The National Innovation System of Japan

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Introduction

"The social process which produces inventions and the social process which produces innovations do not stand in any invariant relation to each other and such relation as they display is much more complex than it appears."

-- Joseph Schumpeter, *Business Cycles*

"An invention is an idea, a sketch or model for a new or improved device, produce, process or system…An innovation in the economic sense is accomplished only with the first commercial transaction involving the new product, process system or device, although the word is also used to describe the whole process."

-- Chris Freeman and Luc Soete, *Economics of Industrial Innovation*

Innovation is a process that involves both invention and entrepreneurial activity: to understand a national innovation system, we must understand the various component systems that produce and reward both invention, and entrepreneurial behavior. Thus, to understand the nature of innovation in Japan, we must understand the culture and policies which undergird its systems of innovation. Culture fundamentally shapes how people perceive problems, delineate the socially appropriate ways to respond to them, and evaluate the desirability of disseminating solutions. We must understand Japan's system of government, given that body's capacity to grant or refuse rights and to shape the course of development through its conferral of rewards and prestige. We must understand the structures of its markets and their responses to new kinds and sites of production, as well as the flows of income those markets rely on as they seek new engines of growth. We must understand the relationships between markets, because those relationships evidence social and political priorities and reproduce them. We must understand the incentives workers and citizens face in their choices of work and consumption. We must understand the systems that move people and ideas between places and the features that structure that movement. In short, to understand how and why Japan innovates, we must develop a greater understanding of the policies and practices that generate Japan's national innovation system. We will define innovation in Japan by the social, political, and economic processes that surround it, describing its shape and success through the materials, ideologies, and people that produce it.

Social Norms, Customs, and Institutions

Japanese culture has often been operationalized to explain the country's economic successes and failures. Early observers, documenting Japan's explosive growth in the sixties, frequently described differences between Japanese and Western workplaces in cultural terms and attributed the nation's "miraculous" transformation to immutable values (Johnson, 1982). These

values constituted a Japanese "national character," defined chiefly by a "unique, culturally derived capacity to cooperate" (Johnson, 1982); only forty years later, the "deficiency" of Japanese business culture was considered to be productive of slow growth and a lack of meaningful innovation (Herbig and Jacobs, 1999). This growth-slowing "deficiency" was essentially identical to the growth-enhancing trait that supported the earlier boom: an overvaluation of "harmony, cooperation, [the] status quo, and consensus," as well as hierarchical relationships between workers and an aversion to risk (Lee and Peterson, 2000). Now, Japanese culture was a force to be worked around and subverted in the pursuit of American-style innovation and entrepreneurialism, requiring the placement of "more emphasis on individualism and less importance on absolute group subservience" (Herbig and Jacobs, 1999). The culture thesis, which links seemingly widely-shared values to economic and innovative performance, ignores the impact of consciously pursued government and corporate policies on innovation and economic growth; the incentives of these policies may be internalized over time in a process of "culture creation." In other words, "we may end up with systematic national differences and strong influences on entrepreneurship, but we do not start with them" (Whittaker, 2009); thus, "'culture' and 'nation' cannot be used interchangeably, and…the latter appears to be more decisive in explaining entrepreneurs' strategic orientations" (Whittaker, 2009).

Examining the impact of Japanese culture on innovation consequently becomes a question of which policies and practices are immediately relevant to an innovator's perception of the rewards to innovation. Such policies and practices include the seniority wage (*nenko*) and lifetime employment systems. The *nenko* system explicitly ties compensation and advancement to length of employment, while the lifetime employment practice ensures that "nearly everyone graduating from university is guaranteed a good job, many until retirement" (Cusumano, 2016). The prospect of long-term, well-paid work for top students favors their entrance into existent firms, and later encourages intra-firm cooperation (given the direct, positive relationship between time at a company and pay, interfirm movement is clearly discouraged). Of course, labor practices do not account for the entirety of workplace behavior: Kambayashi (2008) finds that "the so-called 'typical' Japanese features such as diligence and the cooperative relationship between the management and workers cannot be identified in firms in Sri Lanka even on the same social institutional basis." Therefore, it is also important to consider the conditions that produced particular practices *and* the conditions that supported their enshrinement. Most of the

Japanese institutions that incentivize highly cooperative behavior were adopted in the interim between the two World Wars. According to Johnson (1982), "it was conscious institutional innovation which began to shape the Japanese system in the first two decades of this century, perfected the system of enterprise familism (or what one might call corporate paternalism) in the 1930s, and revamped the system to accommodate the new strength of unions in the late 1940s to produce what is called [by authority on Japanese industrialism R.P. Dore] the 'welfare corporatism' of today." These economic practices were seen as essential to transforming Japan from a "technologically backward" nation into an economic powerhouse, and produced a variety of venerated manufacturing policies, including the *kanban*, or "just-in-time," system. The practices outlasted World War II due to their "systemic advantages, such as a high-level of worker morale," a trait especially important to a wartime economy (Otsubo, 2007).

The long persistence of these labor practices (a persistence which has resulted in their conflation with cultural practices), coupled with a weak economy and a declining population, have contributed to low rates of entrepreneurial activity, but high rates of innovative capacity, as measured by patent rates per population (Cusumano, 2016). A strong incentive, in the form of the *nenko* and lifetime employment systems, to join existent firms seems to have resulted in less path-breaking innovation and entrepreneurship.

Government Policies Toward Innovation

Japan has adopted government policies which encouraged international trade, political stability and economic unification. It has been highly involved in the development of its innovation system and helped to coordinate R&D activities. While Japan's industrial structure was put into place before WWII, Wakasugi notes that prior to the 1980s, Japanese firms were focused on commercialization and the level of government intervention in R&D was relatively small (Wakasugi, 1986). During the 1980s, however, Japanese growth and the innovative capacity of Japanese firms increased. Following the recessionary period in the 1990s, Japan enacted the Science and Technology Basic Law in 1995, which outlined an integrated government policy towards science and technology. The policy introduced successive five-year S&T Basic Plans, defining different priority fields and reflecting a number of important goals including strengthening Japan's scientific and technological capacity and advancing Japan's industrial competitiveness (OECD, 2016). The different focus areas each have their own national strategy and have resulted in increased funding to Japanese universities and national laboratories.

The fifth S&T Basic Plan for 2016 to 2020 identifies sustainable development, climate change, national security and biodiversity as important areas of research for long term STI strategy. These plans are overseen by the government including the Ministry of International Trade and Industry (MITI), an important coordinator of Japanese industry. MITI helps direct companies toward targeted goals and encourages cooperation between firms. Once MITI selects an industry and a long-term strategic need that can be addressed by that industry, it provides a number of incentives including accelerated depreciation allowances and special R&D funding. For example, following the 1973 oil shock, MITI pushed Japan into knowledge-intensive industries and initiated a number of projects designed to reduce Japan's reliance on foreign oil (Feigenbaum and McCorduck, 1983).

Japan established R&D consortia in an effort to encourage the dissemination of research to participating firms. Government-initiated consortia can be seen as a tool, used for administrative intervention in Japan. The Japanese government provided tax breaks to companies that cooperated. Branstetter and Sakakibara find that the establishment of R&D consortia have also had positive effects on innovation of participating firms in Japan and brought together firms that had complementary research assets to work on projects with shared R&D (Branstetter and Sakakibara, 2002). Okimoto notes that R&D consortia were successful in part because of the collaboration between MITI and the private firms involved (Okimoto, 1989).

Because of the emphasis placed on innovation as a source of economic growth through the Basic Plans, Japan has adopted a policy towards S&T which prioritizes different goals and determines how government funds are used. In 2006, Prime Minister Shinzo Abe introduced the "Innovation 25" initiative which reflected the government's desire to increase international relevance of Japanese innovation, and to connect innovation to changing social values. The initiative suggested that innovation policy needed to be focused on solving pressing problems such as climate change and meeting the needs of Japan's citizens (Stenberg and Nagano, 2009). Prime Minister Shinzo Abe's has also initiated other policies to encourage economic growth including the "Three Arrows" economic revitalization agenda - also known as "Abenomics" - which has attempted to introduce structural reform, monetary easing and more flexible fiscal policy measures to Japan.

In light of heightened regional and geopolitical tensions, Japan's Prime Minister Shinzo Abe has tried to incentivize NEDO and MITI to work with firms to work on technologies that

have both military and commercial uses. Efforts to encourage dual-use technology mirror similar programs already in place in the United States. However, this policy is relatively new as, following WWII, Japan discarded superpower aspirations and, as a result, the Japanese government did not promote defense-related industries (Okimoto, 1989). Unlike other developed nations, Japan's limited spending on R&D in the defense industries was due to the industry's low commercial viability and a deemphasis on national prestige (Okimoto, 1989). In recent years, Japan has also introduced policies that are increasingly focused on fostering start-ups and developing new sources of funding for research and investment. While Japan has developed a reputation for technological excellence and corporate acumen, it has room for improvements as evidenced in the information provided above. A key area of improvement will be in the development of start-up firms and supportive mechanisms which encourage entrepreneurial activity.

Intellectual Property Regime

Japanese patent law has evolved significantly between the passage of the 1885 Statute of Monopoly Patent and the adoption of the post-WWII Patent Law of 1959. Japan was considered to be an "imitator" rather than an "innovator": literature on the Japanese economy often attributed its success to "copying, imitating, and importing foreign technology" (Freeman, 1995). The importance of harmonizing domestic patent laws with changing international guidelines, and the laws of trading partners, has long been recognized by Japanese policymakers. The Japanese government has frequently emphasized the value of policies that increase ease of patenting and strengthen intellectual property rights, with the goal of stimulating innovation and competition in international markets. Japan moved from a "one-patent, one-claim" principle, to a system that allows a collection of inventions to be included under a single patent application. In the late 1990s, Japan saw an increase in patent applications, particularly in the IT and pharmaceutical fields. Patent protection was extended to software in 2000 and, by 2002, protection was also granted to software which circulated on computer networks (Kazyunki, 2003).

However, certain features of Japan's intellectual property regime present implicit barriers to patenting, and result in inefficiency. Japan's first-to-file standard results in the inundation of the "severely understaffed" Japan Patent Office (JPO) with a large number of patents that "often represent minor, incremental changes around an existing patentee's core technology" (Ginarte and Park, 1997). This "patent flooding" is further exacerbated by complications in Japanese

legislation that limit the scope of patents (Ordover, 1991). The patent system ultimately "rewards those who reverse engineer and modify, often in minor ways, the existing inventions and penalizes those who wish to protect their major technological breakthroughs" (Ordover, 1991). This diminishes the exclusivity of a single patent, and often requires that patentees rely on cross-licensing to continue using their technologies.

The pre-granting policies require potential patentees to "lay open the[ir patent] application for 18 months after filing," allowing competitors to contest the granting of that patent on the grounds of a lack of "novelty, non-obviousness, and industrial applicability" (Ordover, 1991). While this does make it more difficult for Japanese innovators to receive patents, it also enhances incentives to license and, in some cases, the government explicitly pressures potential patent-holders to cross-license. The Japanese government retains the power to grant extensions of patent terms for inventions in different sectors, including pharmaceuticals. MITI also has the ability to "compel a patent-holder to cross-license an innovation if its subject matter pertains to technology of national importance" (Ordover, 1991). Understanding the particular features of Japanese pre-grant exposure and opposition policies is essential to understanding the licensing behavior of firms. As a result, firms often license to settle the differences between patent claims (Ordover, 1991). Licensing has been an important instrument for enhancing knowledge spillovers between Japanese firms, and a prominent source of revenue for innovative parties: the total amount of revenues from the licensing of university-owned patents in 2012 was JPY 2.2 billion ("Japan's governmental intermediary patent platforms for open innovation," 2015). In Japan, investors at national universities retain title to inventions, but they do have to assign title to the government if the president determines that the invention meets certain criteria.

In addition to patents, Japan has also recognized the role of technology licensing organizations (TLOs), which were established in Japan through the 1998 Law Promoting Technology Transfer from Universities to Industry (Jackson and Debroux, 2013). As part of an effort to establish collaboration between the Ministry of Economy, Trade, and Industry (METI) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the TLO law aimed to encourage universities to participate in the licensing of technology. It reduced patent fees for government-approved TLOs and allowed universities to realize greater profits from intellectual property developed by faculty members (Jackson and Debroux, 2013).

The contemporary Japanese patent system can thus be characterized in terms of the narrow coverage it offers a given patent and its weak novelty requirement, which together incentivize licensing. This incentive is also rooted in the existence of pre-granting disclosure and opposition policies, relatively weak trade secret law, and TLOs. Though these policies were adopted with the intention of facilitating the diffusion of technology, they have ultimately resulted in innovation-inhibiting patent thickets and cross-licensing (Ordover, 1991). Japan has attempted to balance the aforementioned incentives to strengthen individual intellectual property rights against the social value of innovation, and appears to favor realizing the full social (rather than private) returns to innovation relatively more heavily than many of its trading partners do.

Market Structure and Innovation

The Japanese market is dominated by large corporations in relatively technology-intensive industries. This structure makes it particularly hard for startups to compete because of their relatively limited access to capital. Japanese firms usually self-finance their research, since the market and industries allow large firms to have continuous access to capital. This is because, although Japan is a capitalist economy, the firms that dominate the economy and the R&D sector function like oligopolies in their respective industries.

Historically, Japan had the *zaibatsu*, conglomerates who owned numerous firms across many industries and had enormous political power. The *zaibatsu* system began in the Meiji Period and lasted until WWII, when it faced dissolution by the US government. During the Meiji Restoration, there was enormous political upheaval, and the country went through massive cultural and economic changes: banks were established, currency was formalized, the first Japanese bonds and stocks were created, and the basis of the current economic system was born (Addicott, 2017). When they were active, there were four main *zaibatsu* (Mitsui, Mitsubishi, Yosuda and Sumitomo) and several other, "second-tier" *zaibatsu* (including Nissan and Kawasaki), which were organized around a central bank that furnished a *zaibatsu* firm with bonds and loans (Addicott, 2017). This original form of self-finance continues to influence the structure of innovation today. The Japanese government supported these groups and was supported by them: the Mitsui group was even responsible for managing the country's currency in the wake of the Meiji Restoration (Addicott, 2017). However, after WWII, the US branded these groups as monopolistic and anti-capitalist, and attempted to dismantle them. The US succeeded in taking power away from the large *zaibatsu* groups, dissolving some of them, but

they failed to completely wipe out the system, as many subsidiaries and smaller groups survived – of the 235 subsidiaries targeted, only 25 were actually dissolved (Rotwein, 1964). In the aftermath of this dissolution, the *keiretsu* were created.

These groups have a much looser control of the economy. Instead of directly owning a large number of companies, the *keiretsu* are affiliated through stock, banking and production practices. This creates a network of companies interested in helping each other succeed. Each *keiretsu* is insular and vertically integrated, and firms within the group own each other's stock and use a single bank for finance, like the *zaibatsu* (Ibata-Arens, 2005). This system of stockholding is inter-firm, and inter-*keiretsu* group, through different banking and stockholding networks (Rotwein, 1964). This serves to insulate the *keiretsu* from economic shocks and competition. It has been argued that this security has allowed Japanese companies to invest in researching more long-term projects than would have been possible under more competitive markets.

It has also been argued that the *keiretsu* provide a barrier to entry and to trade, and the US has been adamant about dismantling the system. Though the *keiretsu* do not have the same amount of economic or political power that the *zaibatsu* had, the US still views them as monopolistic and restrictive to trade and competition. From 1989 to 1993, the US and Japan negotiated and debated the "Structural Impediments Initiative," a controversial plan that targeted "public expenditure, land use policy, restrictive business behavior, close inter-corporate relationships and the system by which goods are distributed" (Mitsuo, 1991). The plan addressed the tariffs and border policies that Japan had, but US also deemed the *keiretsu* an unacceptable barrier to trade. They demanded that the system be abolished, and to this day, continue to criticize the *keiretsu* with this justification.

This system has been unfavorable to entrepreneurship: the OECD puts Japan at below average for "ease of entrepreneurship" (OECD, 2012). Japan has been ranked as one of least entrepreneurial countries in the world in (Ibata-Arens, 2005). Government policies attempted to address these issues, but economic and cultural legacy of the *zaibatsu's* extensive self-financing continues to this day.

Financing of Innovation

Investments in S&T and the effective utilization of their results are generally considered to be key to stable Japanese economic growth in the long run. As a result, spending on R&D has

been prioritized by both the private sector and the government. It has resulted in the development of a number of different mechanisms to fund R&D, including grants-in-aid to national and private universities. In contrast to other nations, innovation by large Japanese firms relies less on contracted public research and international collaboration than on innovation within the corporate group. Japan does have an established venture capital market, but there are relatively few start-ups and Japanese venture capital firms are usually thought to pursue a risk-diversification approach by investing in a relatively large number of start-up companies without engaging in management assistance (Cummings, 2012). The OECD finds that the participation of small and young start-ups in national R&D efforts and output is relatively limited (OECD, 2017).

Historically, the Japanese financial system has been biased against providing capital to new firms. This bias is partially attributable to collateralized lending, which made it difficult for start-ups with no assets to receive funding. The situation was further exacerbated by a relationship-based culture of bank lending decisions. However, since the 1980s, the Japanese government has encouraged the development of start-ups through policies which promote venture capital funds and the creation of stock markets where small, new firms can carry out initial public offerings (Park and Hugh, 2013). Regulatory changes such as a guarantee of limited liability for venture capital partnerships in 1998, subsidized loans from the government, and the creation of three different venture capital funds owned by the government have all promoted the development of the venture capital industry (Park and Hugh, 2013).

One of the largest state-funded R&D agencies in Japan is the New Energy and Industrial Technology Development Organization (NEDO) which has an annual budget of close to $1.5 billion (Kelly and Kubo, 2015). Other Japanese research institutes which receive funding from the government are thought of as independent administrative institutions (IAIs). National universities, as well as government research institutes, derive a portion of their funding from the Japanese government in the form of general funds and non-competitive grants. In 2014, for example, the government established a $500 million innovation fund to help finance university research (Kelly and Kubo, 2015).

While Japan is home to one of the largest investors in the world, SoftBank, and is the third-largest economy in the world, the relatively small amount of investment made in domestic start-ups has remained a persistent challenge for the country. A National Academy report found

that, while Japan has addressed a number of weaknesses in its S&T system, it has still not adequately solved problems of "immobility of personnel, inadequate entrepreneurialism, insufficient opportunity for younger researchers and abiding problems with industry-university-government collaboration" (*S&T Strategies of Six Countries*, 2010). However, efforts to address these challenges are apparent. The removal of minimum capitalization requirements and the establishment of the Innovation Network Corporation of Japan to provide capital and managerial support have boosted venture capital efforts in the country. In 2016 start-ups raised an estimated 92.8 billion yen according to Japan Venture Research (Kajimoto, 2016). This is higher than the sum raised in 2015, 165.8 billion yen (Kajimoto, 2016). This positive trend is expected to continue, and it is hoped that this will help develop networks among Japanese entrepreneurs, investors and research institutions.

Structure of R&D Activity

Japan's focus on developing R&D capabilities has been one of the central pillars of its economic policies. About 77% of Japan's R&D is done by large corporations, putting it among world's largest corporate R&D investors, and 98% of that research is self-financed (OECD, 2012). As noted above, Japan has one of the most R&D-intensive economies, with about 3.28% of GDP going to gross domestic expenditure on research and development (GERD), while the world average is only 2.23% of GDP (World Bank, 2018). Japan's R&D activities primarily occur in three sectors: industry, universities, and national research institutions. While each of these sectors play special roles in facilitating innovation and R&D activity, they interact with each other to form an interlocking system characterized by heavy government involvement. This has been described as an "in-house development principle"; many other countries (including the United States) rely on a network-type system (OECD, 2006).

The structure of R&D activity in Japan includes a number of different national research institutes including the National Institute of Materials Science (NIMS) and the National Institute of Advanced Industrial Science and Technology (AIST). MEXT, along with other ministries covering the areas of health, agriculture, telecommunications, environment, and transportation, have played an important role in determining the direction of S&T and allocating government funds. The government has played a central role in Japan's R&D efforts, and the resulting structure encourages research in priority areas. Following the passage of the 1995 Science and Technology Basic Law, the first Science and Technology Basic Plan (1996 to 2000) emphasized

not only an increase in the budget for research, but greater collaboration between universities and industry. As a result of this policy change, Turpin and Krishna find that the Japanese research system underwent a rapid change that included the development of new industry-science links (Turpin and Krishna, 2007). Japan's public research system now primarily focuses on applied and experimental R&D (70% of public expenditures) and mostly uses public labs (41%) (OECD, 2012). Small startup firms do not make up a significant part of R&D because it is relatively hard for them to accumulate the necessary capital. Generally, in Japan, larger companies prefer to do their own research and do not buy startups: while approximately 80% of tech startups are purchased by larger companies in the US, only about 20% of Japanese startups are bought (Solomon, 2017). The cooperation between industry, universities, national research institutions and government structures R&D in Japan.

Leading and Lagging Industries

In 2017, 1% of Japanese GDP came from the agricultural sector, 29.7% from the industrial sector, and 69.3% from the service sector (Japan Economy Profile, 2018). However, most Japanese innovation occurs in the industrial sector. Japan is home to many technology-intensive firms that are global leaders in technological innovation, mainly in the motor vehicle, pharmaceutical and electronics industries. Japan produces more motor vehicles than any other country in the world. They made close to ten million more than the next largest producer, the United States, in 2012 (Putra et al., 2016). This high productivity is due to conditions that streamline the supply chains of auto parts, as well as the “Toyota Production System,” a development process innovation which is attuned to both consumer and producer needs. The efficiency of this process represents a technical advantage for Japanese firms.

The Japanese pharmaceuticals industry is a leader in innovation relative to foreign nations, and this is caused by both demand- and supply-side factors. According to an article by the United States International Trade Association (2017), the demand for new pharmaceuticals comes from an aging population that is in need of higher-quality and lower-cost health care. On the supply-side, the pharmaceutical review process is expedited in Japan, with 70% of new product approved in less than 12 months; this occurs much more quickly than approval does in other industrialized nations, giving firms an advantage. Additionally, pharmaceuticals are priced nationally, which, according to the previously mentioned report, results in a stable price for drugs for the entirety of the patent. This incentivizes innovation by ensuring that a drug with a

particular predictable market share receives a set amount of revenue; this system is especially attractive to pharmaceutical firms because prices are generally set above the market prices generated under other regimes (Nihon et al., 1995). This price stability differs from previous regimes in Japan, which lowered prices by a dramatic amount.

Japan is also a leader in the electronics industry, particularly in the fields of robotics and artificial intelligence. Japanese firms innovate at all levels of electronics production, positing novel solutions to the problems posed by everything from the manufacturing process, to team development. One driver of these innovations is the aging population, which demands robotic substitutes for human care and companionship, and better medical technology; as Japanese workers age out of the workforce, manufacturers seek also robotic substitutes for labor, further increasing demand for robots.

While Japan demonstrates global leadership in many technology- and knowledge-intensive industries, restrictive policies have forced Japanese farmers to develop an agricultural policy framework which has isolated them from both markets and competition. Japan's agriculture industry lags behind those of similarly industrialized nations despite the high level of government support and protection granted to farmers. Geographical and topographical constraints are partially responsible for this lag: according to the 2017 OECD Economic Survey of Japan, only 12% of Japanese land is arable. Over half of farmers (56.7%) are at least 70 years old, and 89.6% of farmers are at least 60; finding young farmers to fill the role of aging farmers presents an issue for the agricultural industry (OECD, 2017). Along with small farms and demographic issues, Japan's agriculture sector is difficult to enter and offers a limited choice of crops and livestock to potential farmers. In this way, industry structure inhibits success. Additionally, fertilizer and other material input costs are very high. Because Japanese industry is structurally different than agriculture industries in other nations, it is not successful at imitating agricultural management techniques, as those techniques require access to economies of scale that do not exist in Japan.

Rather than immediately imitating as a mechanism for improvement, the Japanese government has proposed industry-wide reforms that will increase the industry's eventual ability to imitate. The 2016 Annual Report on Food, Agriculture and Rural Areas in Japan from the country's Ministry of Agriculture, Forestry and Fisheries explain the initiative the country is undertaking to make this sector more globally competitive. The plan has thirteen specific goals,

which address many of the issues present in the system. One major area of reform is the input markets for farming. Potential improvements to this area include increasing the efficiency of chemical distribution, breaking up monopolies in farm equipment, and increasing production of feeds and fertilizer. Another focus area is the distribution and processing of agricultural products: the government seeks to reform wholesale markets, promote quality competition in the retail market, and increase channels for marketing. Officials plan to augment these reforms by increasing transparency in the industry and introducing a national cooperative association. Finally, they propose reforms in more specific areas: reforming raw milk distribution, encouraging more workers to enter agriculture, labeling food by its components' countries of origin, protecting revenue through insurance, granting farmers the legal authority to engage in collective action, and improving land and employment opportunities in rural areas.

Overall, the Japanese agricultural sector is working to narrow the gap between domestic and international prices through structural reform that makes agriculture more responsive to market needs.

University System

Universities have played an important role in developing Japan's technological prowess since the nineteenth century. The School of Engineering (called Kogakyro University) set up by the Meiji government in 1873, for example, was responsible for education in fields such as civil and mechanical engineering, telecommunications and chemistry (Odagiri et al.,1996). In the post-WWII era, universities helped to facilitate the growth of Japan's economy. Through the framework provided by the Law on the Establishment of National Schools, a system for colleges of technology was established in 1962, in response to increased need for diverse human resources brought about by industrial economic development. In 1964, two and three-year junior college programs which had been temporarily established in 1950, were made permanent under the School Education Law (Motohashi, 2004). Since the 1980s, Japan has focused on making its higher education system more accessible to international students. International students studying in Japan were formerly required to complete a Japanese language test, as all education was provided exclusively in Japanese. This is changing, however, with a gradually increasing number of study programs being offered in English (Etzkowitz, 2000). Additionally, programs like CAMPUS Asia, an exchange program between Japan, China and South Korea, attempt to increase student mobility. CAMPUS Asia is part of the "Reinventing Japan" project, which seeks

to internationalize educational programs. This is part of a concerted effort to build an international S&T research network between universities **(**Motohashi, 2004**)**.

MEXT is responsible for overseeing the structure of all education in Japan, which involves making decisions on the establishment of new educational institutions, determining the budgets for all national educational institutions, and approving and funding grants for private institutions and several publicly funded research institutions. After reforms in 2004, national universities were "reorganized as corporations" with the "[aim of improving] each university's independence and autonomy to enhance education and research activities" (Higher Education in Japan, 2008). Corporatization both enhances the autonomy of these universities, and downsizes the public sector by legally identifying national universities as IAIs (Yamamoto, 2004).

The role of universities has changed in Japan since the adoption of the 1995 Basic Science and Technology Plans, which marked the development of a more cohesive and integrated government S&T policy. The enactment of the plans has led to the formation of a dense network of university-industry collaboration efforts (Ranga et al. 2017). The second Basic Plan made national universities independent from MEXT, through the previously mentioned corporatization process. The fourth and fifth S&T Basic plans have emphasized the important role played by researchers in engineering innovation-based growth. They identify the development of world-class basic research, the development and shared use of advanced research, and the continued expansion of open data and open science infrastructure as areas of future growth.

Despite the number of universities in Japan, the publication productivity and the international mobility of researchers are below the OECD median ("Japan," Innovation Policy Platform, 2018). There is concern that young researchers in Japan have little opportunity to secure stable academic positions. In response, the Japanese government launched the Programme to Distinguished Researchers in 2016 in an effort to ensure not only stable employment for researchers but also to assist in the building of new career paths in the industry, university and national research systems ("Japan," Innovation Policy Platform, 2018). Another challenge is the low participation of women in research. The OECD finds that women accounted for only 15.3% of all researchers in Japan ("Japan," Innovation Policy Platform, 2018).

Recent Japanese education policy has focused on solidifying multinational relationships between academic researchers and corporations, using the rhetoric of revitalization and national

status maintenance. This represents a shift away from centralization (though not from *integrated* S&T goals) and may ultimately be rooted in the changing fortunes of the national government, which currently favor downsizing.

Innovation Infrastructure

The Japanese government has focused on developing high-speed channels of communication (in the form of "bullet" train and computer networks) as a means of fostering connection and innovation and boosting national claims to technological superiority. Yuko Harayama (2014), an executive member of Japan's Council for Science and Technology Policy, characterized the completion of the Tōkaidō Shinkansen network as a symbolic event equal in weight to Japan's accession to the OECD and the country's hosting of the Olympic games, which "triggered a transformation of Japan's international image." The Tōkaidō Shinkansen's first journey was completed about a week before the 1964 Tokyo Olympics began, connecting Japan's two largest cities (Tokyo and Osaka) and making the country the first to have a high-speed commercial train (Brasor and Tsubuku, 2014). The Shinkansen supported Tokyo's rapid growth by enabling mass commuting, resulting in the city's current status as a hub of innovative and productive activity: Tokyo was one of only six prefectures to see an increase in population in the eight years preceding 2017 ("Slow regional revitalization," 2017).

Computer-networks are the modern-day equivalent of the Shinkansen networks in their perceived ability to increase Japan's innovative capacity and protect the country's status as a global leader. In 2007, "broadband service [in Japan was] eight to 30 times as fast as in the United States - and considerably cheaper" (Harden, 2007). The speed of broadband service is attributable to competition between broadband companies (which transmit low wire rental rates to consumers), the government-subsidized building of fiber-optic lines, and the relatively new, better copper wiring that is a legacy of post-WWII reconstruction (Harden, 2007). The quality of Japan's broadband service was a point of contention for American innovators in the early 2000s, who were disproportionately harmed by slow connections. More recently, the Nippon Telegraph and Telephone Corporation and other large carriers have focused on installing fiber-optic cables (an effort supported by government policies, as previously noted) to further raise speed and productivity, though it is unclear how much of an economic advantage such cables offer over their copper counterparts; some observers have concluded that this exercise is driven at least partially by internal concerns regarding Japan's image (Belson, 2007).

The Shinkansen and broadband services have effectively facilitated intranational communication and the low-barrier transportation of ideas and people essential to innovation. These services have also affirmed Japan's technological potential to an international audience.

Regional Issues

Ensuring the continued economic health of Japan's regions is a priority for the Shinzo Abe administration. In 2014, the administration introduced a law intended to "[revitalize] rural communities and [create] jobs in depopulated areas"; it eventually also produced a "comprehensive strategy for regional revitalization complete with specific goals and policy steps" ("Slow regional revitalization," 2017). This constituted a response to years of rural decline, and an ongoing, country-wide population decline. While the effectiveness of this top-down approach to regional revitalization is ambiguous, it *is* clear that several cities across Japan are actively engaging in the revitalization process (or, as in the case of Tokyo, maintaining their relative vitality) by attempting to attract innovators and innovation.

One of the most proactive cities, Fukuoka, is located on the southern island of Kyushu. Fukuoka is pursuing innovation-induced growth with the "Startup City Fukuoka Declaration," a six-step plan. This plan consists of "tax reduction schemes, where taxable income is reduced by 20% for five years," the attraction of foreign talent through "a startup visa [which] provides entrepreneurs with a six month window to establish their business," the provision of subsidies (loans and financial aid for entrepreneurs who want to rent space), business plan pitching contests (with awards for winning ideas and further financial aid), "a culling of regulation to make the city more business friendly," and "urban development with private companies to make the city more conducive for businesses" (Chin, 2016). Fukuoka has also implemented a startup café initiative, organizing "regular networking session[s] that [gather] venture capitalists and specialists like accountants and public-sector officials to give free business advice and support" (Chin, 2016). The city's efforts seem to be provocative of some success: Fukuoka boasts the highest annual growth rate of start-ups and the highest share of young people interested in starting a business among Japan's 21 major cities, and saw its number of young residents increase by almost 20% between 2010 and 2015 (Springer, 2016). Furthermore, Fukuoka "added 260 companies in emerging industries in the four years [prior to 2016] and welcomed 11,638 new employees, according to city officials" (Wells, 2017).

While Fukuoka is engaged in the process of generating an innovative identity, Kyoto is reclaiming a long-standing status through its work to define itself as a desirable location for innovation. Kyoto "was the political, economic, and cultural hub of Japan for over a millennium" (Ibata-Arens, 2005), and currently possesses a "self-sustaining core of innovative firms - a critical mass reached by the 1990s" (Ibata-Arens, 2005). This core favors hardware producers, including Murata Manufacturing, Rohm, and Kocera (Wells, 2017). Local innovators benefit from the presence of Kyoto University, which has "long-standing ties to private industry, [with a] number of enterprise spin-offs [resulting] from these synergies" (Ibata-Arens, 2005). Innovators also have access to a pocket-money finance system that is sustained by a strong sense of community and an established tradition of time- and expertise-offering by successful entrepreneurs to younger counterparts (Ibata-Arens, 2005). Kyoto is governed by a limited bureaucracy and policy entrepreneurs, who design effective and innovative solutions to problems of governance by creating coalitions between interested stakeholders and cultivating a sense of local strength. The "Kyoto Model" of innovation relies on this nexus of favorable, mutually reinforcing social, political, and economic conditions.

The success of Tokyo in attracting and sustaining innovative activity, given its size and the central role it plays in Japan's transportation network, is unsurprising. Tokyo "became Japan's financial hub in the period of rapid industrialization following the [Meiji Restoration] in 1868," rendering it attractive to businesses (Ibata-Arens, 2005). Its Akihabara electronics district played a role in the development of important software, while nearby Tsukuba Science City is "home to more than 60 national research institutes and boasts half the national research budget" (Wells, 2017); Tokyo's Shibuya district was the center of start-up activity during the dotcom boom. Yukawa (2004) even finds that rhetoric depicting internet companies in the Minato, Shibuya, Akasaka, and Kanda (which includes Akihabara) areas as shattered by the collapse of the internet bubble do not correspond to realities of continued high-growth potential among surviving firms. Taken together, Tokyo appears to be an important center of internet innovation in Japan.

Though the project of nationally structured regional revitalization has been imperfectly attempted and implemented in Japan, several regions do appear to be seeking future economic growth through innovative activity. Fukuoka has realized success in its adoption of new policies

that favor innovation, while Kyoto and Tokyo have continued to rely on the social, political, and economic networks that were and are the sources of their respective identities.

International Trade and Investment

As discussed in previous sections, Japan makes it a goal to participate in global trade markets. Japan is a member of World Trade Organization as well as sixteen other trade agreements. The values of the country's combined imports and exports is 36% of GDP, and the average tariff rate is 1.4% (Heritage Institute, 2018). The existence of METI itself speaks to the importance trade has in innovation and industry in the country. Founded in 1949, this institution, according to its own fact sheet, aims to "develop Japan's economy and industry by promoting economic vitality in the private sector and advancing international trade relationships." This body is quite unique in terms of international industrial bodies, which generally do not use trade as driver of industry and growth, and is therefore indicative of the value Japan feels is added to its economy by trade.

Trade also played a large role in the growth of innovation during Japan's modernization period. Japan was devastated by WWII, and efforts were made to rebuild the economy from the ground up. As commentator Junichi Goto (1995) explains, Japan was low in natural resources, and consequently needed to import them, and export other goods to pay for the imports. Japanese policy largely incentivized the export of manufactured goods through tax policy and direct export financing, which, in turn, created incentives to innovate (Goto, 1995). Additionally, in the 1950s and 1960s Japan held export contests to produce the best goods for export, which likewise incentivized innovation. In the 1970s, as author Takeshi Abe (2017) explains, the OPEC oil shock led Japan to develop the less labor intensive or 'lean management' system in the manufacturing sector in an effort to cut down on input costs (Abe, 2017). Throughout the mid-twentieth century, Japan retained many barriers to importation, which allowed for the growth of domestic industries and innovation. These systems were broken down with import expansion policies in the 1980s and 1990s. Since the 1990s, Japan has made efforts to liberalize trade.

Currently, Japan's Statistical Bureau reports that the country's largest value-added exports are transportation equipment (including automobiles), machinery and electrical machinery, which made up 24.8%, 19.4% and 17.6% of all exports in 2017 respectively ("Statistical Handbook of Japan 2017," 2017). Overall, Japan's exports are technologically intensive compared to their imports which, as the previously mentioned report states, are largely

natural gas, petroleum, and foodstuffs. The composition of Japan's trade suggests that it has a comparative advantage in highly technical goods (which are exported) and that this specialization has encouraged further innovation in these industries. Exporting technologically intensive goods is self-reinforcing, with high returns to those goods incentivizing production and innovation.

Foreign direct investment is a complement to local innovation in Japan. In 2015, as the WTO reports, Japan's foreign direct investment was 4% of GDP, and according to a report from the Japanese government, it grew to 5% by 2017. This change is largely due to a push by the Japanese government for FDI, which was encoded in changes to regulation, business registration, taxes and cultural institutions (Government of Japan, 2018). They believe that FDI can create small and medium size start-up firms, which will be able partner with existing large corporations and research institutes, and eventually streamline the diffusion process. This particular type of FDI is intentionally complementary to existent innovation.

However, the industry that sees the majority of barriers to trade is the Japanese agriculture industry. One particularly egregious aspect of the regulations surrounding this industry was the former import tariff on rice, which was unusually high and therefore had a large impact on the market. In this industry, all but 2% of farmers work on fields of less than five hectares, up to a third of fields were out of commission at any given time due to government subsidies for non-production, and technology is quite antiquated (The Economist, 2013). The tariff for rice imports was 777.7% as of 2013, and as of 2018 was eliminated for nations in the World Trade Organization (and would have been eliminated for nations participating in the Trans-Pacific Partnership). While tariffs are no longer prominent policy tools, they have been replaced by quotas, which are similarly prohibitive (Vourazeris, 2017). Prohibitive trade policy has allowed for the continued existence of the inefficient Japanese rice industry, that otherwise would have modernized or been replaced via importation.

Conclusion

A review of the policies and circumstances which constitute Japan's national innovation system reveal the social, political, and economic forces that govern innovative outcomes in the nation. This review indicates that a set of government policies and corporate practices (rather than exogenously determined cultural practices), developed during and before World War II, favor intra-firm and inter-firm cooperation, and may disincentivize entrepreneurial behavior,

though not inventiveness. Innovation is produced by a cooperative context that heavily features government involvement in planning, funding, and structuring the channels through which innovation can flow. This consistent and coordinated government involvement can be clearly seen in Japan's intellectual property regime, its university system, its R&D consortia, and trade policy. It is complemented by long-standing corporate structures that are responsive to government goals, including the S&T Basic Plans. This has ultimately created an innovation ecosystem that reflects government priorities, chosen because they are perceived to be necessary for future growth and global technological leadership.

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