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Invention and the Mobile Economy

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EXECUTIVE SUMMARY

In 1967, inventor Martin Cooper was working on a portable communications device for Motorola. The Chicago Police needed hand-held radios and he was using his background in electrical engineering to develop a device. As he explained in a recent phone interview with me, "all good inventions try to solve a social need." In the course of experimenting with mobile products, he came up with the idea of a phone that would operate over a cellular network. By 1973, he had created such a device and made a call with a cell phone.[1]

This example shows the importance of invention to mobile communications. Whether it involves cellular networks, microchips, scrolling, batteries, or antennas, invention has been a big part of mobile technology. In the 40 years since Cooper's invention, creative engineers have developed a range of new products that enable mobile activity.

The result has been the formation of a sector that has become one of our most vibrant drivers of economic development. The mobile industry contributes significantly to GDP growth and job creation around the globe. In many countries, mobile is one of the fastest growing business areas. With mobile devices spreading at a rapid pace, it is important to understand how progress has been made and what we need to do to facilitate continued development.

As part of our Mobile Economy Project, this paper focuses on invention. I look at key inventors, how different countries handle invention, and barriers that need to be overcome in order to promote mobile invention. I argue that invention is critical to future growth. In order to guarantee continued prosperity, we need to maintain the culture of invention that has propelled the mobile industry to the economic forefront. This involves making needed research and development investment, commercializing knowledge, promoting STEM (Science, Technology, Engineering and Mathematics) education, reforming our immigration system, and maintaining a sound patent system.

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The Center for Technology Innovation

Founded in 2010, the Center for Technology Innovation at Brookings is at the forefront of shaping public debate on technology innovation and developing data-driven scholarship to enhance understanding of technology's legal, economic, social, and governance ramifications.

Key Inventors

Cellular communication is fundamental to mobile devices. The transmission of radio waves liberates phones from fixed landlines and makes it possible for there to be wireless phones. Other crucial ingredients have come in the form of microchips, connectivity improvements, batteries, and antennas. Each of these advances has promoted particular kinds of wireless innovation and made it possible to develop mobile communications devices.[2]

A number of individuals have played a crucial role in mobile technology. One important inventor is Jesse Russell. He is a major figure in mobile communications because of his innovative work on cellular base stations, digital phones, and digital software radio. He was hired by AT&T Bell Laboratories and led its cellular team. Among his key patents are ones for "Base Station for Mobile Radio Telecommunications Systems" (1992), the "Mobile Data Telephone" (1993), and the "Wireless Communication Base Station" (1998)."[3]

From his standpoint, "invention starts with discovery and comes from individuals who have special talent at seeing the future." In the case of the early cell phones, one of his contributions was in reconceptualizing the location of mobile devices from cars to people's hands. Previously, he pointed out in an interview, cell phones were put in cars. The problem was that much of the time when people placed a call, the recipient was not in a car and therefore not in a position to answer the call. Drawing on his own experiences growing up, he suggested there would be greater utility if people carried phones as opposed to keeping them in cars. That would "help people become more productive" and improve the utility of the cell phone. Once he sold his team on the concept, he sketched out a way to make phones smaller, cheaper, and accessible to people wherever they were. This helped launch a new era of mobile communications.

Another person is Arlene Harris, whose work propelled a number of wireless companies. Her latest invention is a virtual network operator for the Jitterbug phone. This is a mobile device for those who want a "large keypad, bright screen, and emergency response numbers."[4] It has big buttons and clear audio, and is thereby more user-friendly for senior citizens. Her company GreatCall "offers the Jitterbug phone (developed by Samsung) to those that want simple, easy and affordable cell phone service."[5]

Irwin Jacobs, the former CEO and co-founder of Qualcomm, oversaw revolutionary innovations in wireless technology that laid the groundwork of today's 3G mobile wireless standards. He was a professor of electrical engineering at MIT and later at the University of California at San Diego. Along with five colleagues, he commercialized Code Division Multiple Access (CDMA) technology. By figuring out how to share spectrum, their inventions have made cellular service more efficient and led to making the mobile Internet a reality.[6]

In looking toward the future, invention is continuing and there are a number of promising inventions with the potential to be impactful. For example, Harald Haas focuses on Visible Light Communication that uses "a new type of light bulb that can communicate as well as illuminate – access the Internet using light instead of radio waves."[7] He explained the principle in a recent TED Talk on Ideas Worth Spreading. His system, known as D-Light, "uses a mathematical trick called OFDM (orthogonal frequency division multiplexing), which allows it to vary the intensity of the LED's output at a very fast rate, invisible to the human eye." In experiments to date, he has found "data rates of up to 10 MBit/s per second (faster than a typical broadband connection), and 100 MBit/s by the end of this year and possibly up to 1 GB in the future." He argues that the invention makes it possible to "piggy-back existing wireless services on the back of lighting equipment."[8]

Meredith Perry is the co-founder of UBeam.[9] She was looking for a way to recharge wireless devices through ultrasonic waves. People often have laptops or smartphones that run out of power but do not have access to power cords. She came up with the idea of employing a "piezoelectric transducer" to vibrate the air and produce an electrical current through movements in the crystals."[10] This then recharges electrical equipment.

Maryam Rofougaran is vice president of Radio Engineering at Broadcom. She and her brother Reza launched a company that integrated Bluetooth and Wi-Fi onto an affordable computer chip. This allows the chip to support "wireless radios for mobile backhaul, femtocells and other mobile network technologies."[11] Their division ships around two billion wireless radio chips each year. This allows mobile devices to improve their battery life and overall performance.[12]

Steve Perlman is the Founder and Chief Executive Officer of Rearden. He has designed a "distributed input-distributed output" system called DIDO.[13] It sends individually formatted data in distributed fashion to users. This allows DIDO servers to tailor service delivery in the most efficient manner. Early research finds that it is much faster that Wi-Fi, helps to reduce dropped calls, and protects against signal interference.[14]

Across each of these inventions is a creative person who comes up with an innovative idea, patents the creation, and brings the discovery to marketplace. Having a culture of invention has been crucial to past innovation and is necessary for going forward. Without understanding how to sustain invention, it will be difficult to encourage the innovation that is needed for future development.

How Different Nations Handle Invention

There are many models for invention. Different nations have quite varied approaches to facilitating scientific discovery based on recruiting inventors, importing them, acquiring them, or growing them through education.

Singapore represents an example of a nation that recruits invention by offering lucrative salaries and startup packages for inventors from the developed world. It has identified skilled talent from other countries and brought them to Singapore. The country's Agency for Science, Technology, and Research has a $2 billion National Biomedical Science Strategy that targets grants on university scientists at its Biopolis life sciences center.[15] In recent years, it has brought in leading British and American scientists and used their expertise to stimulate local invention.

33% of American employees have science or technology positions. This is slightly less than 34%...of the Netherlands and Germany, but higher than 28% in France and Canada, respectively.

Canada, meanwhile, focuses on importing inventors through immigration. It has a skills-based approach to talent development that identifies national priorities and uses immigration to address those needs.[16] Immigrants get points for certain education levels and skills background that move them up the immigration ladder. Once they meet certain standards for vital skills in high priority areas, they are given visas to enter the country. This enables Canada to restock its inventor inventory and recruit top-flight talent from around the world.

Mergers and acquisitions have been a way to enable invention in recent years in the United States. By buying companies, it is possible to gain access to patents and intellectual property assets. In 2012, Google purchased Motorola Mobility for $12.5 billion, which allowed the company to acquire around 17,000 cell phone patents.[17] Companies often beef up their patent inventory through mergers with other firms.

A number of other countries use basic education, research, and development to grow domestic talent. Rather than buying, importing, or acquiring intellectual property, they invest in educational activities with hopes of spurring invention. From the 1950s up through today, the United States and other nations have devoted billions to higher education, K-12 education, biomedical education, and research infrastructure.

Overall, the United States spends around 2.8 percent of its Gross Domestic Product on research and development. This is less than the 4.3 percent spent by Sweden, 3.1 percent by Japan, and 3.0 percent by South Korea, but higher than that of Germany (2.5 percent), France (2.2 percent), Canada (1.9 percent), or England (1.9 percent). Europe as a whole devotes 1.9 percent to research and development, while industrialized nations spend around 2.3 percent.[18]

Technology is a big business in industrialized countries. If one adds together all the science and technology workers in the United States, 33 percent of American employees have science or technology positions. This is slightly less than the 34 percent figure for the Netherlands and Germany, but higher than the 28 percent in France and Canada, respectively.[19]

The global growth rate for high-tech products has increased by 6.5 percent in recent years, far higher than the 2.4 percent growth for other kinds of manufactured items. High-tech now constitutes about 23 percent of American manufacturing output, 31 percent in South Korea, and 18 percent in France and England, respectively.[20]

The productivity in this area has fueled considerable demand for those with science and engineering expertise. Thirty-eight percent of Korean students now earn degrees in science and engineering, compared to 33 percent for Germany, 28 percent for France, 27 percent for England, and 26 percent for Japan. The United States has fallen behind in this area. Despite great demand for this kind of training, only 16 percent of American graduates have backgrounds in science and engineering.[21]

In America, the private sector surpassed the federal government in 1980 in terms of the amount of money spent on research and development. Commercial companies provide 66 percent of the $340 billion spent on research and development, compared to 28 percent from the federal government. According to information from the National Science Board, the percentage of research and development spending coming from the federal government has dropped from around 63 percent in the early 1960s to 28 percent today, while that of the private sector increased from 30 to 66 percent.[22]

A similar pattern is found in many industrialized nations. The commercial sector in most countries provides a far higher share of research and development funding than does the government. For example, the private sector in Japan provides 72 percent of funding. In Germany, commercial companies provide 66 percent, while in France, private enterprise provides 52 percent of the research funding. In most of these places, relatively little investment comes from the public sector.[23]

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Ways to Facilitate Invention

There has been a dramatic increase in patent filings around the world. In 1985, for example, around 75,000 patents were filed in the United States and 41,000 in Europe. By 2000, these numbers had jumped to 180,000 for the United States (up 140 percent) and 110,000 in Europe (up 168 percent). [24] A 2013 study by the Brookings Metropolitan Policy program found that "the rate of patenting in the United States has been increasing in recent decades and stands at historically high levels."[25]

A number of factors affect the quantity and quality of invention. This includes investment in research and development, the quality of STEM education, the nature of immigration, and the patent system. In each of these areas, we need to maintain the culture of invention that encourages future prosperity. This involves making much-needed research and development investments, helping universities commercialize knowledge, promoting STEM education, reforming our immigration system, and maintaining a sound patent system.

The U.S. federal government invests around $147 billion in research and development, with $90 billion going to institutions of higher learning to underwrite faculty research projects and the training of graduate students and post-doctoral fellows. However, based on licensing fees, federal dollars generated only $2.5 billion in licensing fees for institutions of higher education. Given the billions in

government money invested in higher education research, there should be a higher yield than that for universities.[26]

Part of the problem is that universities focus too much on outputs as opposed to outcomes. Those indicators represent proxy measures of getting material to the market as opposed to whether particular research ideas actually are having an impact and being successful in the marketplace. If a patent is awarded, a license issued, or a start-up business established, it does not guarantee that the product is used or generates revenue.

In judging performance, most current university reporting approaches are inadequate for determining the efficiency and optimum use of research investments. There is no way through tabulations of patents and startups to measure money in versus money out on university research investments. Public and private donors invest considerable funding in support of faculty work, and backers need better information to determine whether universities are making the most effective use of external resources or whether new models would produce better results. With improved metrics, it would be possible to envision alternative approaches or different personnel configurations and resource allocations.

In addition, we need an immigration system that encourages entrepreneurs, keeps those with graduate training in STEM fields in the United States, and promotes the recruitment of high-skilled talent. National leaders should elevate brains, talent, and special skills to a higher plane in order to attract individuals with the potential to enhance invention. The goal is to boost the national economy and bring individuals to America with the potential to make significant contributions and increase prosperity down the road.

Right now, only around 15 percent of annual visas are set aside for employment purposes. Of these, some go to seasonal agricultural workers, while a small number of H-1B visas (65,000) are reserved for "specialty occupations" such as scientists, engineers, and technological experts. Individuals who are admitted with this work permit can stay for up to six years, and are able to apply for a green card if their employer is willing to sponsor their application.

The number reserved for scientists and engineers is drastically below the figure allowed between 1999 and 2004. In that interval, the federal government set aside up to 195,000 visas each year for H-1B entry. The idea was that scientific innovators were so important for long-term economic development that we needed to boost the number set aside for those specialty professions.

Today, most of the current allocation of 65,000 visas runs out within a few months of the start of the government's fiscal year in October. Even in the recession-plagued period of 2009, visa applications exceeded the supply within the first three months of the fiscal year. American companies were responsible for 49 percent of the H-1B visa requests in 2009, up from 43 percent in 2008.[27]

High-skill visas need to be expanded back to 195,000 because at its current level, that program represents a very small percentage of the overall work permits

granted each year by the United States. That percentage is woefully inadequate in terms of the supply needed. We need immigration policies that enable U.S. companies to attract top people to domestic industries, and represent a great way to encourage invention and entrepreneurship.

Other countries such as Canada, the United Kingdom, and Australia are more strategic in viewing immigration as a way to attract foreign talent. All of these nations explicitly target foreign workers in short supply who can contribute to their economy. Their percentages are nearly the reverse of national policy in the United States, where visas for family reunification far out-weigh those allocated to employment entries. Unlike other countries whose leaders understand the value of skilled labor and occupations in short supply for long-term economic development, we continue to place a very low priority on admitting immigrants with special talents.

The patent system needs to preserve the protection of intellectual property as well as ensure the use of new ideas.

Furthermore, we need to maintain a sound patent system that rewards invention and encourages inventors to keep innovating. The patent system is rooted in the U.S. Constitution and provides incentives to inventors to develop new products. As noted by Martin Cooper, it is important for inventors to "garner the fruits of their invention through profits." Randall Rader, the Chief Judge of the U.S. Court of Appeals for the Federal Circuit, has argued that the goal is having a system that will promote scientific progress and the useful arts.

Right now, we have a system that takes a long time for patents to be approved. The U.S. Patent and Trademark Office has sought to expedite patent processing. But Congress had hindered progress by using patent fees for other purposes, according to Steve Perlman. The agency should keep the fees it collects from inventors.

The Office has hired new examiners and opened branch offices outside of Washington, D.C. It is attempting to reduce the backlog of patents filed and recruited reviewers with greater understanding of patents and trademarks. Its goal is to hire more experienced intellectual property professionals.[28] But more progress needs to be made in these areas.

The patent system needs to preserve the protection of intellectual property as well as ensure the use of new ideas. Inventors need guarantees that they will benefit from their creations. We need a culture that values invention. Jesse Russell pointed out that we should "put inventors on the same pedestal as doctors, lawyers, entertainers, and athletes." It is important to inculcate these values early in children so they understand "you are doing something of value in invention." If we can do that, it is possible to maintain a culture of invention that encourages innovation and promotes long-term economic prosperity.

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Endnotes

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