Lesson

Technology and Japan

Organizing Questions

- What are some of the key strengths and weaknesses of Japanese technology and the Japanese tech industry at large?
- What has the trajectory of the Japanese tech industry looked like?
- How has the cooperation and competitiveness between Japan and the United States aided and fueled innovation in each country?

Introduction

This lesson focuses on Japanese technology and provides a broad overview of some of the key technological innovations throughout the years. The lesson will introduce some of the core strengths of Japanese technology as well as some of its weaknesses. Students will be provided with a brief overview of the trajectory of the Japanese tech industry from Japan's ascent to a global high-tech manufacturing superpower to its decreasing global competitiveness as a heavily hardware-focused industry in an increasingly software-oriented world. Through a discussion of the development of the Japanese tech industry and the strengths and weaknesses of Japanese technology, students will be provided with a better understanding of Japan's global presence and influence on global markets, highlighting especially the importance of U.S.–Japan cooperation and competitiveness in fueling innovation.

Objectives

In this lesson, students will

- gain a broad understanding of various technologies and technological development in Japan;
- learn some of the key innovations and strengths of Japanese technology, with an understanding of the context out of which it arose;
- develop an understanding and appreciation for U.S.–Japan cooperation and competitiveness that has been a key driver of innovation throughout the years;
- practice the ability to absorb and process readings and a scholarly lecture, and draw upon this information to answer and discuss questions; and
- practice the ability to critically reflect and develop an argument based on readings, and defend this stance.

Connections to Curriculum Standards

This lesson has been designed to meet certain national social studies and common core standards as defined by the National Council for the Social Studies and the Common Core State Standards Initiative. The standards for the lesson are listed here.

National Social Studies Standards (from the National Council for the Social Studies)

- Culture; Thematic Strand I: Social studies programs should include experiences that provide for the study of culture and cultural diversity.
- Time, Continuity, and Change; Thematic Strand II: Social studies programs should include experiences that provide for the study of the past and its legacy.
- People, Places, and Environments; Thematic Strand III: Social studies programs should include experiences that provide for the study of people, places, and environments.
- Individuals, Groups, and Institutions; Thematic Strand V: Social studies programs should include experiences that provide for the study of interactions among individuals, groups, and institutions.
- Power, Authority, and Governance; Thematic Strand VI: Social studies programs should include experiences that provide for the study of how people create, interact with, and change structures of power, authority, and governance.
- Science, Technology, and Society; Thematic Strand VIII: Social studies programs should include experiences that provide for the study of relationships among science, technology, and society.
- Global Connections; Thematic Strand IX: Social studies programs should include experiences that provide for the study of global connections and interdependence.

Reading Standards for Literacy in History/Social Studies (from the Common Core State Standards Initiative)

- Standard 3, Grades 9–10: Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.
- Standard 4, Grades 9–10: Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social science.
- Standard 7, Grades 11–12: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects (from the Common Core State Standards Initiative)

- Standard 4, Grades 6–12: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

- Standard 6, Grades 9–12: Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- Standard 9, Grades 6–12: Draw evidence from informational tests to support analysis, reflection, and research.

Materials

Handout 1, *Japanese Technology in Historical and Global Perspective*, 10 copies

Handout 2, *Viewing of a Scholarly Lecture*, 30 copies

Handout 3, *The Japanese Software Industry*, 30 copies

Handout 4, *Software Innovation and Policy Activity*, 4 copies

Handout 5, *Assessment Criteria for Software Innovation and Policy Activity*, 4 copies

Answer Key, *Viewing of a Scholarly Lecture*

Video Lecture, "Japan and Silicon Valley: Origins, Trajectories, and Implications" (14 minutes 47 seconds), online at https://vimeo.com/184387830.

Equipment

Computer with Internet access and a Flash-enabled or HTML5-supported web browser

Computer projector and screen

Computer speakers

Teacher Preparation

Instructions and materials are based on a class size of 30 students. Adjust accordingly for different class sizes.

1. Make the appropriate number of copies of handouts.
2. Become familiar with the content of the handouts and answer key, and view the video lecture.
3. Set up and test computer, projector, speakers, and streaming video lecture. Confirm that you are able to play the video lecture and project sound audibly to students.

Time

Two 50-minute class periods

Procedures Day One

1. Mention to the class that they will be learning about Japanese technology through readings, discussions, and a scholarly lecture. Begin the lesson by asking students the question: "What do you know or think of when you hear the term, 'Japanese technology'?" Allow students to share their thoughts. Record their responses for reference at the end of the lesson.

2. Distribute a copy of Handout 1, *Japanese Technology in Historical and Global Perspective*, to small groups of three students. Ask the students to consider the prompts at the end of the handout as they read the handout. After students have had a chance to read the handout and discuss the prompts, debrief the handout by providing the information below.

   - Briefly summarize some of the key strengths of Japanese technology.

     Strength in manufacturing and especially manufacturing high-quality products is one of the greatest strengths of the Japanese tech industry (for better and for worse, as we will see in the lesson). In the 1960s and 1970s the Japanese proved their abilities in hardware manufacturing by implementing some of the most cutting-edge technology into hugely successful everyday consumer electronics products, gaining them global recognition. It was also around this time that the Japanese automotive industry burst into the global arena with energy-efficient designs of Japanese cars, and further down the line, bringing the world the hybrid car. The first shinkansen *[bullet train] was also implemented around this time, gaining global recognition for being the fastest train in the world. While the shinkansen no longer tops the list as the world's fastest train, the shift in focus to implementing designs that allow enhanced passenger comfort and safety, which is continuously improving with newer models, embraces not only impressive feats in train technology, but also exhibits a disposition towards high quality.* Kaizen*, for example, which forms the basis of the Toyota Production System (TPS), is a philosophy that embraces the idea of continuously striving toward improvement and higher quality.*

   - As we have seen, there has been quite a bit of cooperation and competition between the U.S. and Japanese tech industries throughout the years. In what ways has this relationship aided and fueled innovation?

     In the 1960s and 1970s, a number of Japanese consumer electronics firms rose in the ranks to become strong competitors in the global tech market after a series of hugely successful products such as handheld digital calculators, synthesizers, lightweight handheld cameras, wristwatches, and CD players. Most of these products were inspired by inventions by researchers in the United States and studied and improved upon by Japanese manufacturers. The TPS was a production system designed by Toyota Motor Corporation that gave rise to global lean production systems, and elevated Toyota to become one of the most successful car manufacturers in the world. The implementation of this system was driven by the desire to "catch up" to the United States. In 1973 after the oil crisis, the Japanese automotive industry found success when global consumers turned away from big, energy-consuming U.S. cars to small, energy-efficient Japanese models. Further down the line, we see that the cooperation/competition relationship still exists as both countries continue *to compete in the global arena. Although companies such as Komatsu have been developing technology much more quietly than U.S. companies such as Google and Tesla, we see that in both countries there is development of products based on similar cutting-edge technologies. The examples that were mentioned in the handout were intelligence augmentation and artificial intelligence.*

- In many ways, some of the most innovative technological developments in Japan have been a reflection of the region. Explain.

  Here, students can talk about TPS, technological developments for energy efficiency, and safety technology. TPS was developed with the U.S. automobile industry's mass manufacturing as a framework, but with certain constraints in mind, such as scarce materials, spotty orders, and a demand for variety. The drive to produce technology that is as energy-efficient as possible is also a development due to Japan's scarcity of natural resources. High energy costs due to imports have led the Japanese tech industry to capitalize on the energy efficiency of its products. Furthermore, the Japanese have developed impeccable safety technology in order to combat its number one natural threat, earthquakes. Various developments in seismic technology have allowed for the building of very safety-conscious trains and structures.

- Does anything you have read in this handout reinforce or contradict what you knew and/or thought about Japanese technology?

  Student answers will vary.

3. Mention to students that now that they have some basic background information on Japanese technology, they will be viewing a video lecture. Distribute Handout 2, *Viewing of a Scholarly Lecture*, to each student and ask them to review the bio of Dr. Kenji Kushida as well as the prompts. Play Video Lecture, "Japan and Silicon Valley: Origins, Trajectories, and Implications," online at https://vimeo.com/184387830.
4. Once the lecture has ended, give the students some time to write their responses to the prompts on a separate sheet of paper, then discuss the prompts as a class. Collect written responses for assessment.
5. At the end of class, distribute one copy of Handout 3, *The Japanese Software Industry*, to each student for homework. Ask students to read the handout and answer the accompanying questions. Inform students that the activity for Day Two will be based on this material.

Day Two

1. Mention to students that Day Two will focus on a software innovation and policy activity that draws upon content in Handout 3. Divide the class into four groups and distribute one copy of Handout 4, *Software Innovation and Policy Activity*, to each group. The groups are:
   - Group 1—poor human capital development due to weakness of computer science programs and curricula at Japanese universities
   - Group 2—the lack of a large independent software sector
   - Group 3—underestimation, undervaluation, and sluggishness of large corporations
   - Group 4—heavily hardware-dominated thinking of Japanese tech companies, continuously reinstated by traditional corporate management systems and weaknesses in corporate leadership
2. In Handout 4, students are asked to propose one policy as a group. Inform students that they will have 20 minutes to craft their policy. At the end of this allotted time, each group will be asked to present a two-minute proposal. Distribute one copy of Handout 5, *Assessment Criteria for Software Innovation and Policy Activity*, to each group and inform students that their presentations will be assessed on the criteria in the rubric. Inform the students that their presentations should:
   - clearly state what their proposed policy is;
   - elaborate on what issue the policy is in response to; and
   - state the anticipated outcome.
3. Allow each group to present for up to two minutes. Allow for a three- to four-minute Q&A session after each presentation. Other students in the class should ask the presenting group to elaborate on particular points, or challenge certain claims. Each group presentation should be five to six minutes in total length. While observing each presenting group, use the rubric on Handout 5, *Assessment Criteria for Software Innovation and Policy Activity*, to assess each group.
4. After all groups have completed their presentations, pose the following questions to the class as a quick debrief of the lesson and an opportunity for student reflection and informal self-evaluation.
   - Do you feel you have gained an understanding of the usage and development of technology in Japan and the Japanese tech industry in this lesson?
   - What topics interested you the most? The least? About which topics or issues would you like to gain a deeper understanding?

   Take a moment to compare their responses to their initial responses to the question, "What do you know or think of when you hear the term, 'Japanese technology'?," that was posed at the outset of the lesson. What are some differences and/or similarities?
5. Collect students' written responses to the questions assigned to them for homework on Handout 3, *The Japanese Software Industry*, for assessment.

Assessment

The following are suggestions for assessing student work in this lesson:

1. Evaluate student responses to questions on Handout 2, *Viewing of a Scholarly Lecture*, and Handout 3, *The Japanese Software Industry*.
2. Assess student preparation and performance in the class activity based on:
   - responses to homework questions;
   - level of familiarity with and understanding of the reading material assigned to them as homework;
   - ability to work with peers in small groups;
   - ability to persuasively articulate and defend their team's policy and the reasons for this policy;
   - ability to use specific information in making a point; and
   - clarity and effectiveness of argument.
3. Assess student participation in group and class discussions, evaluating students' ability to:
   - clearly state their opinions, questions and/or answers;
   - provide thoughtful answers;
   - exhibit sensitivity toward different cultures and ideas;
   - respect and acknowledge other students' comments; and
   - ask relevant and insightful questions.

Japanese Technology in Historical and Global Perspective

by Elin Matsumae and Dr. Kenji Kushida

As you read this handout, consider the prompts at the end of the handout.

Implementation and Deployment

During the 1960s and 1970s, several Japanese consumer electronics firms took U.S. inventions such as microchip cameras, liquid crystal displays, semiconductor lasers, and sound chips, to create products including digital calculators, wrist watches, synthesizers, camcorders, and compact disc players. Where U.S. inventors had failed to put their ideas into production, Japanese companies learned and improved U.S.-born inventions to manufacture Japanese products. In doing so, they transformed a few, obscure Japanese tech companies into the consumer giants we know them as today.[1]

synthesizer—an electronic musical instrument that generates electric signals that are converted to sound. It can imitate instruments such as the piano, organ, flute, and others. It is often played with a musical keyboard but can be controlled through other devices such as controllers, fingerboards, electronic drums, etc.

When calculators were still large, expensive devices that plugged into the wall, Tadashi Sasaki of Sharp Corporation had the idea to make a portable calculator small enough to hold in one's hand, and cheap enough for anyone to afford. In order to realize a truly portable handheld calculator, a key component was the development of a portable power source. For his earlier models, Sasaki used chips using a technology called MOS/LSI, from a U.S. company called Autonetics. However, later on, by the urging of Sasaki himself, Toshiba Corporation began the development of a much lower power/lower cost complementary-MOS (C-MOS) chip that would sever the power cord that bound calculators to the wall socket, and finally make them portable. These C-MOS chips went on to be the core technology for the entire semiconductor industry with Toshiba as its leading manufacturer. Even further down the line, two researchers from Dundee University in the United Kingdom observed that a material called amorphous silicon seemed to be converting sunlight into energy. Yukinori Kuwano at Sanyo Electric Co. picked up this research and in 1980, amorphous silicon solar cells were incorporated into the calculator. With the incorporation of various inventions, by 1985, Sharp had managed to reduce the price of a calculator by a factor of 100, its weight by a factor of 2000, and its power consumption by a factor of 10 million.

Charge-coupled devices (CCD) were an invention that transformed the camcorder from a pricey piece of professional broadcasting equipment into a consumer product in most households, and was first developed in the labs of a U.S. research and scientific development company, Bell Laboratories. In 1970, a Japanese researcher at Sony picked up this invention and began research on CCDs. When Kazuo Iwama became Sony's deputy president in 1972, he announced a complete reorganization of the company with CCD as a top priority. After many iterations, Sony introduced the lightweight passport-sized Handycam in June 1989, which became the most profitable product in Sony's history.

In 1973, Stanford-affiliated composer John Chowning approached the Japanese company Yamaha Corporation with his new invention, frequency modulation synthesis (FM synthesis), after being rejected from all of the most prominent organ and piano manufacturers in the United States. The challenge was to build an inexpensive electric organ that musicians could compose on at home by using FM synthesis in the form of a chip. In order to produce high-quality sound, Yamaha engineers saw that there was a need to develop digital sound chips that would be able to run fast enough to perform several million calculations per second to produce sounds in real time the instant a key was pressed. In 1983, Yamaha introduced the DX-7, which became the first synthesizer to incorporate this FM chip, and which became the best-selling synthesizer ever. This microchip has become a key component for a whole range of keyboard instruments, soundboards, and personal computer accessories, which in 1994 became multimedia's first billion-dollar market.

These are but a few examples of Japan's incredible technological innovation in the past. Today, Japan continues to be at the forefront of information technology (IT). Komatsu Ltd., one of the world's leading heavy machinery producers, is developing innovative new systems and technologies in a number of different areas. Komatsu developed a system called Komtrax, which is able to gather detailed information on its machinery around the world, and can alert customers of wear and tear on parts that require maintenance or replacement.[2] This system enables Komatsu to even cease operation of leased machinery if installment payments are late, or alert customers if fuel levels decrease despite non-usage of the machinery, indicating illegal fuel siphoning. As we have eagerly waited for Google, Tesla, and Apple to bring us into the era of autonomously driven vehicles, as it turns out, Komatsu has been commercially deploying automated mining dump trucks since 2008. Furthermore, Komatsu has made significant progress in the area of intelligence augmentation (IA)—a process that, rather than replacing human activity like artificial intelligence (AI), aims to enhance and augment human activity. Komatsu develops technology that allows high-skill jobs—such as operating heavy equipment—to be performed by low-skilled workers, by designing equipment with built-in intelligence. Komatsu is also attempting to make an open platform that will connect any device that is part of a construction site. Much like the cases we have seen in the past where U.S. inventions were taken, improved, and deployed as Japanese products, Komatsu has implemented technologies that it has acquired from outside the company, pioneering open innovation in Japan. The company has acquired external technologies, such as sensors and AI systems for its automated dump trucks and GPS sensors to map the terrain and determine the position of equipment parts, and improved and integrated these technologies. It has also partnered with drone companies that provide wireless drones for large open-air operations, and for construction sites.[3]

artificial intelligence (AI)—intelligence exhibited by machines. The term is applied when a machine mimics cognitive functions that humans associate with other human minds, such as learning and problem-solving.

open innovation—innovation that occurs when a firm combines external and internal ideas to advance its technology

Production Systems—Toyota Production System[4]

The Toyota Production System (TPS) was a production process that was initially developed in 1945 by the founder of Toyota Motor Corporation, Kiichiro Toyoda, and implemented in 1962. The idea was initially inspired by Toyoda's desire to "catch up with America." At the time, the U.S. automotive industry had found success in its mass production model by manufacturing thousands of identical parts to gain economies of scale. However, in Japan, where materials were scarce, orders were spotty, and variety was in demand, this type of production process simply would not work. The new system that was developed was designed to eliminate stockpiles of inventory by making everything in small batches, and make use of information flows from the factory floor upwards to improve product quality and allow for variety with little additional cost. TPS is the precursor to lean manufacturing systems globally, and is one way in which Toyota became one of the largest automakers in the world.[5]

mass production model—the production or manufacturing of goods in large quantities, especially on assembly lines

economy of scale—an economy based on the principle that when an item is produced in larger amounts, the cost of the item decreases. This principle is apparent especially in mechanized and automated-production processes.

lean manufacturing system—a production system that strives to continuously eliminate or reduce waste in design, manufacturing, distribution, and customer service

At the very heart of TPS is *kaizen*, or continuous improvement. This philosophy dictates that all tasks along an assembly line must be very precisely defined and standardized to ensure maximum quality while improving efficiency and eliminating waste. All employees in the company from production line workers to sales representatives have a responsibility to make day-to-day improvements to their work practices and equipment—that is, to strive for continuous improvement. TPS is grounded in two main pillars. (1) Just-in-Time Flow, which is based on the economic concept of supply and demand, means that customer demand stimulates the production of a vehicle, which stimulates the production and delivery of parts. As a result, parts and materials are manufactured and provided in the exact amount needed. (2) *Jidoka*, or automation with a human touch, means that equipment design and work is organized so that the slightest abnormality can be immediately detected, and upon doing so, work stops until the cause of the problem is solved.

Energy Efficiency

Another key feature of technological design and innovation in Japan is energy efficiency, or *sho-ene*. As Japan has a scarcity of natural resources, most of its energy has to be imported (a whopping 90 percent), making energy costs quite high. Japan's development of energy-efficient technology can be seen from railway and industrial construction to everyday household products.

Today, Japan has one of the largest automobile markets in the world, and automobiles are one of the country's most profitable exports. The origins of this success on a global scale can be traced back to the energy-efficient designs of Japanese cars. In 1973 an oil embargo was imposed by members of the Organization of the Petroleum Exporting Countries (OPEC). The oil crisis of 1973 led to a global fuel shortage and sky-high gas prices throughout that decade. Japanese automakers, however, benefited from this energy crisis as consumers began to turn their

Organization of the Petroleum Exporting Countries (OPEC)—an association of major oil-producing countries, founded in 1960 to coordinate oil policies and prices attention away from large, gas-guzzling U.S. cars toward the smaller, more fuel-efficient Japanese models, giving the Japanese automotive industry a real foothold in the global market.[6]

The Japanese automotive industry continued to design energy-efficient cars, introducing the world to the hybrid electric vehicle. In 1997, the Toyota Prius was introduced to the Japanese market, and in 1999 the Japanese hybrid car hit the global market when Honda released the first two-door hybrid car to hit the mass market in the United States, followed shortly after by the Toyota Prius, which became the first four-door hybrid sedan in the U.S. market. It was not until 2004 that Ford released the first U.S. brand hybrid.[7] Today, Japan—with Toyota at the forefront—is the market leader in hybrid sales.

Toyota Prius—the world's first hybrid car, introduced by Toyota in 1997

Furthermore, large corporations such as Komatsu have made commitments toward increased energy efficiency. After the Great East Japan Earthquake on March 11, 2011, electric power shortages led to Komatsu's announcement that it would cut energy consumption by 50 percent, not only in anticipation of further electric power shortages, but also to reduce its environmental impact. Komatsu vowed to save power by (1) realizing lower energy requirements by constructing a system to automatically track power consumption in their plants and relay this information to the head office, thus making it possible to pinpoint power that is being wasted and improve facilities with poor energy efficiencies; (2) reducing power usage with improved processing equipment and manufacturing processes; and (3) using alternative energy such as solar power and developing ways of using renewable energy, such as stabilized temperature of groundwater to help with air conditioning.[8]

Great East Japan Earthquake—(or 2011 Tohoku Earthquake) a 9.0-magnitude earthquake that struck off the coast of Tohoku, Japan on March 11, 2011 (with the epicenter approximately 200 miles from Tokyo). The earthquake was the strongest ever recorded in Japan. It triggered an even more destructive tsunami with waves reaching as high as 133 feet, which destroyed coastal towns along Japan's northern islands. The tsunami also caused the meltdown of three nuclear reactors at the Fukushima Daiichi Nuclear Power Plant and the expulsion of radioactive material into the ocean and surrounding environment. This nuclear disaster is one of the worst the world has ever seen, on par with the Chernobyl nuclear disaster of 1986, and continues to be a crisis.

Seismic Technology and Safety

Another feat of Japanese technology is safety. Especially in seismic technology, some of Japan's most impressive examples of safety are in train manufacturing and construction. Japan is an earthquake country, and monstrously destructive earthquakes in the past such as the 2011 Great East Japan Earthquake, the 2004 Niigata Chuetsu earthquakes, and the 1995 Great Hanshin-Awaji earthquake, have helped shape technological design today.

seismic technology—technology developed for or relating to earthquakes

We can first turn our attention to the high-speed *shinkansen*. It has been over 50 years since the first shinkansen was debuted, and remarkably, there has not been a single passenger killed or injured by a derailment or collision. Right before the massive 9.0-magnitude Great East Japan Earthquake of 2011, seismometers installed in 97 locations as part of the Urgent Earthquake Detection and Alarm System were able to detect premonitory tremors and send automatic stop signals that triggered the emergency brake on 33 trains. These seismometers are installed alongside anti-seismic reinforcement works such as quakeproof structures and anti-derailing systems.[9] Furthermore, the shinkansen is full of sensors that can detect obstructions on the railways and proximity of other trains,

shinkansen—in Japan, a railroad system carrying high-speed passenger trains triggering an automatic braking system that can stop a train moving at top speed within a mere 300 meters.[10]

Sudden braking itself is no easy feat. The shinkansen uses disc brakes which stop the train by pressing brake pads against metal discs that rotate with the wheels, and for a train that runs at a maximum of 320 kph, the temperature of the discs pressed by the brake pads rises above 800 degrees Celsius, which deforms the discs, reducing the area in contact with the brake pads and rendering them incapable of producing sufficient braking force. To address this issue, the shinkansen has a spring under the friction material that comes into contact with the disc so that the pad can move along the deformed shape, keeping the disc in contact with the brake pad even if the disc is deformed by heat.[11]

Japan's great advances in seismic technology are also evident in many shake-proof innovations in construction. Footage from the 2011 Great East Japan Earthquake and the many aftershocks that followed shows Tokyo's high-rise structures swaying drastically. Such flexibility is in fact essential, as it prevents the building from snapping and minimizes structural damage. Huge shock absorbers, walls that slide, and Teflon foundation pads that isolate buildings from the ground and basically turn large buildings into subtly floating structures—these are all structural innovations that have kept medium and high-rise structures in Japan intact and safe during otherwise catastrophic earthquakes. Newer structures include hollow walls hiding heavy sliding metal plates that help dissipate motion, and fluid-filled shock absorbers that slosh thick oil in the opposite direction of any swaying. The engineering of such structures is in compliance with strict building codes, ensuring that all modern buildings in Japan are designed and updated to withstand even the most destructive of earthquakes.[12]

Prompts

- Briefly summarize some of the key strengths of Japanese technology.
- As we have seen, there has been quite a bit of cooperation and competition between the U.S. and Japanese tech industries throughout the years. In what ways has this relationship aided and fueled innovation?
- In many ways, some of the most innovative technological developments in Japan have been a reflection of the region. Explain.
- Does anything you have read in this handout reinforce or contradict what you knew and/or thought about Japanese technology?

Viewing of a Scholarly Lecture

Topic: U.S.–Japan Competition and Cooperation: The Case of Silicon Valley and Japan

Video clip: "Japan and Silicon Valley: Origins, Trajectories, and Implications"

Lecturer: Dr. Kenji E. Kushida

Dr. Kushida is the Japan Program Research Associate at the Shorenstein Asia-Pacific Research Center (APARC) at Stanford University, and Project Leader of the Stanford Silicon Valley-New Japan Project. The Silicon Valley-New Japan Project focuses on understanding how large firms, fast-growing large startups, and emerging startups "harness" the Silicon Valley ecosystem and successfully use it as an innovation engine. With the steady growth of Japanese startups in Silicon Valley and a renewed interest in the region by large Japanese firms in the context of the increased importance of innovation and entrepreneurship in Japan, the mission of the project is to provide intellectual background and analytical perspectives and to create knowledge and research while becoming a platform for interpersonal relations to enable Silicon Valley to benefit from Japan, and for Japan to better harness Silicon Valley.

Please keep the following prompts in mind while you view the lecture. Respond to the prompts on a separate sheet of paper after viewing the lecture.

1. Compare and contrast economic innovation in Silicon Valley and in Japan. What do their innovation ecosystems look like, and what are their strengths?
2. Dr. Kushida states, "Silicon Valley and Japan have a history of competition, and now we're moving towards working together." Explain.
3. What is the benefit of increased cooperation and collaboration between Silicon Valley and Japan for each side?
4. In an attempt to revitalize the Japanese economy, there have been calls for Japanese companies to embrace "open innovation," where firms use external as well as internal ideas, products, and services. How does adopting an open innovation business model lead to more innovation? Use examples mentioned in the lecture.

The Japanese Software Industry

by Elin Matsumae

Hardware versus software

high technology—advanced technological development, especially in electronics

information technology (IT)—the application of computers and the Internet to store, retrieve, transmit, and manipulate data or information. The term is commonly used as a synonym for computers and computer networks, but also encompasses other information distribution technologies such as television and telephones.

Japan emerged as a leader in the world of high technology based on its strengths in manufacturing and managing complex systems. However, findings show that after the 1990s, information technology (IT) inventions have become much more focused on software. While U.S. firms have actively incorporated software inventions into their products and services, Japanese firms have become disproportionately less focused on software-intensive sectors within IT. Within this global technological shift, Japanese leaders have continued manufacturing hardware, and have largely failed to see the importance of software innovation or to reorient the Japanese IT sector. As a result, Japanese IT firms have failed to compete with consumer products such as smartphones and tablets, both globally and in the domestic market. Furthermore, Japanese electronics firms have increasingly turned to the production of parts and components for other manufacturers, which is problematic because the bulk of profits go to the sellers of the final products (companies such as Apple and Samsung). In a world that is becoming increasingly software-oriented, Japan's inability to transition from hardware to software has had large ramifications for its tech industry. In "The Japanese Software Industry: What Went Wrong and What Can We Learn From It?" Robert Cole and Yoshifumi Nakata investigate the following four causes, along with others.[13]

1. Lack of human capital development and universities

computer science (CS)—the study of the theory, experimentation, and engineering that form the basis for the design and use of computers

startup—a newly emerged, fast-growing business that aims to meet a marketplace need by developing or offering an innovative product

The Japanese educational establishment was slow to incorporate strong computer science (CS) education into the curriculum, thus leading to a lack of developers with software knowledge and skills. In the United States, about 20 percent of software developers have a graduate school education, compared to 10 percent in Japan. Japan has an even more limited number of PhDs working in software-related private sector jobs, and most CS PhDs aim for academic careers, partially as a result of the lack of demand by Japanese industry for engineering PhDs overall, and scarcity of software startups. Many CS PhDs in the United States, on the other hand, are hired by industry or government and have been the pioneers of this technological revolution.

The problem is not just the shortage of CS graduates, but the weakness of CS faculties and curricula in Japanese universities. Japan's slow incorporation process of CS education (an average six-year delay) meant that standards in curricula were often outdated due to quickly evolving IT technology. Lack of faculty with up-to-date knowledge also presented an issue. Universities hired retired IT executives whose expertise was in outdated hardware and software technology and who were not necessarily competent to teach or make contributions to research. Furthermore, new university deregulations by the Ministry of Education simultaneously created a large number of displaced faculty who could not be fired and expanded university IT departments. IT departments became a convenient place to offload faculty who needed to be relocated from their original departments. As a result, a large proportion of IT faculty had no educational specialization or anything to do with CS, and went on teaching their own specializations. The greater issue is the fact that CS was not respected or seen as a distinct discipline in Japan. Information engineering or CS faculty were given relatively low status in the hierarchy of engineering fields, and graduates were not in high demand.

2. Lack of a large independent software sector

At the most basic level, the lack of a large independent software sector contributes to a low demand for software experts. The problem then is cyclical. The low demand for CS experts in the industry causes the low popularity and prestige of university CS departments, which then leads to fewer interested students. However, the issue is even more complex. For one, large companies are typically unwilling to put money into the development of innovative new technologies internally due to large costs and high chances of failure. In the United States, therefore, large tech companies rely on software startups that are funded by outside investors for truly innovative new technologies. In Japan, however, the percentage of software-focused startups is very low. The lack of an independent software sector and a high reliance on software imports contributes to weak software capabilities nationally and the lack of innovative software in large Japanese tech firms.

In the United States, the innovators of new software are usually independent software startups. In Japan, however, large established companies tend to enter into the software field by creating new divisions and spinoffs, staffed by parent firm employees who carry over existing management practices and ideas, as well as existing ties to old technology. These parent firms tend to exercise significant guidance or control that new spinoffs cannot challenge. All these factors can dampen the ability to innovate.

(corporate) spinoff—a new company created by "splitting off" sections of a parent company as a separate business, with assets, employees, intellectual property, technology, and existing products taken from the parent company

system integrator—a company that markets commercial integrated software and hardware systems

Another interesting and significant dimension to consider is the fact that system integrators account for the majority of software development sales in Japan, but corporate customers who work with these system integrators often don't understand software and therefore cannot articulate their IT needs very well. The Japanese "the customer is king" mentality also comes into play here, as the system integrator must act on what the customer says and deliver specific demands, rather than assess needs and propose alternative solutions that might work better. Because of this relationship and because customers are not always able to articulate their needs very well, this mismatch leads to not only a lack of innovation, but also an undervaluation of the capabilities of software.

3. Underestimation, undervaluation, and sluggishness of large corporations

U.S. firms, outcompeted in manufacturing globally, had a strong incentive to search and respond to opportunities created by software. Japanese high tech firms, on the other hand, were competitive globally and did not see their success being dependent on IT, and had weak incentives for creating software products. Here arises another key hypothesis: the Japanese IT sector lags in software innovation due to undervaluation of software products by corporations. Japanese firms not only invest much less in software development than U.S. firms, but there is also a difference in the types of IT investments. Japanese firms are more inclined to develop software that supports existing business practices rather than focus on services and products that might change practices. Japanese firms have chosen to develop software to focus on operational effectiveness (e.g., cost, productivity, and quality), and seen as a cost center rather than a tool enabling strategic activities (e.g., winning new customers, sales increases, faster access to market information). One indication of the undervaluation of IT by Japanese firms is the low proportion of large Japanese firms with full-time chief information officers (CIOs). Reports have shown that while over 50 percent of large Japanese firms do have someone with the title of CIO, the amount of time they spend on IT work is only around 10 percent.

undervalue—to assign too low a value to

chief information officer (CIO)—(or IT director) a senior executive responsible for the information technology strategy and computer systems required to support a company's objectives and goals

Finally, Japanese corporations have not only been sluggish to respond to the new opportunities created by software, but they have also been sluggish in product development and implementation. Japanese manufacturing firms prioritize product quality in both hardware and software. While this has proven to be effective for hardware manufacturing and earned Japan a reputation for manufacturing some of the highest quality products in the world, for software, this rigorous approach to quality has caused firms to overly focus on eliminating software bugs even if they are non-critical, which can slow entry to market as well as inhibit innovation.

4. Hardware centricity/lags in leadership

In Japan, employees are promoted based on age and seniority. Based on this system, upper-level managers at Japanese tech companies rose to their positions in a time when hardware capabilities were crucial to success. As a result, top management teams responsible for promoting new generations of management were made up of hardware engineers who associated success with hardware innovation, and were more likely to promote other hardware engineers whose work they were familiar and more comfortable with, than to promote software engineers whose work was less relatable or understandable to them. As a result, in Japanese tech companies, hardware engineers were promoted faster than software engineers. Although change is taking place with the retirement of the older generation, the transition to the software era has been slow, which, for an especially fast-paced field, has had its consequences.

1999 Basic Act on the Revival of Monozukuri Core Technology—a law that defined monozukuri core technology as technology pertaining to the design, manufacture, or repair of industry products, or further defined it as technology supporting the development of the manufacturing industry. Areas for support included the improvement of the supply and quality of skilled manufacturing workers. The new act also promoted research and development, industrial agglomeration, startups, development of small and medium-sized enterprises, and the learning about monozukuri.

Furthermore, as Japanese IT firms have lost their competitive edge, they have become less adaptive, and *monozukuri*. Monozukuri (the Japanese worker's unique spirit in making things) has become a management philosophy about maintaining and building up Japan's hardware capabilities. It has been reinforced by the government through acts such as the 1999 Basic Act on the Revival of Monozukuri Core Technology. As a result of this new law, government agencies began a conversation that includes software only as a facilitator of hardware capabilities.

Another issue has been the often weak English capabilities of Japanese management. Stronger English skills could have given Japanese companies the opportunity to grow software businesses abroad by opening up export markets, giving Japanese IT companies the option to acquire foreign software firms and personnel. This could have introduced new software knowledge and capabilities, loosened the dominance of the hardware engineers, and also created a pool of Japanese IT specialists who would have been able to access and understand global developments and therefore understand the significance of software development. It is important for firms to be able to monitor and evaluate trends in the global IT landscape, and the story of the Japanese IT industry is testament to the importance of leaders acting on emerging technological shifts.

Questions

Answer the following questions on a separate sheet of paper.

1. Is the weakness of the Japanese software industry necessarily a bad thing? What ramifications does this have for the Japanese tech industry as a whole?
2. In your opinion, out of the four categories that have been laid out and elaborated on, which do you see as the most addressable area? That is, what is an issue that can be realistically addressed by a policy or initiative? What would such a policy or initiative look like?

Software Innovation and Policy Activity

Prompt:

Imagine that you are an advisor or policymaker in the Japanese government. The Japanese IT sector is increasingly losing its global competitiveness, and you have been tasked with addressing this issue. As a group, propose one policy that you think could stimulate software innovation and the growth of the Japanese IT sector, based on the information given in Handout 3, *The Japanese Software Industry*. These hypothetical policies can include things such as educational reforms, reorganization of corporate structures, governance styles, trade, etc.

You will be divided into groups based on the categories from Handout 3:

Group 1—poor human capital development due to weakness of computer science programs and curricula at Japanese universities

Group 2—the lack of a large independent software sector

Group 3—underestimation, undervaluation, and sluggishness of large corporations

Group 4—heavily hardware-dominated thinking of Japanese tech companies, continuously reinstated by traditional corporate management systems and weaknesses in corporate leadership

You will give a short (two-minute) presentation on your policy. This presentation should:

- clearly state what your proposed policy is;
- elaborate on what issue the policy is in response to; and
- state the anticipated outcome.

At the end of your presentation there will be a three- to four-minute Q&A session in which you should be prepared to clarify and elaborate on any arguments you have made, and defend your claims.

Your group will be assessed based on the criteria specified in Handout 5, *Assessment Criteria for Software Innovation and Policy Activity*.

Assessment Criteria for Software Innovation and Policy Activity

Scoring Criteria	Score	Score Description
Organization and Clarity: The presentation and responses are outlined clearly and orderly, with a clearly articulated policy, the issues it addresses, and a proposed outcome.		1—Unclear in most parts, missing most of the required components 2—Clear in some parts but not overall, missing some of the required components 3—Mostly clear and orderly in all parts 4—Completely clear and orderly presentation, covers all required components
Use of Arguments: Reasons are given to support and defend claims.		1—Few or no relevant reasons 2—Some relevant reasons given 3—Many relevant reasons given, most relevant 4—Many relevant reasons given in support
Presentation Style: Tone of voice, use of gestures, and level of enthusiasm are convincing to audience.		1—Few style features were used, but not convincingly 2—Few style features were used convincingly 3—All style features were used, most convincingly 4—All style features were used convincingly
Use of Examples and Facts: Examples and facts are given to support reasons.		1—Few or no relevant supporting examples/facts 2—Some relevant examples/ facts given 3—Many examples/facts given, most relevant 4—Many relevant supporting examples and facts given
Group Cohesiveness: All members of the group contribute during discussion, and the presentation represents work as a group.		1—Few members contribute to group discussion and presentation 2—Some members contribute to group discussion and presentation 3—Most members contribute to group discussion and presentation 4—All members contribute to group discussion and presentation

Viewing of a Scholarly Lecture

1. Compare and contrast economic innovation in Silicon Valley and in Japan. What do their innovation ecosystems look like, and what are their strengths?

   Japan's innovation comes mostly from its background as a rapid industrializing country starting in the late 1800s, and then the post-war period. Industries such as automobiles and precision tools are Japan's strengths. Its strengths were more in heavy industries. Japan traditionally has had a large firm-centered economic model, with big companies that do a variety of activities and with lifetime employment for its employees. As a result, innovation is slower and more incremental. Japanese firms will work for years to continuously improve technology.

   Silicon Valley is newer. Historically, innovation came from semiconductors, and then software, and recently in companies like Apple, Google, Facebook, and Tesla. Silicon Valley is today considered as the world's center of innovation in areas related to information technology, and as IT is increasingly becoming central to innovation, Silicon Valley's influence will become even further reaching. Silicon Valley has a business ecosystem based on high-growth startup firms, business models, and technologies that disrupt existing firms and industries. These disruptions and Silicon-Valley-born innovations are much more radical, breaking apart existing firms and transforming how we think about many things. Unlike the Japanese focus on continuous improvement, Silicon Valley firms will come up with all sorts of interesting software and services that they test out in different areas, and if it doesn't work they pull back and try new things.

2. Dr. Kushida states, "Silicon Valley and Japan have a history of competition, and now we're moving towards working together." Explain.

   The United States was in a big recession in the 1980s after the oil shocks. At this time, there was a surge of Japanese manufacturing firms. Silicon Valley was an area that had a lot of semiconductor and other types of factories, and during this time, many of these factories got decimated by Japanese firms, which were very good at making semiconductors. Many Silicon Valley firms could not adjust and died, and moved on to high-value things like design. Products and technology were designed here and then manufactured elsewhere in places like Taiwan and China. U.S. firms reformed themselves and moved towards open innovation, where they utilized products and services from outside the company. This period was also characterized by a lot of turnover in companies. Up until this point U.S. firms had looked a lot like big Japanese firms with lifetime employment. At this time, large companies fired large numbers of employees, providing a large workforce for entrepreneurs in Silicon Valley who built an ecosystem of high-growth startups. In the 1990s and late 2000s, there was a U.S. resurgence centered around the computer industry, and large firms regained competitiveness while a lot of new firms simultaneously emerged. At the same time, in the 1990s, Japan's asset bubble burst. The United States had now positioned itself as a big competitive threat, and had set the precedent for a model where the competitive advantage was in designing something well, and then having somebody else make it cheaply. The Japanese model had a lot of difficulty competing against and adjusting to this, and this is where we currently are, with Japan slowly trying to adjust to this new innovation paradigm.

3. What is the benefit of increased cooperation and collaboration between Silicon Valley and Japan for each side?

   As mentioned above, the historical trajectory of U.S.–Japan competition and cooperation has looked like this: At first, both countries came in with very contrasting models but similar levels of innovation. Then Japan outcompeted Silicon Valley and much of the United States, and then the United States adjusted, and now it is Japan's turn to figure out how to make use of the innovation engine that is Silicon Valley through open innovation. Silicon Valley is today considered the world's center of innovation in areas of information technology—which is an area that Japan has weak capabilities in. So the challenge now is to figure out how to bring Silicon Valley innovations into large Japanese companies in a way that is mutually beneficial to both regions.

   Japanese firms, on the other hand, can provide their manufacturing expertise to Silicon Valley researchers, which opens up the potential for the creation of new algorithms for artificial intelligence, robotics, etc. The Japanese focus on incremental innovation and continuous improvement of technology and products also makes Japan a place where services can be improved significantly. Google and Apple both have major research and development operations in Japan. Also, by pairing up with Japanese firms, Silicon Valley firms can also find a big new potential consumer base.

4. In an attempt to revitalize the Japanese economy, there have been calls for Japanese companies to embrace "open innovation," where firms use external as well as internal ideas, products, and services. How does adopting an open innovation business model lead to more innovation? Use examples mentioned in the lecture.

   At the most basic level, what an open innovation business model does is establish an information flow, bringing in different and more ideas and ways of doing things. For a place like Japan with an economic model traditionally centered around large firms with lifetime employment, there is little mobility of human capital. Open innovation can become an important source of innovation solely based on the idea of bringing in new perspectives. Yamaha Motors is an example of the huge potential of open innovation and Japan-Silicon Valley collaboration. They are developing technology to make a robot that is able to operate a human interface. In order to do so they partnered with SRI, which has a lot of robotics and artificial intelligence engineers and scientists, and were able to develop this technology in 10 months—which is incredibly fast—at a very low budget. This is an example of a mutually beneficial collaboration, as a lot of the Silicon Valley researchers did not have big companies that were going to make something based on their research, and Yamaha provided their manufacturing expertise and resources.

   Komatsu is another example. One of their new developments is construction equipment that uses drones to map out the topography of the construction site and do all the background calculations to determine how much equipment is needed and how much time a project might take. Komatsu does not make its own drones, and instead came to Silicon Valley to make deals with drone companies. Komatsu also acquired companies that make sensors in order to add it to their core expertise. Furthermore, Komatsu works with intelligence augmentation technology, and in order to develop this technology they have sent their researchers to top universities in the San Francisco Bay Area such as Stanford and U.C. Berkeley. This helps to facilitate the study of artificial intelligence as well as bring their own expertise in manufacturing and workflow knowledge.

Berman, Brad. “History of Hybrid Vehicles.” 14 June 2011. http://www.hybridcars.com/history-of-hybrid-vehicles/ [25 September 2016].

Central Japan Railway Company Visitors Guide 2014. http://english.jr-central.co.jp/company/company/others/data-book/_pdf/2014.pdf [25 September 2016].

Cole, Robert E. and Yoshifumi Nakata. “The Japanese Software Industry.” *California Management Review*, Vol. 57, No. 1, 2014.

“Energy Crisis (1970s).” History.com. 2010. http://www.history.com/topics/energy-crisis [25 September 2016].

Fischer, Elisabeth. “How Japan’s Rail Network Survived the Earthquake.” 28 June 2011. http://www.railway-technology.com/features/feature122751/ [25 September 2016].

“Japan’s Shinkansen Best in World at Safety, Punctuality, Tech, but Not Marketing.” *Japan Today*. 22 March 2016. http://www.japantoday.com/category/kuchikomi/view/japans-shinkansen-best-in-world-at-safety-punctuality-tech-but-not-marketing [25 September 2016].

Johnstone, Bob. *We Were Burning: Japanese Entrepreneurs and the Forging of the Electronic Age*. New York: Basic Books, 1999.

Kikuchi, Takayuki. “Safe, Reliable ‘Shinkansen’ Sparking Interest Overseas.” *Nikkei Asian Review*. 14 May 2015. http://asia.nikkei.com/Tech-Science/Tech/Safe-reliable-shinkansen-sparking-interest-overseas [25 September 24, 2016].

Komatsu. “Halving Electricity Usage Project.” http://www.komatsu.com/CompanyInfo/csr/environment/2014/16.html [25 September 2016].

Komatsu America Corp. http://www.komatsuamerica.com/ [25 September 2016].

Okimoto, Daniel. “Prime Minister Shinzo Abe’s Visit to Silicon Valley.” U.S.-Japan Council. 2015. http://www.usjapancouncil.org/prime_minister_shinzo_abe_sv [25 September 2016].

Olleros, F. Xavier and Majlinda Zhegu, eds. *Research Handbook on Digital Transformations*. Edward Elgar Publishing. Forthcoming.

Stanford Silicon Valley-New Japan Project. http://www.stanford-svnj.org/ [25 September 2016].

“Toyota Production System.” Toyota Motor Corporation Australia Limited. http://www.toyota.com.au/toyota/company/operations/toyota-production-system [25 September 2016].

Vastag, Brian. “Japan a Leader in Engineering Earthquake-Proof Structures, Helping to Limit Damage.” *Washington Post*. 11 March 2011. http://www.washingtonpost.com/wp-dyn/content/article/2011/03/11/AR2011031104541.html [25 September 2016].

[1] This section is based on Bob Johnstone, *We Were Burning* (New York: Basic Books, 1999).

[2] Komatsu America, "KOMTRAX for Construction Machines," http://www.komatsuamerica.com/komtrax/construction-machines.

[3] Research Handbook on Digital Transformations ed. F. Xavier. Olleros, Majlinda Zhegu (S.I.: Edward Elgar Publishing, 2016). Forthcoming.

[4] "Toyota Production System," Toyota Australia, http://www.toyota.com.au/toyota/company/operations/toyota-production-system.

[5] Lean manufacturing describes a philosophy that incorporates a collection of tools and techniques into processes in order to optimize time, human resources, and productivity while simultaneously improving the quality of products and services. After seeing the success of Toyota and TPS, lean thinking generated a growing audience, and today, the concept has spread to every country and industry.

[6] "Energy Crisis (1970s)," History.com, 2010, http://www.history.com/topics/energy-crisis.

[7] "History of Hybrid Vehicles," http://www.hybridcars.com/history-of-hybrid-vehicles/.

[8] Komatsu, "Halving Electricity Usage Project," http://www.komatsu.com/CompanyInfo/csr/environment/2014/16.html.

[9] Elisabeth Fischer, "How Japan's Rail Network Survived the Earthquake," Railway Technology, 28 June 2011, http://www.railway-technology.com/features/feature122751/.

[10] "Japan's Shinkansen Best in World at Safety, Punctuality, Tech, but Not Marketing," *Japan Today*, 22 March 2016, http://www.japantoday.com/category/kuchikomi/view/japans-shinkansen-best-in-world-at-safety-punctuality-tech-but-not-marketing.

[11] Takayuki Kikuchi, "Safe, Reliable 'Shinkansen' Sparking Interest Overseas," *Nikkei Asian Review*, 14 May 2015, http://asia.nikkei.com/Tech-Science/Tech/Safe-reliable-shinkansen-sparking-interest-overseas.

[12] Brian Vastag, "Japan a Leader in Engineering Earthquake-Proof Structures, Helping to Limit Damage," *Washington Post*, 11 March 2011, http://www.washingtonpost.com/wp-dyn/content/article/2011/03/11/AR2011031104541.html.

[13] This handout is based on Robert E. Cole and Yoshifumi Nakata, "The Japanese Software Industry," *California Management Review*, Vol. 57, No. 1, Fall 2014.