Work Smart: Information Technology and Productivity in Japan

Master's Thesis

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By

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Abstract

Productivity growth drives long-term economic growth and rising living standards in a modern economy. Information and communications technology (ICT) has been a key driver of both total factor productivity (TFP) and labor productivity growth since the 1990s. Japan, which has consistently had the lowest labor productivity in the G7, has not seen significant levels of ICT-driven productivity growth in its non-manufacturing sectors despite investing heavily in ICT hardware.

This paper explores the reasons for Japan's failure to reap productivity gains from its ICT investments. I claim Japanese firms have failed to invest in organizational capital and new business practices to maximize the potential of ICT. A preponderance of very small firms with elderly managers have left large swaths of the economy with minimal ICT investment. Part of the failure to update business practices stems from labor market rigidity which reduces the labor input savings from ICT systems and inefficient capital markets which protect inefficient incumbent firms. Furthermore, the low rate of firm entry and exit, coupled with a lack of foreign direct investment, hinders the adoption of new ideas and the reallocation of capital and labor.

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1: Introduction

After making remarkable total factor productivity (TFP) and labor productivity gains in the post-war era, Japan has struggled to raise its productivity levels since the asset bubble crash of 1991. Japan's labor productivity is the lowest in the G7. Japanese workers toil for more hours a day than most of their rich world peers and earn less for their efforts. To compound the problem, Japan is rapidly ageing, causing the workforce to shrink so that it can no longer rely on increased labor inputs to boost growth. While Japan is still a wealthy country, with an educated workforce and a high standard of living, there is both a need, and room, for improvement.

There is a broad understanding of this fact in Japan as well. Newspapers and media sites are sprinkled with phrases such as "work-style reform" (働き方改革 *hatarakikata kaikaku)* and the English-Japanese combination, *no zangyo day* (ノー残業デー) meaning "no overtime day." Meanwhile, a cottage industry has popped up in think-tanks and research institutes churning out policy prescriptions to lift lagging productivity.

An important source of productivity growth in the past four decades has been the proliferation of information and communications technology (ICT). Computers, digitalized information, software, and internet connectivity have spread throughout society, creating new industries, and revolutionizing the way business is done. Some firms have been able to harness the potential of ICT to achieve impressive productivity gains. Japan, despite its relative strengths in advanced ICT hardware, has not been able to realize the same productivity gains as many of its OECD peers.

The reasons for this are myriad, and include factors such as a rigid labor market, a lack of venture capital, a preponderance of very small, old, firms, Japanese business practices, and corporate governance issues. The one commonality that links the disparate reasons is that they are all impediments to the formation of the intangible capital needed to realize the productivity gains that are possible with ICT.

As such, a large part of this paper deals with the intangible capital of firms. Intangible capital is the non-physical assets of a firm. Unlike buildings or machinery, intangible capital does not exist in the physical sense. Intangible capital shows up on the books of a firm only through the expenses that are required to create it, i.e., by paying for designers, system engineers, or software. The intangible capital itself does not appear directly on the books of a firm, though its value can be seen via equity market valuations.

One simple example would be the Nike “swoosh.” It is not a physical asset, nor does it show up on Nike’s accounting statements. It does though undoubtably have monetary value. Other examples of intangible assets include firm-specific systems to manage and utilize digitized information, firm-specific human resources management systems, and brand names.

In this paper I will explore the reasons Japan has struggled to develop the necessary intangible capital to utilize ICT effectively. I lay out the rest of my paper in the following order. Section 2 introduces the concept of productivity and exploring the state of productivity in Japan. Section 3 examines the connection between intangible capital and ICT. Section 4 looks at Japanese business practices in relation to ICT. Section 5 explains structural impediments to improved productivity through the better utilization of ICT. Concluding remarks are in Section 6.

2: Productivity

Production, at first glance, is a very simple concept. One takes capital, such as machines and buildings, hires labor, and secures physical inputs that are shaped and molded by the machines and workers into a product. In reality, there is far more to the story: a U.S. manufacturing plant in the 90th percentile of productivity, for example, produces nearly twice as much output with the same measurable inputs as a plant in the 10th percentile (Syverson 2011). Somewhere in the production process, unseen, intangible elements allow some firms to create more value with the same inputs than might otherwise be expected. The gap between expected and actual output for a specific bundle of capital and labor is due to differences in productivity.

2.1: Total Factor Productivity

This paper will be referring to two types of productivity: total factor productivity (TFP) and labor productivity. First, let us look at TFP. The basic idea of TFP is imbedded in the Cobb-Douglas production function:

$$Y = AL^{\beta}K^{\alpha}$$

Where Y is output, L is labor inputs, and K is capital inputs. L and K are weighted by their factor elasticities, β and α. A is TFP. TFP represents the relationship between capital and labor, a measure of how well they are utilized together in production. Disparate techniques and methods exist to convert the same inputs into outputs, some of which are more efficient than others. These differences can be difficult to define and measure. Another way to phrase it is that TFP measures what we do not know. (Cardona, Kretschmer and Strobel 2013).

Overtime, the relationship between these factors evolves. Labor and capital may be utilized in new ways to shift the production function to the right without changing the amount of measurable inputs. Robert Solow referred to this process as "technical change," and in 1957 modified the Cobbs-Douglas production function to measure changes in TFP over time:

$$Q = A(t)F\,(K,L)$$

in which Q is output, K is capital and L is labor. $A(t)$ measures TFP change over time. It is the Hicks-neutral shift parameter, or, in simpler terms, the parameter that measures the shift in output without changing the inputs of capital or labor (Solow 1957).

Solow's concept of technical change refers to any one thing or combination of things that causes the production function to shift. This includes things such as organizational capacity, network effects, spillover effects, educational advances, economies of scale, brand name value, and general knowledge (OECD 2019).

Over the past 20 years TFP, along with capital services, has been one of the two main drivers of GDP growth in all OECD countries (OECD 2019). In short, trillions of dollars have been added to global GDP due to a metric that measures what we cannot directly measure. As such, it is of keen interest to find out what combination of intangible factors contributes to TFP growth.

2.2: Labor Productivity

Labor productivity is a measure of the efficiency with which one unit of labor input can be converted into output. There are several ways to measure it including dividing output by number of employees, or by dividing output by the number of hours worked (Nakamura, Kaihatsu and Yagi 2019). As a metric, labor productivity only partially measures the productivity of labor in terms of the characteristics of the laborers themselves such as personal capacity or effort. More broadly, it measures how labor interacts with inputs such capital investments, organizational structures, and management techniques (OECD 2021b).

Labor productivity growth can be decomposed into two parts, the capital equipment ratio (capital deepening), and TFP. The capital equipment ratio measures the amount of capital goods such as machinery, buildings, computers etc. that are used by each worker for production. TFP, as mentioned above, measures technical change. Thus, one can examine whether a change in the growth rate of output per worker was due to changes in capital deepening or technical change.

As can be seen in Figure 1, Japan has historically relied more on capital deepening than TFP growth when compared to Germany and the U.S.

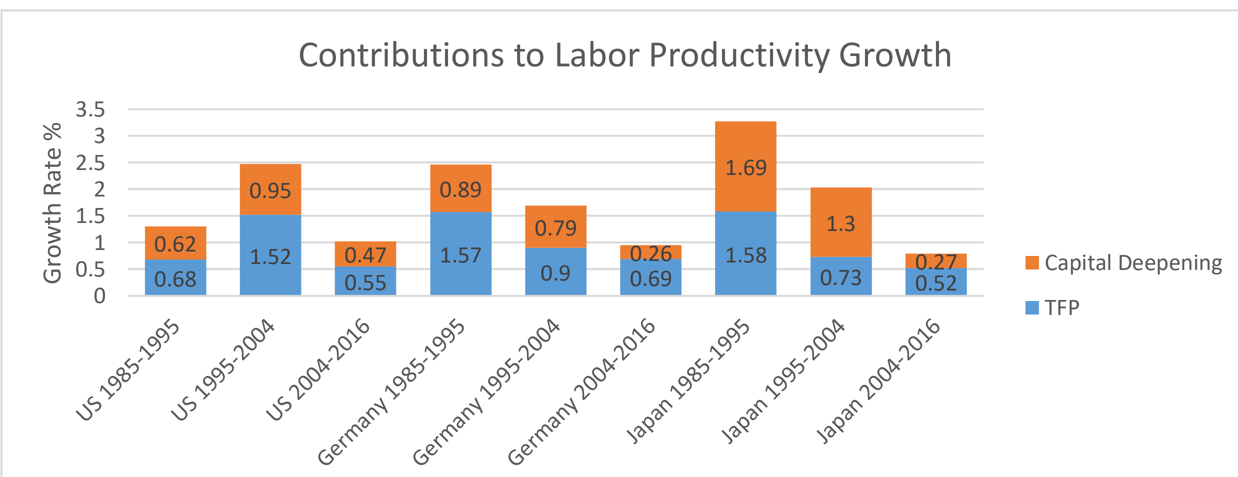


Figure 1: Contributions to Labor Productivity Growth in US, Germany, and Japan (Bailey, Bosworth and Doshi 2020)

Labor productivity is a useful metric due to its simplicity and the fact that it links GDP growth to wage growth. The GDP growth rate is roughly equal to the sum of the growth rate of employment and the growth rate of GDP per worker. Total output can be divided by hours worked to find the output per hour of labor. As output per hour increases, real wages should increase as well. Thus, increased labor productivity is key for higher wages (Bailey, Bosworth and Doshi 2020).

Some industries, such as automobile manufacturing, inherently require more capital inputs per worker than other industries such as food service. Thus, when comparing different industries, it may be more appropriate to focus on TFP as opposed to labor productivity as TFP is not affected by the capital equipment ratio. However, TFP, labor productivity, and capital deepening are all interconnected in the long term. Thus, when comparing national output, both TFP and labor productivity are useful measures and should generally show similar trends assuming that both countries have similar industrial profiles (Nakamura, Kaihatsu and Yagi 2019).

Although labor productivity is simpler to measure and quite intuitive, many economists favor TFP for comparing national productivity rates as it separates changes to output growth that are due to changes to inputs, and changes in output growth that are due to technical change. However, since TFP is calculated as a residual, it is vulnerable to misleading results due to measurement errors. These errors can mismeasurement in the quality and quantity of inputs, or when inputs such as intangible capital is ignored (Cardona, Kretschmer and Strobel 2013) (Bailey, Bosworth and Doshi 2020).

2.3: Accounting for ICT in TFP Growth

Solow's model became the framework for growth accounting, which is widely used to measure the contribution of ICT investment to economic growth. Growth accounting decomposes the growth of outputs into the growth of inputs, namely labor, ICT capital, and non-ICT capital.

This decomposition requires a measure of the output elasticity of each input, i.e., the increase in output caused by a 1% increase in the use of a given input. However, the elasticities of inputs are not directly measurable and must be estimated. This can be done either parametrically, or non-parametrically.

The non-parametric approach relies on neoclassical assumptions including constant returns to scale and perfect competition and assumes that the elasticity of inputs is equal to its share in the value added. Although it is prone to measurement errors, it has the advantage of needing less data than the parametric approach and has a well-established history and intuitive design (Spiezia 2012).

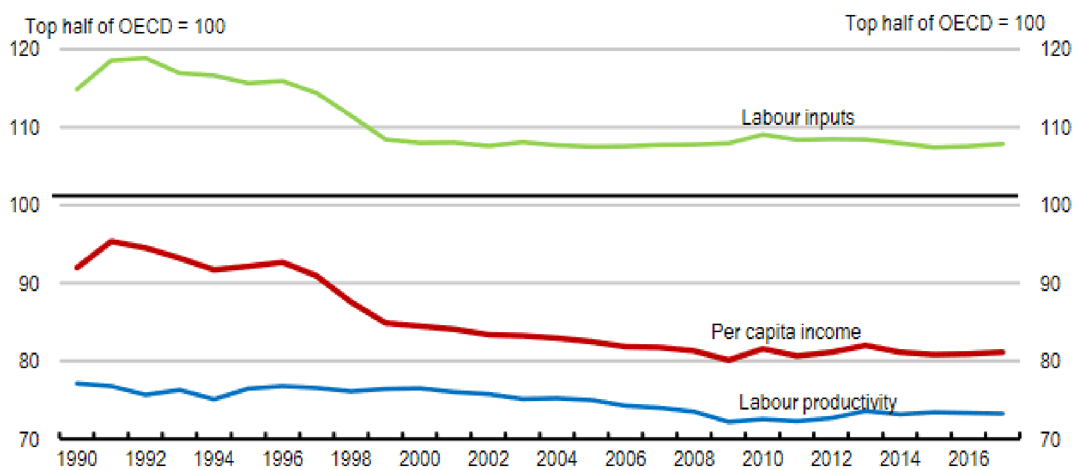
The parametric approach estimates the elasticity of inputs using econometric techniques. Although it requires more datapoints and is somewhat less flexible than the non-parametric approach, it has two key benefits. First, it makes no assumptions about the technology of production, firm behavior, or perfect competition. Second, it is less prone to measurement error (Ibid).

Many recent studies favor the parametric approach. Importantly though, no matter the approach used, ICT capital is consistently shown to be in important driver of both TFP and labor productivity growth (Cardona, Kretschmer and Strobel 2013).

2.4: Productivity in Japan

Japan's success, rising from the ashes of World War II to build one of the largest economies in the world, is an achievement to be recognized. Shortly after the war, in 1955 Japan's TFP was equal to roughly 45% of the U.S. level. However, due to an average rate of TFP growth five times greater than that of the U.S. Japan was nearly able to close the gap between 1955 and 1991. By 1991 Japanese TFP had reached an impressive 92.9% of America's. However, with the bursting of the property asset bubble and the onset of the "lost decades" Japan's TFP growth rate plummeted, to the extent that in 2012, 21 years later, total TFP remained essentially unchanged (Jorgenson, Nomura and Samuels 2015).

The problems extend to labor productivity as well. According to the OECD, Japan's labor productivity rate is roughly 25% below the top half of the OECD and is the lowest in the G7



Source: OECD Economic Outlook database.

StatLink http://dx.doi.org/10.1787/888933953582

Figure 2: Labor Productivity in Japan Relative to OECD Peers (OECD 2019b)

(OECD 2019b). Japan has had to offset this low productivity with very high labor inputs, which is increasingly untenable given that the population is ageing, and Japanese workers already work long hours (OECD 2020).

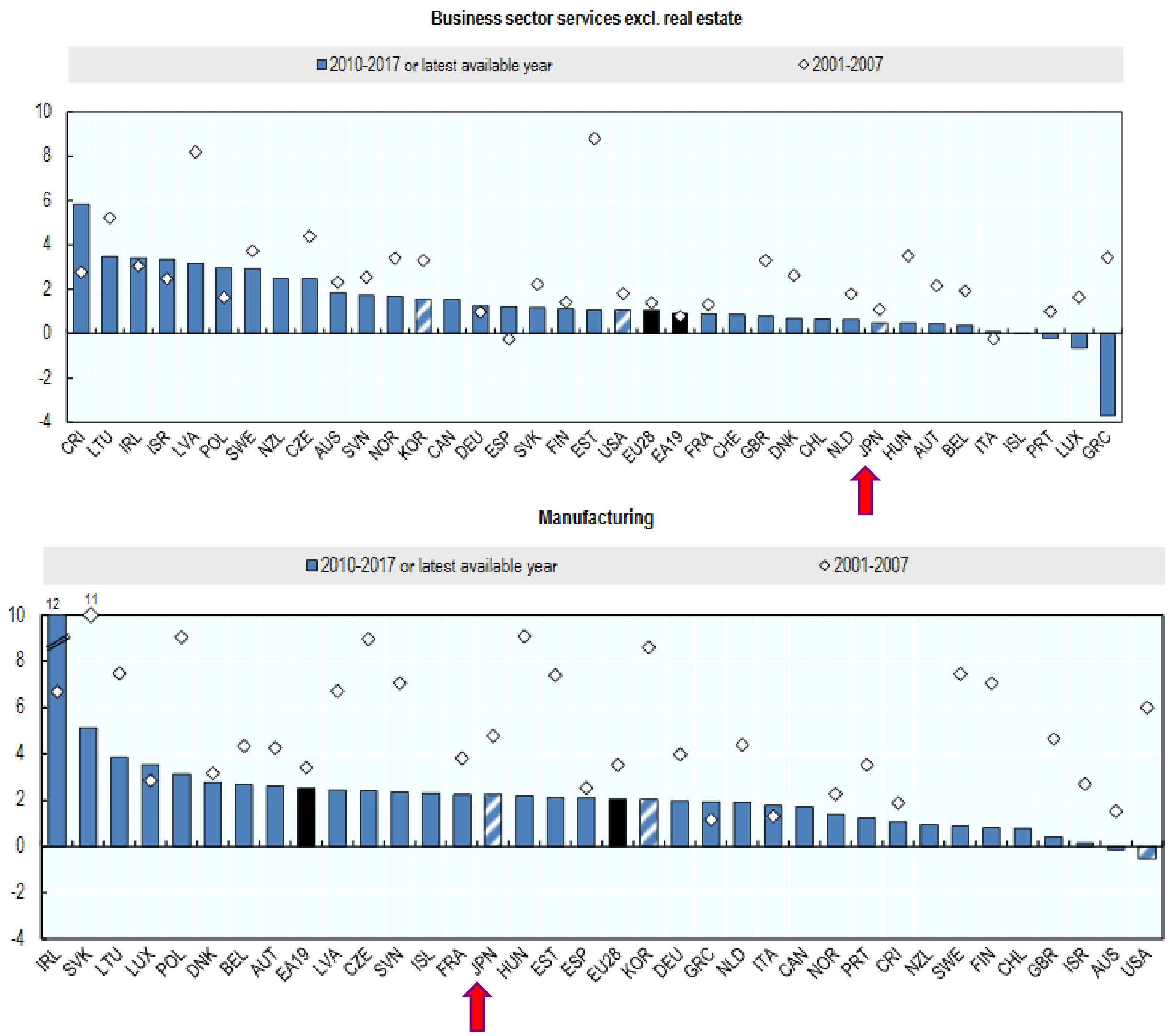


Figure 3: OECD Labor Productivity by Sector

(OECD 2019c)

In recent years there have been glimmers of hope. In the period between 2010-2017 Japan's labor productivity growth rate was nearly identical to the OECD average. However, this growth was driven by the already highly productive manufacturing sector while service sector productivity growth remained stuck in the bottom quarter of the OECD (OECD 2019c).

The headline numbers hide some important information, and by delving into micro-level data the contours of the productivity gap may begin to take a clearer shape. In 2005 Japan's TFP led that of the U.S. in 12 of 36 industries measured. In industries such as medical care, automotive manufacturing, primary metals, and miscellaneous manufacturing Japanese firms are more productive than their American counterparts. The three industries that contribute the most to Japan's overall low productivity are finance and insurance, other services, and most of all, retail and wholesale. Retail and wholesale on its own accounts for a whopping 6.9% of the total TFP gap between Japan and the U.S. (Jorgenson, Nomura and Samuels 2015). Looking at the manufacturing sector, the top 5% of Japanese firms are on the global productivity frontier. It is the median 90% which drag down the overall TFP rate. In the U.S., which has the highest TFP globally, the median 90% of firms tend not to be far from the top 5% of firms in terms of productivity. However, at the rump of the productivity distribution, the lowest 5% are extremely unproductive. In Japan, the gap between the lowest 5% and the median 90% is not particularly large, but the gap between the top 5% and the median 90% is. In short, Japan has a highly productive vanguard of manufacturing firms, while the middle 90% are unproductive compared to their U.S. counterparts (Nakamura, Kaihatsu and Yagi 2019).

Ito and Lechevalier (2009) find similar results when examining both labor productivity and TFP dispersion in Japanese firms. They show that there is a large gap between the top 10% and the bottom 90% of manufacturing firms, but that there is little dispersion among the bottom

90%. In the non-manufacturing sector, there is more TFP and labor productivity dispersion, with the bottom 25% of firms dragging down the total average. Once again, the non-manufacturing sector is shown to have lower productivity than the manufacturing sector.

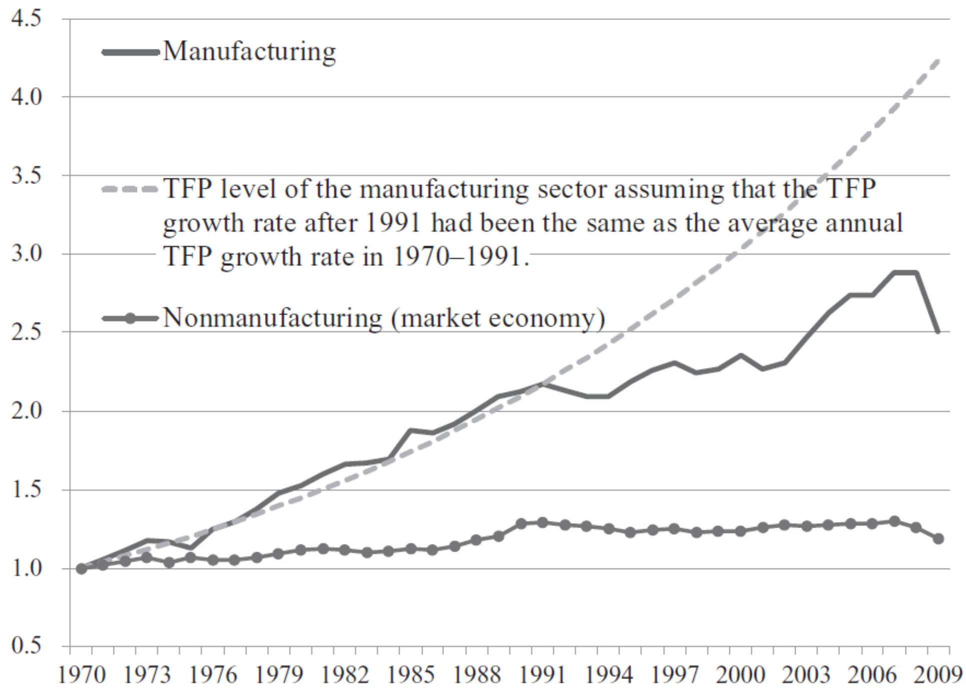


Figure 4: TFP Level of the Manufacturing and Nonmanufacturing Sector, 1970-2009 (1970=1)
(Fukao 2013)

Digging deeper into the data we can begin to see a profile of the typical low-productivity firm. A low productivity firm in Japan is most likely to be in the service sector, with the least productive being small and medium sized enterprises (SME). Older firms, especially SMEs, are less productive, with the least productive being in the retail and wholesale sector. SMEs in the manufacturing sector are more productive than SMEs in the non-manufacturing sector, but they are less productive than larger manufacturing firms (Colacelli and Hee 2019) (OECD 2019b).

The tepid rates of growth are a drag on the economy as well as society and the urgency to increase productivity is especially acute in Japan. With its rapidly aging population, Japan is projected to lose 24% of its labor force within the next 30 years (Jones and Seitani 2017). Japan is ranked 5th out of 40 countries with the highest percentage of employees who work very long hours, and 35th out of 40 for countries with the best work-life balance (OECD 2020). As there is a word for literally working to death (*karoshi)* it may be unrealistic to rely on increased labor inputs for GDP growth. Barring a significant change in immigration rates, and even with an uptick in the female labor participation rate, Japan will be hard pressed to maintain output with rapidly shrinking labor inputs.

To summarize, in order for Japan to maintain a high standard of living and grow economically with a shrinking labor force, it is essential to raise its low labor productivity and TFP. The manufacturing sector has a cadre of firms that operate on the productivity frontier with a long tail of middling firms, most of which are SMEs. The service sector overall suffers from low rates of TFP and labor productivity, with SMEs, especially the smallest and oldest, being the least productive.

3: ICT, Intangible Capital, and Productivity Growth

There is a broad consensus that ICT investment has been a leading factor in both TFP growth and labor productivity growth (Cardona, Kretschmer and Strobel 2013). Jorgenson et al (2007) find that ICT-using industries played the greatest role in boosting U.S. TFP growth between 1995-2004. Jorgenson and Motohashi (2005) compare the role of ICT on output and productivity growth in the U.S. and Japan and find that ICT-producing industries (firms that manufacture ICT related hardware) accounted for two thirds of Japanese output growth from 1995 to 2003, sparked in part by massive investments in ICT capital by Japanese firms. Japanese ICT-producing industries contributed to TFP at a similar rate as their American counterparts. However, the ICT-using sectors (mainly services) despite making large investments in ICT capital, have not seen the same TFP growth as their American counterparts. Japan finds itself in a situation where its ICT-producing sector operates on the productivity frontier while its ICT-consuming sectors lag behind. Research on ICT-using firms in the EU also finds they underperform their American counterparts, suggesting that there is a complementary aspect between U.S. firms' management practices and ICT investments (Bloom, Sadun and Van Reenen 2012).

3.1: ICT as a General-Purpose Technology

ICT can be considered a general-purpose technology (GPT) (Cardona, Kretschmer and Strobel 2013). Bresnahan and Trajtenberg (1996) as cited in Jovanovic and Rousseau (2005) lay out the three characteristics that define a GPT:

- Pervasiveness: The technology should be widespread across a multitude of sectors, firms, and applications
- Improvement: The technology should improve over time and provide cost savings
- Innovation spawning: The technology should spur innovation in products and processes

It is simply not enough to make capital investments in a GPT. Workflows need to be organized in a way that make proper use of it. Thus, although ICT capital investment is important, the complementary organizational investments that firms make are the real key to increased productivity.

Just as factories were forced to change their layouts to take advantage of electric power (another GPT), modern firms must design their work processes around ICT (Brynjolfsson and Hitt 2000). Brynjolfsson, Hitt and Yang (2002), for example, find that when U.S. companies invest in ICT systems as well as the organizational capital needed to make use of those systems, their stock values increase greatly. ICT at its heart is merely a tool that allows information to be stored, transmitted, organized, and analyzed. What a firm does with that tool can vary greatly, and firms that are able to utilize ITC in a meaningful way reap the rewards.

When thinking of organizational capital and ICT, it might be useful to think of an organization as a means of processing information (Brynjolfsson and Hitt 2000). A firm decides to allocate resources to its various parts based on the information it receives and the methods it possesses to process and utilize that information. Investments in human capital, plants, intermediate goods, marketing etc., are planned around firm-specific information resources. When a firm invests in ICT it is adding a tool to help it process and utilize that information.

However, to use the tool effectively and to reduce the costs associated with gathering, processing, and utilizing that information, a firm must structure it business processes in a manner that allows it to utilize the tool.

3.2: Intangible Capital

One cannot begin to talk about ICT without addressing intangible capital. In a modern, developed economy, ideas, organizational structures, brands, and knowledge can be more valuable than the physical assets a company owns. Corrado, Hulten and Sichel (2005) in their work showing the importance of intangible assets on economic growth define three broad groups of intangible assets: computerized information, innovative property, and economic competencies. Computerized information includes software, databases, and knowledge embedded in computerized systems. Innovative property includes knowledge gained via R&D, artistic designs, licenses, copywrites, and mineral rights. Economic competencies encompass things such as organizational capital, firm specific human capital, and brand equity.

Their model, which expands the framework of growth accounting to better encompass intangible assets, shows the vital importance of these assets to the economy of the United States. They reckon that investment in intangible assets was 13% of U.S. GDP in the late 1990s and was increasing year-on-year. The level of investment in intangible assets was larger than the level of investment in tangible assets.

Fukao et al. (2009) utilizing the same methodology, measured the level of intangible investment in Japan. While an apples-to-apples comparison with the U.S. is impossible due to differences in how data are collected, it is clear that Japanese firms are more dependent on investments in tangible goods relative to the U.S. The ICT using service sector in particular had a far higher ratio of tangible assets to intangible assets than the U.S. Part of the reason may be due to the central role of banks, which require physical collateral, in providing capital to Japanese firms. This point will be discussed in more detail later.

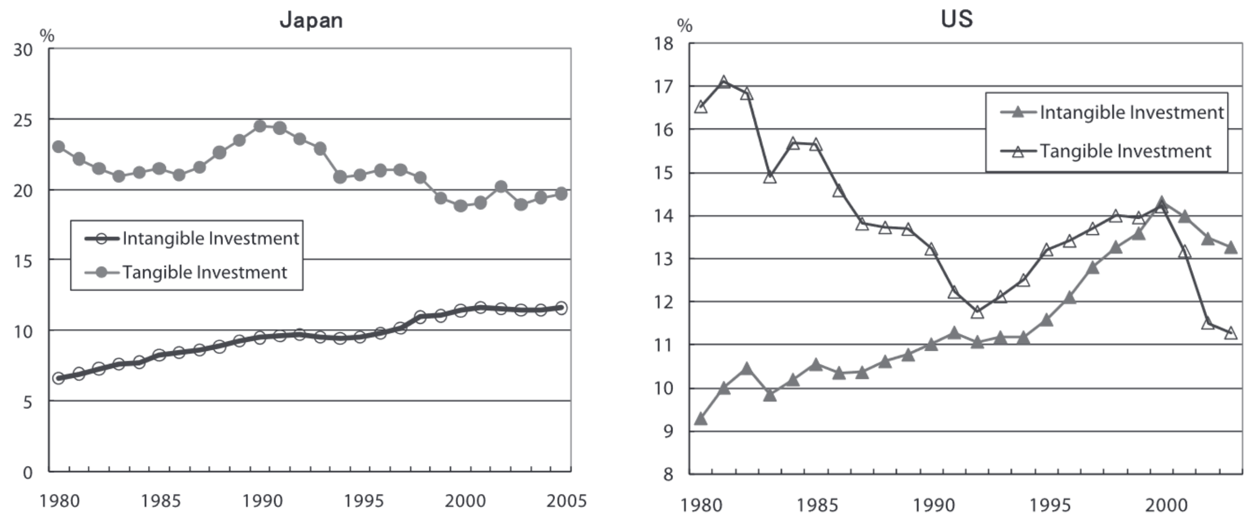


Figure 5: Intangible and Tangible Investment (% of business output) (Fukao, et al. 2009)

3.2: Productivity Supercenter

To illustrate the concept of organizational capital it may be useful to include a real-world example. In the U.S., the retail and wholesale sectors were one of the main drivers of TFP growth from 1995-2000, and most of that growth was spurred by the Behemoth of Bentonville, Wal-Mart.

Between 1987 and the mid-1990s Wal-Mart's market share grew in the U.S. from 9% to 27%. More alarmingly for its competitors, its productivity advantage grew from 40% to 48%. It did this not only by investing in ICT technology, but by completely redesigning its business model around ICT. Inventory, purchasing, logistics, and warehousing were reorganized around electronic data interchanges, wireless barcode scanners, and other ICT systems.

Wal-Mart invested $4 billion in its “Retail Link” supply chain system, which used real-time point of sale information to automate its purchasing. This system spurred $40 billion in investment as its suppliers were forced to build ICT systems to interact with Wal-Mart’s. The ICT hardware that Wal-Mart used, such as bar code scanners and servers, was widely available. However, by organizing its business operations to make efficient use of widely available ICT hardware Wal-Mart created a large amount of firm-specific organizational capital (McKinsey Global Institute 2002).

4: Firms, Business Practices, and ICT

4.1: ICT and the J-Firm

As mentioned before, the productivity gains of ICT-using service sector firms in Japan have been low considering the amount of ICT-capital invested. Thus, the way in which Japanese firms are using ICT may explain the unrealized productivity gains vis-à-vis U.S. firms. Motohashi (2008) finds that ICT systems can be broken down into two basic areas: “mission-critical systems” such as payroll, accounting and other back-office systems and “information systems” which convert large amounts of information into usable formats to assist in product design, customer retention, market analysis and managerial decision making. Both Japanese and U.S. firms invest heavily in mission-critical systems, while U.S. firms tend to lead in information systems. Information systems, in order to be utilized effectively, require large amounts of investments in organizational capital, such as workflow processes and worker training, which many U.S. firms have successfully undertaken.

Survey data shows that U.S. firms were roughly twice as likely as Japanese firms to use their ICT budget for product and service development and changing business models. They were also significantly more likely to use their ICT budgets to analyze customer behavior and markets (Nakamura, Kaihatsu and Yagi 2019). Netflix is an example of a firm that has done this successfully. Netflix’s algorithm is incredibly successful at predicting a customer’s taste and even modifies the thumbnails of movies titles shown to viewers. The system is estimated to create $1 billion of value annually for Netflix (Gomez-Uribe and Hunt 2015).

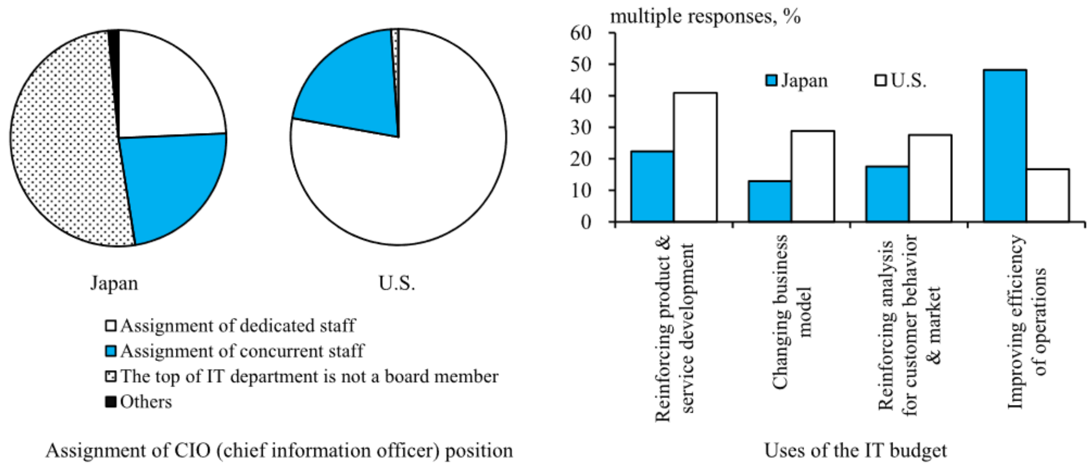


Figure 6: IT Budget and Organization
(Nakamura, Kaihatsu and Yagi 2019)

One can see from Figure 6 that in over half of Japanese firms the head of the IT department is not a member of the board, and in many cases the CIO has other responsibilities as well. These facts, combined with the prevalence of using the ICT budget for "improving efficiency of operations" implies that ICT is not a driver of an organization's business strategy, but rather a tool to streamline already existing processes and functions. To return to a point made earlier, ICT systems are relegated to back-office systems as opposed to being an analytical tool driving strategic decisions.

The lack of ICT leadership at the top of the firm has real implications for how ICT systems are implemented. Roughly two thirds of Japanese firms do not have enterprise-wide information systems. Rather, different units invest in their own independent systems, creating a "hodge-podge" of ICT systems that cannot communicate with each other (Motohashi 2006). Because ICT investment happens at the division level, it is difficult to develop a firm-wide strategy to reorganize business practices around ICT. Japanese companies tend to outsource the construction of ICT systems without well-defined specifications. As a result, costs tend to be higher and the systems themselves limited in their usefulness (Motohashi 2008).

Why do Japanese firms utilize ICT in such a different way than their American counterparts? Motohashi (2006) theorizes that some of the unique characteristics of the standard Japanese firm may explain the different approaches to ICT. Borrowing from the work on comparative institutional analysis by Masahiko Aoki (1990), he identifies four areas where U.S. and Japanese firms diverge: compared to American firms, Japanese firms have active cross-functional coordination, unclear job descriptions and responsibilities, a bottom-up decision-making process, and tacit forms of knowledge creation.

He argues that Japanese firms developed robust inter-group knowledge sharing networks that predate ICT based information systems. These networks rely on cross-functional coordination between units and the rotation of staff in various positions within the firm. Thus, because information sharing systems are already robust, there may be less benefit in ICT-based information sharing.

Japanese business practices are also hard to codify. Japanese firms rely on tacit knowledge for innovation as opposed to explicit knowledge. On the day-to-day level, implicit understandings, intentional ambiguity, and poorly defined job roles do not translate well into the explicit information that ICT-based information systems need to function. As a result, Japanese organizational and informational practices may be poorly suited to the quantifiable, data driven organizational techniques that complement ICT-based informational systems.

This idea of cross-functional coordination and information sharing can be seen in the job title *sougoushoku* (総合職) which can be loosely defined as “composite work.” The HR site

Mynavi defines it as a position with an "undefined scope of work." [1] *Sougoushoku*, essentially, is a position where an employee can expect to be shuffled around to different departments in order to be trained on the overall workings of the company. Employees who are assigned this type of work are usually being groomed for management, with the idea that they need to learn all aspects of the firm's work processes.

Nakahara (2018) describes the "limitless character of a job" (仕事の無限性) when writing about Japanese HR practices. In Japanese firms there is often no clear distinction between where one person's responsibilities start and another person's ends. Instead of hiring a person for a specific job, Japanese firms hire people and then assign them work as needed. These unclear job definitions, sharing of responsibilities, and ad-hoc assignments are the antithesis of the well-defined work processes that ICT systems require.

Another important term that helps explain the poor implementation of ICT-systems in Japanese firms is *yarikata* (やり方) which translates as the "way of doing things." Anyone who has either worked in Japan or with a Japanese organization knows the importance of *yarikata.* Ulrike Schaede describes *yarikata* as "strong as religion" (Schaede 2020, p. 38). As such, Japanese firms tend to eschew off-the shelf software and prefer custom software that can be tailored to their *yarikata* (Dujarric and Hagui 2009).

One aspect of *yarikata* that is deeply ingrained in Japanese business practices that hinders efficient ICT systems is the use of *hanko* name seals. *Hanko* are ubiquitous personalized carved stamps baring the holder's name. Business documents typically need to be stamped as they filter up through the chain of command.

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[1] [Mynavi 2020] https://mynavi-agent.jp/dainishinsotsu/canvas/2020/12/post-418.html#sec1-1

Examples of *hanko* creating impediments to digitized workflows are rife. Only 40% of Japanese companies allow digital signatures for contracts, leading to news reports of office workers going to the office during the Corona pandemic solely to stamp paperwork (NHK 2020). The Japanese government recently identified roughly 15,000 bureaucratic procedures that currently require an *hanko*, the vast majority of which could be eliminated (Nikkei Shinbun 2020). Until recently all package deliveries required a *hanko* stamp, a custom which was phased out partly due to pressure from Amazon (Makabe 2020).

As companies digitize there is even a demand from some companies to build a "digital *hanko* system" so that documents can be circulated and "stamped" in a digital format (Kaya 2020). It is impossible to know the economic cost of printing, physically circulating, sorting, and filing millions of documents, but one can imagine that the drag on productivity is at least marginally significant.

While I was unable to find any literature on this topic, I would venture that risk tolerance may play a part as well. Japanese firms have historically been risk-averse.[2] Investing in the large-scale organizational changes required to utilize information systems is inherently risky as there is no set formula for success. As such, even in industries with very high ICT-intensity such as finance, ICT budgets are spent disproportionally on maintenance, leaving little room for new development (Fukao, Ikeuchi, et al. 2015). The high levels of testing and surety mean that the downtime for systems are significantly lower in Japanese financial institutions when compared to their U.S. counterparts. It also means they are only able to allocate 21% of their ICT budget to new development as opposed to 42% in the U.S. (Deloitte Tohmatsu Consulting LLC 2017).

[2] See Ulirke Schaede (2008) "Choose and Focus" for a in depth and thoughtful overview of evolving risk tolerance

4.2: SMEs

The relatively small size of large firms in Japan, as well as the prevalence of SMEs is a drag on ICT-related productivity gains. The retail and wholesale sector, for example, is the largest drag on Japan's TFP. However, Japan does have highly productive retailers, mostly concentrated in convenience stores. However, by international standards, these firms are relatively small. Japan's three largest retailers had $133.53 billion[3] (IMRG 2018) in combined revenue compared to $387.66 billion for Wal-Mart alone (National Retail Federation 2019). One company, when it is as big as Wal-Mart, can help change statistics at a national level. Nor is it just in retail that Japanese firms lack heft. Overall, listed companies tend to be smaller, limiting the impact that any one firm can have on the economy writ large (Schaede 2020).

Much of Japan's service sector is dominated by small firms. In Japan 99.7% of companies are SMEs which is comparable with the rate in America (99.7%), Germany (99.5%), and the U.K. (99.9%). However, there are a few features about Japanese SMEs which make them unique. First, small firms in Japan are very small. In the U.S. 50% of all SMEs have under 10 people, in Japan the share is 80%. Second, the share of the workforce that is employed in SMEs is very high in Japan, at 69.7% (Japan Finance Corporation Research Office 2015). If one excludes the two largest cities, Tokyo and Osaka, that share rises to 85.9% (METI 2014). The smallest companies (under four employees) are concentrated in retail and food and hospitality, which tend to be some of the least productive sectors. By 2025 over two-thirds of managers at SMEs will be 70 or older (Office of the Prime Minister of Japan 2019).

[3] April 1, 2021 exchange rate

Looking at these figures, it is hard to imagine that many of these firms will ever adopt the ICT systems needed to become more productive. Politically, it is hard to imagine the government letting these firms fail en masse by pulling credit guarantees or further loosening restrictive zoning laws. Thus, in the retail and wholesale sector, the only viable strategy may be to wait and let nature take its course.

5: Structural Impediments

5.1: Labor Markets and Human Capital

There are numerous mechanisms by which the Japanese labor market is inhibiting productivity growth through the application of ICT. Perhaps the most significant is the highly rigid labor market for regular employees (Nakamura, Kaihatsu and Yagi 2019). Investing in technology, whether it be steam powered machines or massive data processing power, necessitates organizational changes, and can lead to a decrease in certain types of labor inputs. However, with the strong protections afforded regular employees, companies have fewer incentives to significantly restructure their operations.

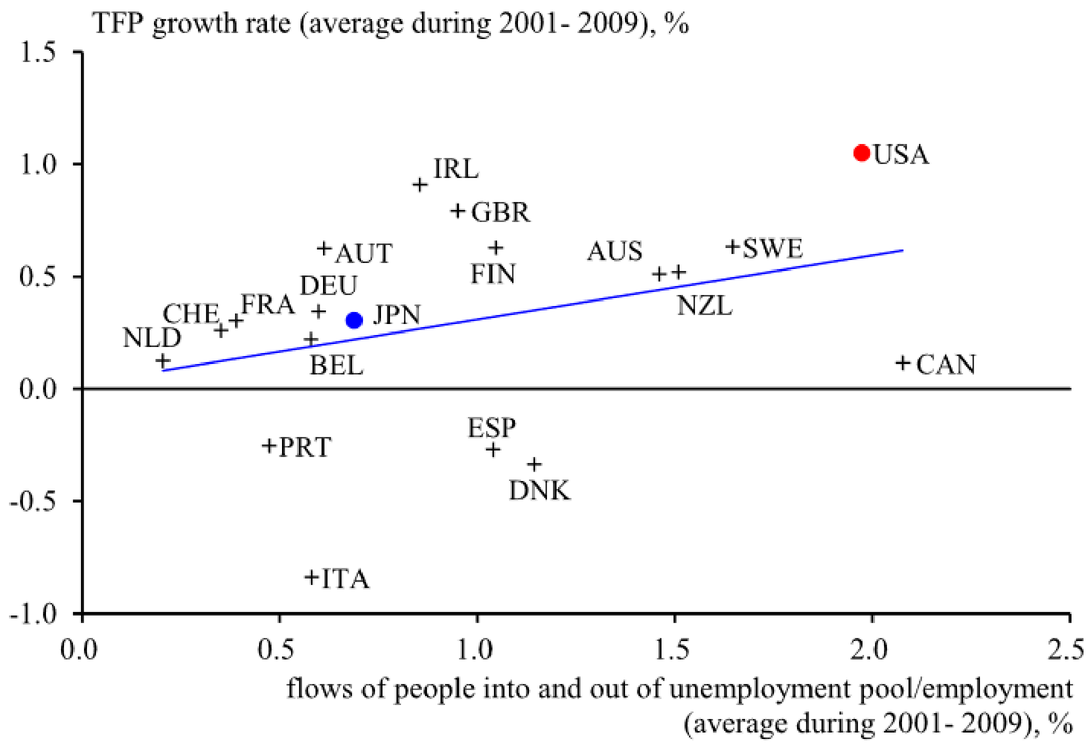

Figure 8: TFP and Labor Mobility
(Nakamura, Kaihatsu and Yagi 2019)

Redundant employees are difficult to remove, and downsizing is often achieved through the slow process of attrition, reducing gains made by investment. Even in areas where ICT-automation has flourished, such as back-office functions, the staff were not eliminated but simply transferred to other areas of the firm (Motohashi 2006). Developing organization capital to compliment ICT-based informational systems requires work force flexibility, something which Japanese firms lack.

Labor market rigidity affects ICT adoption in other, more subtle ways as well. Fukao, Ikeuchi et al. (2015) describes the ways in which labor market rigidity inhibit small service sector firms from utilizing ICT. Graduates of top-level universities in Japan with technology degrees are far more likely to work for large companies, and far less likely to change jobs than their U.S. counterparts. Large Japanese firms snap up graduates with technology degrees, and, due to the rigid labor market, employ them for the duration of their career. This not only makes it difficult for smaller firms to attract ICT talent, but it also affects the market for business process outsourcing (BPO). In 2008 the BPO industry in Japan was only 5% of the size of the BPO industry in the U.S. Although internal business processing is costly, firms are less like to restructure these units since it is expensive to get rid of workers. When they do restructure business processing units, they tend to transfer workers to affiliated or same-group firms and then hire that firm to do their business processing instead of the most efficient firm. The stunted BPO industry in Japan makes it prohibitively expensive for smaller firms to outsource, thus deterring them from utilizing ICT sufficiently.

According to the OECD 21.2% of the 45-54 age group and 40.9% of the 55-64 age group in Japan lack even basic computer skills, which is higher than most other OECD countries (Jones and Jin 2017). Accordingly ICT use at work is low compared to other countries. Given the large share of mid-to-late-career aged adults without basic computer skills, and the propensity of Japanese companies to provide on-the-job training, one can only imagine the difficulty and cost of training this group of workers to utilize ICT systems. That is assuming of course that managers were even aware of some of the existing ICT technology available. Surveys shows that nearly half of managers in non-IT business units of Japanese firms with over 300 employees were unaware of cloud computing or big data (Fukao, Ikeuchi, et al. 2015). The Japanese educational system also lacks a focus on technology use, so even young workers are not as technologically proficient as their peers in other developed nations (Jones and Jin 2017).

5.2: MITI

The former Ministry of International Trade and Industry (MITI), currently known as the Ministry of Economy, Trade and Industry (METI), played an outsized role in the economic development of post-war Japan. Thus, it should come as no surprise that MITI policy is partly responsible for the lack of organizational capital formation related to ICT investment.

Until the early 1980s, the PC market was a vertically integrated industry dominated by a few players. Companies such as IBM and Honeywell built the hardware and wrote the software for their machines. In the 1960s MITI pressured Japanese electronics firms to secure licensing agreements with separate American companies: Hitachi paired with IBM, NEC with Honeywell, Toshiba with GE, etc.

Although the Japanese firms licensed the hardware technology from the American firms, they created the software themselves. These firms would build highly customized, proprietary software packages for customers at a low cost and then lock them into to long-term agreements to supply profitable hardware, technical support, and upgrades. The customized software packages were designed around the *yarikata*, or way of doing business, for each client.

In the U.S., an anti-trust suit provided the impetus for IBM to allow third-party software and hardware add-ons to its systems, culminating in the decision allow an outside company to create the operating system (that company being a small startup called Microsoft). The computer business morphed from a vertically integrated industry to a horizontally distributed one based on platforms. This allowed a proliferation of both software and hardware companies in the U.S.

This process never occurred in Japan. There was no government push to allow computer system makers to allow software or hardware from other companies to run on their systems. Computer companies remained focused on proprietary systems, while their corporate clients had extensive sunk costs in their customed ICT systems. Even in personal computers NEC retained a near monopoly until the early 1990s. Its computers used their own operating system and were incompatible with other hardware and software makers' products.

It was not until the mid-1980s that MITI saw the danger and urged Japanese computer system manufacturers to collaborate on the development of an open hardware and software standard similar to the one developed by Microsoft and Intel. The initiative was a failure (Dujarric and Hagui 2009).

5.3: Creative Destruction

It is a stylized fact that productivity declines with firm age. Newer firms are better able to design business processes from scratch around new technologies and business ideas, which, in the modern era typically involves ICT. Japan, as can be seen in Figure 9, has a very low rate of firm entry. Part of this is due to a lack of venture capital (VC).

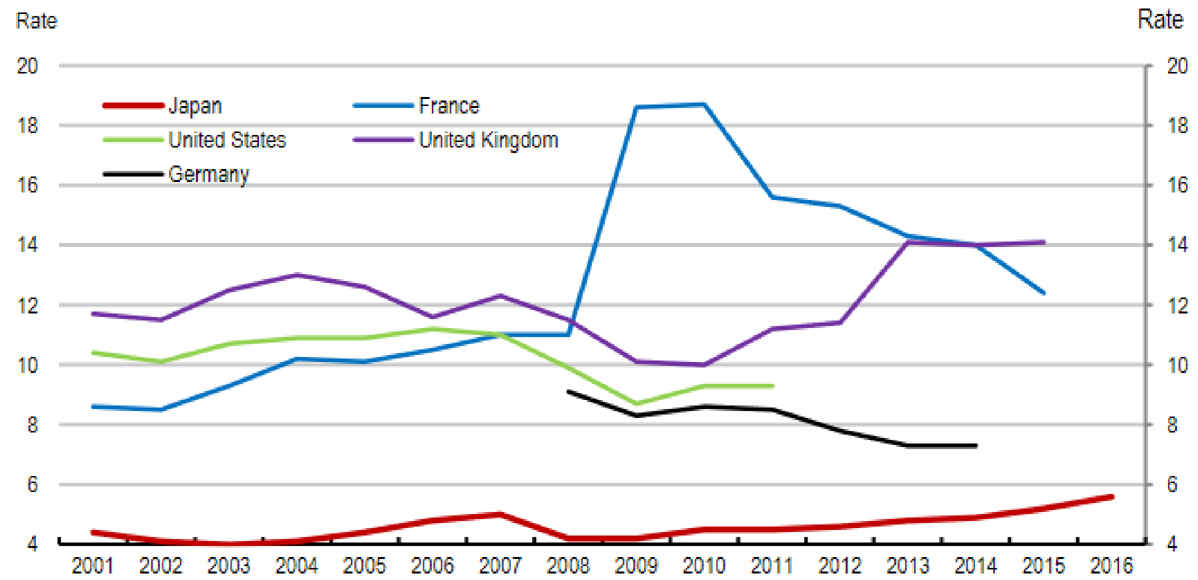

Figure 9: Firm Entry and Exit Rates (OECD 2019b)

Between 2012-2014 Japanese VC investment as a share of GDP was only 10% that of the U.S. In 2014, there were 36 acquisitions of a startup by a larger company in Japan as opposed to 918 in the U.S. The acquisition of startups by large firms is not just an important source of profits for VC firms, it is also a conduit for new technologies and ideas to penetrate establish firms. METI has gotten involved, channeling money towards startups and pressuring large corporations to be more proactive in purchasing them up, although it remains to be seen if this will be effective (Schaede 2020).

In addition to a lack of VC, there is a lack of entrepreneurship in Japan. Very few people opt of create firms and enter the market. Part of this is due to the negative view of entrepreneurship that exists in Japan. There is a perceived lack of opportunities, as well as a general fear of failure, which, due to the strictness of the bankruptcy system and the use of guarantors, is a legitimate fear. The rate of female entrepreneurship is the second lowest in the OECD, reflecting traditional gender attitudes. Finally, Japanese feel as if their entrepreneurial skills are less developed than their OECD peers' (Jones and Jin 2017).

The problem with financing new ideas is not limited to the lack of VC. Japan's overreliance on bank financing is a potential weakness in promoting intangible investments related to ICT. First, banks tend to rely on tangible assets for collateral, meaning that firms which we rely on bank financing maintain larger tangible asset stocks than needed, discouraging investment in intangible assets (Fukao, et al. 2009). Second, equity markets may do a better job at valuing intangible assets than banks, as banks are overly reliant on book value (Brynjolfsson, Hitt and Yang 2002).

5.4: Corporate Governance

Issues with corporate governance may also be slowing down the needed investments in ICT and its associate intangible capital. Traditionally, financing has come from banks, and cross shareholding has limited equity market exposure. Boards of directors are almost exclusively made up of former employees of the firm, limiting oversight of management. In this way, firms that failed to make the necessary investments in the intangible capital needed to increase labor productivity through ICT systems were not punished by the market (OECD 2019b) (Schaede 2008).

However, a series of reforms to the corporate governance framework, most recently in 2014, are beginning to have an effect. The 2014 Stewardship Code give institutional investors a larger role on boards, recommending that at least two board members be outsiders. The appointment of women and foreigners was also encouraged. With the increased power of asset managers on boards, companies are more focused on increasing returns to shareholders (Schaede 2020).

Although it is too soon to know to what extent these changes will affect investments in ICT systems and intangible capital, the increased power of shareholders bodes well for creating a more dynamic business environment.

5.5: Trade, FDI, and Internationalization

If a country is struggling to boost TFP and labor productivity using ICT, one solution may be to import the ICT-facilitating intangible capital from abroad. One of the main channels to facilitate intangible capital imports is via inbound and outbound foreign direct investment (FDI). It has been shown that only the most productive firms tend to engage in FDI (Helpman, Melitz and Yeaple 2004), and that multi-national enterprises tend to be more productive than purely domestic ones (Kimura and Kiyota 2006).

Although there is debate about the benefits of FDI overall, Japan in particular seems to possess the necessary prerequisites, such as regulatory capacity and a highly educated workforce, to benefit from FDI. Japan-specific research suggests that FDI could play in part in increasing productivity in Japan (Hoshi 2018). Japan however has the lowest level of inward FDI at a ratio of its GDP in the OECD. As such, it may be missing out on ICT-related innovations pioneered abroad (Saito 2017).

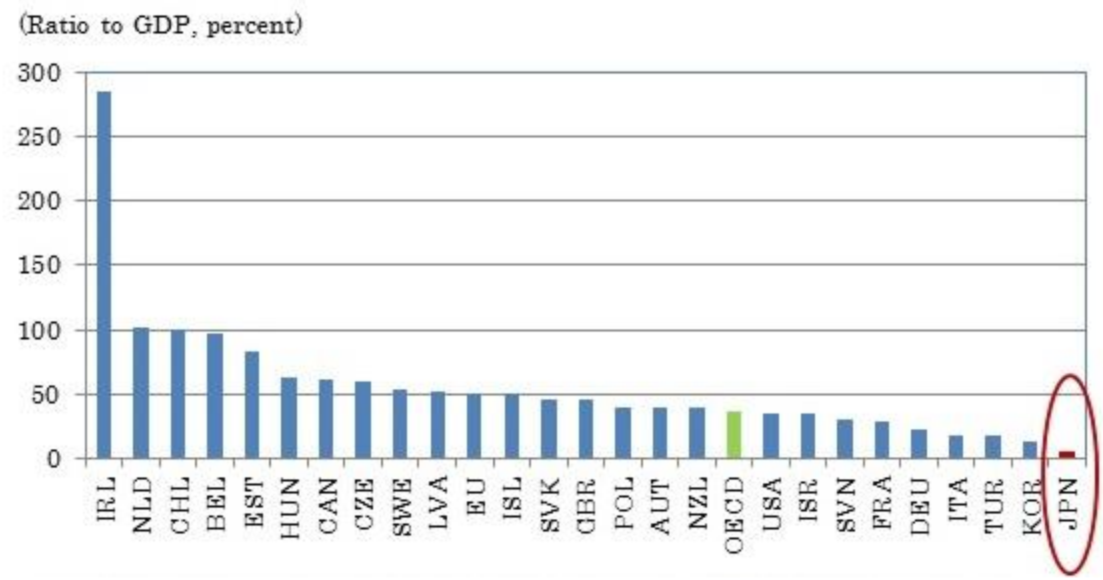

Figure 10: Stock of Inward Foreign Direct Investment in OECD Countries (2016) (Saito 2017)

Bloom, Sadun and Van Reenen (2012) show that U.S. multinationals operating in Europe have higher levels of ICT output elasticity than their European counterparts, a fact which they attribute to American management practices. As discussed in Section 3, large upfront investments are needed to create the intangible capital needed to fully benefit from ICT adoption. Japan could benefit for the investments already made abroad by increasing the amount of FDI coming into the country.

Hoshi (2018) provides a Japan-specific review of the FDI literature and finds that most of the factors influencing inward FDI to Japan is out of the government’s control. Gravity equations, which look at GDP and geographical distance, have been used to model FDI flows with some accuracy. These models find that Japan’s geographic distance from other wealthy nations may be the largest hinderance to increased inward FDI (Head and Ries 2005). Countries tend to invest more in Japan when their exports to Japan are low, implying the substitution effect, and when there are cultural similarities. Labor market rigidity and corporate tax rates seem to be the only important factors that Japanese regulators can adjust (Hoshi 2018).

The focus on inward FDI can hide the importance of outward FDI on technology improvements. One of the main ways firms can acquire new technology and learn new organizational techniques is by acquiring other firms. Most FDI occurs via mergers and acquisitions, allowing technology to flow between the source and target country.

Japanese outward FDI skews more towards greenfield investments when compared with other OECD countries. Japanese firms, instead of buying other companies, are establishing production centers abroad (Head and Ries 2005). This may have an effect on the flow of technology and ideas, although it is difficult to quantify.

6: Conclusion

Japan is rapidly ageing while its workers put in long hours for low pay. In order to simply maintain its current standard of living, Japan must improve its productivity. To do so Japan needs to reform the economic framework which served it so well in the decades immediately after WWII.

In the post-war system large companies formed alliances centered around main banks and were granted oligopolistic rents. These rents were then dispersed to disparate stakeholders including suppliers, workers, management, and banks. Small firms were protected with loan guarantees and, in the case of the retail sector, restrictive zoning laws. This system provided social stability and rapid growth in the decades immediately after the war as firms were able to invest in capital goods with the knowledge their investments would be protected, and workers were assured of job security even during downturns.

However, as Japan's economy has become more advanced, and the global economy has become more interconnected, the costs of the post-war framework now exceed the benefits. Stability has turned to stagnation. Due to an overreliance on bank financing, low-productivity firms are protected from the discipline imposed by capital markets. Unable to shed workers, firms lack an incentive to make their operations more efficient. Small firms, led by aged managers, are coddled, and stuck in old ways of doing business.

To innovate and improve workflows, Japan must revamp its labor and capital markets. Firms should be able to shed employees more easily, and market discipline should play a larger role in capital allocation. The role of equity markets and venture capital should increase. Japan should learn from best practice abroad and import new business models through both outward and inward bound FDI. Finally, Japan needs to find a way to encourage more entrepreneurship.

Japan has a highly educated population and cutting-edge technology. There is no reason that Japanese startups should not be developing the businesses of the future and disseminating new technologies and business practices throughout the economy.

As Japan reforms social stability and the well-being of its citizenry must be of paramount importance. The social safety net, which for so long was provided by corporate Japan and funded through oligopolistic rents, cannot be allowed to be torn down. Rather, the burden of social well-being should be funded by taxes, not rents, and carried by the government, not the private sector. With a new social compact, in which the government provides more robust unemployment insurance, and mid-career employment changes are not stigmatized, firms will become nimbler, and skills can be more efficiently matched with the needs of firms.

The effective use of ICT-system requires firms to organize their workflows and organizational structures around the tools at their disposal. For firms to make the massive investment that reorganization takes, they must be incentivized. Without the cost savings from reduced labor inputs or pressure from owners, firms do not have a large incentive to change. Without deep structural reform, these incentives will be muffled.

Japan has already begun to make some of the reforms needed. Capital markets are beginning to play a more active role, and corporate boards are changing. There is also broad discussion on how best to move forward and a recognition of the need to do so. Japan is a prosperous nation with a capable bureaucracy, functioning institutions, a large export sector, and an educated workforce. As it begins to reform, it does so from a position of strength.

Works Cited

Aoki, Kosuke, Naoko Hara, and Maiko Koga. 2017. "Structural Reforms, Innovation and Economic Growth." *Bank of Japan Working Paper Series 17-E-2.*

Bailey, Martin Neil, Barry Bosworth, and Siddhi Doshi. 2020. *Productivity Comparisons: Lessons from Japan, the United States, and Germany.* The Brookings Institute.

Bloom, Nicholas, Raffaella Sadun, and John Van Reenen. 2012. "Americans Do IT Better: US Multinationals and the Productivity Miracle." *The American Economic Review 102 (1)* 167-201.

Brynjolfsson, Erik, and Lorin Hitt. 2000. "Beyond Computation: Information Technology, Organizational Transformation and Business Performance." *Journal of Economic Perspectives 14 (4)* 23-48.

Brynjolfsson, Erik, Lorin M. Hitt, and Shinkyu Yang. 2002. "Intangible Assets: Computers and Organizational Capital." *Brookings Papers on Economic Activity (1)* 137-198.

Cardona, M., T. Kretschmer, and T. Strobel. 2013. "ICT and productivity: conclusions from the empirical literature." *Information Economics and Policy 25* 109-125.

Colacelli, Mariana, and Hong Gee Hee. 2019. "Productivity Drag from Small and Medium-Sized Enterprises in Japan." *IMF Working Paper WP/19/137.*

Corrado, Carol, Charles Hulten, and Dan Sichel. 2005. "Measuring Capital and Technology: An Expanded Framework." In *Measuring Capital in the New Economy*, edited by Carol Corrado, John Haltiwanger and Dan Sichel, 11-46. Chicago: University of Chicago Press.

Crespo, Nuno, and Maria Paula Fontoura. 2007. "Determinant Factors of FDI Spillovers – What Do We Really Know?" *World Development 35 (3)* 410-425.

Dujarric, Robert, and Andre Hagui. 2009. "Capitalizing On Innovation: The Case of Japan." *Harvard Business School Working Paper 09-114.*

Fukao, Kyoji, Tsutomu Miyagawa, Kentaro Mukai, Yukio Shinoda, and Konomi Tonogi. 2009. "Intangible Investment in Japan: Measurement and Contribution to Economic Growth." *The Review of Income and Weath 55 (3)* 717-736.

Gomez-Uribe, Carlos, and Neil Hunt. 2015. "The Netflix Recommender System: Algorithms, Business Value, and Innovation." *ACM Transactions on Management Information Systems 6 (4).*

Head, Keith, and John Ries. 2005. "Judging Japan's FDI: The verdict from a dartboard model." *Journal of the Japanese and International Economies 19 (2)* 215-232.

Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple. 2004. "Export Versus FDI with Heterogeneous Firms." *The American Economic Review 94 (1)* 300-316.

Hoshi, Takeo. 2018. "Has Abenomics Succeeded in Raising Japan'sInward Foreign Direct Investment?" *Asian Economic Policy Review 13* 149-168.

Ito, Keiko, and Sébastien Lechevalier. 2009. "The evolution of the productivity dispersion of firms: a reevaluation of its determinant in the case of Japan." *Review of World Economics 145 (3)* 405-429.

Jones, Randall, and Haruki Seitani. 2017. "Labor Market Reform to Cope with a Shrinking and Ageing Population." *OECD Economics Working Paper No. 1568.*

Jorgenson, Dale W. 2001. "Information Technology and the U.S. Economy." *The American Economic 91 (1)* 1-32.

Jorgenson, Dale W., Koji Nomura, and Jon D. Samuels. 2015. "A Half Century of Trans-Pacific Competition: Price Levels, Indices and Productivity Gaps for Japanese and U.S. Industries, 1955-2012." *RIETI Discussion Paper Series 15-E-054.*

Jorgenson, Dale, and Kazuyuki Motohashi. 2005. "Information Technology and the Japanese Economy." *NBER Working Paper 11801.*

Jorgenson, Dale, and Koji Nomura. 2007. "The Industry Origins of the US-Japan Productivity Gap." *Economic Systems Research 19 (3)* 315-412.

Jorgenson, Dale, Mun Ho, Jon Samuels, and Kevin Stiroh. 2007. "Industry Origins of the American Productivity Resurgence." *Economic System Research 19 (3)* 229-252.

Jovanovic, Boyan, and Peter Rousseau. 2005. "General Purpose Technologies." *NBER Working Paper 11093.*

Kantar. 2019. "Top 50 Global Retailors." https://www.kantar.com/Inspiration/Retail/Top-50-Global-Retailers-2019.

Kaya, Keiichi. 2020. "デジタル庁の創設をムダに終わらせないための 3 つの「ない」." *President Online*, October 10. https://president.jp/articles/-/39382?page=1.

Kimura, Fukunari, and Kozo Kiyota. 2006. " Exports, FDI, and Productivity: Dynamic Evidence from Japanese Firms." *Review of World Economic 142 (4)* 695-719.

Makabe, Akio. 2020. "「ハンコ廃止はハンコのためだけに非ず」日本の押印文化が抱える本当の問題点." *President Online*, October 09. https://president.jp/articles/-/39415.

McKinsey Global Institute. 2002. *How IT Enables Productivity Growth: The US experience across three sectors in the 1990s.* McKinsey & Company.

Miyazaki, Hajime. 1993. "Employeeism, Corporate Governance, and the J-Firm." *Journal of Comparitive Economics 17* 443-469.

Motohashi, Kazuyuki. 2008. "Comparative Analysis of IT Management and Productivity between Japanese and U.S. Firms." *RIETI Discussion Paper Series 08-E-007*.

Motohashi, Kazuyuki. 2006. "The IT Revolution's Implications for the Japanese Economy." In *Japan, Moving Toward a More Advanced Knowledge Economy, Vol 1*, edited by Tsutomu Shibata, 89-104. Washington, DC: The World Bank.

Nakahara, Jun. 2018. "日本人が山ほど残業を強いられる２つの根因 Nihonjin ga yamahodo zangyou wo shiirareru futatsu no gennin." *東洋経済新報 Touyou Keizai Shinpou*, 12 21.

Nakamura, Koji, Sohei Kaihatsu, and Tomoyuki Yagi. 2019. "Productivity Improvement and Economic Growth: Lessons from Japan." *Economic Analysis and Policy 62* 57-79.

NHK. 2020. "在宅勤務なのにハンコを押すために出社… Zaitaku kimu nanoni hanko wo osu tame ni shusha." *NHK*, April 11. https://www3.nhk.or.jp/news/html/20200411/k10012381401000.html.

Nikkei Shinbun. 2020. "行政手続きのハンコ、99%廃止へ　閣議請議の押印も Gyouseitetsuzuki no hanko, 99% haishi he kakugiseigi no ouin mo." *日本経済新聞 Nippon Keizai Shinbun*, October 16. https://www.nikkei.com/article/DGXMZO65079520W0A011C2EA3000/.

OECD. 2019c. *OECD Compendium of Productivity Indicators 2019.* Paris: OECD.

—. 2021b. *GDP per hour worked.* Accessed April 4, 2021. https://data.oecd.org/lprdty/gdp-per-hour-worked.htm.

OECD. 2019. "Multifactor Productivity Over the Cycle." In *OECD Compendium of Productivity Indicators*. Paris: OECD Publishing.

OECD. 2019b. "OECD Economic Surveys: Japan." *OECD Economic Surveys.*

OECD. 2021. *OECD Work-Life Balance.* OECD. Accessed 04 01, 2021. http://www.oecdbetterlifeindex.org/topics/work-life-balance/.

Saito, Jun. 2017. *Why is Japan's inward FDI so low?* 08 08. Accessed 04 13, 2021. https://www.jcer.or.jp/english/why-is-japans-inward-fdi-so-low.

Schaede, Ulrike. 2008. *Choose and Focus.* Ithaca: Cornell University Press.

—. 2020. *The Business Reinvention of Japan: How to Make Sense of the New Japan and Why it Matters.* Stanford: Stanford University Press.

Solow, Robert. 1957. "Technical Change and the Aggregate Production Function." *The Review of Economics and Statistics 39 (3)* 312-320.

Spiezia, Vincenzo. 2012. "ICT investments and productivity:Measuring the contributionof ICTs to growth." *OECD Journal: Economic Studies 2012 (1)* 199-2011.

Syverson, Chad. 2011. "What Determines Productivity?" *Journal of Economic Literature 49 (2)* 326-365.

n.d. *総合職と一般職との違いは？キャリア選択で迷った際のポイントについても解説.* Accessed April 16, 2021. https://mynavi-agent.jp/dainishinsotsu/canvas/2020/12/post-418.html#sec1-1.