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Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth

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There is a growing consensus that in all cases of successful and unsuccessful economic growth, institutions mattered (Elhanan Helpman 2008; Daron Acemoglu, Simon Johnson, and James Robinson 2005). Somewhat oddly, little detailed research has been done to date to relate the Industrial Revolution, the taproot of modern economic growth, to its institutional origins (but see Mokyr 2008). The focus of institutional analysis has been either on earlier episodes of mostly Smithian growth, such as the commercial revolutions in medieval Europe (Avner Greif 2005), or on more modern experiences, when good data allowed researchers to have a meaningful debate on how to test hypotheses on the importance of institutions. The main argument made about institutions and the British Industrial Revolution is that political events from the late seventeenth century on created a regime that supported an executive that was sufficiently constrained to create a "rule of law" and respect private property rights, and yet not engage in (or permit others to engage in) unbridled rent-seeking (Douglass North and Barry Weingast 1989; Kenneth Dam 2005).

Part of this argument is that in this age intellectual property rights (IPR) began to be increasingly respected. The reason this argument is central is that, in the end, the Industrial Revolution was a set of technological improvements, a few large and dramatic, most mundane and incremental. The kind of institutions that incentivize technological progress differ from those that support the growth of markets by protecting property rights. It is true that in a wholly lawless society technological progress is unlikely, but all the same the institutions that support the different kinds of growth are not likely to be identical. Indeed, one could argue that to some extent the reverse was needed for rapid technological change: some property rights had to be extinguishable when they got in the way. This was true not just for such concrete matters as eminent domain used to expropriate land or parliamentary enclosures (which terminated de facto property rights of smallholders), but also to extinguish a host of monopolies and other rent-generating exclusions and *privilèges* that had been regarded as assets in an earlier age but were effectively used to block technological progress.

What kind of institutions encouraged technological progress? Inventions needed incentives, and IPRs provided incentives for successful inventors. It was therefore fortunate, the argument goes, that Britain indeed had a patent system, established in 1624. While the number of patents was stagnant until the middle of the eighteenth century, it started rising steeply in the mid-1750s, more or less at the time of the traditional Industrial Revolution (Richard Sullivan 1989). It thus stands to reason that IPR's provide an essential part of the puzzle of how institutions contributed to the origins of the Industrial Revolution. North (1981, 164–66) provided the canonical statement: the rate of technological change depended on the inventor's ability to capture a larger share of the benefits of his invention. Only the patent system created a set of systematic incentives that raised the private rate of return closer to the social rate.

What could be wrong with this picture? The answer is basically "almost everything." Yet this is not to deny the importance of *some* form of IPRs for the process. The historical difficulty is not to establish that the patent system had on balance a positive effect on technological progress, but rather to ask whether the effect could be large enough to account for a substantial proportion of the acceleration of technological progress we are trying to explain. Moreover, other institutions may have been equally important or more so than the patent office.

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I. Patents and the Industrial Revolution

The notion that patents were part and parcel of an enlightened economy was already stressed by Adam Smith and still expressed in similar terms a century later by John Stuart Mill (Smith 1759, 83; Mill 1848, 933). Enlightenment thinkers reasonably argued that it would be better if market forces and free enterprise (as opposed to government officials or academic committees) determined payoffs. Moreover, they felt that patents encouraged innovation and that innovation was the key element in economic growth, both by encouraging more R&D and by getting more investors to put "venture capital" into risky projects. No less a light that J. W. Goethe thought that in Britain patents transformed inventions into real assets. "One may well ask why are they in every respect in advance of us?" (cited by Friedrich Klemm 1964, 173). From a practical point of view, they felt that patents were the price society paid for disclosure and that disclosure was essential for the unfettered dissemination of useful knowledge. The full specification of the patent made the technical details accessible to others.

Yet there was legitimate doubt, even from those who shared the same objectives and hopes for society. Eighteenth century thought developed a growing belief that monopolies of all types, even temporary ones, were bad. There was an intuitive sense that access to knowledge should be free because anything that limited access to useful knowledge was bad for the Baconian program, the cornerstone of Enlightenment economic thought. It was realized that patents were used strategically, for example, to block research by nonpatentees in some directions, and thus actually slowed down innovation (as the classic examples of Thomas Savery's patent blocking Thomas Newcomen from patenting his steam engine, and James Watt blocking high-pressure engines, attest). Some writers also pointed out that patents were used as false quality signals and lured investors and consumers into fraudulent schemes (e.g., "patent medicine"). There was also a moral sense that inventors, like scientists, were serving the public good, and should be rewarded by honors and patronage, not necessarily financial rewards related to the economic impact of the invention.

In short, there were considerable ideological differences between adherents of the Baconian program as to the efficacy of a patent system. The eighteenth-century *philosophes* had to confront the notion that if a society wished to promote technological change, it needed to create the economic incentives for inventive activities to take place. An uncomfortable clash between what seemed "just" and what was necessary if progress were to be attained was recognized. The question is, of course, what the historical record has to say about the impact of the patent system on the Industrial Revolution.

The number of patents filed in Britain, as noted, seems at first glance to track the history of the Industrial Revolution. Yet the question remains if this can be taken as evidence of the role that patents played in incentivizing and stimulating the processes that eventually generated modern economic growth. It is important to stress that the experience of Britain with patents during the Industrial Revolution was based on the British system as it existed, not as it might have been if a new system had been designed *de novo*, as the United States was after Independence. The differences between the two were striking (B. Zorina Khan and Kenneth L. Sokoloff 1998). Before the big reform of 1852, taking out a patent in Britain was very expensive: for England alone the filing fee was £100, but for the Kingdom as a whole it came to £350, not counting other expenses. A Lancashire linen manufacturer, Samuel Taylor, spent £125 on filing for a patent in 1772, and in addition had to be in London away from his business for six months to complete the formalities (James Harrison 2006, 11). Many patents were infringed upon, and judges before 1825 or so were often hostile to patentees, considering them monopolists (Eric Robinson 1972, 137). No patent was fully valid until it had been tested by courts, but people rarely sued: between 1770 and 1850 only 257 patent cases came before the courts, out of 11,962 patents granted (Harry I. Dutton 1984, 71). The patent system was riddled by the widely condemned practice of so-called *caveats*, which were an expression of the intent to file a particular patent later on, and acquiring a block on any application before warning the filer. Competitors could use caveats to delay the sealing of a patent, as well as for industrial espionage. The bureaucratic process that a potential patentee had to go through has been described as a "tortuous labyrinth" and was ridiculed by none other than Charles Dickens in his little

novella *A Poor Man's Tale of a Patent.* Some of the most eminent men of science and technology in the period condemned the system as it existed. Babbage, never one to mince words, denounced the patent law as a "system of vicious and fraudulent legislation" which deprived the inventor of the fruits of his genius and put the most productive citizens of society in a position of "legalized banditti," and "a fraudulent lottery which gives its blanks to genius and its prizes to knaves" (Charles Babbage 1830, 321, 333). The objections were not so much against the system in general as against the way the law was written and carried out in Britain, especially the high cost of patenting and the sense that even the granting of a patent was "almost wholly illusory" until the patent had been sustained by a court of law, at an even higher cost (Babbage, 334).

Moreover, the experience of other countries seems to lend little support for a central role for patents. The most striking case is the Netherlands which, despite its high degree of economic development in the seventeenth century, did not figure prominently in the Industrial Revolution. Yet it had a patent system, established in the sixteenth century. The number of patents fell sharply at the end of the Dutch Golden Age in the 1670s and did not recover before 1800 (Karel Davids 2008).

Finally, the impact of costly and cumbersome patents is illustrated by the sharp increase in the number of patents filed in 1852 after the filing costs were reduced, which by itself does not prove that the number of patents filed until then was suboptimal. It has also been suggested that patents were primarily the outcome of a non-cooperative competitive "race to the bottom" process in which patents were taken out preemptively, much like an arms race or an advertisement campaign that lead to an equilibrium in which all actors are worse off. Patents, together with the heavy use of caveats in competitive industries, were more of a competitive tool to thwart would-be competitors than a genuine reward for technological creativity (Dutton 1984, 182–83).

Moreover, it is striking that many of the important inventors of the Industrial Revolution viewed the patent system negatively and chose not to use it. Some of them were eminent scientists who brought the cultural norms of the world of science into technology, such as Papin, Davy, Hales, Faraday, Priestley, and Rumford. They refused to take out patents as a matter of principle. Many eighteenth century scientists dabbled in invention, and this cultural spillover tells us something interesting about their motivation and incentives. "When one loves science," wrote Claude Berthollet to another inventor, James Watt, "one had little need for fortune which would only risk one's happiness" (cited by A.E. Musson and Eric Robinson 1969, 266). The same holds for the field of engineering, central to technological growth during the Industrial Revolution. Many of the great engineers of the Industrial Revolution, Watt being the great exception, had little interest in patenting (Christine MacLeod 1988, 103–06). A case in point is the career of John Rennie, who opened the revolutionary Albion Mills (using steam engines to grind flour) for anyone to see in 1786, to James Watt's horror, and did not take out a patent in his life. Rennie was obviously *signaling his capabilities* rather than *selling specific knowledge*, soon securing consulting and special manufacturing jobs from all over Britain, as well as from the Continent. Abraham Darby II declined to take out a patent on his coke-smelting process, allegedly saying that "he would not deprive the public from such an acquisition" (cited by MacLeod 1988, 185). Others tried to patent and failed, with little effect on their subsequent careers, or in some of the most famous cases, successful inventors were let down by the intellectual property system, Parliament stepped in to reward them for their contributions to the welfare of the realm. Thus, Samuel Crompton, inventor of the mule, and Edmund Cartwright, inventor of the power loom, were awarded such grants. The largest award, not surprisingly, went to Edward Jenner, discoverer of the smallpox vaccination process, who was awarded £30,000 in 1815.

Adam Smith's strictures notwithstanding, Britain did not entirely rely on the verdict of the market when rewarding innovation, even in the realm of prescriptive knowledge. The signaling and reputation culture of the world of science and mathematics spilled over onto large areas of prescriptive knowledge, and in those areas patents had no large role to play. Moreover, other incentives beside patents mattered. In a few instances prizes may have been decisive, especially in the famous case of the marine chronometer: the prize was given not only to John

Harrison, the inventor (after much trouble) but also to lesser-known inventors who had made further improvements on the original longitude-measuring clock. Much smaller but perhaps not insignificant were the prizes awarded by the Society of Arts, founded in 1754, a society that was in principle opposed to patents. In all these cases, and many others, there was an explicit recognition that if society wanted a continuous stream of technical improvements, it had to make the activity that generated innovation financially attractive, even to those who did not rely on patents. Technological progress, at least in some areas, was not the fiercely competitive process that a well-functioning patent system implies. Economic historians have found some examples of what Robert C. Allen (1983) has termed collective invention, that is, the main actors in technological innovation freely sharing information and claiming no ownership to it (see also Alessandro Nuvolari 2004). Examples are few, but technical knowledge was shared on a much larger scale than the cases of collective invention suggest. Within the technical committees of the Society of Arts, people shared ideas and "sharpened minds" with others engaged in similar occupations (Harrison 2006, xxiii).

Equally enlightening regarding the role of the patent system in the Industrial Revolution is the question of what proportion of inventions was ever patented in the first place. The question is hard to answer because, while the numerator of the ratio is known and recorded, the denominator is vague and poorly defined: what is the set of total inventions made over this time? This is a different question from what proportion of patents were ever commercially exploited or even technically feasible, which is often raised as a source of doubt on the use of patent statistics as an indicator of inventive activity. An elegant and persuasive answer for one point in time was provided recently in pioneering papers by Petra Moser (2005, 2007). Moser argued that the proportion of new inventions exhibited in major industrial exhibitions would be an upper bound of the true and observed ratio, since the exhibits were the most innovative and potentially important of all inventions. Her data show that of all British exhibits that were selected to be displayed at the Crystal Palace in London in 1851, only 11 percent were patented, and that even if we look at award winners (the *crème de la crème* of all exhibits) only less than 16 percent were patented. This cannot be attributed entirely to the high cost of the British patent system alone, since the American system was far cheaper and more accessible, yet the proportion of American exhibits that were patented was not much different (14.2 percent).

II. Patents and Incentives in the Industrial Revolution

All in all, then, the enthusiasm shown by North for a patent system as one of the decisive factors in stimulating technological progress in this age must be tempered by some undeniable historical facts and data. Yet it remains to be seen to what extent that actually reduces the patent system to insignificance, as some economists have recently argued (David Levine and Michele Boldrin 2008). The propensity to patent differed greatly between industries, and in industries in which patenting was important, such as machinery, innovation would tend to be concentrated in economies in which patent protection was stronger, whereas textile inventions could be found in countries in which patent protection was weak or absent (Moser 2005). A particularly striking case for patents biasing the process is documented by Murmann (2003) for the nineteenth century German chemical industry.

The question of incentives has not, however, been fully settled. The point that should be made is that for the purpose of achieving technological progress, what mattered was not the *actual* working of the patent system but the way it was *perceived* by inventors contemplating a project. There is considerable anecdotal evidence that the *hope* for a successful patent remained heavily on the minds of many of the great inventors of the age. Richard Roberts, a prodigiously creative engineer, told an 1851 parliamentary committee that, were it not for the patent system, he would not have invented as much as he did, and the inventions he would have made would have lain on the shelves. A patent made it possible for an independent inventor to find a manufacturer who would take up a proposed invention, giving him the security he required that profits would not be competed away right away (Great Britain 1851, 187). Otherwise, Bessemer wrote in his *Autobiography*, "no manufacturer will go to the trouble and expense of trying to work out the

proposed invention …. And so the invention is lost to the world in consequence of having been given away" (Henry Bessemer 1905, ch. VIII). This was by no means a universally held view, but it did not have to be. As long as a significant number of would-be inventors believed they had a reasonable chance at hitting a jackpot, some case for an incentive system would be established. In that regard, the economic success of a few famous players would provide the signal needed.

The basic argument goes back to a "lucky fools" theory of entrepreneurship, suggested in a seminal paper by John Vincent Nye (1991). The main idea is that entrepreneurship and invention are like unfair gambles or lotteries, but a few spectacular and well-publicized success cases led others to believe that the odds were better than they really were. After all, precisely because by definition all inventions are in some dimension dissimilar (unlike lottery tickets), the *conditional* odds that underlie decisions in this activity may be systematically higher than the unconditional ones. Modern theory has developed the concept of optimal expectations, in which agents have higher current utility if they are overly optimistic about the future and therefore behave as if they are risk-loving when the returns are highly skewed (Markus Brunnermeier and Jonathan Parker 2005). This is hardly a new insight: Adam Smith already noted (in a different context) people had an absurd presumption in their own good fortunes: "The over-weening conceit which the greater part of men have of their own abilities … The chance of gain is by every man more or less over-valued, and the chance of loss … undervalued" (Smith 1776, 120).

There were, of course, examples to support such views. In a few cases, patents were sufficiently successful that Parliament actually voted to extend them: the Lombe brothers and Thomas Savery's patents were both extended, and so was Watt's patent of 1769, possibly the most famous patent in history. Some others, too, gambled on the patent system and won: the Scottish bleacher Charles Tennant's 1798 patent on bleaching powder made him a very rich man. The effect these salient events must have had on would-be inventors must be a bit like the effect of a few fabulously wealthy National Basketball Association players on aspiring teenage basketball players, who invest huge amounts of their time in trying to "be like Mike" (Michael Jordan). The skewed distribution of rents may have created an exaggerated impression of the potential payoffs. From a private welfare point of view, this was inefficient (since the vast bulk of this R&D paid no return), but from a social point it may have been desirable precisely because of the vast spillover effects of a few successful inventors. These spillovers constituted the vast bulk of the social surplus created by technological change. William Nordhaus (2004) has estimated that in modern America only 2.2 percent of the surplus of an invention is captured by the inventor himself. Things were surely not looking better for inventors in the eighteenth century. As long as, on average, people were willing to be fooled, a few vastly successful patents would keep hope alive. The incentive effects of the patent system may have been larger than its historical importance, if it led potential inventors to believe that a patent was a possible way to riches. However, it was not the *only* way to exploit inventions for financial benefit. First-mover advantage or overall good business acumen (or partnering with someone who had it) was another, as the careers of Josiah Wedgwood and Richard Arkwright illustrate. To win the patent gamble in eighteenth century Britain, one had to be more ingenious. One also had to be lucky.

III. Concluding Remarks

The importance of the patent system in the British Industrial Revolution has to be scaled down. Inventors were not all motivated primarily by a desire to maximize income: the "two sharp spurs that quicken invention and animate application," as William Shipley, the founder of the Society of Arts, put it in 1753, were "Profit and Honour." Much of the reward was indirect, through "honor," which was clearly a reflection of the importance of signaling and reputation in this world. Nor can we altogether rule out any role for altruism, as well as a direct utility from being able to solve hard problems—what could be termed the "crossword puzzle" motive.

None of this is to suggest that money was unimportant to most inventors. But the patent system, for the vast majority of them, offered a false hope, and the expected payoff of a patent was in all likelihood negative. Why, then, did people come back? Even after the debacles of

Arkwright and Argand in the 1780s, hopeful inventors were filing for patents. The answer must be that learning from the experience of others, when those others are demonstrably different, is limited, and that individuals have a strong ability to cling to the belief that their odds are better than they really are. This is clearly not a rational expectations equilibrium, but ex ante it is not individually irrational, because there is no easy way to test whether any invention will be one of the chosen ones. Once inventors learned their true type, it may have been too late for them. For the vast bulk of inventors, patenting was either not an option at all, an option declined, or an option that disappointed bitterly. For them this setup was surely inferior.

But inventors were a small subset of the population. Given that the benefits of the inventions were almost entirely captured by the population of consumers at large in increased consumer surpluses, the patent system may well have had the unintentional side effect of stimulating a level of inventive activity that was about right. By cheating the few, it benefitted the many. Had there been no patent system altogether, or had no one ever been able to get rich on 14 years of monopoly, the level of inventive activity may have been lower. Honor alone would not have been enough in some industries. On the other hand, had the system been more open and accessible, and had patents been more enforced, blocking patents and monopolies in rapidly changing industries may have slowed down the pace of progress. As it was, it may just have been enough to help keep Britain as the Workshop of the World until deep into the nineteenth century.

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