late 1990s, Japanese IT firms were faced with a hollowing out of manufacturing capabilities, loss of key global markets, and challenged by the rise of modular production and Asian competitors. It is in this challenging and uncertain environment that Japan's traditional “*monozukuri*” concept was invoked. Barry Staw and colleagues, in their classic study, concluded that when people or organizations are under threat, they often tend to be less adaptive. Instead of innovating, they tend to become rigid in their thinking and actions and to revert to prior known behaviors.⁶³

Monozukuri is a term in common use in Japan to denote the Japanese worker's unique spirit in making things. Japanese commentators often refer to Japan as a *monozukuri* country. The term was resuscitated, massaged, and came to characterize postwar Japanese manufacturing's core capabilities. It came to refer to Japan's special ability and practices in building high-quality, continually improving (aiming for perfection) precision hardware products. *Monozukuri* was elevated to management dogma and a national strategy.

In 1999, the Basic Act on the Revival of *Monozukuri* Core Technology was enacted. *Monozukuri* core technology is defined in the act as such technology pertaining to the design, manufacture, or repair of industry products, further specified by a Cabinet order, as versatile technology that supports the development of the manufacturing industry. Areas targeted for support include, above all, improving the supply and quality of skilled manufacturing workers, "who are the main supporters of *monozukuri* core technology." The new act also targeted research and development, the promotion of industrial agglomeration, startups, development of small and medium-size enterprise, and the promotion of learning about *monozukuri*.⁶⁴ As a result of the new law, various government agencies began initiating *monozukuri*-related activities in their quest to renew corporate health and Japanese prosperity. Firms themselves began using the term to designate some of their initiatives. There is an annual *Monozukuri* White Paper (translated as the White Paper on Manufacturing Industries) devoted to reporting on the current state of the industry, its challenges and corporate and government responses. Above all, as promoted and understood by manufacturing managers, *monozukuri* is all about maintaining and building up Japan's hardware capabilities. The *monozukuri* conversation seldom includes software. When it does, software is often seen simply as a facilitator of hardware capability, an assistant and a controller, not in itself a driver of customer value. Even when its potential for value creation is acknowledged, as in the 307-page 2012 *Monozukuri* White Paper published by METI in 2013, just four pages were devoted to software (pp. 95-98).⁶⁵ It is extraordinary that this was still the case in 2013.

Of relevance here is the aforementioned tendency of large old established Japanese firms to enter new fields by creating new divisions and spinoffs.⁶⁶ They tend to staff their new divisions and spinoffs with parent firm employees who are likely to perpetuate existing work routines and management practices. This limits the innovativeness of these new entries. Moreover, with their dominant purchasing power, the established firms and their chosen entries tend to choke off opportunities for true startups. As measured in sales, there have been no new entries among the top Japanese electronics manufacturers for more than 50 years.⁶⁷

In the U.S., established electronic firms more often disappeared and were replaced by new firms. These new firms likely have no commercial or emotional stake in the old technology and associated work routines and management practices. Among the top 21 electronics manufacturing firms in the U.S. in 2010, eight did not exist in 1970 and six were too small to be listed in the *Fortune 500* a decade earlier.⁶⁸

All things being equal, the large Japanese electronics firms and their new sponsored entries are more likely to carry over their organizational culture to new fields and be slower to adopt current practices and conventions. Consistent with

this overall pattern, it would not be surprising if they were slow in recognizing and adapting to the expanding importance and benefits of cutting-edge software. By contrast, in the U.S. the carriers of the new message that software matters, were often independent startups. These new firms embodied state-of-the-art practices, norms, and conventions and their commercial success highlighted the strength of their products and management practices, pushing incumbent firms to adopt their IT innovations.

Mitsuhiro Fukuzawa traces the long painful journey that Ricoh Co., Ltd., took from the release of its first hardware- (and copy-) centric digital multifunctional printer in 1987, for which software was largely seen as trivial.⁶⁹ After a remarkable six product architectural generations leading to 150 new models, they finally were able to produce a sophisticated digital multifunctional printer (MFP) in 2001. It was the first one that had a software project leader and in which software design dominated the product architecture (its GW architecture) and in which the product design was based on strong collaborative relationships between hardware and software engineers as well as between copy and other functional departments. If we adjust for the needed hardware capabilities to produce a satisfactory digital MFP, which did not become available until the early 1990s, we can say that this learning process took at least eight years.

The product produced in 2001, using the GW software architecture, was a commercial success in Japan. Indeed, since 2001, numerous digital MFP products including Ricoh's major products (such as mid-range MFPs) have successfully used GW platforms. This suggests that Ricoh's Japanese competitors, like Canon, were no faster or more successful at arriving at a high-performance digital MFP solution than Ricoh. If that were not the case, Ricoh would have suffered major market losses on these products. Yet, it is hard from an outside perspective to see, as a timely solution, a large sophisticated manufacturing company in 1994 taking eight years to recognize and act on the reality that software design had become decisive for the whole product architecture. The length of time taken to solve the problem in bringing together all the needed organizational pieces and capabilities and what it signifies is quite underplayed in the article.

Why did it take so long? Pulling all the threads of our analysis together, a plausible scenario looks something like the following: At Japanese firms in the copier/printer business such as Ricoh, Canon, and Toshiba, the hierarchy of decision making and status has been mechanical or chemical engineers at the top, then electronic engineers, with software engineers a long way down at the bottom. Notwithstanding, software engineers increasingly constitute a majority of software development costs in embedded software products across a broad range of manufacturing industries. In the 2010 annual METI survey of embedded products, software development costs accounted for 61% and hardware development costs for 24% of total project development costs.⁷⁰ Even when this is the case and even when software engineers constitute a majority of product development employees, fierce political dynamics are at play that maintain the status quo power hierarchy and keep software engineers far from major decision-making roles. As a result, hardware-centric designs tend to be perpetuated with software's role often seen as limited to an assistant and controller of functions.

Not until the market demonstrates convincingly that these solutions will no longer work do mindsets change and software engineers start to rise in political power. Contributing to the lengthy learning process at Ricoh was the absence of large numbers of newly graduated students from computer science and related fields with up-to-date software capabilities entering firms that were willing to make early use their talent. Also relatively absent from Japan compared to the U.S. were a young generation starting up companies without a commitment to existing management practices. This made it easier for these startup companies to integrate software into new product development, which could serve as a model for incumbent companies.⁷¹

If a firm regularly brings in software personnel late in the product development process, it leads to the self-fulfilling prophecy that software doesn't have much to contribute—that it is basically just a set of tools for implementing hardware-centric product design. In a recent Japanese study of complex automotive products requiring the coordination of mechanical, electronic, and software engineers, Fujimoto and Park found that Japanese embedded software engineers had low status and power. By the time embedded software engineers are called upon to perform their tasks, the product development process was often behind schedule and the software engineers were under intense pressure to complete their tasks. In this environment, it is less likely that software engineers will be able to fully understand and take advantage of the hardware design strengths to make innovative contributions.⁷² In summary, the cost of hardware coming first is that it sacrifices the optimization of software innovation.

Outsiders often remark on the high quality of Japanese embedded software and infer that embedded software is one kind of software where Japanese manufacturing firms have strong innovative capabilities. Here, they confuse quality with innovation. Japanese manufacturing firms do indeed prioritize product quality in both hardware and software. They have carried over their rigorous approach to hardware quality to software quality. This leads them to focus on eliminating software bugs, even in non-mission critical systems. These practices, however, may not always be appropriate to software and in any case they have little to do with incentivizing innovation and may even interfere with it. They can also slow entry to market.⁷³ To optimize the probability that embedded software engineers will be able to develop innovative solutions requires that they be involved early in the product development process, can collaborate fully and on equal terms with hardware engineers, and that they have access to needed resources and the time to exploit their capabilities. The problems Stringer, Fukuzawa, and Fujimoto and Park described are mirrored at many other high-tech Japanese firms.

A further example of how deployment of software personnel is related to positions of power and control presented itself in our field research. A Samsung manager recounted the aftermath of the firm's development of a hit product. A few years after the product was released, it was found that the hardware engineers, who worked on it, were being promoted faster than the software engineers who worked on it. An internal study of why this happened was quickly undertaken and revealed that those higher-level managers, who were making promotion decisions, were hardware personnel. The contributions of the software engineers weren't as visible

to them as were the contributions of the hardware engineers and therefore the software engineers were promoted at a slower rate.⁷⁴

In short, organizational history, culture, and power shape which and how performance metrics get applied, often with participants being unaware of the biases they exhibit. The actions of Samsung's higher-level management showed their priorities. They first demonstrated leadership by seeing to it that they became aware of the situation, second by defining it as a problem, third by setting about trying to understand why it happened, and fourth by developing countermeasures. Japanese firms could well benefit from applying this same kind of energetic effort on the part of top executives to overcome the inertial organizational forces arrayed against the software/services transition.

Conclusion

In summary, we found considerable support for the thesis that there have not been enough Japanese products focused on software and not enough software professionals focused on product. Both of these lead to lack of demand for excellent software architects/designers. The net result is not enough software innovation. Finally, we have also seen that an independent software sector, heavily populated by startups, has not played a transformational role in the Japanese economy as it has in the U.S.

As we review how the Japanese software industry evolved toward its current state, it can be valuable to identify particular inflection points during which times and places, a different set of management, government, or university administrators' decisions might have led to a more positive trajectory for the industry. Policymakers from different nations other than Japan might well benefit from such an analysis. What follows are suggestive scenarios showing where we believe decision makers could have put the Japanese software industry on a more positive course. Some of these alternative trajectories would have been more realistic choices for Japanese decision makers than others. Even those less probable, however, such as emphasizing the acquisition of strong English language skills, may be more realistic policy choices for policy makers in other nations seeking to build a vibrant IT industry.

- The Japanese software industry has largely created "blue collar" jobs for those of modest software skills in software factories in the IT service sector. This has been a huge factor inhibiting software innovation. As discussed, driving forces in this software factory environment are delivery time, quality, and cost—targets that are enabled by standardization of processes and tools and module reuse. This outcome, while it has important benefits, arose out of a failure of firms to treat software differently from hardware. Could Japanese firms have recognized much earlier the limitations of such an approach and the constraints it imposed on exploiting the innovative potential of software? The current dominant software factory model reflects the cumulative impact of two factors. The first is excessive outsourcing and the second is excessive customization.

With the notable exception of Germany, most nations seeking to build a viable software industry today do not have as advanced a manufacturing sector as Japan's, and thus the pressure to mimic hardware practices and customize software to further differentiate successful hardware practices is less. There remains, however, the challenge of calibrating how much outsourcing is optimal. We can identify a possible inflection point in the early 1990s that would have altered the strong movement toward the domestic outsourcing and narrowing of IT capabilities at Japanese large firms. As discussed above, in the early 1990s, there was a thinning out of IT capabilities of large Japanese manufacturing and service sector firms. Large firms spun off their IT departments as domestic subsidiaries and came to rely more on these and other system integrators and their subcontractors. A common incentive of these initiatives was to reduce labor costs.

Instead of responding to strong pressures to reduce overall corporate costs at the time, what was required was a recognition of IT's value creation potential and that, as such, IT was evolving into one of the modern firm's core capabilities. It is plausible that had large Japanese firms decided instead to maintain more of their in-house capabilities, these firms would have been much more able to recognize new IT opportunities, to develop in-house software that more closely met internal and external customer needs. It is a widespread view in the Japanese IT industry even today, that much of Japanese top management continues to be ill informed as to IT's value creation potential and its competitive benefits. With stronger in-house IT capabilities, firms would have had stronger internal voices informing, educating, and lobbying top management on IT policy.

- Japan would have also benefitted from the establishment of curriculum on software's transformational capacity in the elite educational institutions from which top management personnel are drawn. At a minimum, when the engineering schools were no longer required to teach a liberal arts curriculum for the first two years, these schools could and should have chosen to establish strong required curriculum on emerging global trends in science and technology. This surely would have elevated young technologists' understanding of the importance and broad dimensions of the IT revolution. In the current global environment, all things being equal, firms with strong internal IT capabilities should have better outcomes for the economy as a whole. Thus, the lesson here for those policy makers seeking development of their IT industries is the importance of educating top institutional leaders in all domains on the value creation power of IT. Even if they are not going to develop their own software, firms need the capabilities to monitor and evaluate the rapidly evolving global IT landscape. Similarly, executives in all departments need the capabilities to interact intelligently with IT specialists to make strategic IT purchases and deployment decisions.
- We have documented the weakness of the independent software sector in Japan and in particular the modest nature of software startup activities. It is part of the larger weakness of the overall startup sector in Japan. The Japanese government has sought to stimulate entrepreneurship through a

variety of measures over the past 15 years. These included better tax treatment for new ventures, reduced cost and bureaucratic procedures when creating new companies, provision of knowledge to startups, regional clusters, and improved ease of transfer of university innovation to the private sector. None of these separately, or in the aggregate, have had the desired effect.

By contrast, little effort has been made to identify and remove institutional barriers. Of relevance here is the already discussed well-documented practice of large established Japanese firms entering new fields by creating new divisions and spinoffs. They tend to exercise significant guidance, if not control, over their new divisions and spinoffs, and they staff them with parent firm employees who are likely to perpetuate existing parent firm work routines and management practices. This tends to limit their innovativeness; most significantly, corporate spinoffs are not likely to challenge their incumbent parents.

Also relevant in this context are the vertical *keiretsu* relationships established between parent firm and their suppliers. Both Japanese and American scholars have written a great deal about these relationships embodying what is known as “relational contracting.” These relationships involve long-term market exchanges with suppliers of products and services, and are based on mutual trust, inter-firm learning, and reciprocity. If a new venture comes up with an innovative solution (product or service) and tries to market it to an established firm, it is highly likely that the established firm will turn to its existing suppliers and encourage and even support them in finding a comparable solution. They will wait for such a solution to emerge rather than simply turning to the new venture. These practices are particularly prevalent in the enterprise software market.

Partnering with a new venture is often a highly risky business. Their management is untested, they may not be able to provide reliable delivery much less be able to deliver what they promised. They are not yet seen as legitimate. In this environment, corporate customers tend to be reluctant to do due diligence vis-à-vis a possible new partner. A related problem is the lack of exit opportunities for investors given the weak domestic merger and acquisition market in Japan. Finally, still other institutional barriers lie in the dense thicket of Japanese national and municipal government regulations, which operate to thwart new entries.

The measured strategy of the Japanese firms using spinoffs appears to have worked well in the past. When faced with strong challenges posed by first movers in fast-moving discontinuous technology industries (such as IT, with implications for innovation in a broad array of other industries), however, it appears far less competitive. The extant institutional practices described above inhibit the development of a market for venture capital backed startup products and services.

What are the management decisions that could have instead created better opportunities for startups, and software startups in particular? By relying on spinoffs and supporting existing partners, Japanese management displays

strong risk averseness. They are unwilling to aim for bigger rewards by taking bigger risks (promising more radical innovation) by partnering with startups. Indeed, there is a long list of Japanese technology startups that found it necessary to go abroad in order to become commercial successes. There are multiple lessons for policy makers in other nations. Government policy makers can work to educate corporate managers to give purchasing managers more leeway and incentives to buy from startups. Government can serve as a role model by changing their purchasing policies to give startups a better chance to compete. Independent software companies have long called on the Japanese government to do just that. There are such policies in effect in the U.S. and they were recently emulated by New Zealand, so this is a realistic option. In pursuing such measures, policy makers could stimulate more software startups, creating a more dynamic software industry. In summary, policy makers, in thinking about how to promote startups, should not just focus on stimulating the supply but think also how corporate and government policies might stimulate growth through reducing obstacles on the demand side.

- As the Indian case demonstrates, even a software industry with strong basis in custom software, can use its engineering communities' English language skills to grow its software business abroad. Japanese leaders could have set Japan on a more positive trajectory for IT by instituting strong English language skill requirements for IT engineers. This would have greatly widened the pool of capable Japanese IT specialists with easy access to the latest global developments in IT, thereby increasing the numbers of IT professionals who understood their significance. As discussed earlier, this also would have opened up export markets by enabling more localization of Japanese IT services.

Perhaps more significantly, much stronger English capability by Japanese IT professionals would have made acquisitions of foreign software firms and personnel a far more viable option. Such acquisitions could have been used to infuse new software knowledge and capabilities into both business application systems and embedded software. Applied to embedded software, such acquisitions possibly could have loosened the dominance of hardware engineers and even challenged the reliance on custom software.

It is striking that Samsung top executives in recent years, starting out from much the same place as their Japanese peers, have championed software acquisitions and the hiring of foreign English speaking nationals both in Korea and abroad to challenge their existing hardware culture and help lead their growing exploitation of software capabilities. Their willingness to do so and the possibilities that at least some of these efforts will be successful is surely enhanced by the far stronger efforts in South Korea by both parents and the government to support the development of English language skills. Japan typically ranks among the lowest-scoring Asian nations in English language proficiency scores. The Korean case reminds us that policy makers in other nations can choose to build strong English language proficiency not only among those aiming for IT professional occupations, but indeed among the broad population. The potential benefits for

growing an IT industry by having the youth of the society grow up with English languages skill (accessing the English language internet from an early age on a regular basis) should not be underestimated.

In summary, by analyzing where Japan's software industry went wrong, there are a variety of alternative policy directions that can be suggested to policy makers seeking to build a strong IT industry. The ones discussed here constitute just the beginning of such an effort.

Notes

1. R. Florida and M. Kenny, *The Breakthrough Illusion: America's Failure To Move From Innovation To Mass Production* (New York, NY: Basic Books, 1990); M. Cusumano, *Japan's Software Factories: A Challenge to U.S. Management* (New York, NY: Oxford University Press, 1991), p. 89.
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