Innovation, Not Manna from Heaven

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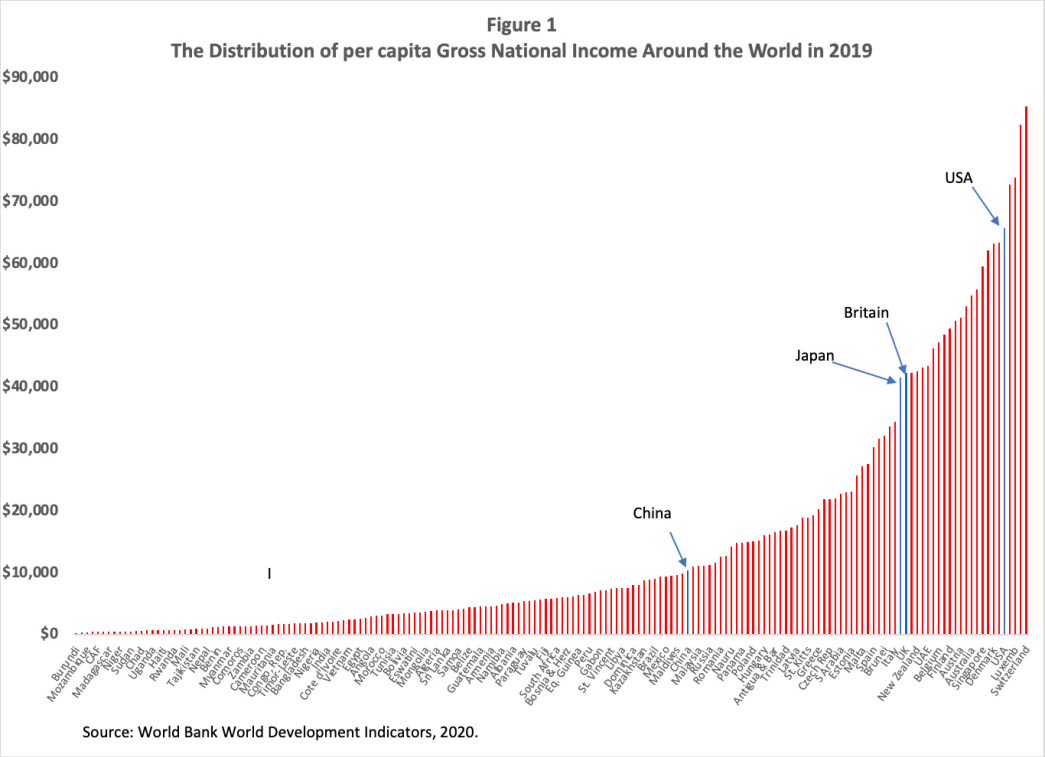
The United States is an outlier in the distribution of prosperity. As figure 1 shows, there is a small group of countries with per capita incomes above $40,000 that stand out from all the others—and the United States, with a per capita income of nearly $66,000, stands out even within this small group.



How can it be that the United States has a per capita income roughly 50 percent higher than that of Britain, its former colonizer? What explains why US per capita income is roughly six times that of China, which was one of the wealthiest societies on the planet when the first British colonists arrived in Jamestown?

The short answer is that the United States is a highly innovative society that competes effectively in markets for high value-added products and services. Some sense of the US innovative edge can be gleaned from the PWC Global Innovation Study, which ranks the world's one thousand most innovative firms and provides information about the sectors in which they compete, their revenues, and their spending on research and development (R&D). In 2018, 34 percent of the world's one thousand most innovative firms, accounting for 28 percent of total revenues and 42 percent of total R&D spending, were located in the United States. Within the information technology sector—commonly referred to as high-tech—the results are even more striking. In 2018, 46 percent of the world's most innovative information technology firms, accounting for 48 percent of total revenues and 58 percent of R&D spending, were located in the United States.[1]

A somewhat more complete answer to the question of why the United States is uncommonly wealthy is that innovation is the creative act of seeing a demand curve that may not yet exist, imagining a product or service that will meet that demand, combining multiple technologies that already exist, while inventing others that do not yet exist, to build that product or service, recruiting people with the necessary skill sets, and persuading yet other people to risk their savings on the idea and the people. Innovation is, in short, about risk taking—but it is not about taking wild risks. It is about taking calculated risks—to start a company, to become an inventor, to invest in specialized skills, to deploy one's capital—in an environment in which it is common knowledge that lots of other people are taking complementary calculated risks. The key to innovation is therefore the maintenance of a social and institutional environment in which calculated risk taking is incentivized. The United States has an innovative society and economy because, at least up until recently, risk taking has been rewarded with a share of the economic rents generated by a commercially successful innovation.

An even more complete answer to the question of how a former colonial backwater became one of the world's most innovative economies is that the social and institutional environment of the United States promoted calculated risk taking because, from the very start of the society, the United States was built around decentralized markets, not centralized political power. An innovative economy/society was not manna from heaven. It was the result of a complex combination of

legal, financial, governance, transport, production, education, and warfare technologies—in which the word technology is understood to mean a way of carrying out a task that can be replicated.[2] No one chose this particular combination of technologies in any meaningful sense of the word. In point of fact, many of the technologies were initially conceived elsewhere and were then absorbed, modified, or improved upon locally. These technologies had a powerful impact because of their interactions; each technology amplified the effects of the others.

The key to the success of this process of innovation was the lack of centralized planning: people were free to pursue their self-interest through markets. Some of those markets were economic, in which the currency was dollars. Some of those markets were political, in which the currency was votes. The net result is the equilibrium outcome we observe in figure 1: a society with an unusually high level of material prosperity.

In order to illustrate this idea I draw on the historical records of the United States and China. Section 1 explains the challenge that faced societies at the beginning of the modern era, which is to say the eighteenth and nineteenth centuries. Section 2 focuses on the history of innovation in the eighteenth- and nineteenth-century United States. Section 3 focuses on eighteenth- and nineteenth-century China in order to illustrate the concept that innovation is not simply production techniques but the outcome of a complex institutional environment. Section 4 concludes and discusses the implications of our findings.

Section 1: The Challenge of Modernity

Most of human history has been characterized by stasis, rather than innovation. The archaeological evidence indicates that from the emergence of *Homo sapiens* as a species roughly three hundred thousand years ago to the Neolithic Revolution (the domestication of plants and animals that took place roughly ten thousand years ago) there was little in the way of technological change. Innovation after the Neolithic Revolution tended to be slow. Thomas Malthus's *An Essay on the Principle of Population* perhaps captures the pace and state of technological development. As of its publication in 1798, the fundamental problem facing human societies had not really changed since the invention of agriculture: it remained how to avoid starvation under the constraints imposed by local soils and climates.

Beginning in the late eighteenth century, and then intensifying in the nineteenth and twentieth centuries, a suite of new legal, financial, educational, governance, production, transportation, communication, and warfare technologies that historians refer to as "modernity" began to emerge. It is beyond the scope of this essay to explain why those technologies emerged when they did. But suffice it to say that the new technologies did not emerge fully formed from any single society. Rather, the process was recursive, multicountry, iterative, and mutually reinforcing. That is, from the point of view of any society, modernity was an exogenous shock.

The challenge facing societies in the nineteenth and twentieth centuries was how to absorb the new technologies as a broad suite. Societies that were able to accomplish this task relaxed climatologic and geographic constraints on food availability, produced manufactured items on a scale previously unimaginable, conducted industrialized warfare, and built capacious nation-states. Those that were unable to do so were open to being dominated by, colonized by, or subsumed into those that had moved more quickly.

Section 2: The United States

A social and institutional environment conducive to innovation began to emerge in the United States from well before independence. The key to it was a decentralized and democratic political system.

This did not happen because anyone planned it. Quite the contrary: Stuart kings used the colonies to reward their family, friends, and political supporters by setting up proprietary colonies. A "lord proprietor" was essentially a monarch in his own realm, a prince who ran an outlying part of the kingdom with full authority to establish courts, appoint judges and magistrates, impose martial law, pardon crimes, call up the men of fighting age to wage war, grant land titles, levy duties, and collect tolls, so long as he agreed to maintain allegiance to the king (Galenson 1996). Maryland, for example, was founded as a proprietary colony run by Cecil Calvert, the second Baron Baltimore, who had received a grant from Charles I in 1632. New York, to cite another example, was granted by King Charles II to his brother, James, the Duke of York, who would later become King James II. James, in turn, sold what is currently the state of New Jersey to two of his friends, Lord Berkeley and Sir George Carteret, as proprietors. Berkeley and Carteret were both already proprietors of Carolina. Pennsylvania and Delaware were also granted as a proprietorship by Charles II to William Penn. In short, the Massachusetts Bay Colony, which was founded by Puritans and consumes so many pages in high school history textbooks, was an outlier.

The goal of the lords proprietors was not to create a democratic society of yeoman farmers that would one day throw off British rule. It was to re-create the manorial system, which had long since disappeared from England. The problem with this plan was that British North America contained neither a *Potosí* that produced piles of silver coins nor a Pernambuco that yielded prodigious quantities of highly valuable sugar. Cotton would play this role in the US South, but only much later, in the nineteenth century, after the cotton gin made it possible

to process the short-staple varieties that could be grown in American soils. The one thing that the thirteen colonies did have, however, was seemingly endless expanses of farmland suitable for tobacco, corn, and wheat. Crucially, those crops share characteristics that allow them to be grown efficiently on family farms: they are highly storable and exhibit modest scale economies in production (Binswanger and Rosenzweig 1986). Growing tobacco, corn, and wheat was not particularly attractive to the gentlemen that the lords proprietors hoped would establish rural manors, but it did prove attractive to small farmers who came as freemen and indentured workers in order to take advantage of the "headright system" that permitted them to obtain family-sized tracts in fee simple.[3]

Much to the shock of the lords proprietors, the free farmers soon began to take advantage of the fact that many of the royal charters called for the establishment of colonial assemblies. The charters creating those assemblies had envisioned a system in which lords proprietors, or governors acting on their behalf, would decree laws, "with the advice, assent, and approbation of the freemen of the same province" (Land 1981, 4). Rather than approving or suggesting changes to laws crafted by the lords proprietors, however, the assembled freemen began to draw up their own laws, challenged the lords proprietors to veto them, and gave one another proxies to represent them at assembly meetings.[4] That is, independent farmers created the right to vote for representatives endogenously in the seventeenth century; no one "granted" it. Even when formal restrictions on suffrage began to be established in the late seventeenth century, they were not onerous (Morgan 1975, 145). Suffrage was widespread, with typically 40 to 50 percent of early eighteenth-century white male colonists eligible to vote for colonial assemblies in the mid-Atlantic states (Keysaar 2000, 7).

When the United States threw off British rule there was never any doubt that the political system would remain decentralized and, by the standards of the eighteenth century, would be democratic. When the founders crafted the Constitution they grafted two additional eighteenth-century governance technologies onto these native-born institutions: judicial independence, which was created by England's 1701 Act of Settlement through the stipulation that a judge's commission could only be removed by both Houses of Parliament; and separation of powers, an institution whose benefits were first articulated, at least in the modern world, by Montesquieu in 1748 in *The Spirit of the Laws*.

One of the first acts of the new constitutional government was the creation of a patent system that was designed to encourage inventive activities by a broad cross section of American society.[5] As Bottomley (2014) has shown, the legal concept that a patent of invention was not a monopoly, but was a temporary property right to something that did not exist before and that could be sold, licensed, or traded, emerged out of British jurisprudence over the period 1730 to 1780.[6] The United States Patent Acts of 1790 and 1793 were crafted with an eye to democratizing the British system by simplifying the application process, lowering the fees to 5 percent of the British level, requiring the patentee to be "the first and true inventor" anywhere in the world, and obliging the inventor to provide sufficient technical detail that the technology could be copied upon expiration or invented around prior to expiration (Sokoloff and Khan 1990; Khan and Sokoloff 2001).[7]

The legal technology of a patent of invention as a tradable property right interacted with the governance technology of judicial independence, thereby creating an institutional environment in which patents were enforceable. The perspective of nineteenth-century American courts about the patent system is perhaps best captured in the decision by Joseph Story, the acknowledged patent expert on the Supreme Court from 1812 to 1845, in Ex Parte Wood and Brundage (1824): "[T]he inventor has a property in his invention; a property which is often of very great value, and of which the law intended to give him the absolute enjoyment and possession … involving some of the dearest and most valuable rights which society acknowledges, and the constitution itself means to favor" (quoted in Khan 1995).[8]

The response of the American public was even more enthusiastic than the authors of the patent acts had imagined. By 1810, the United States surpassed Britain in patenting per capita. From the 1840s through the 1870s the per capita rate of patenting increased fifteen times. Many of these patents were taken out by ordinary citizens operating with common skills and represented technological improvements across a broad range of economic sectors (Sokoloff and Kahn 1990, Kahn and Sokoloff 1993, 2001; Kahn 2005). As Khan and Sokoloff (1993, 2004) show, they played a crucial role in incentivizing many of the key inventions of the nineteenth century. Virtually all the great inventors of the nineteenth century made use of the patent system to appropriate returns to their efforts. In fact, rather than practicing their inventions themselves, more than half of them licensed or assigned their patents to other firms or individuals. Among these licensors were people whose names still adorn products today, such as Charles Goodyear, who invented the process for vulcanized rubber in 1839 but never manufactured or sold rubber products. Instead, Goodyear transferred his patent rights to other individuals and firms so that they could commercialize them.[9]

The US patent system was, in fact, a key input to the emergence of one of the most important breakthroughs of the nineteenth century, interchangeable parts manufacturing: components manufactured to specifications such that they will fit into any assembly of the same type. The idea of interchangeable parts was not new; it had been conceptualized in France in the 1760s and had then been employed in the manufacture of pulley blocks for sailing ships in Britain at the turn of the

nineteenth century. The big jump came, however, out of the workshops of inventors and craftsmen in the United States in the 1810s, who developed the jigs and milling machines that made it possible to cut metal to precise tolerances, thereby allowing for the mass production of interchangeable metal components. These were then used in the manufacture of clocks and small arms and later in the manufacture of engines, electrical machinery, and automobiles. The combination of interchangeable parts and mass production came to be known as the "American system" and served as the model for late nineteenth-century industrialization around the rest of the world (Engerman and Sokoloff 2000).[10]

The legal technology of a patent of invention as a tradable property right and the governance technologies of federalism and judicial independence interacted with yet another American invention: general incorporation (the creation of a limited liability, joint stock company without a special act of a legislature or royal decree). The idea of the limited liability, joint stock company extends back to ancient Rome in the form of the societas publicanorum, which was used to mobilize capital for public works and services (Malmendier 2009). Cities, universities, and trading companies in medieval and early modern Europe were often organized as corporations operating under special charters. In eighteenth-century Britain, as a result of the treatment of patents by courts as property rights, joint stock companies were created, with inventors as shareholders, that specialized in commercializing patents by licensing them to manufacturers (Bottomley 2014). General incorporation built upon these preexisting corporate forms, but it democratized access to incorporation by eliminating the need for a special act of a legislature or ruler. From the 1780s to the early 1800s, US states had used general incorporation for restricted purposes, such as religious congregations, colleges, libraries, and turnpikes. In 1811, the New York State Legislature, seeking to expand metal working and textile manufacturing in the state, extended general incorporation to manufacturing, so long as the company was capitalized at less than $100,000 and had no more than nine trustees (Seavoy 1972). New Jersey and Connecticut soon followed New York's lead. As each copied the others and sought to attract business enterprises to their states, they progressively reduced the restrictions on capital and business type that were part of the 1811 New York law.[11]

We cannot stress strongly enough that general incorporation, much like the patent system, was not a stand-alone technology: it could only mobilize capital efficiently in the context of a governance technology that prevented rulers or legislatures from arbitrarily amending or abolishing corporate charters. Thus, the spread of general incorporation was dependent upon an independent judiciary that limited the power of the government to interfere with private charters, as the US Supreme Court did in Trustees of Dartmouth College v. Woodward (1819).[12]

The combination of these legal, financial, governance, and metal-working technologies yielded innovations whose products were greater than the sum of their parts. The railroad, perhaps *the* quintessential innovation of the nineteenth century, provides an example. The social returns to railroads were immense because they fed back into production, military, and governance technologies: food could be moved longer distances, making it possible to support larger populations devoted to nonagricultural activities; manufacturers could reach larger markets, allowing them to capture scale economies; and militaries could move troops and materiel rapidly, allowing governments to expand the scale and scope of the nation-state. Nevertheless, railroads did not diffuse around the planet at a uniform rate. While the technical innovations that underpinned the railroad were worked out in Britain during the first three decades of the nineteenth century, financing, building, and operating a railroad network required the absorption of numerous complementary technologies, such as electrical telegraphy to adjust schedules; metal cutting and joining to repair locomotives and cars; patents as property rights to incentivize improvements in locomotives, cars, brakes, and steel rail production; and general incorporation to mobilize capital to build trunk lines. The absorption of these technologies, in turn, required the absorption of additional complementary governance technologies, such as separation of powers, judicial independence, and electoral democracy, which prevented governments from amending corporate charters or patents arbitrarily.

In the United States all of these complementary technologies predated the railroad. Thus, railway construction got underway in the 1830s, and by 1860—which is to say even before the transcontinental railroad—the United States already had a rail system with thirty thousand miles of track in operation. To give a sense of its extent, this was roughly three times the size of the British system, four times that of Germany, thirty times that of Spain, and 1,560 times that of Mexico—a difference that is all the more remarkable in light of the fact that the alternative to a railroad in the United States east of the Mississippi was a riverine barge, while the alternative to railroads in Mexico was a much less efficient two-wheeled wagon pulled by oxen (Comin and Hobijn 2009).

The innovation machine that emerged from America's underlying political and economic system did more than build railroads; it played a critical role in the emergence of new industrial centers. In the late eighteenth century, these centers were located in eastern Pennsylvania, New York, and Connecticut, and the industries that flourished there were sawmills, gristmills, paper mills, textile mills, breweries, distilleries, tanneries, and iron works (Scranton 1983, 75–83). Beginning in the 1820s, the fastest growing industry was cotton textiles, and the new industrial centers had moved to Rhode Island and Massachusetts to take advantage of their

abundant water power (Engerman and Sokoloff 2000). By the 1870s and 1880s, the innovation frontier had shifted to Cleveland, Ohio, which specialized in electrical machinery. Indeed, as Lamoreaux, Levenstein, and Sokoloff (2006) have shown, from the 1880s to the 1920s Cleveland bore a strong resemblance to today's Silicon Valley, where local networks of firms and complementary educational, technological, and financial institutions helped to initiate and sustain waves of start-up enterprises. Not only did Cleveland have a high rate of patenting, its manufacturing firms were intense users of those patented technologies—and, importantly, Cleveland was stunningly wealthy.

Section 3: Successful as Compared to What? A Chinese Counterpoint

Any statement about a process being fast or slow implies a counterfactual. Let us therefore draw a comparison to China during the same period in order to put the experience of the United States into stark relief.

China's political organization was almost the polar opposite of both the colonial and early national United States. Chinese dynasties since the Warring States period (475 to 221 BCE) had built immense bureaucracies to levy internal customs and directly tax farm output (Will and Wong 1991). By the Qing Dynasty (1644–1912) the system had become highly centralized. There were the emperor and his court, plus an immense, far-flung bureaucracy, headed by appointed governors, that reported to the court. There were no representative assemblies, nor was there voting of any kind.

This system had served China well, in the sense that it had allowed the territory of the realm to expand and had maintained social stability by using stocks of state-owned grain to normalize grain prices during periods of drought and flood (Will and Wong 1991). China was immense, in terms of both its territory and population size; circa 1800 it contained roughly 300 million people, as compared to a British population of roughly 10.5 million and a US population of 5.4 million.

China's centralized political structure proved, however, to be a major disadvantage in meeting the challenges posed by the new technologies of the modern era. Dynasties had long intervened in the commercial economy. In 1371, the first emperor of the Ming Dynasty decreed that all foreign trade had to be conducted by official "tribute missions" and that private foreign trade was punishable by death. Between 1613 and 1684, the emperor prohibited coastal trade even among Chinese between the lands north and south of the Yangtze River, the goal being to force all north-south trade through the Grand Canal, where it could be monitored, restricted, or taxed (Myers and Wang 2002, 587). In 1661 the government "ordered all people residing along the coast from Chekiang [roughly speaking, the present-day city of Hangzhou] to the border with Vietnam to move some seventeen miles inland. Troops constructed watchtowers and positioned guards on the coast to prevent anyone from living there" (Myers and Wang 2002, 565). In 1704 the emperor required all trade with the West to go through the port of Canton (Guangzhou), thereby allowing him to grant exclusive trading rights to a small number of merchant guilds, in exchange for which they forwarded an annual amount of customs revenue to the imperial government. Similar restrictions were imposed on mining and trade in salt (Myers and Wang 2002, 589, 608, 625).

Restrictions on commercial activity during the Qing Dynasty went beyond foreign trade, mining, and salt. Emperors and their courts worried that merchants might form coalitions with local officials that would weaken Beijing's power. In order to prevent that from happening, they throttled the commercial economy. The government required that merchants and brokers obtain licenses, set the fees for those licenses as a function of the value of trade moving through a town, and then limited the number of licenses. The net result was that by 1800, "few private organizations had achieved large scale size and complexity or been able to integrate different market activities" (Myers and Wang 2002, 606, 644).

As a result of the humiliating defeats in the Opium Wars (1839–42 and 1856–60), Chinese elites took note of a broad suite of new technologies that comprised modernity—and then rejected them. The fundamental problem was that the emperor and his court understood those technologies to be a threat to the imperial system. Qing elites therefore sought to modernize militarily while maintaining the stable agrarian society that had been the basis for Chinese dynasties for the previous two millennia. The Self-Strengthening Movement of 1861–95 encouraged the domestic manufacture of Western armaments, but the production and distribution of commercial goods remained tightly controlled. Unlike Japan, which responded to the threat from the West by adapting the US patent system (Kahn 2008), the British banking system (Calomiris and Haber), German civil and corporate law (Kirby 1995), German military organization (Ravina 2017), and parliamentary government on the German model (Ramseyer and Rosenbluth 1998), China's bureaucrats chose only to build government-run armories, run by incompetent managers appointed on the basis of patronage, that made inferior copies of Western rifles and cannons.

The limitation on the formation of private enterprises provides a sense of the restraints the Chinese political environment imposed on innovation. In the 1870s and 1880s, the government permitted some industrial enterprises to be founded, but only if they had active sponsorship *and supervision* from the government and its official bureaucrats.

As Goetzmann and Koll (2005) point out, these arrangements meant the private actors who put up the capital for the firms bore all of the financial risks, while "they were required to work under the thumb of supervising government officials who often followed their own, not necessarily government-directed business agendas and who introduced bribes, corruption, and inflexible management into these enterprises." When these restrictions were finally knocked down in 1895 it was not because the government sought to modernize the private economy. Rather, the Treaty of Shimonoseki, signed after the first Sino-Japanese war of 1894–95, required China to grant foreigners permission to engage in manufacturing operations in Chinese treaty ports. The government could not give foreigners this permission without also granting permission to its own nationals (Goetzmann and Koll 2005).

It was not just that the government imposed restrictions, it was that the political and economic system that had emerged in China was not built around the idea of independent agents contracting with one another, as existed in the United States, but around the idea that business enterprises were the outgrowths of family lineages and guilds, which were regulated through patronage by state bureaucrats. Business did not exist apart from home and family. Until 1904, there was neither a commercial code nor a civil code. To the degree that there was a body of law that regulated business enterprise, it was through the penal code, which specified punishments for bribe-taking by government officials (Kirby 1995).

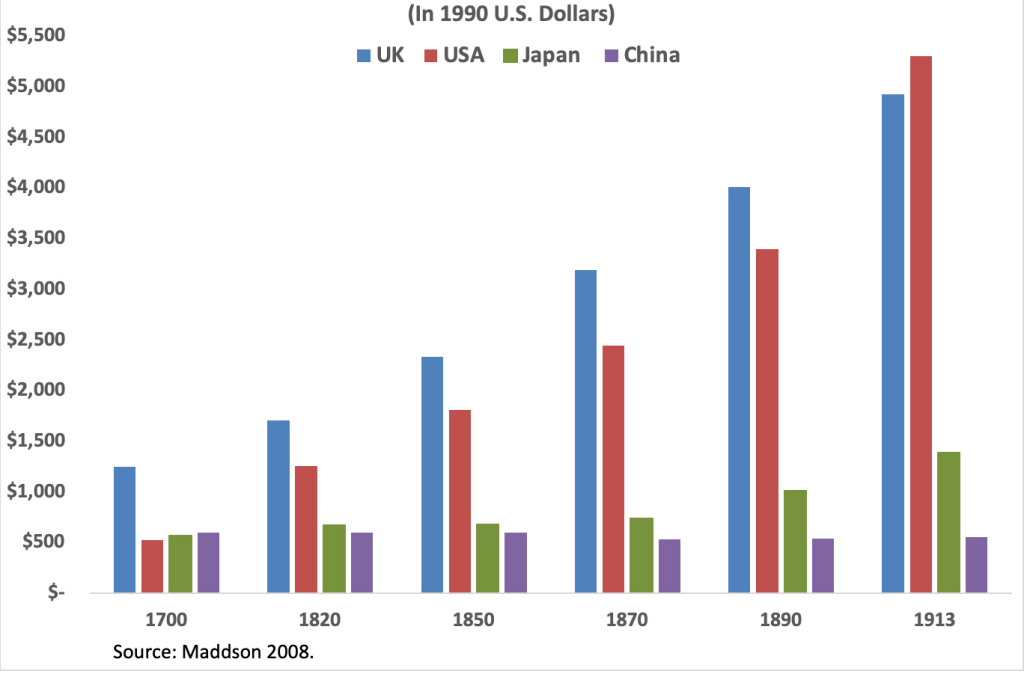
In 1904, the Chinese government finally made it legally possible to found an industrial enterprise as a limited liability, joint stock company. It did so, however, by cobbling together an abbreviated version of Japanese and English laws. Not surprisingly, the law had little impact. Only twenty-two of the 227 companies that registered were of any size, and much of the capital authorized for these firms was never raised. Given that the law was a transplant into a social and institutional context in which business was a family affair, regulated by patronage, in which disputes were adjudicated by custom, this should hardly be surprising. Chinese courts were not designed to handle disputes involving corporations. Thus, corporate disputes were referred to the Ministry of Commerce, an administrative, not legal, entity whose decisions had uncertain legal force (Kirby 1995). The lack of legal force was, in fact a reflection of a highly centralized political system; no force of law or countervailing political body could challenge a decision made by the bureaucrats in Beijing.

The educational system was similarly poorly designed to generate an innovative economy and society. It had been crafted in order to train young people to be imperial bureaucrats; the emphasis was preparation for an arcane examination on Confucian thought. The response of the government to the lack of engineers and factory managers was to send 120 students to study in the United States in 1872, but they were all called back by 1875 because of concerns about the students becoming overly familiar with Western political ideas (Kuo 1978).

Some sense of the way that all of these arrangements held back innovation can be garnered by looking at the growth of the railroad. Railway construction did not get underway in China until the 1890s. By 1910, the entire system had only nine thousand miles of track; which is to say that China had a rail system smaller than even that of Mexico and only 4 percent that of the United States (Comin and Hobijn 2009).

Some sense of the differences in equilibrium outcomes across China and the United States can be approximated using data on per capita GDP. We present the data covering the period from 1700 to 1913 in figure 2, as well as the data for two other societies we have mentioned in this essay, Britain and Japan. These figures should be taken with a grain of salt. Modern systems of national accounting were not developed until the 1950s; everything before that is a reconstruction.

Figure 2
Estimates of Real Per Capita GDP, UK, USA, China, and Japan, 1700 to 1913
(In 1990 U.S. Dollars)



Source: Maddson 2008.

Generally speaking, the further back one goes the less reliable the figures tend to be. Thus, the data points should be taken as statements of relative magnitude rather than as absolute values. That said, one does not have to squint to see the difference in relative magnitudes.

There are three salient patterns in figure 2, the first of which is that there was little difference in per capita income across the United States, Japan, and China circa 1700, while Britain was considerably more prosperous. The second is that the United States began to pull away from Japan and China in the early nineteenth century and began to close the gap with Britain. The third is that by the eve of World War I, the United States had outstripped Britain—at this point it had the highest per capita income in the world. Japanese growth had accelerated following the economic and political reforms of the Meiji Restoration, but the gap between the United States and Japan was on the order of four-to-one. Fourth, across the entire period of 1700–1913, Chinese per capita income had not grown at all.

Section 4: Conclusion and Implications

We began this essay by inquiring into the question of why some societies are much more innovative than others, and thus much more prosperous. We hope that at least one implication is now fixed in the reader's mind: innovation is not an event, it is a process. It happens when individuals take risks because they know that risk taking will be rewarded. Without a common belief that individuals will share in the rents from innovation, the necessary complementary skills, laws, and technologies do not come into existence. We hope, as well, that at least one secondary implication is jostling about in the reader's mind: it is that innovation and the prosperity it brings are not manna from heaven. They are equilibrium outcomes of a complex combination of political structures, laws, judicial systems, stocks of human capital, and belief systems. As such, they are fragile plants.

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Endnotes

[1] The most recent version of the dataset, covering 2012–to 2018, was retrieved from https://www.strategyand.pwc.com/gx/en/insights/innovation1000.html on September 8, 2020. Readers curious about the other countries highlighted in figure 1 may find it interesting that 160 of the one thousand most innovative firms, accounting for 15 percent of total revenues and 15 percent of R&D spending, were located in Japan; 133 firms, accounting for 14 percent of total revenues and 7 percent of R&D spending, were located in China; and thirty-seven firms, accounting for 4 percent of total revenues and 3 percent of R&D spending, were located in Britain.

[2] In this sense, a patent system is a legal technology that incentivizes invention by creating a tradable property right; a banking system is a financial technology that mobilizes capital by removing the need for savers and investors to know one another; public schools are an educational technology that promotes a broad distribution of human capital by giving all children the opportunity to study; and political correctness is a governance technology that reduces the ability of citizens to make up their own minds by shaming those who reject the orthodoxies promulgated by cultural elites.

[3] The lands were obtained as grants from the lords proprietors. Each grantee received fifty acres of land for each person they brought into the colony, whether as settler, indentured servant, or slave. The lord proprietors received an annual "quitrent" from the grantees (Land 1981, 25).

[4] In some colonies, such as Maryland, New Jersey, and Pennsylvania, the resistance of the colonial assemblies to the lord proprietor and his agents occurred almost immediately (Land 1981; Murrin 1984, 443–44). But even in New York, whose initial charter did not include a colonial assembly, the farmers agitated for one and were successful in their demands by 1691.

[5] It is beyond the scope of this essay to explore every nuance of how patent systems work, but suffice it to say that most products are not themselves patented; what are patented are the technologies that make the products possible. You may, for example, be reading these words on a laptop computer, a tablet, or (eyesight permitting) a smart phone. However, there is no patent for a laptop, a tablet, or a smart phone. Rather, there are tens of thousands of patented technologies that allow you to download this essay, display the words on a screen, make notes in the margins, and share your thoughts about its ideas with friends and colleagues—and do all of these things regardless of the type and brand of the device you are using. Most of those patented technologies were not developed by the firm whose brand name appears on your device. They were developed by specialized firms, most of which you have never heard of. See Kieff (2006).

[6] A patent can only confer a monopoly in production if there are *absolutely* no substitutes for a patented technology, the technology is itself being sold legally by the owner or her affiliates, and the patent owner declines to sell licenses. Put differently, a patent is only a right to exclude, not use. Any particular patented product or service may, and often does, compete with many substitutes in the market. Moreover, a patent requires that the invention be clearly specified such that a competitor can invent around it. This gives a patentee an incentive to sell others a license to the patent: the patentee can either get a royalty equal to some percentage of output, or he can get zero; others have the choice between paying a royalty equal to some percentage of their output or bearing the costs of inventing around a patent. Writing a contract to license the patent therefore makes both parties better off. In fact, if someone actually had a technology for which there were no substitutes and which could not be reverse-engineered by a third party at a lower cost than the R&D and other costs already incurred by the inventor, he would not patent it at all! He would instead take advantage of his proprietary knowledge to dominate the market. The result *would be* a monopoly—but it would have nothing to do with patents. See Barnett (2009).

[7] Patents were further strengthened by the Patent Act of 1836, which introduced the examination system still in use today, thereby reducing concerns third parties might have had about a patent's

novelty. Britain, seeing the superiority of the US system at the Crystal Palace Exhibition of 1851, adopted many of the features of the US system in 1852. The US system also became the basis for Germany's 1877 patent law and Japan's 1888 patent law. The German system, in turn, influenced the patent systems of Argentina, Austria, Brazil, Denmark, Finland, Holland, Norway, Poland, Russia, and Sweden (Kahn 2008). Also see Mossoff (2001).

[8] Also see Mossoff (2007).

[9] The practice of patent licensing has a long history in the United States, and its emergence allowed for gains from specialization. But those gains could only come if an inventor could reap the returns from his or her investment through a well-defined and enforced property right (Sokoloff 1988; Khan and Sokoloff 1993; Lamoreaux, Sokoloff, and Sutthiphisal 2013).

[10] This history of the US patent system perhaps comes as a surprise to readers of this essay, who have in recent years been inundated with literature about patent trolls, patent failure, and patent holdup. See, for example, Bessen Meurer (2008), Boldrin and Levine (2008, 2013), and Lemley and Shapiro (2007). For a critique of that literature, questioning its logic and evidence, see Kahn (2014), Galetovic, Haber, and Levine (2015), Galetovic and Haber (2017), and Barnett (2017).

[11] The concept proved so successful that it was gradually adopted by Britain in the 1840s and 1850s, by France in the 1860s, by Germany in the 1870s, and by Mexico, Brazil, and Japan in the 1880s (Hannah 2014).

[12] Even though general incorporation laws were later adopted by other countries, the extent to which they could mobilize capital varied widely. In settings in which connections to political elites were important to the success of an enterprise, general incorporation tended to only be used by those who were already well connected (Haber, Razo, and Maurer 2003). This point about the political basis for general incorporation is explored in Malmendier (2009), who shows that the societas publicanorum was widely used during the Roman republic but fell into disuse after centralization of political power during the empire.

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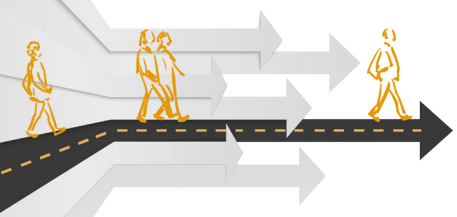

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